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Effect of Porous Pipe Characteristics on Soil Wetting Pattern in a Negative Pressure Difference Irrigation System

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ABSTRACT:*Sub-surface irrigation has been widely used to reduce conveyance, evaporation and percolation losses. This system involves the application of water directly into the root zone of crops. Negative Pressure Difference Irrigation (NPDI) is one kind of subsurface irrigation which is effective in management of irrigation water. The efficiency of this system is dependent on the soil wetting pattern as well as the characteristics of porous pipe. To examine the effect of characteristics of six different porous pipes on soil wetting pattern using NPDI system, experiments were done in laboratory at a negative pressure (P_n) of -3 cm. That P_n was generated by placing water reservoir in a lower level than porous pipe, which was installed vertically at the center of soil column. The water was supplied for four hours and after removing dry soil from the column wetted soil was observed. The experimental results show that the soil wetting pattern varies for each type of porous pipe. The study reveals that the shape of the wetted soil is roughly truncated sphere. The maximum vertical expansion and maximum radial expansion vary with the change in diameter and length of porous pipes. With the change in diameter of 128.6%, the maximum radial expansion differs from 24.1% and 34.48% for X and Y axis respectively. Since the water use efficiency is in the range of 0.94 to 0.97, this advanced method can be used as alternative of other traditional methods.*

Keywords – *Negative Pressure Difference Irrigation, Porous Pipe, Soil Wetting Pattern, Wetting Front*

I. INTRODUCTION

Water is the most important factor that affects the agricultural production.When there is a lack of water, farmers always make an effort to irrigate their field to obtain high crop production. Vast majority of people is generally used conventional methods such as surface, furrow, sprinkler, basin irrigation etc.It is estimated that out of total 80% water losses, about 20% are farm water losses because of deep percolation and surface evaporation due to practice of traditional surface irrigation methods (Siyal2008[1]).In a sprinkler irrigation system, spray losses can become as high as 45% under extreme weather conditions such as bright sunlight, high temperature and low humidity (Frost and Schwalen 1955[2]). Moreover, owing to high water losses and installation cost, Furrow and Basin irrigation are rarely used in remote regions.

Consequently, there is a call for new irrigation method which will supply uniform soil moisture in the root zone e.g. high water use efficiency. Subsurface irrigation is one of the most well suited methods because precise amount of water is directly applied to the root zone and thus reduce water losses due to conveyance, evaporation and deep percolation. Negative Pressure Difference Irrigation (NPDI) is an improved version of subsurface irrigation whose water use efficiency is much higher than other traditional irrigation methods that are mentioned in this article and has no conveyance loss. NPDI system is an attractive mode of irrigation system in which water is supplied to the soil by means of porous pipe from the water reservoir using a negative pressure. The water wasted in the NPDI is less than that of the drip irrigation (Yabe et al. 1986[3]). The configuration of wetting front, porous pipe compositions are helpful for optimizing the performance of the NPDI system.

In past studies, most of the investigations on NPDI system were conducted with horizontal installation of porous pipe(For example, Kato et al. 1982[4], Tanigawa et al. 1988[5], Ashrafi et al. 2002[6], Siyal et al. 2009[7]). The infiltration rate and soil wetting pattern in vertically installed porous pipe has been rarely experimented except two groups of researcher (Peifu et al. 2004 [8] and Akhoond et al. 2008[9]). It can be easily predicted that the soil wetting pattern for vertically installed porous pipe will be different from horizontally installed porous pipe. Hence, it is necessary to know the variation in soil wetting pattern when porous pipe installed vertically.

The main objective of the study is to visualize and measure the soil wetting front. Another is to observe the effect of characteristics of six different porous pipes such as lengths, diameters on wetted soil volume at a negative pressure. The remaining objective is to detect the water use efficiency of different porous pipes.

II. MECHANISM OF NPDI SYSTEM

In the NPDI system, water moves in a water supply conduit that links a water reservoir and a porous pipe which is installed vertically at the center of soil as shown in Figure 1.When the soil water matric potential (referred as matric potential, ψ) is smaller than the negative pressure in the porous pipe, P_n, water moves up from the reservoir to the porous pipe and then infiltrates through the porous pipe into the surrounding soil.

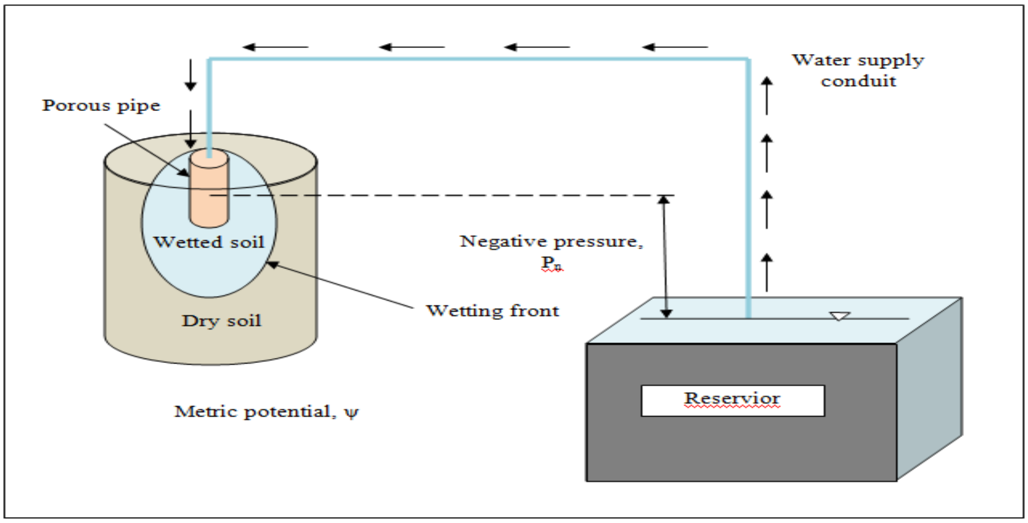

Fig. 1 Mechanism of a negative pressure difference irrigation system

On the other hand, when ψ is equal or larger than P_n, the seepage stops automatically without any artificial work. The supplied water per unit time (Supplied water rate) is in proportion to the negative pressure difference (NPD), $|\psi - P_n|$ (Moniruzzaman et al. 2011[10]).

III. MATERIALS AND METHODS

3.1 Location of the Study

The full research was conducted within the Department of Civil Engineering, Khulna University of Engineering and Technology.The preparation of porous pipes was completedin the geotechnical laboratory and the experimental set up and its related works were done in the environmental laboratory.

3.2 Fabrication of Porous Pipe

For the manufacture of porous pipe, locally available silty clay and rice husk were the main components. The percentages of them were 80% and 20% respectively. Rice husk is a good combustible material which can be used to produce porous pipe because their complete combustion could create pores within the bulk of a sand composite material.

For the necessity of the study, six different dimensions of porous pipe were selected. In Table 1, both dimensions and specifications are given.

Table 1 Dimensions and Specifications of porous pipe

Sample No	Material Type	Shape of Porous Pipe	Length (cm)	Outer Diameter (cm)	Thickness (cm)
P1	Silty Clay and Rice Husk	Cylindrical (One side closed)	11	4.2	1
P2			10.5	7	
P3			12	8	
P4			8	5.5	
P5			8	3.5	
P6			10.5	4.5	

To execute the making process, silty clay and rice husk were collected from local field and rice-mill respectively. The ingredients were sieved by # 40 and # 30 respectively. Using 4:1 ratio, the ingredients were mixed homogeneously with sufficient amount of water. In order to reduce the manufacturing cost and since the porous pipe was locally made, tap water was used instead of de-ionized water.

To make the preferred shape of porous pipe, different types of wooden mold was prepared and PVC pipe was cut into pieces to fulfill the dimension requirement. The entire mold was covered by polythene and enclosed it by the pipe. This produced structure was filled with mixture. A knife was used to remove the excess portion of mixture and for leveling the upper portion. Then the pipe and mold were removed respectively.

The rest of the porous pipes were prepared in the same process. Then, all of them were brought outside to dry primarily in sunlight for a period of half hour. Eventually, the porous pipes were kept in oven at 105°C for 24 hours and desired one side open, hollow cylindrical shape porous pipes were obtained. In Figure 2, the complete manufacturing process is shown.

Fig. 2 Complete manufacturing process in form of pictures

3.3 Experimental Set Up

For the necessity of the arrangement, first of all, two electric balances with a minimum reading of 0.1 gm and a bottle which would be used as reservoir were collected. A soil column was made by using seven rings which was sliced from PVC pipe and each ring was of 3 cm, 20 cm and 0.5 cm in height, outer diameter and thickness respectively and attached to each other with binding tape to give a form of soil column. One end of the soil column was joined with a piece of glass by Silicon gum. The local sand wasused to fill the soil column and the bottle was loaded with water. Since the main theme of Negative Pressure Difference Irrigation (NPDI) system is negative pressure, for that reason, soil column was placed in higher elevation than the reservoir to produce a negative pressure of 3 cm. One of two electric balances was placed below the soil column to measure the amount of water stored in the soil, $M_{soil}$and the remaining one was under the reservoirto measure the supplied water from reservoir, M_{sup}. A pump was used to maintain the continuous flow with a pumping rate of 0.02292 gm/sec. Figure 3 shows the experimental arrangement.

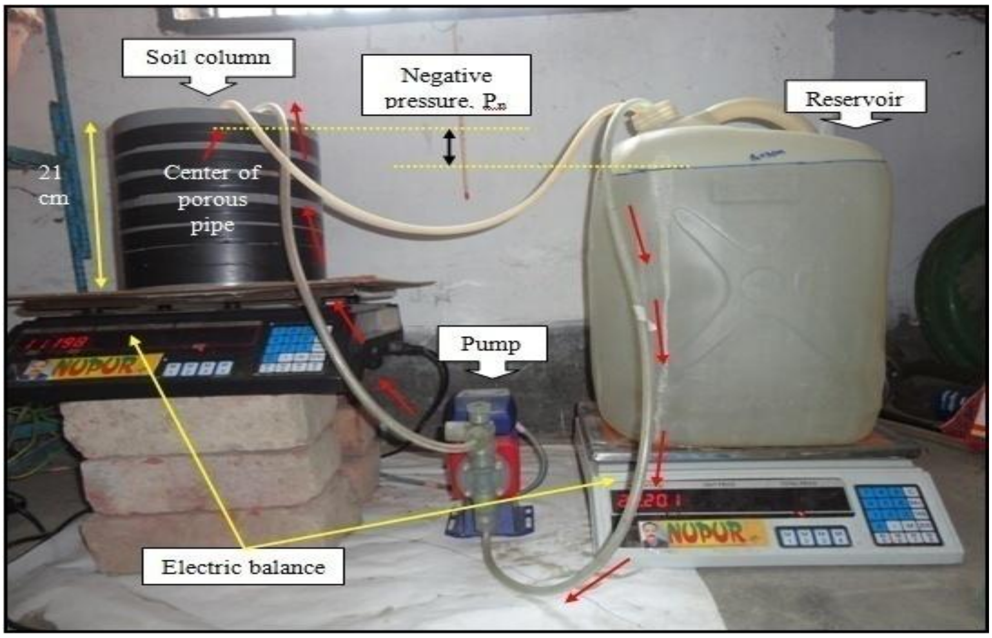

Fig. 3Overall experimental arrangements

All the data were collected at 40 minute intervals of total 4 hours. After recording data, evaporation from the soil surface, $M_{eva}$was calculated using following formula

$$M_{eva} = M_{sup} - M_{soil} \quad (1)$$

After water supply four hours, the measurements of soil wetting pattern were taken layer by layer after removing the dry soil from the column. Each layer was of 3 cm in depth. The measurements were taken both in X axis and Y axis of wetted soil surface.

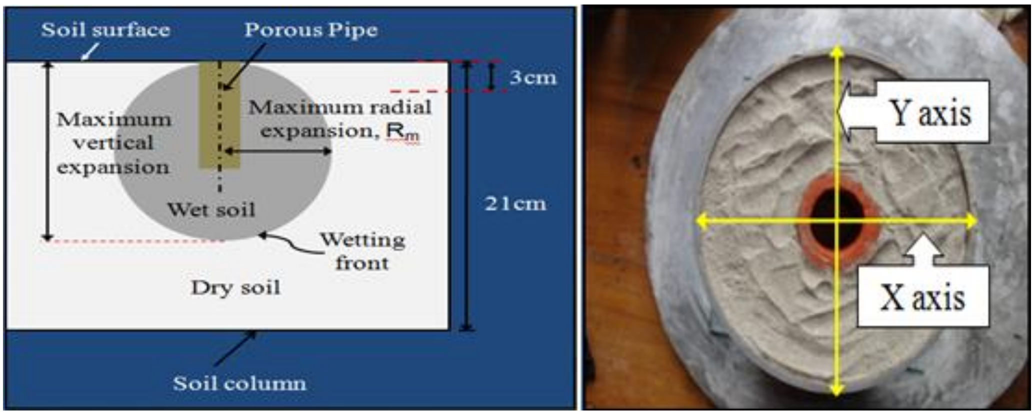

Fig. 4From left - Schematic diagram of soil wetting pattern measurement and picture showing axis

IV. RESULTS AND DISCUSSIONS

4.1 Soil Wetting Pattern

The experimental results of soil wetting pattern for different porous pipes P1, P2, P3, P4….are shown in Table 2, Table 3, …… respectively.

Table 2Experimental Results for Porous Pipe P_1

Mass Balance			
Time (min)	M_{sup} (kg)	M_{soil} (kg)	M_{eva} (kg)
40	0.053	0.052	0.001
80	0.053	0.051	0.002
120	0.056	0.054	0.002
160	0.055	0.053	0.002
200	0.056	0.054	0.002
240	0.057	0.055	0.002

Depth from soil surface, Z (cm)	Expansion of wetted soil in X axis and Y axis			
	+X (cm)	-X (cm)	+ Y (cm)	-Y (cm)
0	2.4	2.4	2.4	2.4
3	2.7	2.7	2.7	2.7
6	7	6.5	7	7
9	7	7	7	7
12	7.5	7.5	7.5	7.5
15	6.5	6	6.5	6.5
18	0	0	0	0
21	0	0	0	0

Table 3Experimental Results for Porous Pipe P_2

Mass Balance			
Time (min)	M_{sup} (kg)	M_{soil} (kg)	M_{eva} (kg)
40	0.053	0.052	0.001
80	0.057	0.054	0.003
120	0.055	0.052	0.003
160	0.054	0.050	0.004
200	0.055	0.052	0.003
240	0.055	0.052	0.003

Depth from soil surface, Z (cm)	Expansion of wetted soil in X axis and Y axis			
	+X (cm)	-X (cm)	+ Y (cm)	-Y (cm)
0	3.6	3.6	3.6	3.6
3	3.8	3.8	3.8	3.8
6	6	6	7	6.5
9	8	8	8.5	8.5
12	8.5	9.5	8.5	8.5
15	6	6	6	6.5
18	0	0	0	0
21	0	0	0	0

Table 4 Experimental Results for Porous Pipe P_3

Mass Balance			
Time (min)	M_{sup} (kg)	M_{soil} (kg)	M_{eva} (kg)
40	0.052	0.050	0.002
80	0.055	0.052	0.003
120	0.053	0.050	0.003
160	0.052	0.049	0.003
200	0.053	0.049	0.004
240	0.056	0.052	0.004

Depth from soil surface, Z (cm)	Expansion of wetted soil in X axis and Y axis			
	+X (cm)	-X (cm)	+ Y (cm)	-Y (cm)
0	4.25	4.25	4.25	4.25
3	4.5	4.5	4.5	4.5
6	6	6	7	6
9	7	7	8.5	8
12	9	9	10	9.5
15	6	6	6	6
18	0	0	0	0
21	0	0	0	0

Table 5 Experimental Results for Porous Pipe P_4

Mass Balance				Depth from soil surface, Z (cm)	Expansion of wetted soil in X axis and Y axis			
Time (min)	M_{sup} (kg)	M_{soil} (kg)	M_{eva} (kg)		+X (cm)	-X (cm)	+ Y (cm)	-Y (cm)
				0	3	3	3	3
				3	3.5	3.5	3.5	3.5
40	0.054	0.053	0.001	6	7	6	7	6
80	0.053	0.051	0.002	9	8	8	9	8
120	0.055	0.053	0.002	12	7	6.5	7	6.5
160	0.055	0.052	0.003	15	0	0	0	0
200	0.053	0.050	0.003	18	0	0	0	0
240	0.055	0.052	0.003	21	0	0	0	0

Table 6 Experimental Results for Porous Pipe P_5

Mass Balance				Depth from soil surface, Z (cm)	Expansion of wetted soil in X axis and Y axis			
Time (min)	M_{sup} (kg)	M_{soil} (kg)	M_{eva} (kg)		+X (cm)	-X (cm)	+ Y (cm)	-Y (cm)
				0	2	2	2	2
				3	2.5	2.5	2.5	2.5
40	0.055	0.054	0.001	6	6	6	6	6
80	0.053	0.052	0.001	9	7	7.5	7	7.5
120	0.057	0.055	0.002	12	5.5	6	5.5	6
160	0.055	0.053	0.002	15	0	0	0	0
200	0.056	0.054	0.002	18	0	0	0	0
240	0.054	0.052	0.002	21	0	0	0	0

Table 7Experimental Results for Porous Pipe P_6

Mass Balance				Depth from soil surface, Z (cm)	Expansion of wetted soil in X axis and Y axis			
Time (min)	M_{sup} (kg)	M_{soil} (kg)	M_{eva} (kg)		+X (cm)	-X (cm)	+ Y (cm)	-Y (cm)
				0	2.8	2.8	2.8	2.8
				3	3	3	3	3
40	0.052	0.051	0.001	6	6	6	6.5	7
80	0.054	0.052	0.002	9	8	8	8	7
120	0.056	0.054	0.002	12	8	8	8	7.5
160	0.055	0.053	0.002	15	6	6	6	6
200	0.054	0.051	0.003	18	0	0	0	0
240	0.054	0.052	0.002	21	0	0	0	0

From those data which was obtained for the expansion of wetted soil, it can say that the soil wetting pattern is almost circular in horizontal plane. The following figures show the soil wetting pattern for six porous pipes. It is seen from each of the graph that the cross section of wetting pattern at both X axis and Y axis of the soil column are almost overlaps each other.The shape of the wetted soil is roughly truncated sphere for all the graphs.

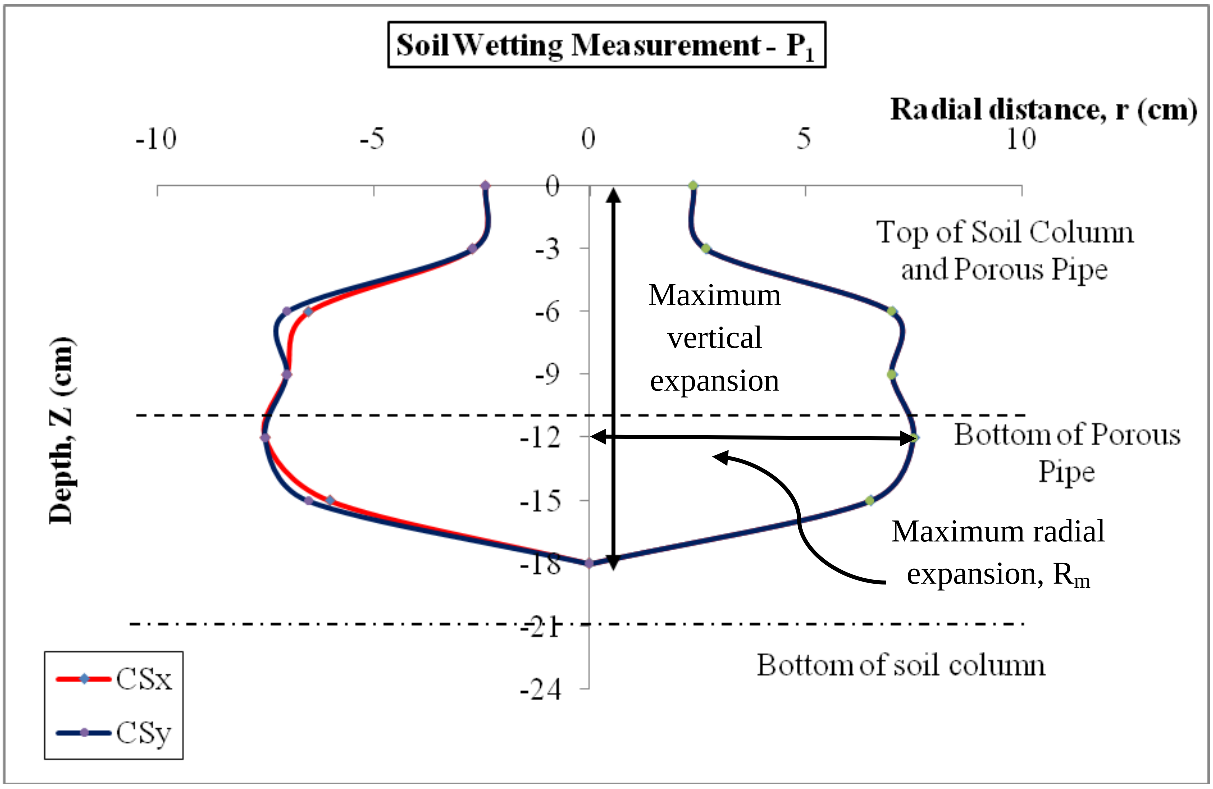

Fig. 5Wetting pattern for porous pipe (P_1). CSx and CSy represent the cross section of wetting at X and Y axis

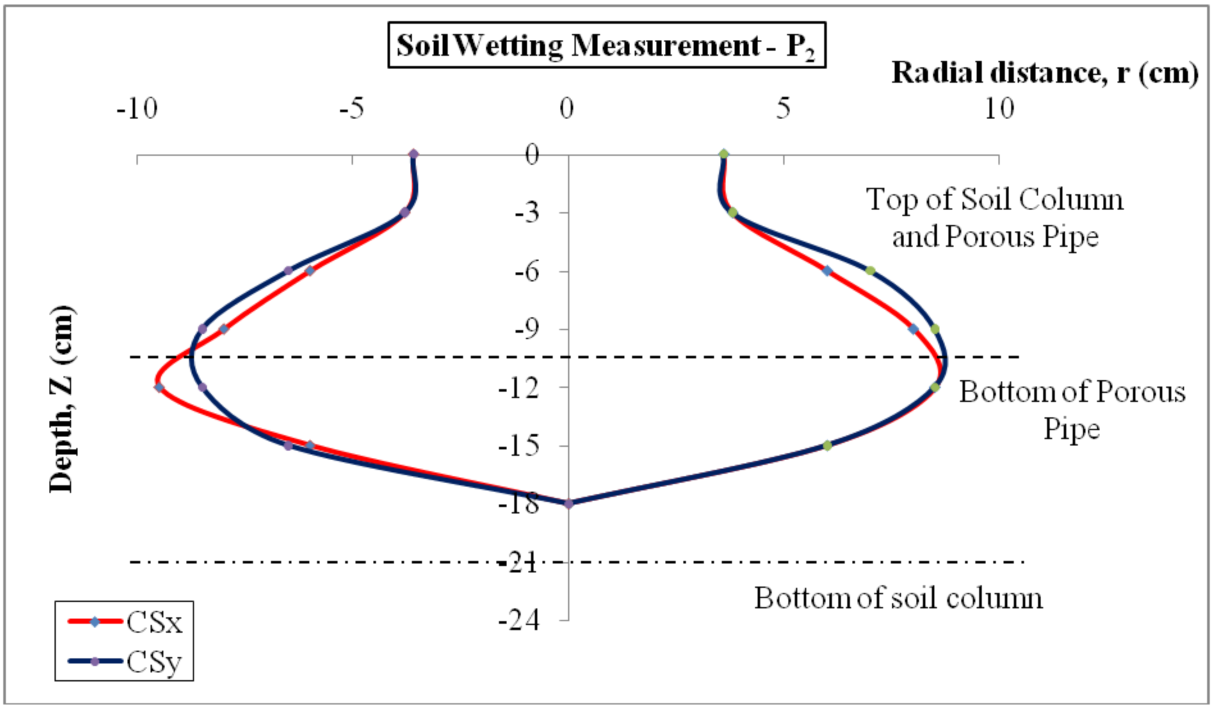

Fig. 6Wetting pattern for porous pipe (P_2)

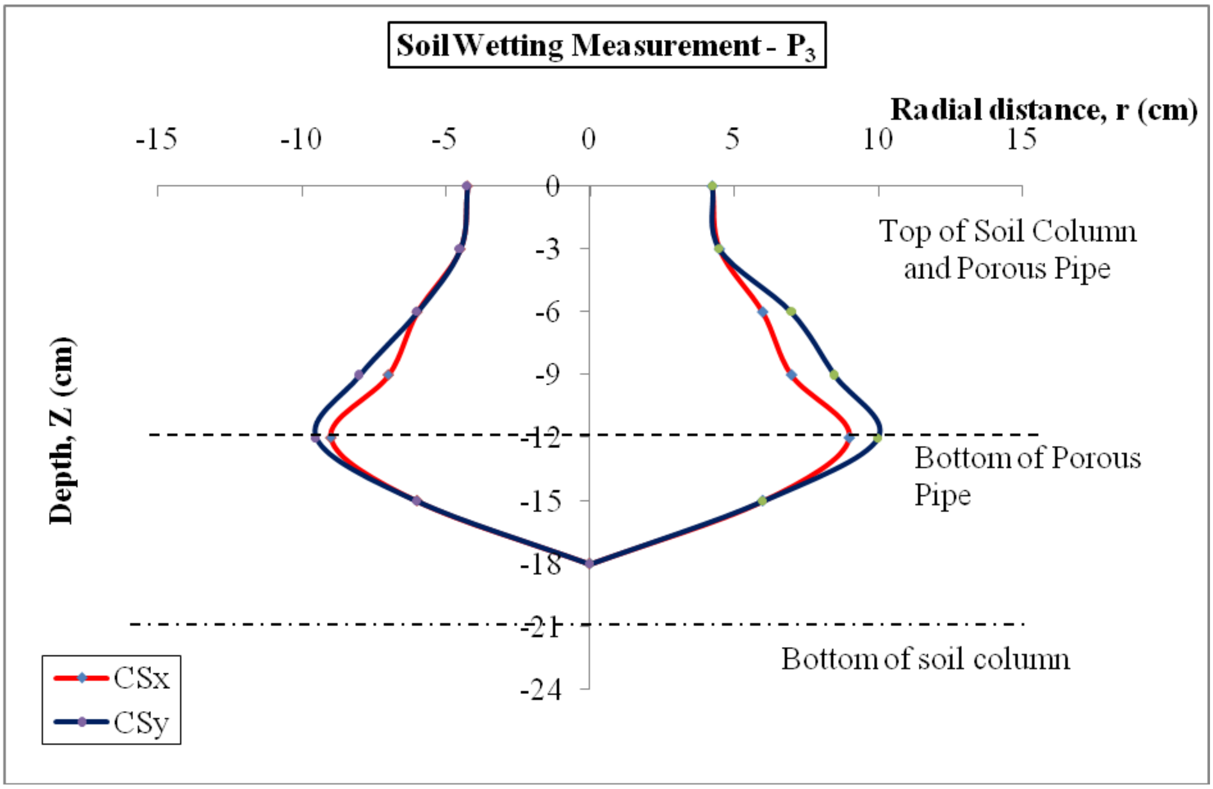

Fig. 7Wetting pattern for porous pipe (P_3)

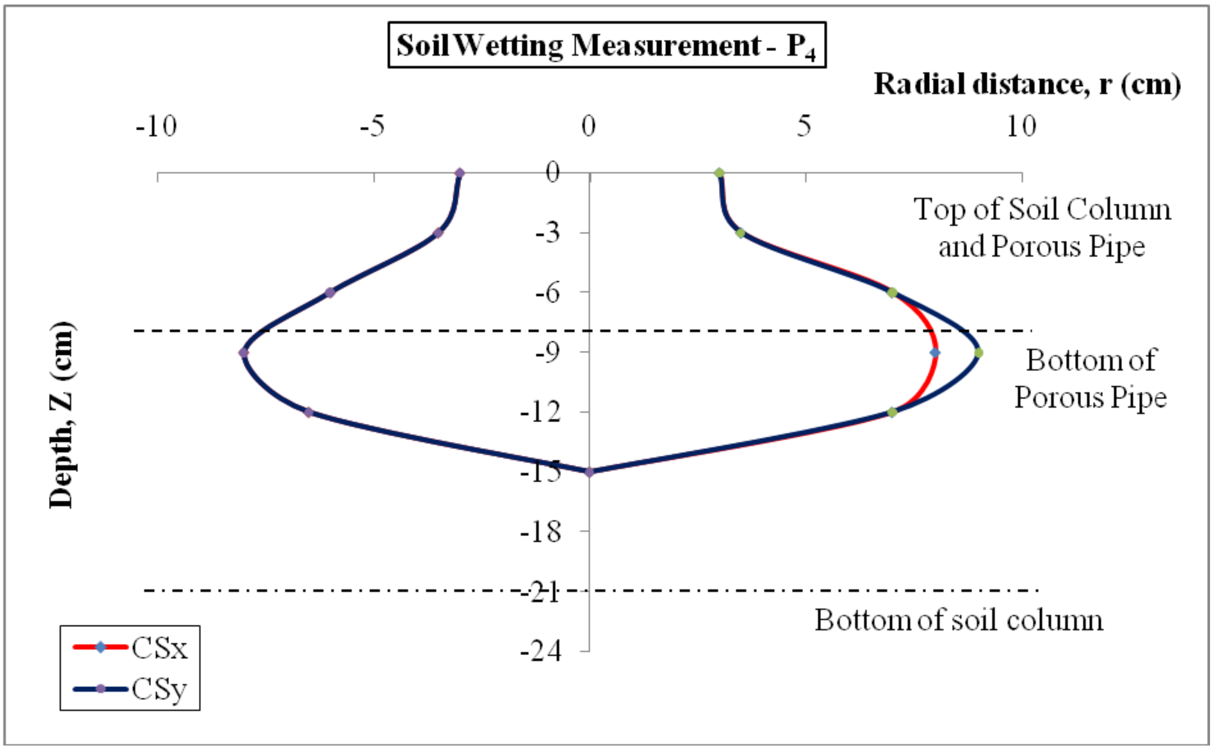

Fig. 8Wetting pattern for porous pipe (P_4)

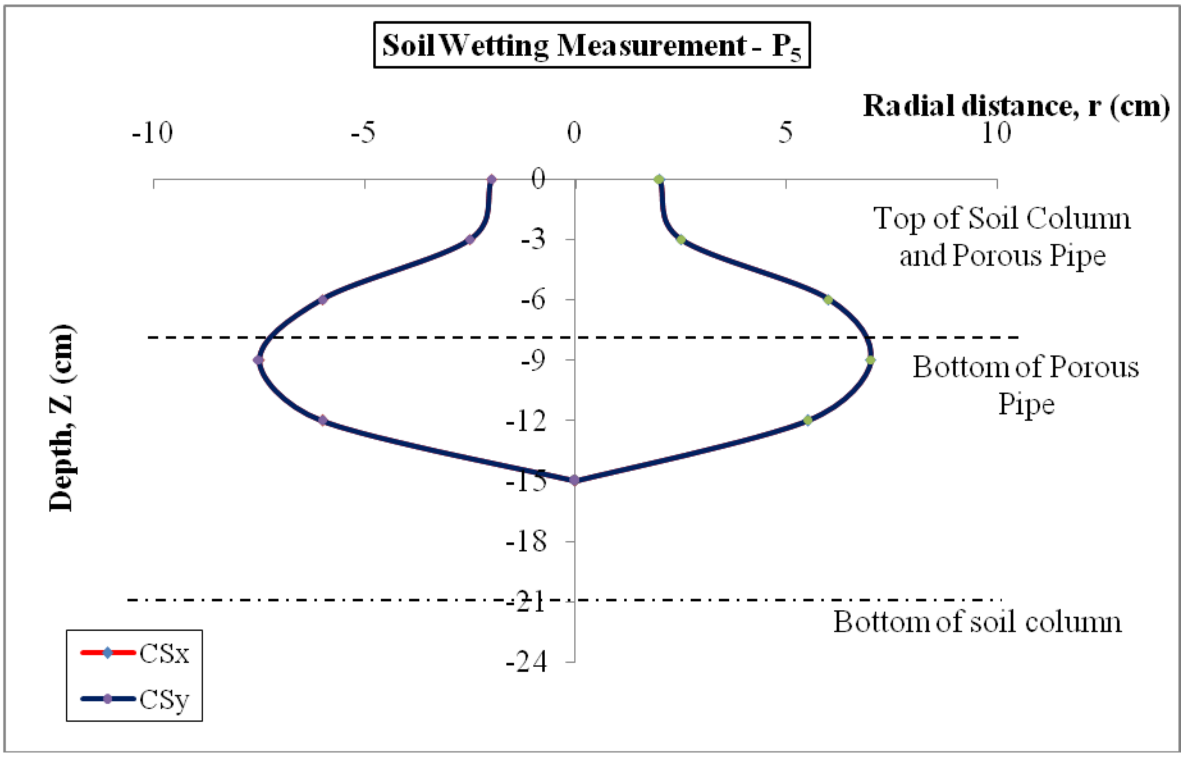

Fig. 9Wetting pattern for porous pipe (P_5)

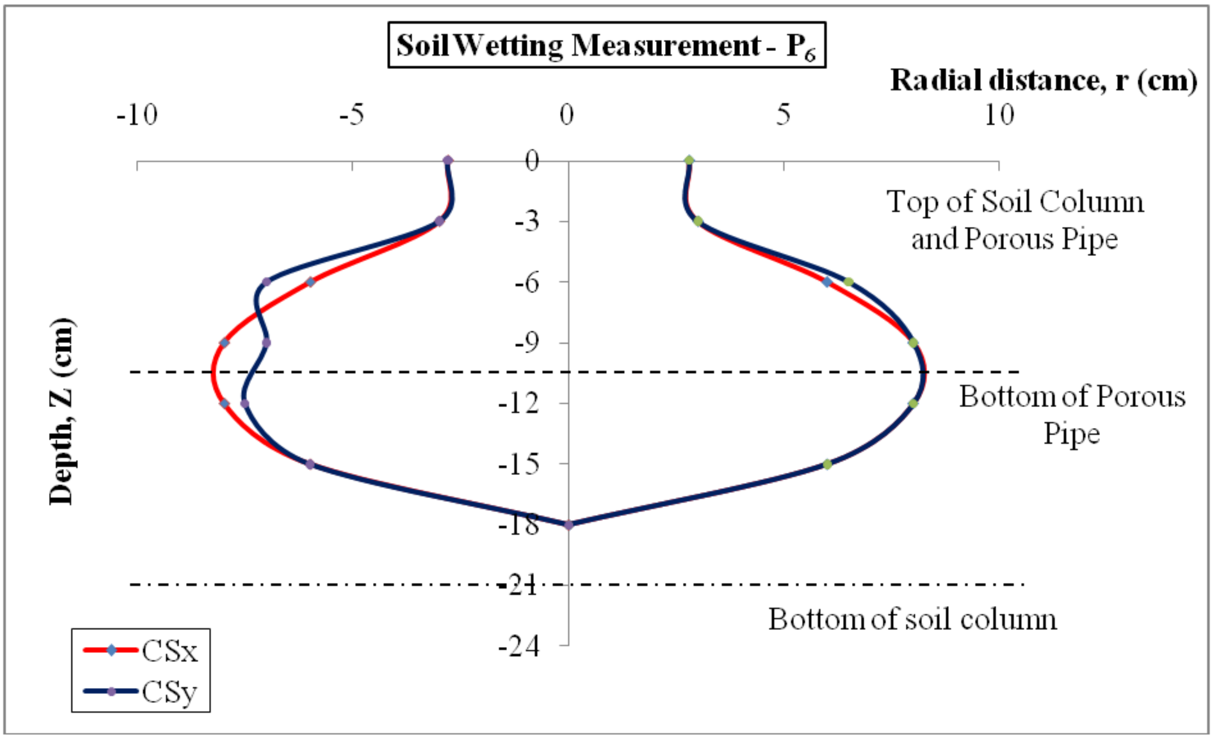

Fig. 10Wetting pattern for porous pipe (P_6)

After observing all the graphs, it can say that the wetted soil volume varies with the dimensions of porous pipe. Since the pipe length of P_1, P_2, P_3 and P_6 are higher than P_4 and P_5, the value of maximum vertical expansion of wetted soil is 18 cm whereas 15 cm for P_4 and P_5.

From the graphs, it can also say that the maximum radial expansion of wetted soil, $R_m$varies with both pipe length and outer diameter of porous pipe. It can be stated that when porous pipes having largerlength than 8cm, the maximum radial expansion, R_m is seen in depth of 12cm. At the same time, the pipes having length equal to 8cm, the R_m is in depth of 9cm.

In addition, it is observed that among the porous pipes whose outer diameter is maximum (P_3 = 8 cm), for that the value of maximum radial expansion, R_m is also maximum and that is 9cm in X axis and 9.75 cm in Y axis. Besides, the pipe of smaller diameter (P_5) has maximum radial expansion of 7.25 cm in both axes.

It can be concluded that for the change in diameter of 128.6%, the Rm varies in percentage of 24.1 and 34.48 for X axis and Y axis respectively.

4.2 Evaporation

There are many factors that affect the evaporation such as temperature, surface area, humidity, wind speed etc. Since the evaporation only takes place at the exposed surface area, so it can say that the increase in diameter increases the evaporation rate. From the Figure11 and Table 8, the same thing is observed. The maximum value of evaporation is 19 gm.

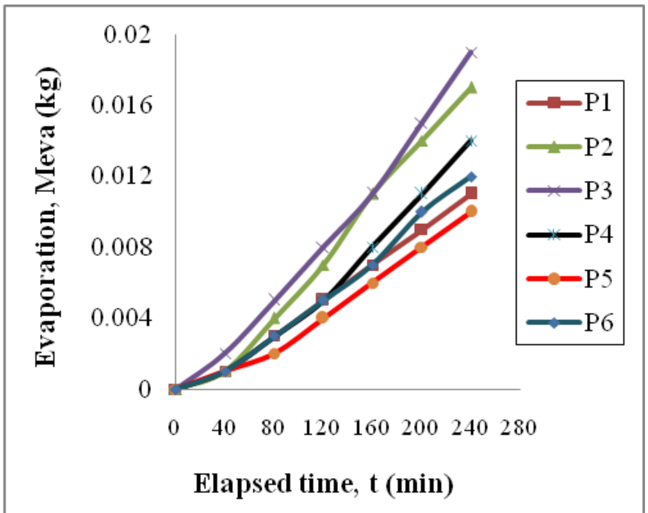

Fig. 11 Evaporation for different porous pipe

Table 8 Values of total evaporation for different porous pipe

Porous Pipe	Outer Diameter (cm)	Total Evaporation, Meva (gm)
P_1	4.2	11
P_2	7	17
P_3	8	19
P_4	5.5	14
P_5	3.5	10
P_6	4.5	12

4.3 Water Use Efficiency

The water use efficiency, E_f may be defined as the ratio of M_{soil} to M_{sup} i.e. M_{soil} / M_{sup}. The following figures representthe variations of the water use efficiency for different porous pipe.

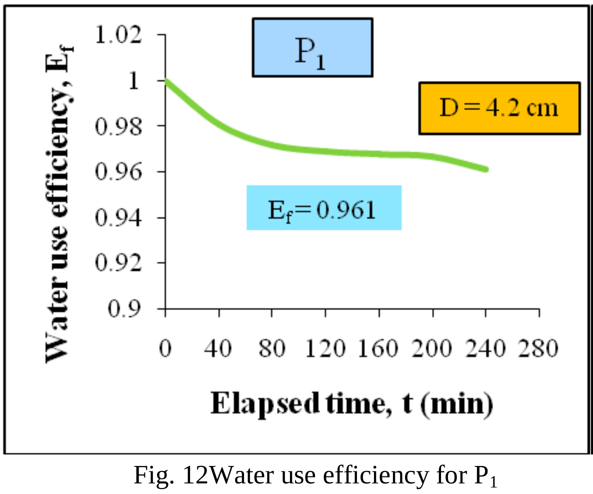

Fig. 12Water use efficiency for P_1

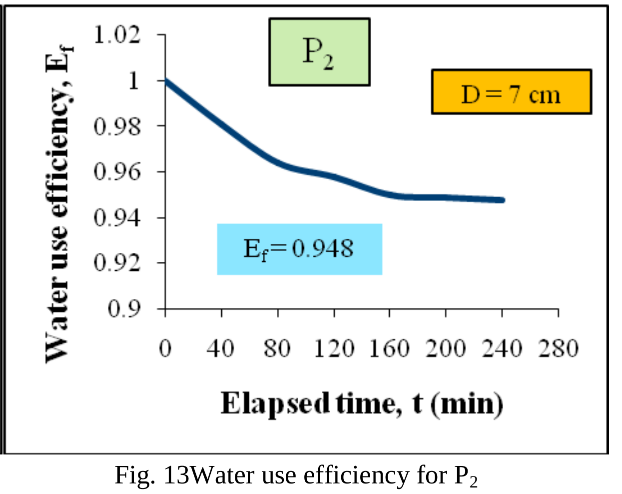

Fig. 13Water use efficiency for P_2

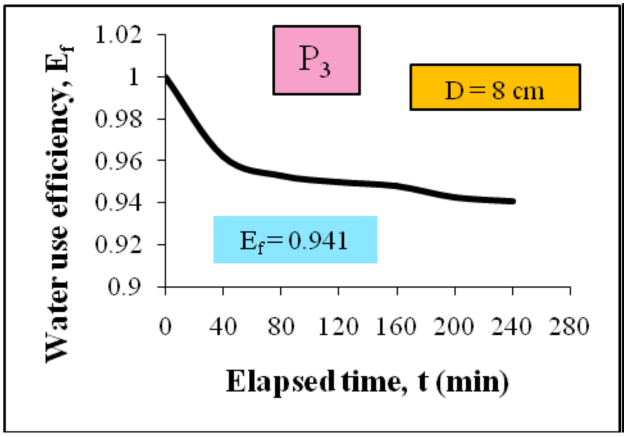

Fig. 14Water use efficiency for P_3

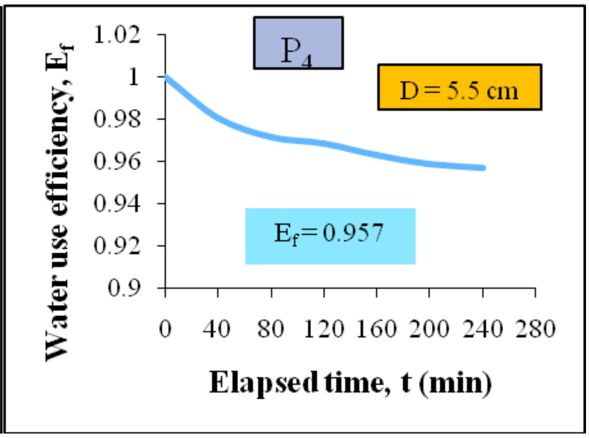

Fig. 15Water use efficiency for P_4

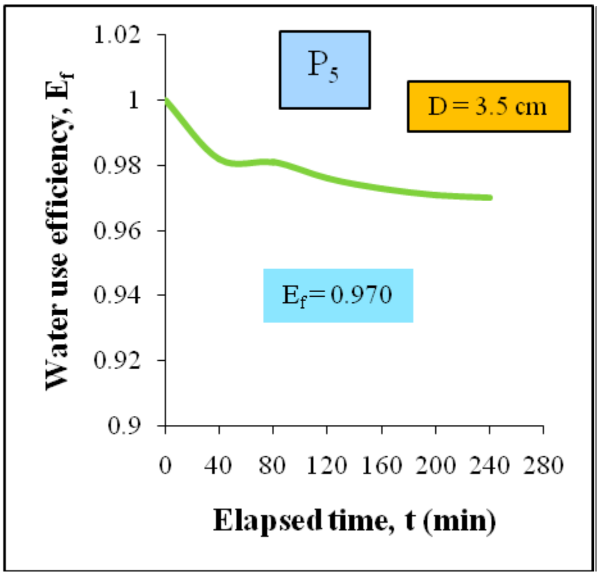

Fig. 16 Water use efficiency for P_5

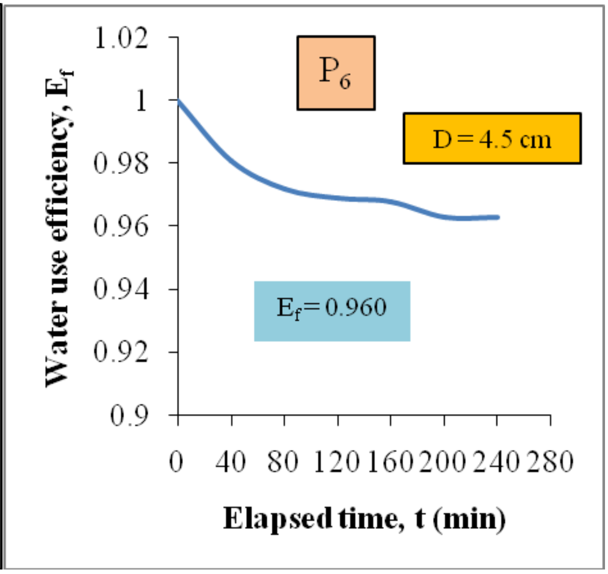

Fig. 17 Water use efficiency for P_6

After observing all the graphs, it can be stated that $E_f$decreases remarkably with time at the commencement of evaporation and then decreases gradually. In addition, it can say that $E_f$increases with a decrease of porous pipe diameter and ranges from 0.94 to 0.97.

V. CONCLUSIONS

Soil wetting pattern is helpful for the management of negative pressure difference irrigation (NPDI) system. To know the effect of porous pipe characteristics on soil wetting pattern, laboratory experiments werecarried out using soil column, local sand, porous pipe, reservoir, pump and two electric balances. For the performance of the study, six different dimensioned porous pipes were used. The supplied water, soil water storage, evaporation and expansion of wetted soil for different porous pipe were measured at a negative pressure of 3 cm.

The main conclusions drawn from the study are as follows

1. Wetting pattern of local sand can be considered as a roughly truncated sphere.
2. The maximum vertical expansion and maximum radial expansion vary with the change in diameter and length of porous pipe.
3. With the change in diameter of 128.6%, the maximum radial expansion differs from 24.1% and 34.48% for X and Y axis respectively.
4. Evaporation increases with the increase in diameter of Porous Pipe.
5. Water use efficiency is very high and it ranges from 0.94 to 0.97.

REFERENCES

[1] Siyal, A. A., (2008). "Water-saving clay pipe irrigation system". Daily Dawn

[2] Frost, K. R. and Schwalen, H. C., (1955). "Sprinkler evaporation losses". Agric. Eng., 36(8): 526-528.

[3] Yabe, K.., Kato, Z. and Tejima, S., (1986). "Disparities of water management in the sub-irrigation method by negative pressure difference and the drip irrigation method". Trans. JSIDRE, 123: 11-16.

[4] Kato, Z. and Tejima, S., (1982). Theory and fundamental studies on subsurface irrigation method by use of negative pressure. Trans. JSIDRE, 101: 46-54.

[5] Tanigawa, T., Yabe, K. and Tejima, S., (1988). Comparison of prediction of actual measurement about dynamic distribution of soil moisture tension. Trans. JSIDRE, 137: 9-16.

[6] Ashrafi, S., Gupta, A. D., Babel, M. S., Izumi, N. and Loof, R., (2002). "Simulation of infiltration from porous clay pipe in subsurface irrigation". Hydrological Science-Journal., 47(2): 253-268.

[7] Siyal, A. A., M. Th. van Genuchten and T. H.Skaggs., (2009). "Performance of Pitcher Irrigation Systems". Soil Science., 174(60): 312-320.

[8] Peifu, J., Lei, T., Xiao, J., Yu, Y. and Bralts, V. F., (2004). A new irrigation system of zero/negative pressure and the experimental verification of its feasibility. ASAE/CSAE Annual International Meeting Presentation, Paper no. 042253, Ontario, Canada.

[9] Akhoond, A. M. and Golabi, M., (2008). Subsurface porous pipe irrigation with vertical option as a suitable irrigation method for light soils. Asian J. of Scientific Research, 1(3): 180-192.

[10] Moniruzzaman, S. M., Fukuhara, T., ISHII, Y. and Terasaki, H., (2011). Effect of negative pressure difference irrigation on soil wetting pattern.

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Ultrasonic Navigation System for the visually impaired & blind pedestrians

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ABSTRACT: *The main aim of this paper is to expand the electronic travel aid for the blind and visually impaired pedestrians by emerging into the ultrasonic technology. The paper represents an innovative project design and implementation of an Ultrasonic Navigation system in order to provide fully automatic obstacle avoidance with audible notification for blind pedestrians. This blind guidance system is safe, reliable and cost-effective.*

Keywords - *Ultrasonic, Microcontroller, Proteus, Sensor, signal.*

I. INTRODUCTION

Blindness is a condition of lacking the visual perception due to physiological or neurological factors partially or fully. The main concept of the paper is to provide an electronic aid as guidance to overcome the lacking of their visualization power by proposing a simple, efficient, configurable electronic guidance system for blind and visually impaired pedestrians.

Ultrasonic Sensor is the proposed electronic aid which senses the obstacles in its path by continuously transmitting the ultrasonic waves. When an obstacle appears in its vicinity then the ultrasonic waves gets reflected to the system immediately. And then ultrasonic receiver senses these ultrasonic waves. This method supports the microcontroller to obtain the information from ultrasonic waves and then it alerts the blind pedestrians through voice message. The advantage of our proposed system is its voice based announcement for easy navigation which can assist a blind pedestrian to pass through a busy road. Moreover, this system is an auditory guidance system for the visually impaired pedestrians using ultrasonic-to-audio signal transformation [1], [3].

II. OVERVIEW OF THE PROJECT

2.1 Block diagram of the project:

In this project, the system is designed in such a way that it gathers data about the environment via ultrasonic sensors and extracts the visual information from that data. This visual information is then transformed into an audio signal immediately and the blind pedestrian can recognize the environmental information through binaural sound generated by the system [2].

The whole operation of the project can be described by using block diagram which is a graphical method for explaining the concept of the system without the presence of the individual components within the project. Figure 1 represents the basic block diagram of the whole system of project.

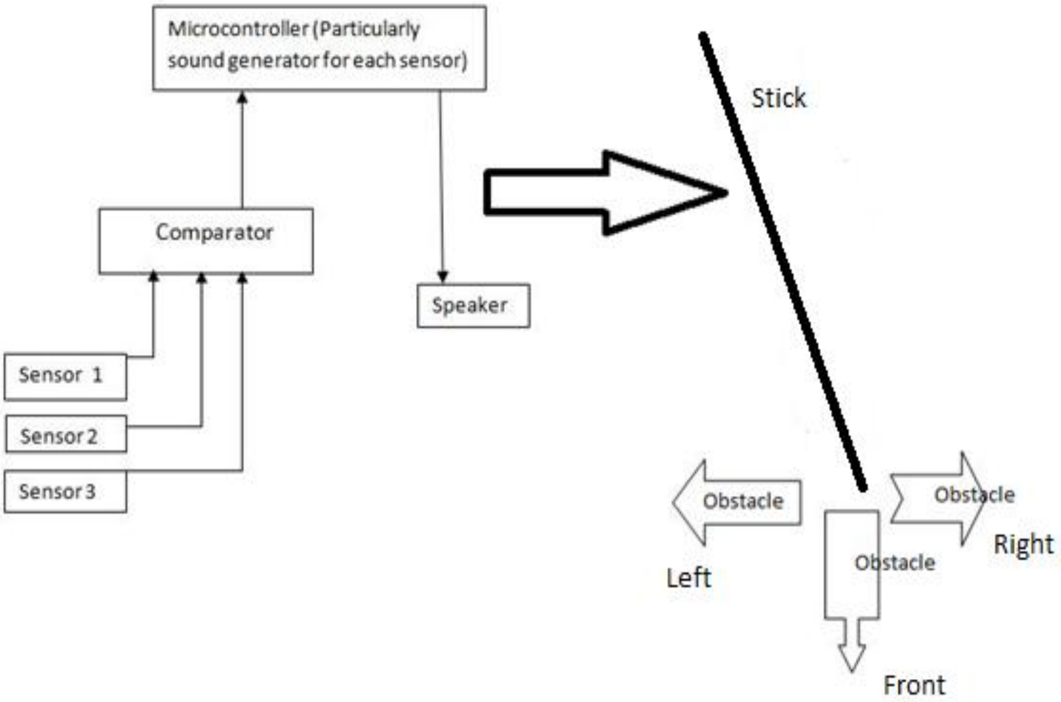


Fig 1: Basic Block Diagram of proposed ultrasonic navigation system for blind pedestrian

In order to describe the whole operation of the project, it is required to explain the block diagrams of Figure 1. The ultrasonic sound sensor is placed in the stick so that the buzzer could only be activated when the system detect any obstacle. So the visually impaired person can easily understand which side is obstacle-free. And different types of sound beep will be produced for different sides. Blind pedestrian should be aware of the sound beep for different sides (left/right/front) before.

The range of detecting obstacle can be controlled in high or low range by the variable resistor (POT) up to 5 meter. So there will be no difficulty for either crossing the road or walking in the stairs for a visually impaired person.

2.2 Flow chart

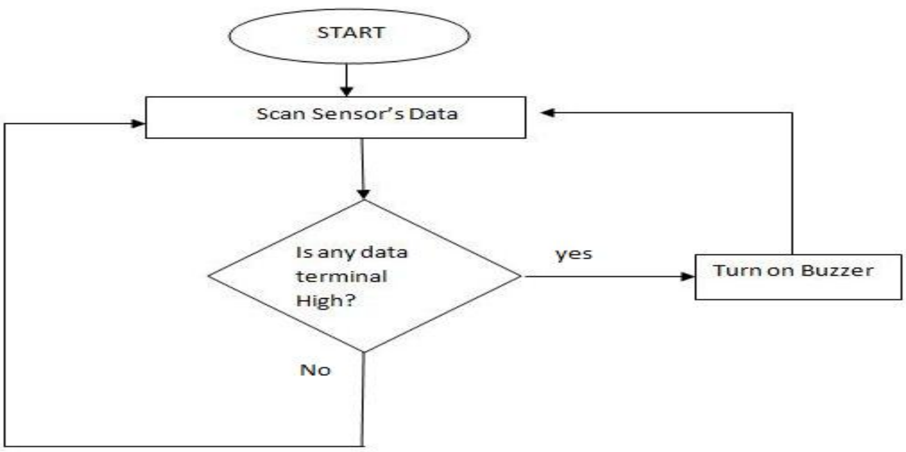


Fig. 2: Flow Chart

2.3 Algorithms
1. Start
2. Scan sensor's data terminal
3. is any data terminal high?
4. If yes, turn on the buzzer. Then go step-3
5. If no, go to step-3

III. SIMULATION AND RESULT ANALYSIS

3.1 Proposed circuit Design

Proteus is the effortless and most essential software with latest technology for circuit implementation and simulation. It has ISIS which is used for circuit designing with simulation and ARES which is used for PCB designing. Including necessary components with corresponding information from its library it can be simulated after building the circuit. Microcontroller needs to include the hex file for the implementation of whole project. Proteus combines circuit simulation to facilitate co-simulation of complete microcontroller based designs.

The authors have built the circuit to simulate project using Proteus v7.8 which is shown in Fig. 3. The authors are using this software because this is very much user friendly to design and simulate any circuits instead of using other software's.

The equipments used for design and implementation of the following circuit are Microcontroller, OP-Amp, diode, voltage regulator, capacitor, crystal oscillator, transistor, variable resistor, ultrasonic sound sensor, and buzzer.

Figure 3 shows three reflective signals that were produced as follow: from front obstacle sensor, right obstacle sensor, and from left obstacle sensor. All signals are inputs for ADC on a PIC microcontroller. After digitizing these signals are used as inputs to a specific program implemented in real time within PIC microcontroller and according to some internal instructions it will produce an output which will be transferred from the PIC to the buzzer and aware the blind pedestrian about the barriers blocking his way.

3.2 Result Analysis

Result part presents two important cases here. Those are:

- When any obstacle is detected
- When more than one obstacle is detected.

3.2.1 When Any Obstacle Is Detected

When a sensor in the data terminal detects any obstacle, the buzzer automatically turns on. Hearing the loud sound of the buzzer the visually impaired person will be able to decide at which side there is an obstacle.

3.2.2 When More Than One Obstacle Is Detected

When more than one sensor of the data terminal detects obstacle, the buzzer automatically turns on and make different kind of noises. Hearing the difference of the sound of the buzzer the visually impaired person will be able to decide at which sides there are obstacles.

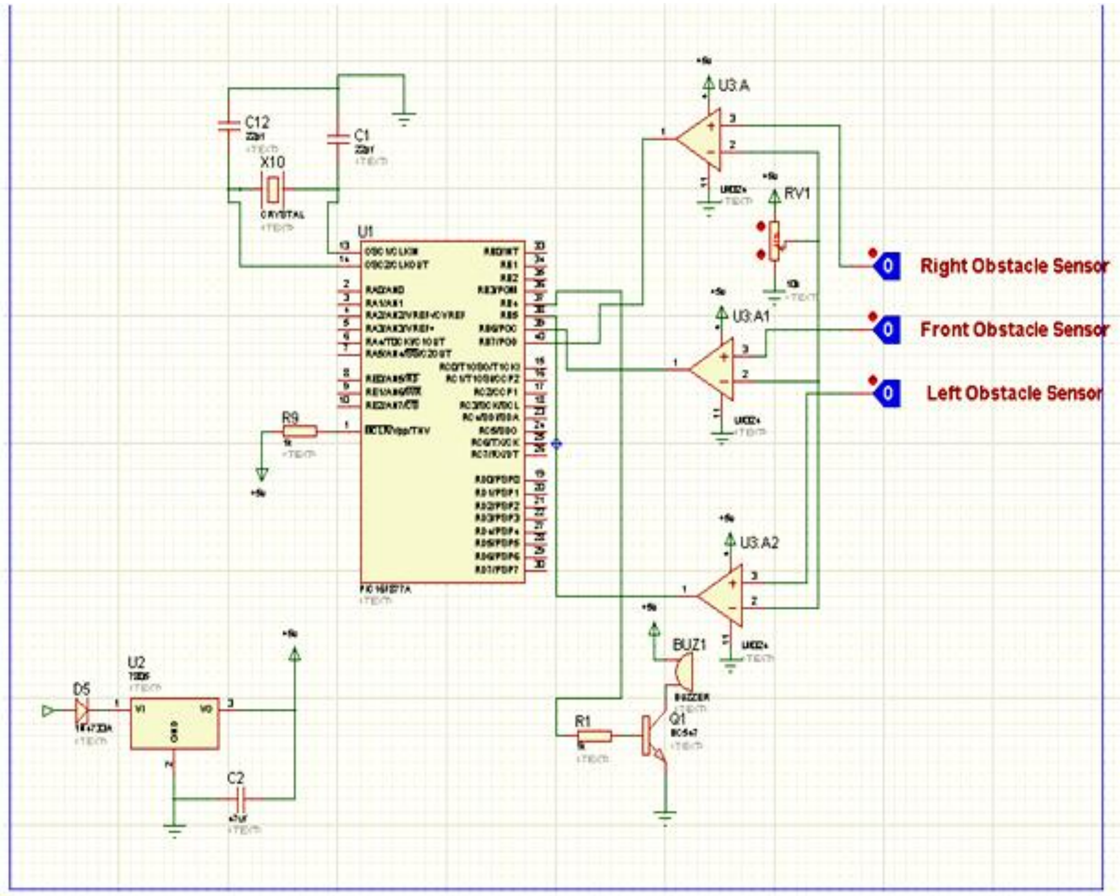
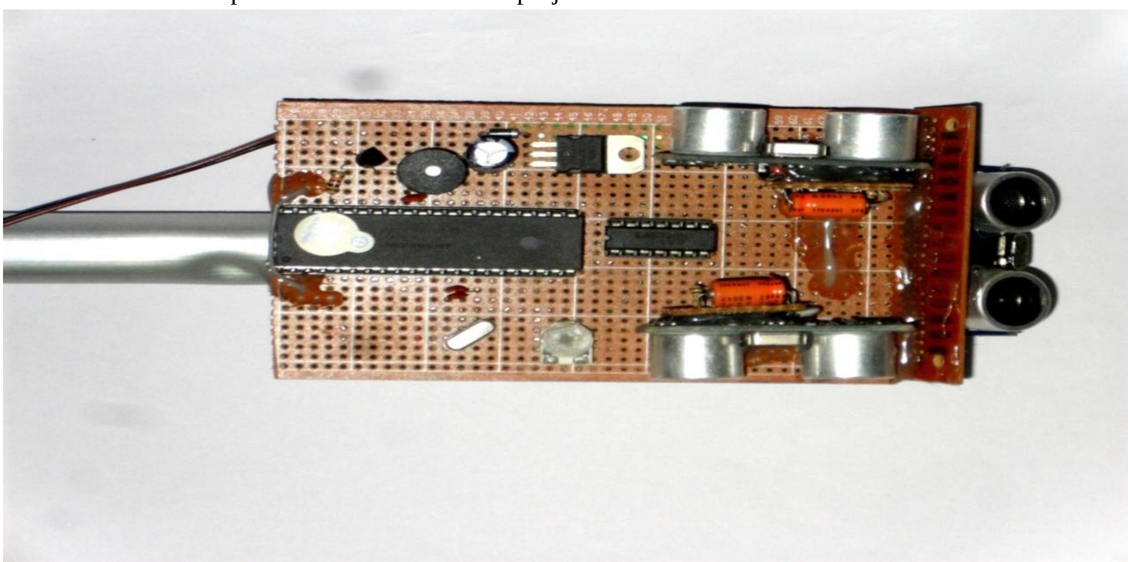


Fig 3: Schematic Diagram of the circuit

IV. HARDWARE DESIGN

The design prototype of the whole project was accomplished after the hardware implementation. Figure 4 shows the hardware implementation of the whole project.



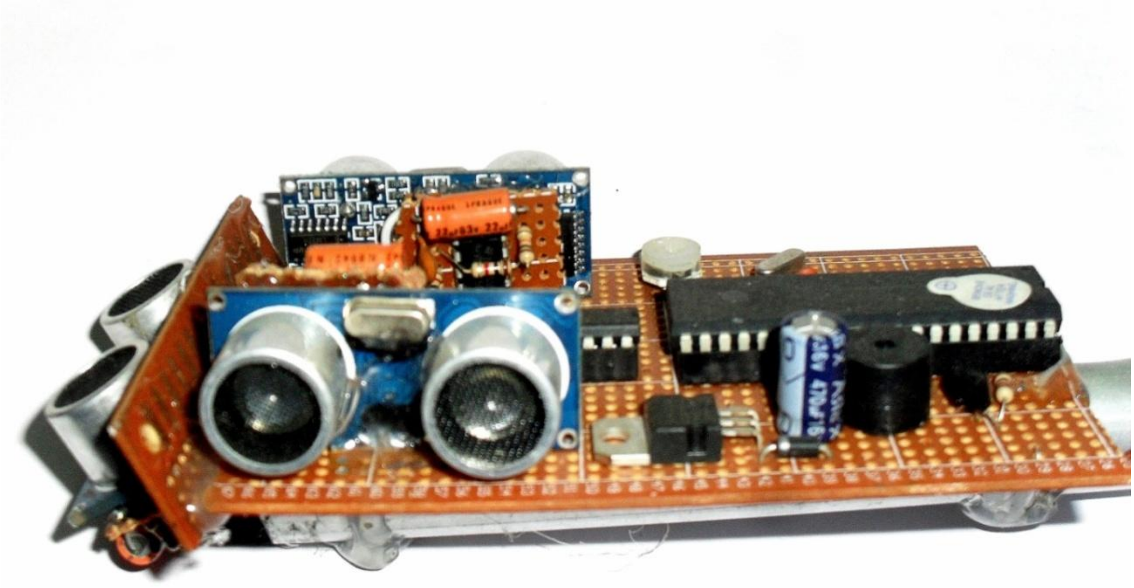


Fig 4: Hardware Implementation

V. CONCLUSION

The main focus of the paper is designing a system to transform visual information to auditory information by the ultrasonic sensors which will be aid for blind pedestrian. The authors expect that the project will be very useful for blind pedestrian where Ultrasonic sensors are used to detect the object or obstacle in path and navigate the blind person by the use of audio instructions.

It is well-estimation from our project that the designed ultrasonic navigation system will ease the road crossing for blind pedestrians with its excellent navigation feature. More powerful sensors can be integrated in the project to provide the detection of obstacles in a wider range.

Appendix:

```
void play_01()
        {
        rb0_bit=0;
        delay_ms(5000);
        rb0_bit=1;
        }
void play_02()
        {
        rb2_bit=0;
        delay_ms(5000);
        rb2_bit=1;
        }
void play_03()
        {
        rb4_bit=0;
        delay_ms(5000);
        rb4_bit=1;
        }
void main() {
ADCON1 = 7;                 // all ADC pins to digital I/O
CMCON    =   7;              // Turn off comparators
INTCON = 0;                  // disable all interrupts
```

```
trisa=0b000111;
porta=0b000000;
trisb=0b00000000;
portb=0b11111111;
while(1)
        {
         if(ra0_bit)
                    {
                    play_01();
                    }
         if(ra1_bit)
                    {
                    play_02();
                    }
         if(ra2_bit)
                    {
                    play_03();
                    }
        };
        };
```

Hexa File

```
:020000006A286C
:0E000600831203132108 8A00200882000800DC
```

REFERENCES

[1] Arjun Sharma1, Rahul Patidar, Shubham Mandovara, Ishwar Rathod, Blind Audio Guidance System, International Journal of Emerging Technology and Advanced Engineering, Volume 3, Special Issue 2, January 2013 .

[2] Amjed S. Al-Fahoum, Heba B. Al-Hmoud, and Ausaila A. Al-Fraihat, A Smart Infrared Microcontroller-Based Blind Guidance System, Hindawi Publishing Corporation, Volume 2013.

[3] Mounir Bousbia-Salah, Abdelghani Redjati, Mohamed Fezari, Maamar Bettayeb, AN ULTRASONIC NAVIGATION SYSTEM FOR BLIND PEOPLE,Proc. 2007 IEEE International Conference on Signal Processing and Communications (ICSPC 2007), 24-27 November 2007, Dubai, United Arab Emirates.

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The Influence of Chemical Treatment on the Mechanical Behaviour of Animal Fibre-Reinforced High Density Polyethylene Composites

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ABSTRACT: *This research work has investigated the influence of chemical treatment on the mechanical behaviour of animal fibre-reinforced high density polyethylene composites. The animal fibres used for this present study were chicken feather and cow hair fibres procured from local poultries and abattoirs. Prior to the development of the composite materials, the animal fibres were washed and dried, cut into 10 mm and divided into two portions; one portion was treated with 0.25 M NaOH maintained at 60 ^{0}C for 1 hour in a water bath, rinsed with distilled water and dried in the oven while the other portion was left untreated. Both portions were then used to reinforce the high density polyethylene polymer at 2, 4, 6, 8 and 10 % fibre loading respectively from which, the flexural and tensile test samples were produced by hot compression moulding. From the test results, it was observed that the chemically treated cow hair and chicken feather fibre reinforced high density polyethylene composites gave the best flexural properties for most fibre loading percentages compared to their untreated animal fibre-reinforced high density polyethylene composites counterparts and the neat high density polyethylene matrix. However, the tensile properties of all the animal fibre-reinforced high density polyethylene composites were not enhanced. Chicken feather and cow hair fibres were chosen for this research work to consider their potential applications as reinforcement for polymeric materials with a view to curtail the environmental pollution they generate by means of their disposal, as they are considered as unusable animal waste.*

Keywords: *Animal fibres, High density polyethylene, Composite, Chemical treatment, Mechanical behaviour*

I. INTRODUCTION

Intensive research in adopting natural fibres as reinforcement in polymeric composites with an objective to take advantage of nature's gift to mankind and contemporaneously reduce the huge expenses pumped into the development of synthetic fibres, has intensely attracted the interests of contemporary materials' scientists and engineers [1]. Natural fibers are integral part of our day to day life and they are appreciably ample all over the earth. They include cotton, coconut fiber, straws of wheat, hemp, sisal, silk, avian fibre, horse hair, alpaca hair, human hair and more. Their availability, renewability, low density, and inexpensiveness as well as satisfactory mechanical properties render them an eye-catching ecological substitute for glass, carbon and man-made fibres that have been conventionally used for the manufacturing of composites [1, 2]. They are subdivided based on their origins, coming from plants, animals, or minerals [3]. The predominant ones exploited, are those of vegetal origins, due to their wide availability and renewability in short time with respect to others [4]. However, this present study concentrates its pivotal point on the animal fibre; specifically fowl feather and cow hair fibres. Research on natural fibre composites has existed since the early 1900's but failed to receive substantial attention until late in the 1980's [5]. In recent times, studies on the use of natural fibres as replacement to synthetic fibres in fibre-reinforced polymeric composites have augmented and unlocked a new channel for supplementary industrial prospects [6]. This has manifested in a rapid growth of interests of researchers in natural fibre reinforced polymeric compositesboth in terms of industrial applications and fundamental research.

A reinforced plastic consists of two main components; a matrix which may be either thermoplastic or thermosetting and reinforcing fillers which usually take the form of fibres but could also be particles [7]. High Density Polyethylene (HDPE) is one of the common thermosetting plastics vastly used for industrial purposes. It was created in the 20th century byCarl Shipp Marvel, an American chemist (by subjecting ethylene to a large amount of pressure), and since then has served great engineering purposes [8]. HDPE is used in a variety of applications and industries where excellent impact resistance, high tensile strength, low moisture absorption, excellent low temperature toughness, relatively high softening temperatures and chemical and corrosion resistance properties are required.Its common applications include making of toys, utensils, bottles, pipes and processing equipment, wire and cable insulation, 3-D printer filaments, snowboard rails and boxes, and corrosion protection for steel pipelines [8-9]. Their ability to be reinforced, even with natural fibres and made into composites further gave them a wider range of applications.

Although, natural fibre reinforced polymericcomposites have moderately a few disadvantages relative to synthetic fibres such aspoor resistance towards moisture and lack of good interfacial adhesion between the reinforcing fibres and the matrix material, nonetheless, the production of composites reinforced with synthetic fibres and matrices requires a large amount of energy which is only partially recovered with incineration of fibre reinforced composites [5], Thus, the renewed interest in the natural fibres, due to their low density, nonabrasive, nonirritating, combustible, nontoxic, fully biodegradable properties, low energy consumption for production, budget zero CO_2 emissions if burned, low cost, pose no health hazards, main availability and renewability compared to synthetic fibres, has resulted in a remarkable number of applications to bring it at par and even superior to synthetic fibres [1 ,4, 10]. The prominentshortcomings of natural fibres in polymeric composites are the poor compatibility between fibres and matrix interface and the relatively high moisture absorption [3]. Hence, a better understanding of fibre-matrix interface and the ability to transfer stress from the matrix to the fibre is highly essential for developing natural fibre-reinforced polymeric composites [3]. To eliminate these shortcomings associated with natural fibres, chemical treatments are considered the best methods in modifying the fibre surface properties [6]. And this has made the chemical treatment of natural fibres an area of research currently receiving significant attention [5]. A good number of researchers have investigated chemical treatments of natural fibres. The ordinary chemical treatments are alkaline treatment, H_2SO_4 treatment, and acetylated treatment. Alkaline treatment is one of the most effectively used treatments of natural fibres when used as reinforcement in thermoplastics and thermosets [3]. This is because alkaline treatment or mercerization has been successfully used by many researchers.In this study, the sodium hydroxide was chosen because of its low cost and availability. Wang et al (2008), Rokbi et al (2011), and Suardana et al (2011) have also used NaOH to chemically treat natural fibres of vegetal origins used as reinforcement in polymeric composites [11-13].

The animal fibres (chicken feather and cow hair) used in this research are commonly described as waste by-product which are contributing to environmental pollution due to their disposal problems. The two main methods of practically disposing them are burning and burying which both have negative impact on the environment [14]. In Nigeria, aside the meat consumption of cows, prevalently, their skins are used to make shoes, mats and outfits. It is obvious that there is very little research into using cow hair as fibre reinforcement for polymers, this study presents it could be a potential reinforcement for polymeric composites depending on the desired properties. On the other hand, recent studies on the chicken feather waste demonstrated that the waste can be a potential composite reinforcement [15]. Additionally, the development of natural fibre reinforced polymeric composites that are biodegradable promotes the use of environmentally friendly materials and provides alternative way to solve the problems associated with agricultural residues [16]. Thus, this usage of these animal fibres will make a better utilization of them as opposed to the environmental concerns relating to their methods of disposal.

II. MATERIALS AND METHOD

Materials

The sourcing and procurement of all the materials utilized for this research work were done in Nigeria. The high density polyethylene was procured from Euro chemical Ventures Limited, Lagos State while the chicken feather and the cow hair fibres were procured from commercial poultry farms and abattoirs in Akure, Ondo State.

Methods

Reinforcement preparation

Prior to the development of the composites, the animal fibres selected for direct use as fibre reinforcements were washed with distilled water and detergent and sun dried for 1 week to remove any form of impurities such as blood, oil and pigments. They were then cut into 10 mm and divided in to two portions. One portion of the cleaned samples was chemically treated to improve wettability and interfacial bonding strength between the fibres and the HPDE matrix and also to reduce the moisture absorption capacity while the other portion was left untreated. The chemical treatment was performed using 0.25 M NaOH in a water bath maintained at a temperature of 60 ^{0}C for 1 hour. The Fibres were removed from the water bath and rinsed with distilled water several times to remove any NaOH solution sticking to fiber surface and dried in the oven at 60 ^{0}C for 1 hour.

Composite Development

The animal fibre-reinforced HPDE composites and the control samples were produced by hot compression moulding technique. To produce the composites, the matrix and the fibres were mixed together in predetermined proportions as shown in table1. The materials were weighed using an electronic weighing balance and poured into the flexural and tensile test moulds made of steel. The filled moulds were placed inside the compression moulding machine maintained at 160 ^{0}C for 5 minutes. The samples were extracted from the mould when they were still warm and allowed to cure in air. The same compositions were adopted for all the various fibre samples used.

Composition of the animal fibre-reinforced HPDE composites

Table 1: Composition of the animal fibres-reinforced HPDE Composites

Composition	*Wt. %*	*Wt. %*	*Wt. %*	*Wt. %*	*Wt. %*
HPDE	98	96	94	92	90
Fibre	2	4	6	8	10

Mechanical Testing of the Materials

Flexural Test

Flexural test was carried out by using Testometric Universal Testing Machine in accordance with ASTM D790[17]. To carry out the test, the grip for the test was fixed on the machine and the test piece with dimension of 150 x 50 x 3 mm was hooked on the grip and the test commenced. As the specimen is stretched the computer generates the required data and graphs. The Flexural Test was performed at the speed of 100 mm/min.

Tensile Test

In the present study, tensile tests were performed on INSTRON 1195 at a fixed Crosshead speed of 10 mm min-^{1}. Samples were prepared according to ASTM D412 [18]standard and tensile strengths of the conditioned samples were calculated.

III. RESULTS AND DISCUSSION

Flexural Properties

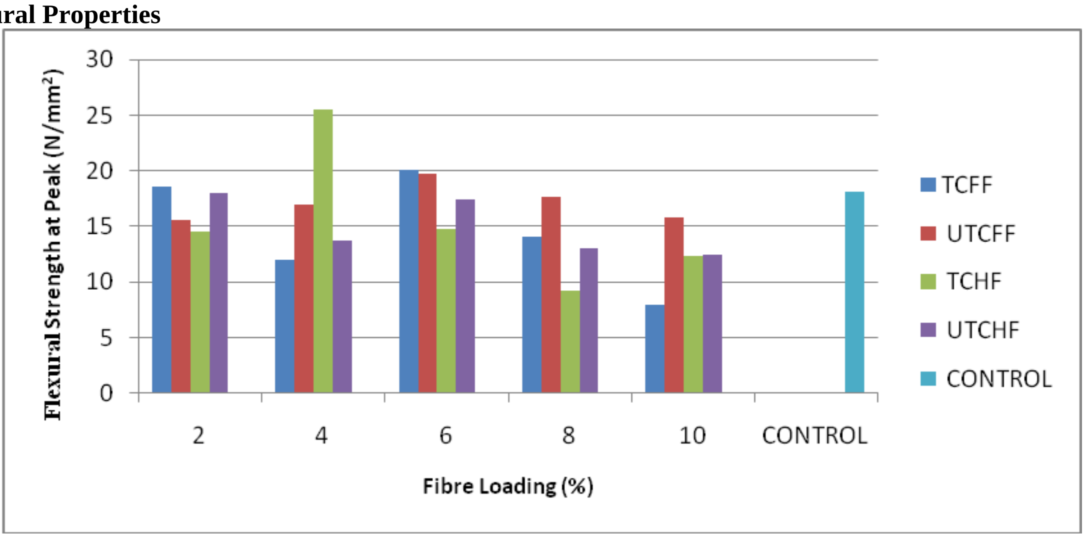

Figure 1: Variation of flexural strength at peak with fibre loading for the animal fibre-reinforced HPDE composites and the control sample

Figure1 above represents the effect of the animal fibres (chicken feather fibre and cow hair fibre) reinforcements on the flexural strength at peak for high density polyethylene (HDPE) composites and the control sample (unreinforced HPDE) from where it was observed that the flexural strength decreases as the fibre loading percentage increases. Although at 2, 6, and 8 % fibre loading, the chemically treated chicken feather fibre (TCFF) gave values higher than that of the treated cow hair fibre (TCHF). However, the TCHF at 4 % fibre loading gave the highest value in comparison with all the other samples. The TCHF-reinforced HPDE at 4 % fibre loading has a flexural strength of 25.46 N/mm^2 which is 81.31 % better than the untreated cow hair fibre (UTCHF) with a value of 13.74 N/mm^2 at the same fibre loading and 40.45 % better than the control sample with a value of 18.13 N/mm^2. Oladele et al (2014) used untreated chicken feather fibre (UTCFF) and untreated cow hair fibre (UTCHF) to reinforce HPDE and it was found out that the flexural strength of the UTCFF was better than that of the UTCHF for each fibre loading. However, the results of this research have revealed that the effect of chemical treatment at 4 % fibre loading on the UTCHF enhanced the flexural strength of the TCHF-reinforced HPDE composite better than that of the TCFF, UTCFF, UTCHF and the control sample. This improvement in flexural strength can be attributed to improved interfacial adhesion between the matrix and the fibre which in turn allows a more efficient transfer of stress between the fibre and the matrix. The overall performance of any fibre-reinforced polymer composite depends extensively on the fibre-matrix interface which is a function of the surface topography of the fibre and the chemical compatibility of fibre surface and resin properties [2]. The decrease in flexural strength with increase in fibre loading has been reported by some researchers[2,15,19,20]. They attributed this phenomenon to increase in fibre-fibre interaction, random orientation of short fibres within the matrix, poor dispersion of fibre in the matrix and more over higher void content (which might be due to the presence of moisture in trace amount) and low interfacial strength resulting in a lower efficiency of load transfer with increase fibre loading.

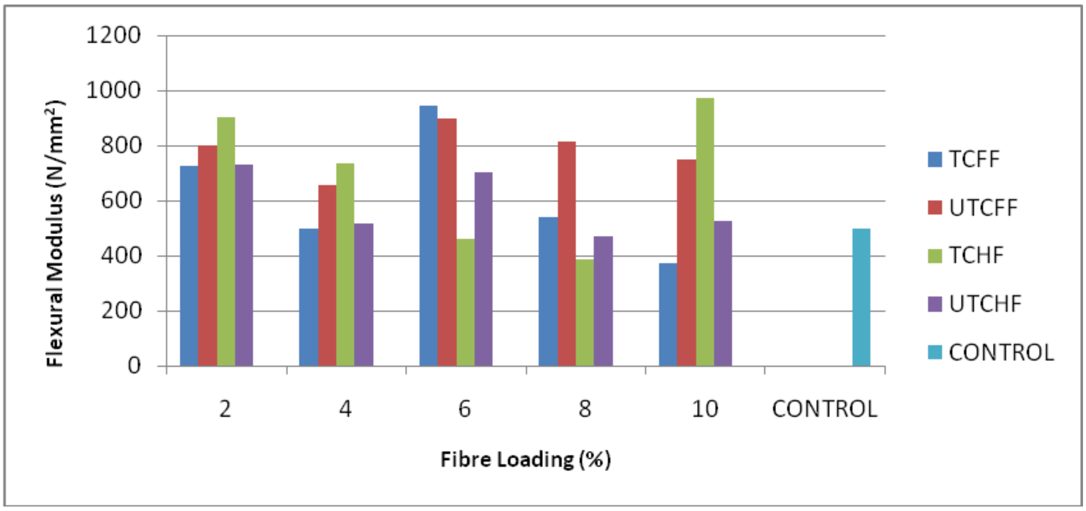

Figure 2: Variation of flexural modulus with fibre loading for the animal fibre-reinforced HPDE composites and the control sample

Figure 2 above represents the effect of animal fibres on the flexural modulus for the samples. From the test results, it was observed that the chemical treatment enhanced the flexural modulus of the cow hair fibre at 2, 4, and 10 % fibre loading respectively. The TCHF reinforcement at 10% fibre loading gave the best result with a value of 972.10 N/mm^2 which is 84.44 % better than the UTCHF with a value of 527.06 N/mm^2 at the same fibre loading and 95.14 % better than the control sample with a value of 498.15 N/mm^2. The results showed that the untreated chicken feather fibre (UTCFF) reinforced composites possess better flexural modulus in all the fibre loading used than the control material. However, the effect of the chemical treatment on the chicken feather fibre (CFF) only increased the flexural modulus at 6 % fibre loading. The TCFF reinforcement has a flexural modulus of 942.80 N/mm^2 at 6 % fibre loading which is 4.87 % better than the UTCFF with a value of 899.00 N/mm^2 at the same fibre loading and 89.26 % better than the control sample.

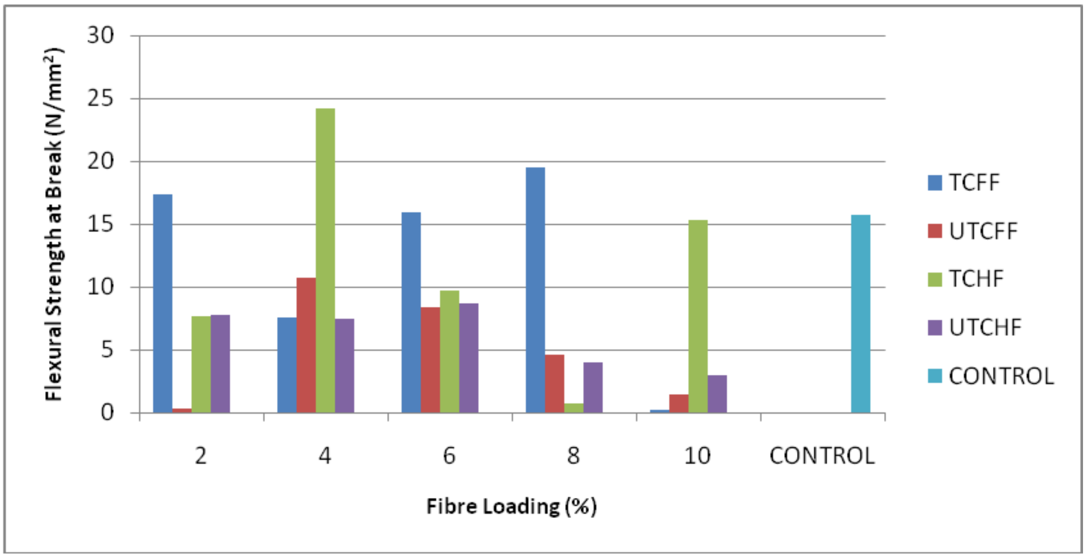

Figure 3: Variation of flexural strength at break with fibre loading for the animal fibre-reinforced HPDE composites and the control sample

Figure 3 above represents the effect of the animal fibres on the flexural strength at break for the samples, from where it was observed, that the TCHF reinforcement at 4 % fibre loading gave the best result with a value of 24.20 N/mm^2 which is 226.04 % better than the UTCHF reinforcement with a value of 7.42 N/mm^2 at the same fibre loading and 53.68 % better than the control sample with a value of 15.75 N/mm^2. The chemical treatment was observed to have improved the flexural strength at break of the cow hair fibre reinforcement as well as that of the chicken feather fibre at variousfibres loading. The results followed a similar pattern as was observed in Figure 2.

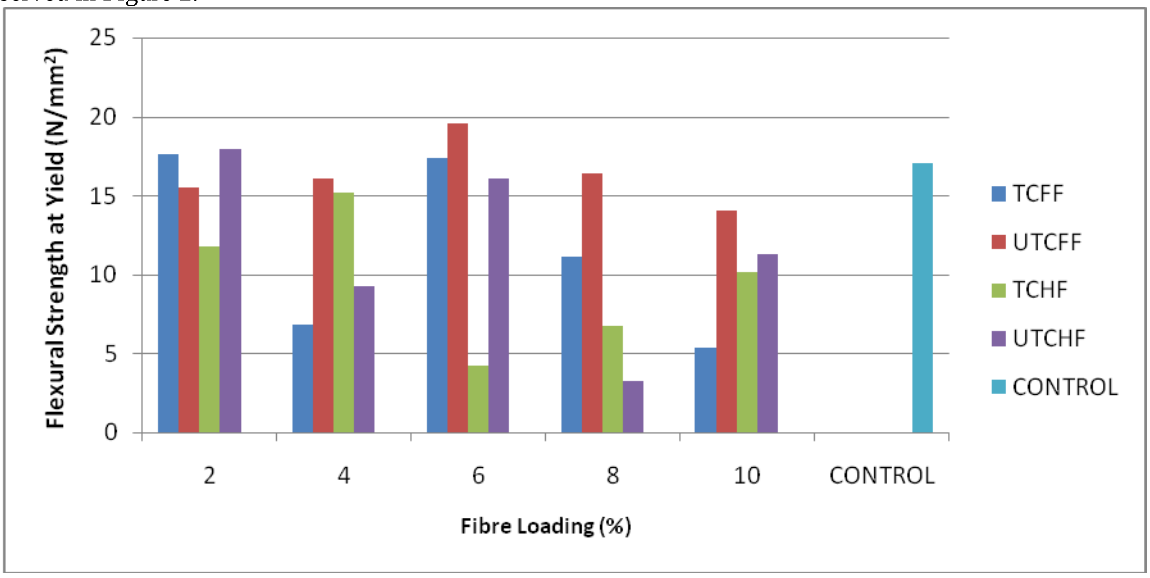

Figure 4: Variation of flexural strength at yield with fibre loading for the animal fibre-reinforced HPDE composites and the control sample

Figure 4 above revealed the variation of flexural strength at yield for the samples. The results showed that the UTCFF reinforcement at 6 % fibre loading gave the best result with a value of 19.60 N/mm^2 which is 12.86 % better than the TCFF reinforcement with a value of 17.36 N/mm^2 at the same fibre loading and 15.16 % better than the control sample with a value of 17.02 N/mm^2. From the test results, it was observed that the chemical treatment only improved the property of the chicken feather fibre reinforcement at 2 and 6 % fibre loading respectively compared to the control sample.

Tensile Properties

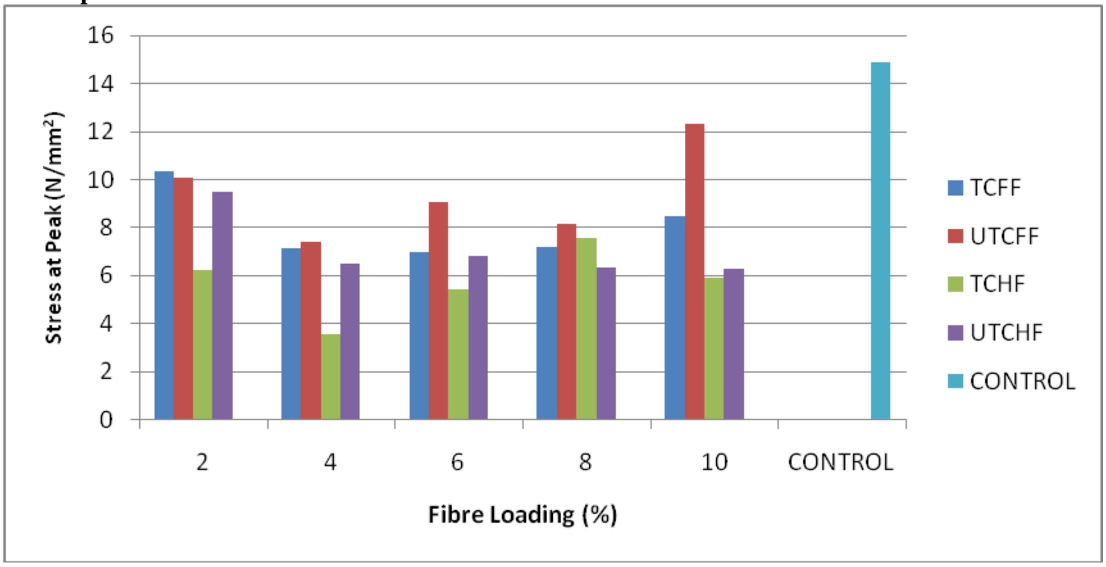

Figure 5: Variation of stress at peak with fibre loading for the animal fibre-reinforced HPDE composites and the control sample

The tensile strength at peak results of the control sample (unreinforced HPDE) and the animal fibre-reinforced HPDE composites are presented in Figure 5. These results showed that the tensile strength at peak of the control sample was highest with a value of 14.89 N/mm^2. The 10 % UTCFF reinforcement gave the best results of the animal fibre reinforcements witha value of 12.32 N/mm$^{2.}$ However, from the results, it was observed that the UTCFF reinforcement at 4-10 % fibre loading gave the best results in comparison with all the other animal fibre-reinforced HPDE composites except at 2 % where the TCFF gave the best result. This decrease in tensile strength exhibited by the animal fibre-reinforced HPDE composites as revealed by these results is similar to what was reported by Uzun et al (2011) when they used chicken feather quill and fibre to reinforce vinylester and polyester and also Reddy et al (2014) when they used Emu feather fibre to reinforce epoxy and polyester[19-20]. The effect of the chemical treatment on the animal fibres reinforcement was only positive for the chicken feather fibre at 2% fibre loading.

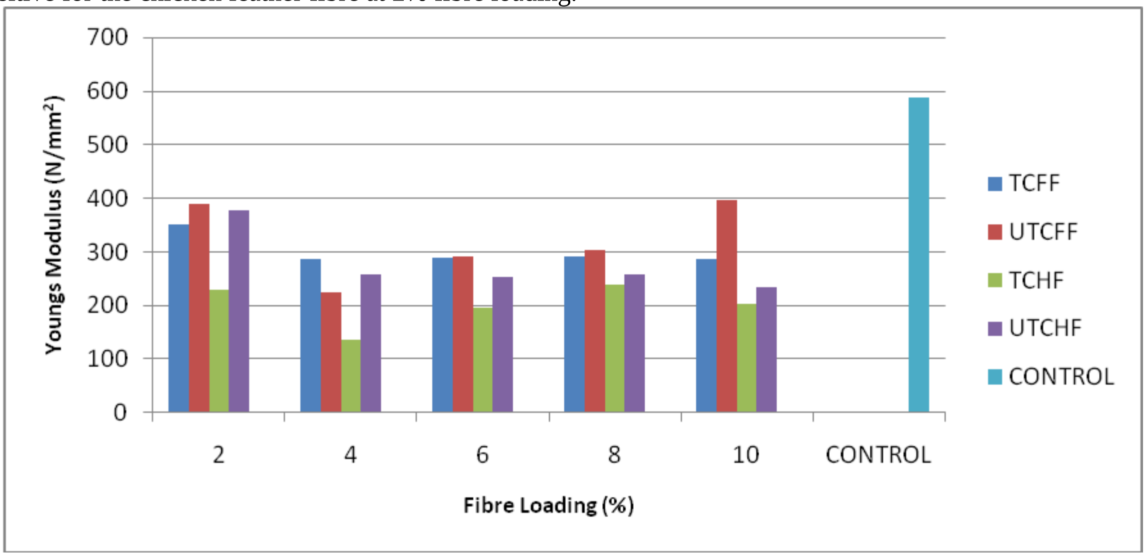

Figure 6: Variation of Young's Modulus with fibre loading for the animal fibre-reinforced HPDE composites and the control sample

The Young's moduli of the control sample and that of the animal fibre-reinforced HPDE composites are presented in Figure 6. These results showed a similar occurrence as was observed in Figure 5 above. From the results, the control sample has the highest value of 588 N/mm^2 Young's modulus. This was followed by 10 % UTCFF reinforced composite with a value of 397.58 N/mm^2. It was observed that the chicken feather fibre has better modulus than the cow hair fibre samples in all samples. For the cow hair fibre reinforcement, the chemically treated samples have lower values than that of the untreated samples. However, the chemical treatment was able to improve the property of the chicken feather fibre reinforcement at 4 % fibre loading in comparison with the UTCFF reinforcement at the same fibre loading. The 2 % fibre loading gave the best performance in terms of weight fraction used with the exception of TCHF. However, the best result was given by the UTCFF at 10% fibre loading.

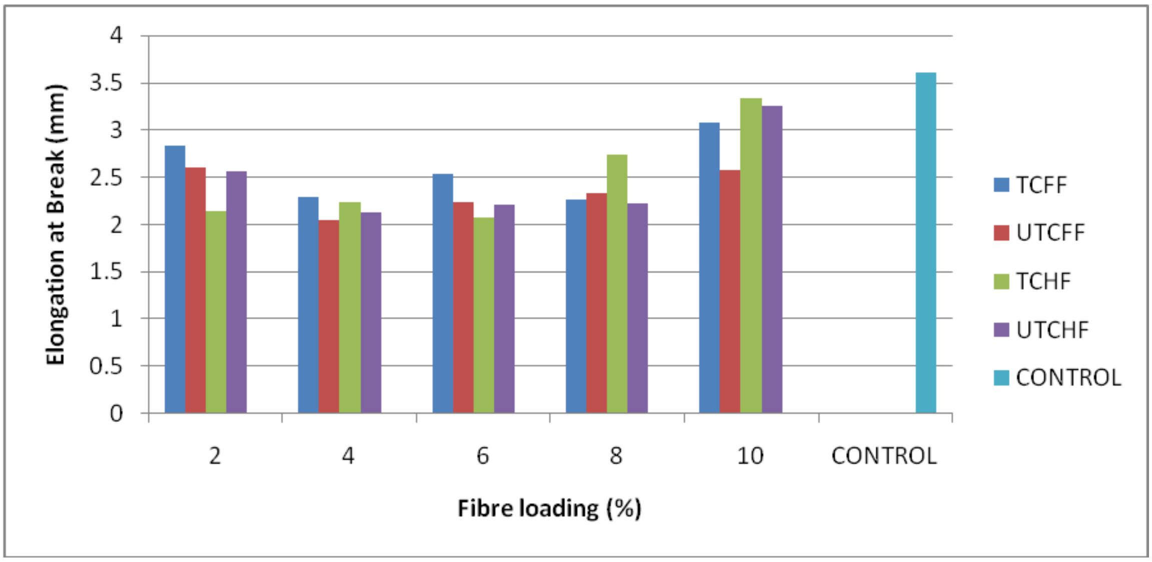

Figure 7: Variation of elongation at break with fibre loading for the animal fibre-reinforced HPDE composites and the control sample

The results for the elongation at break for the animal fibre-reinforced HPDE composites and the control sample are presented in Figure 7. The results of the test also showed that the control sample gave the best result with a value of 3.61 mm. The TCHF reinforcement at 10 % fibre loading gave the best result among the animal fibre-reinforced composites with a value of 3.33 mm which is just 8.31 % lower than the control sample. This performance confirms the reason for the best flexural properties results obtained from TCHF reinforced HDPE in Figures 1-3. The results revealed that the effect of the chemical treatment on the cow hair fiber was more effective at higher fibre loading while the chemically treated chicken feather fibre gave the best results at 2 % and 10 % fibre loading respectively. The 10 % fibre loading gave the best performance in terms of weight fraction used with the exception of UTCFF.

IV. CONCLUSION

The influence of chemical treatment on the mechanical behaviour of animal fibre-reinforced high density polyethylene composites have been investigated where the followings findings were established that;

- Both chicken feather and cow hair fibres can be used to reinforce high density polyethylene in order to enhance the flexural properties of the matrix. This was the case because the addition of these animal fibres to the matrix was able to improve the flexural response of the developed composite materials.
- Chemical treatment can be used to improve the surface condition of the fibres for improve interfacial bonding strength between the animal fibres and the matrix material. This was revealed from the outcome of the results where chemically treated animal fibre reinforced high density polyethylene composites gave the best performance in the flexural properties and elongation at break under tensile properties in comparison with the untreated animal fibre reinforced high density polyethylene composites.
- The work justifies the economic consumption of these otherwise waste materials that are detrimental as environmental pollution agent.

REFERENCES

[1]. **Chandramohan, D., and Marimuthu, K. (2011).** A Review on Natural Fibres, IJRRAS, Volume 8, Issue 2, pp. 197-205.
[2]. **Choudhry, S., and Pandey, B. (2012).** Mechanical Behaviour of Polypropylene and Human Hair Fibres and Polypropylene Reinforced Polymeric Composites, International Journal of Mechanical and Industrial Engineering, Volume 2, Issue 1, pp. 118-121.
[3]. **AzwinbtAhad, N., Parimin, N., Mahmed, N., Ibrahim, S.S., Nizzam, K., and Ho, Y.M. (2009).** Effect of Chemical Treatment on the Surface of Natural Fibres, Journal of Nuclear and Related Technologies, Volume 6, Number 1, pp. 155-156.

[4]. **Gianluca, C., Giuseppe, C., Giuseppe, R., and Alberta, L. (2010).** Composites Based on Natural Fibre Fabrics, Woven Fabric Engineering, PolonaDobnikDubrovski (Ed.), ISBN: 978-953-307-194-7, InTech, Available from: http://www.intechopen.com/books/woven-fabric-engineering/composites-based-on-natural-fibre-fabrics

[5]. **Westman, M.P., Fifield L.S., Simmons, K.L., Laddha, S.G., and Kafentiz T.A. (2010).** Natural Fibre Composites: A Review, pp. 4-9. U.S Department of Energy, Pacific Northwest National Laboratory, Richland, Washington 99352, PNNL 19220.

[6]. **Li, X., Tabil, L.G., and Panigrahi, S. (2007).** Chemical Treatments of Natural Fiber for Use in Natural Fiber-Reinforced Composites: A Review, Journal of Polymer and the Environment, Volume 15, pp. 25-33.

[7]. **Crawford, R.J. (2008).** Plastic Engineering, Third Edition, Butterworth-Heinemann, Department of Mechanical, Manufacturing and Aeronautic Engineering, TheQueens University of Belfast, pp. 185.

[8]. **Lester, H.G. (2007).** Physical Chemistry: History of High Density Polyethylene, Chapter 1, pp. 1. Available from http:// www.plasticpipe.org

[9]. **PHA, H.Q., and MARKS, M.J**. **(2002)**. Encyclopedia of Polymer Science and Technology, A Division of J. Wiley and soSns, Inc, New York.

[10]. **Jagadeeshgouda, K.B., Reddy, P.R., and Ishwaraprasad, K. (2014).** Experimental Study of Behaviour of Poultry Feather Fiber: A Reinforcing Material for Composites, International Journal of Research in Engineering and Technology,

[11]. **Wang, W., and Huang, G. (2008).** Characterization and Utilization of Natural Coconut Fibers Composites, Journal of Materials and Design, Volume 0, Issue 0, pp. 1-10.*

[12]. **Rokbi, M., Osmania, H., Imad, A., and Benseddiq, N. (2011)**, Effect of Chemical treatment on Flexure Properties of Natural Fiber-reinforced Polyester Composite, Procedia Engineering 10, pp. 2092-2097.

[13]. **Suardana, N.P.G., Piao, Y., and Lim, J.K. (2011).** Mechanical Properties of Hemp Fibers and Hemp/PP Composites: Effects of Chemical Surface Treatment, Materials Physics and Mechanics 11, pp. 1-5.

[14]. **Acda, M.N. (2010).** Waste Chicken Feather as Reinforcement in Cement-Bonded Composites, Philippine Journal of Science, 139 (2), pp. 161-165.

[15]. **Oladele, I. O., Omotoyinbo, J. A., and Ayemidejo, S. H. (2014).** Mechanical Properties of Chicken Feather and Cow Hair Fibre Reinforced High Density Polyethylene Composites, International Journal of Science and Technology, Volume 3,Number 1, pp. 63-70

[16]. **Sahari, M., and Sapuan, S.M. (2011).** Natural Fibre Reinforced Biodegradable Composites, Reviews on Advanced Materials Science 30, pp.166-170.

[17]. **ASTM D790,** Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials, ASTM International, West Conshohocken, PA, 20**02**

[18]. **ASTM D412**, Standard Test Methods for Rubbers in Tension, ASTM International, 1983

[19]. **Uzun, M., Sancak, E., Patel, I., Usta, I., Akalın, M., and Yuksek, M. (2011).** Mechanical behaviour of chicken quills and chicken feather fibres reinforced polymeric composites, Archives of Materials Science and Engineering, Volume 52, Issue 2, pp. 82-85.

[20]. **Reddy, K.N., Chanrasekar, V., Reddy, K.T., and Hussain, S.A. (2014).** Performance Evaluation of Emu Feather Fiber Reinforced Polymer Composites, International Journal of Mechanical Engineering and Robotics Research, Volume 3, Number 1, pp. 272-283.

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Optimization of Hydrocolloids Concentration on Fat Reduction in French Fries

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ABSTRACT : *The French fries were prepared from potatoes after pretreating with $CaCl_2$, blanching and then coated with different hydrocolloid solutions. It was observed that French fries pretreated with 0.5% aqueous solution of $CaCl_2$ and coated with 1% aqueous solution of HPMC resulted better product, higher moisture retention and lower oil uptake than the French fries with other hydrocolloids (CMC and xanthan gum).The sensory attributes of these French fries treated with HPMC were better than with the other hydrocolloids.*

KEYWORDS: *French fries, hydrocolloids, Pretreatments, oil uptake, sensory parameters*

I. INTRODUCTION

Awareness of adverse effects of excessive dietary fat intake is virtually universal. Consequently, health conscious individuals are modifying their dietary habits and eating less fat (Miller and Groziak, 1996). Consumer acceptance of any food product depends upon taste which is the most important sensory attribute. Although consumers want food with minimum to no fat or calories, they also want the food to taste good. Because several food items formulated with fat replacers do not compare favorably with the flavor of full-fat counterparts, it is difficult for some people to maintain a reduced fat dietary regime. Food manufacturers continue to search for the elusive "ideal fat replacer" that tastes and functions like conventional fat without the potential adverse health impact.

Rationale for Fat Replacers : As a food component, fat contributes key sensory and physiological benefits. Fat contributes to flavor, or the combined perception of mouth feel, taste, and aroma/odor (Ney, 1988). Fat also contributes to creaminess, appearance, palatability, texture, and lubricity of foods and increases the feeling of satiety during meals. Fat can also carry lipophilic flavor compounds, act as a precursor for flavor development (e.g., by lipolysis or frying), and stabilize flavor (Leland, 1997). From a physiological standpoint, fat is a source of fat-soluble vitamins, essential fatty acids, precursors for prostaglandins, and is a carrier for lipophilic drugs. Fat is the most concentrated source of energy in the diet, providing 9kcal/g compared to 4kcal/g for proteins and carbohydrates. High fat intake is associated with increased risk for obesity and some types of cancer, and saturated fat intake is associated with high blood cholesterol and coronary heart disease (AHA, 1996; USDHHS, 1988). The 1995 Dietary Guidelines (USDA ,USDHHS, 1995) recommend limiting total fat intake to no more than 30% of daily energy intake, with saturated fats no more than 10% and mono unsaturated and poly unsaturated fats accounting for at least two-thirds of daily energy intake. Consumer surveys indicate that 56% of adult Americans try to reduce fat intake and many show interest in trying foods containing fat replacers (Bruhn et al., 1992). A survey conducted by the Calorie Control Council (CCC, 1992) found that 88% of adults reported consuming low-fat, reduced-fat or fat-free foods and beverages (CCC, 1996). Although fat intake is declining, probably due to the increased availability of low and reduced-fat products and lean meats, fat consumption is greater than the recommended levels, and the prevalence of the population classified as overweight is increasing (Frazao, 1996). Foods formulated with fat replacers are enjoyable alternative to familiar high-fat foods. By choosing these alternative foods, health conscious consumers are able to maintain basic food selection patterns and more easily adhere to a low-fat diet (CCC, 1996). Fat may be replaced in food products by traditional techniques such as substituting water or air for fat, using lean meats in frozen entrees, skim milk instead of whole milk in frozen desserts, and baking instead of frying for manufacturing or preparing snack foods (CCC, 1992). Fat may also be replaced in foods by reformulating the foods with lipid, protein, or carbohydrate-based ingredients, individually or in combination. Fat replacers represent a variety of chemical types with diverse functional and sensory properties and physiological effects.

French Fries : *French fries* (American English) or **chips**, **fries, finger chips**, or **French-fried potatoes** are batons of deep-fried potato. Americans and most Canadians refer to any elongated pieces of fried potatoes as *fries*, while in the United Kingdom, Australia, Ireland and New Zealand, long, thinly cut slices of fried potatoes are sometimes called *fries* to distinguish them from the more thickly cut strips called **chips**.

French fries are served hot and generally eaten as an accompaniment with lunch or dinner, or eaten as a snack, and they are a common fixture of fast food. French fries are generally salted and, in their simplest and most common form, are served with ketchup; in many countries, though, they are topped instead with other condiments or toppings, including vinegar, mayonnaise, or other local specialties. Fries can also be topped more elaborately, as is the case with the dishes of poutine and chili cheese fries. Sometimes, fries are made with sweet potatoes instead of potatoes, are baked instead of fried, or are cut into unusual shapes, as is the case with curly fries, wavy fries, or tornado fries.
French fries contain primarily carbohydrates from the potato (mostly in the form of starch) and fat absorbed during the frying process. For example: A large serving of French fries at McDonald's in the United States is 5.4 ounces (154 grams); nearly all of the 500 calories per serving derive from the 63 g of carbohydrates and the 25 g of fat; a serving also contains 6 g of protein, plus 350 mg of sodium.

II. MATERIALS AND METHOD

Materials

Potatoes- Potatoes are tuberous vegetables used for a variety of Food preparations. French Fries are one of the most popular Food product prepared from Potatoes.

Grinded Sugar- Sugar is a commodity compound used in food processing. ‘Sugar dipping’ may affect the appearance (color) and the shrinkage of potato crisps during frying which may or may not be a detrimental factor. Sugar participates in the Maillard browning during frying (Leszkowiat et al., 1990) and may cause more substantially such reactions in potato crisps. Pre-drying followed by dipping potato crisps in a sugar solution can reduce the oil content of the fried crisps with an increased sweetness

Corn flour- Corn Flour is used during blanching of Fries to improve the texture of French Fries.

Calcium chloride- It Improves moisture retention in fries and also contributes to better sensory attributes in the product. The texture and crispiness in fries is improved.

Vegetable oil- Saffola active oil blended with Rice bran oil (80%) and Soybean oil (20%) with an added advantage of Vitamin E, Oryzanol, Fatty acids with Omega 3 was used for frying the product.

Salt- TATA Low Sodium Salt was used for seasoning of the French Fries.

All the above ingredients were purchased from local market of Amravati.

HPMC- **Hydroxypropyl methylcellulose** (**HPMC**) is an emulsifier, thickening and suspending agent, and an alternative to animal gelatin. Its Codex Alimentarius code (E number) is E464. It is generally recognized as safe by the FDA.

CMC-Carboxymethyl cellulose (CMC) or **cellulose gum** is often used as its sodium salt, sodium carboxymethyl cellulose. CMC is used in food science as a viscosity modifier or thickener, and to stabilize emulsions in various products including ice cream. As a food additive, it has E number E466.

Xanthan Gum is used as a food additive and rheology modifier, commonly used as a food thickening agent (in salad dressings, for example) and a stabilizer (in cosmetic products, for example, to prevent ingredients from separating).

The hydrocolloids such as HPMC, CMC and xanthan gum were gifted from Connell Bros. incorporated on Potato sticks on wet basis.

Method for preparation of French Fries : Wash the potatoes thoroughly to remove the soil on it. Then peel the potatoes with a peeler. Now cut the potatoes with a French Fries Cutter in the form of sticks of size 7x1cm.Transfer these sticks in a water bowl so as to avoid enzymatic browning. Warm the same amount of water (amount of water in which fries were dipped) up to 80ºC. Add 2gms grinded sugar, 0.5% aqueous solution of $CaCl_2$ and 2gms of Corn flour in this hot water. Soak the previously dipped sticks in this hot water solution for 7mins for blanching. Meanwhile, warm 100ml of water up to 90ºC. Add 1gm of HPMC in this water and mix this thoroughly so that an even solution is formed. Same procedure was followed for other hydrocolloids such as CMC and Xanthan gum. Then these sticks were dipped in the hydrocolloids solution, for 2-3min so that a layer of hydrocolloid is formed on the surface of the sticks. Then the sticks were removed and frozen for about 20mins at 0ºC.After 20mins sticks were fried in hot oil (160ºC for 2-3min).Then the fries were removed from the fryer and kept at room temperature for 2mins.Again these sticks were fried at 160ºC for 7mins.Then the fries were removed from the fryer and excess oil on the surface of sticks was soaked out with the help of a tissue paper, followed by salt addition and tossing them to mix the salt evenly. The same procedure was followed for other hydrocolloids for concentrations of 0.5%, 1% and 1.5% solution. All other parameters were kept same. The fries were allowed to cool and used for analysis of oil uptake and sensory quality. The frying was carried out in the fresh refined oil at every time. The method of preparation of French Fries is shown in figure1.

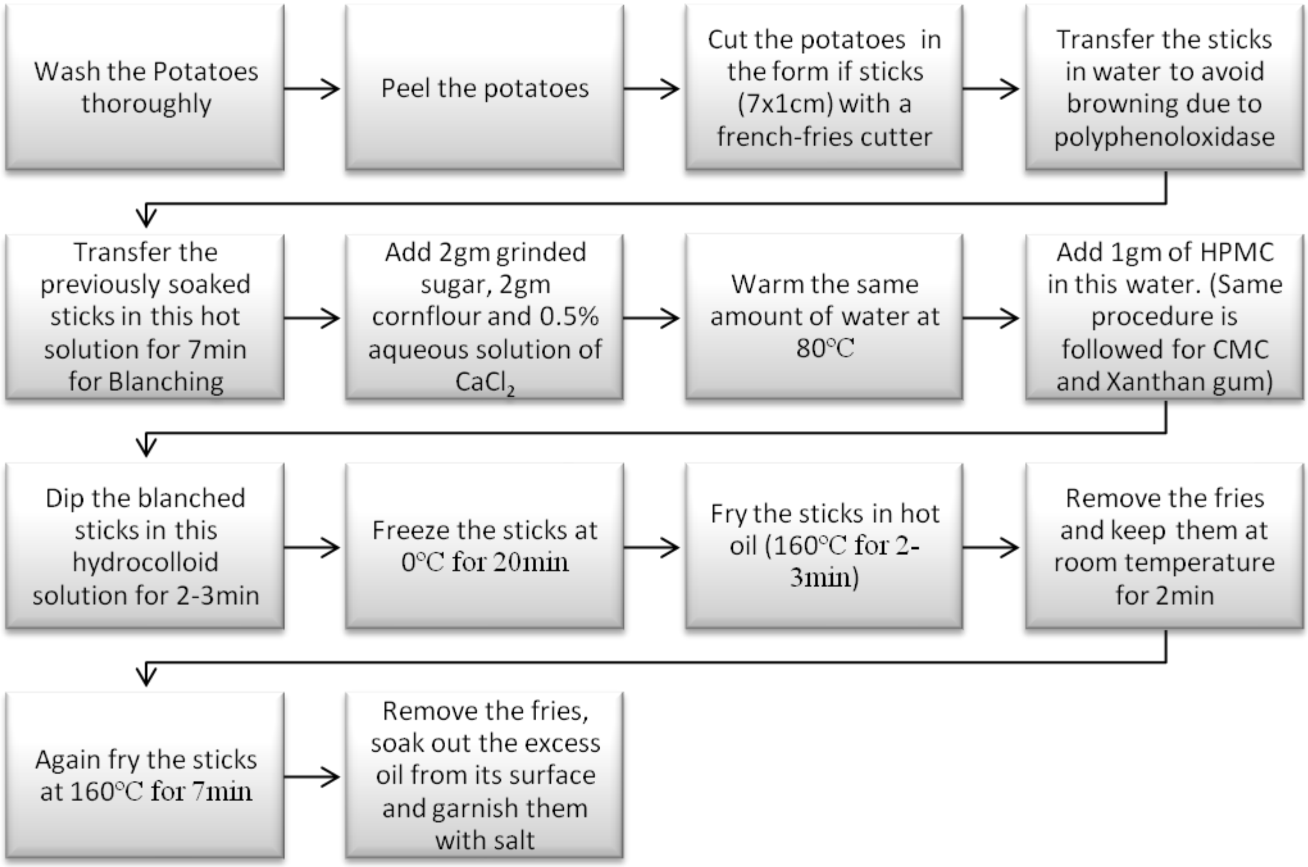

Figure 1: Method for preparation of French Fries

Physico-chemical and sensorial analysis of French Fries

Oil content : Oil Content was determined by using Soxhlet method (AOAC, 2002) using the Pelican Soxhlet apparatus.

Moisture Content : The Moisture Content was determined using RADWAG Moisture analyzer.

Sensory Quality
The Fries were evaluated for sensory quality by using the Hedonic method. Attributes like appearance, aroma, taste, mouth feel, bite and overall acceptability were evaluated by a semi trained panel of 7 judges on 9 point Hedonic scale (1- extremely dislike, 9- extremely like) suggested by Amerine et al. (1965).

III. RESULT AND DISCUSSION

Moisture loss and oil uptake : The data on moisture and oil contents of French fries revealed that the product when pretreated with 0.5% aqueous solution of$CaCl_2$andcoated with 1% aqueous solution of HPMC retained highest moisture (36.23%) in the product. It is known that the HPMC forms a film on the product and decreases the tendency of the product to absorb the oil and lose moisture. The mass transfer ceases to occur. The oil content of French fries decreased considerably with pretreatments and addition of hydrocolloids, irrespective of the type of hydrocolloids as compared to control. In the present study this holds good and French fries retained more moisture and taken up less oil. The moisture retention of control was lowest (28.10%) than any of the other samples which indicated that it was only pretreated with hot water and not coated with any of the hydrocolloids and sufficient mass transfer might have occurred. One of the most important properties of hydrocolloids is their ability to form films and sheets and act as a very effective barrier to oil and therefore used in number of food applications including adhesion, film forming, thermal gelling and non-charring characteristics. The film forming characteristics of these hydrocolloids have prevented the absorption of oil and at the same time helped to retain the natural moisture of foods. This could be the reason of using these hydrocolloids in deep frying of fried products (Ang, 1993; Koelsch and Labuza, 1992; Mallikarjunan *et al.*, 1997; Williams and Mittal, 1999; Sakhale *et al.*, 2011).

1) The addition of **HPMC** in French Fries was varied from 0.5, 1.0 and 1.5% and corresponding oil uptake was observed and is reported in Table 1. From the Table we see that the moisture content (36.23%) was highest on the addition of 1.5% HPMC followed by 1% and then 0.5%. Also, the oil content during 1.5% HPMC (13.02) was the least as compared to control (23.60%) followed by 1% and 0.5% HPMC. From the observations we could conclude that the best results were found during the addition of 1.5%HPMC in the French Fries with the reduction in oil uptake up to 44.83%.

Table 1: Effect of levels of HPMC on oil uptake of French Fries.

Hydrocolloids	Levels of Addition (%)	Moisture Content (%)	Oil Content (%)	% Reduction in oil uptake
Control		28.10	23.60	
HPMC	0.5	32.21	15.54	34.15
HPMC	1.0	34.73	14.12	40.16
HPMC	1.5	36.23	13.02	44.83

2) The addition of **CMC** in French Fries was varied from 0.5, 1.0 and 1.5% and corresponding oil uptake was observed and is reported in Table 2. From the below Table we see that the moisture content (33.26%) was highest on the addition of 1.5% CMC followed by 1% and then 0.5%. Also, the oil content during 1.5% CMC (16.71) was the least as compared to control (23.60%) followed by 1% and 0.5% CMC. From the observations we conclude that the best results were found during the addition of 1.5% CMC in the French Fries with the reduction in oil uptake up to 29.19%.

Table 2: Effect of levels of CMC on oil uptake of French Fries.

Hydrocolloids	Levels of Addition (%)	Moisture Content (%)	Oil Content (%)	% Reduction in oil uptake
Control		28.10	23.60	
CMC	0.5	30.04	20.25	14.19
CMC	1.0	31.92	18.38	22.11
CMC	1.5	33.26	16.71	29.19

3) The addition of **Xanthan Gum** in French Fries was varied from 0.5, 1.0 and 1.5% and corresponding oil uptake was observed and is reported in Table 3. From the Table we see that the moisture content (35.49%) was highest on the addition of 1.5% Xanthan Gum followed by 1% and then 0.5%. Also, the oil content during 1.5% Xanthan Gum (15.20) was the least as compared to control (23.60%) followed by1% and 0.5% Xanthan Gum. From the observations we conclude that the best results were found during the addition of 1.5% Xanthan Gum in the French Fries with the reduction in oil uptake up to 35.59%.

Table 3: Effect of levels of Xanthan gum on oil uptake of French Fries.

Hydrocolloids	Levels of Addition (%)	Moisture Content (%)	Oil Content (%)	% Reduction in oil uptake
Control		28.10	23.60	
Xanthan gum	0.5	31.71	17.30	26.69
Xanthan gum	1.0	33.90	16.56	29.83
Xanthan gum	1.5	35.49	15.20	35.59

Sensory quality of French Fries

The sensory quality is an important aspect in considering the overall acceptability of food product. Deep fat frying is widely used in industrial preparation of foods, because consumers prefer the taste, appearance and texture of fried food products (Saguy and Pinthus 1994). The French Fries prepared by addition of various hydrocolloids in varied levels were subjected to sensory evaluation for various quality parameters like color, aroma, taste, mouth feel and overall acceptability by semi trained panel of seven judges using nine point hedonic scales. The sensory scores obtained with respect to various quality attributes were statistically analyzed and presented in Table 4. The results on sensory quality of French Fries with different hydrocolloids showed that coating with HPMC at1% level was found superior in quality with respect to overall acceptability as compared to all other hydrocolloids. This treatment was followed by xanthan gum at the same level. The French Fries with CMC scored poorly with respect to sensory quality. It is reported that hydrocolloids are used to improve the texture and moisture retention in cake batters and dough, to increase the volume and shelf life of cereal foods by limiting starch retrogradation, improve their eating quality and appearance (Kotoki and Deka 2010; Kohajdova and Karovicova 2009).

Table 4: Effect of levels of hydrocolloids on sensory quality of French Fries.

Hydrocolloids	Levels of Addition (%)	Appearance	Aroma	Taste	Mouth feel	Bite	Overall-acceptability
Control		9	9	8	8	8	8.5
HPMC	0.5	8	7	7	6	7	7
HPMC	1.0	8	8	8	7	8	8
HPMC	1.5	8	7	6.5	6	6	6
CMC	0.5	7	7	6	6.5	6	6
CMC	1.0	7	7	6.5	6.5	6	6.5
CMC	1.5	7	7	6	6	6	6
Xanthan gum	0.5	8	7	6.5	6	6.5	6.75
Xanthan gum	1.0	8	8	7	7	8	7.5
Xanthan gum	1.5	8	7	6	6	6	6.5

IV. CONCLUSION

Among all the hydrocolloids studied at different levels for preparation of French Fries, it can be concluded that potato French fries pretreated with 0.5% calcium chloride and coated with 1% HPMC were found statistically significant over all other hydrocolloids in oil uptake with optimum sensory quality characteristics. Thus, French Fries with low fat and low calorie content with better acceptance can be prepared in order to meet the demand of low fatty foods of health cautious consumers.

REFERENCES

[1]. AHA. Dietary guidelines for healthy Americans. Circulation, 94: 1795-1800, 1996.

[2]. Amerine M. S., Pangborn R. M., Roessler E A. Principles of sensory evaluation of foods. Academic, New York, 1965.

[3]. Ang, J. F. Reduction of fat in fried batter coatings with powdered cellulose, Journal of the American Oil Chemists' Society 70: 619-622, 1993.

[4]. Annapure U.S., Singhal R.S., Kulkarni P.R. Studies on deep-fat fried snacks from some cereals and legumes, J Sci Food Agric76:377–382, 1998.

[5]. Bruhn, C.M., Cotter, A., Diaz-Knauf, K., Sutherlin, J., West, E., Wightman, N., Williamson, E. and Yaffee, M. Consumer attitudes and market potential for foods using fat substitutes, Food Technol. 46(4): 81-86, 1992.

[6]. C.C.C., "Fat Replacers: Food Ingredients for Healthy Eating," 12 pp., Calorie Control Council, Atlanta, Ga, 1992.

[7]. C.C.C., "Fat Reduction in Foods," 111 pp., Calorie Control Council, Atlanta, Ga, 1996.

[8]. Das M. N., Giri N.C., Design and analysis of experiments, 2ndedn. Wiley Eastern Ltd, New Delhi, 1988.

[9]. Feeney R.D., Haralampu S.G., Gross A.T., Potato and other food products coated with edible oil barrier films, US Patent 5:217–736, 1993.

[10]. Frazao, E., The American diet: A costly health problem, Food Review, Jan.-Apr. pp. 1-6, 1996.

[11]. Gamble M.H., Rice P. Effect of pre-frying drying on oil uptake and distribution in potato crisp manufacture, Int J Food Sci. Technology 22:535–539, 1987.

[12]. Holikar M., Annapure U.S., Singhal R.S., Kulkarni P.R.,.Pectin and calcium chloride treatment for low-fat green gram splits, J Sci Food Agric 85:1677–1680, 2005.

[13]. Indira T.N., Baby Latha R, Prakash M. Kinetics of deep- fat –frying of a composite product, J Food Sci Technol 36:310–315, 1999.

[14]. Kimber M.P., Holding S., Some technological aspects of batter. In: 1st European Symposium on Savory Coatings, Elsevier Applied Science Publishers LTD, London, pp 85–89, 1987.

[15]. Koelsch, C., Labuza. Edible water vapor barriers: properties and promise, Trends in Food Science and Technology 5: 76-81, 1992.

[16]. Kohajdova, Z. and Karovicova, J. Application of hydrocolloid as baking improvers, Chemical Papers63: 26-38, 2009.

[17]. Kotoki, D. and Deka, S.C. Baking loss of bread with special emphasis on increasing water holding capacity, Journal of Food Science and Technology 47:128-131, 2010.

[18]. Leland, J.V. Flavor interactions: The greater whole, Food Technol. 51(1): 75-80, 1997.

[19]. Leszkowiat, M. J., Baricello, V., Yada, R. Y., Coffin, R. H., Lougheed, E.C., & Standley, D. W. Contribution of sucrose to non-enzymatic browning in potato chips, Journal of Food Science, 55, 281–282, 1990.

[20]. Mallikarjunan, P., Chinnan, M.S., and Balsubramanium,V.M., Edible coatings for deep fat frying of starchy products, Journal of Food Science and Technology 30: 709 -714, 1997.

[21]. Miller, G.D. and Groziak, S.M., Impact of fat substitutes on fat intake, Lipids 31(S): 293-296, 1996.

[22]. Ney, K.H., Sensogamme, einemethodische Erweiterung derAromagramme, Gordian 88(1): 19, 1988.

[23]. Saguy, I.S. and Pinthus, E.J., Oil uptake during deep fat frying: Factors and Mechanisms, Food Technology 49 (4): 142-145,152, 1994.

[24]. Saha D., Bhattacharya S. Hydrocolloids as thickening and gelling agents in food: a critical review, J Food Sci Technol 47:587–597, 2010.

[25]. Sakhale, B. K., Badgujar, J. B., Pawar, V. D. and Sananse S. L., Effect of hydrocolloids incorporation incasing of samosa on reduction of oil uptake, Journal of Food Science and Technology (Online) DOI: 10.1007/s13197-011-0333-0, 2011.

[26]. USDA and USDHHS. Nutrition and your health: Dietary guidelines for Americans. 4th ed., Home and Garden Bulletin, No. 232, U.S. Dept. Agriculture and U.S. Dept, Health and Human Services, Washington, D.C, 1995.

[27]. USDHHS. "The Surgeon General's Report on Nutrition and Health. Publ. No. 88-50210. U.S. Govt. Print. Office, Washington, D.C, 1988.

[28]. Varela G., Current facts about the frying of foods. In: Valera G, Bender A.E., Morten J.D., (ed) Principles, changes, new approaches.UK, pp 9–25, 1988.

[29]. Williams, R. and Mittal, G. S. Low fat fried foods with edible coatings: modeling and simulation, Journal of Food Science 64: 317-322, 1999.

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Design, Construction and Testing Of a Multipurpose Brick/Block Moulding Machine

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ABSTRACT : *The provision of shelter is one the most basic demand of a Man all over the World. It is one the most important challenges a man faces in his life. The problem of good shelter varies from place to place. A good shelter provides, first and foremost Security and Privacy. In the developed world the problem is less pronounced, but in the developing nation like Nigeria, the problem of shelter is more pronounced. There is about eighteen (18) million housing units' deficit in Nigeria. One of the most important materials used for building of a shelter is block/brick, but majority of the people cannot afford these materials (blocks or bricks) due high cost. Therefore, the production of high quality and affordable blocks/bricks is paramount to solving housing problems in developing countries especially in Nigeria. Thus, this research focused on design construction and testing of a multipurpose machine that produces high quality blocks/bricks for low cost housing. That is, for low income communities/earners. The constructed motorized compressive earth brick (CEB)/block making machine can produce on average a total of 2,215 bricks per day and 950 blocks per day. The cost of production of the machine was two hundred and eighty six thousand, eight hundred ninety (₦286, 890.00) naira only. Whereas, the most common high-tech motorized CEB machine in Nigeria (Hydraform®) with an average capacity of about 3,000 bricks per day costs about six million naira (₦6,000,000.00K) only. Thus, the machine is very affordable for small scale enterprise (SME). In other words, bricks or blocks produced by using this machine are relatively cheap and affordable for those in the rural areas and for low income earners.*

KEY WORDS: *Compressive Earth Bricks (CEB), Bricks, Blocks,*

I. INTRODUCTION

It is an undisputed fact that shelter is one of the basic human necessities. However, irrespective of the importance of shelter, most people do not have access to good shelter, most especially in developing countries. In fact there is an estimated deficit of between 17 and 18 million housing units in Nigeria in 2012, [1]. The poor are most adversely affected by this housing shortage. The most important building materials for low-cost housing are blocks/bricks [2], but conventional quality concrete blocks are too expensive for low-income communities. Due to high cost of Portland cement, a lot of block producers use less than the recommended amount in the concrete mix making the blocks to be substandard. This is one of the most important contributing factors for the frequent building collapse in the country recently. Bricks / Blocks are solid pieces of hard substances, usually with flat sides, used as construction units [3]. They are sometimes referred to as masonry units (MU). Block and brick masonry are strong, fire-resistant, insect-proof building materials. They have a lot of thermal mass, which helps them retain heat and makes up for their relatively low insulation value. However, despite their similarities, block and brick have some major differences: Blocks are bigger in size as compared to bricks; blocks are usually made of concrete and hollow, while bricks, on the other hand, are smaller usually made of clay or other earthen materials and solid [4]. Compressed Earth Brick (CEB) is an alternative building material to concrete blocks which have been proved to be an excellent substitute. However, the full potential of CEB is yet to be utilized due to the fact that most of the commercially available machines that produce CEB are very expensive. The most common CEB machine (Hydrafoam®) is sold at about six million Naira. There are simpler and cheaper low income brick/block producing machines.

The example of such machines are the Light Manual Brick Press known as CINVA RAM [5], the Montgomery's dynamic CEB making machine [2], the Ajao et al's Hydraulic Brick Press [6], the Akerele and Akhire's three-mould Hydraulic Interlocking Brick Moulding machine [7] and so on.

Although simpler and cheaper machines are developed, but they require high level skilled operator and diligence to produce good quality block/brick. In addition, due to the tedious or awkward procedures of running these simple machines, they are used mostly by intending house owners themselves to make the blocks or bricks.

Locally fabricated Cinva Ram (Fig 1.1), is the most common manually operated lever-action CEB press. It costs between ₦120, 000 and ₦180, 000 defending on the quality of the fabrication. Even though it is very cheap, it possesses the following disadvantages: low capacity (usually not more than 1,000 bricks per day), the absence of quality control mechanism and high level of physical labour.

Fig 1.1: Locally fabricated Cinva Ram on site

Therefore, first and foremost, there is need to develop a machine that will be relatively in-expensive, easy to be maintained, easy to operate and, most importantly, has a good quality control mechanism (such as compaction pressure control). Secondly, although the basic principle of block/brick making whether concrete or earthen is the same, no commercially available machines, to best the knowledge of the authors, that produces both concrete block as well as compress earth bricks. Thus, this research seeks to address the aforementioned challenges.

II. MATERIALS AND METHODS

The materials used in this research were Sand, Portland Cement, Earthen Materials (laterite, clay), while the Constructed Multipurpose Brick/Block Moulding Machine, Compression Testing Machine, Shovels etc were the instruments/tools used. The machined was designed to produce bricks/blocks enough to build a two bedroom flat in five days. The flat has a total wall area of 340m^2. The area of 1 brick is 0.022m^2, thus the total required bricks was approximately equal to 15,500. This means that in day an approximate 3,100 bricks was required.

2.1. Design Considerations/Assumptions

Design Considerations/Assumptions are:

- The size of the block/brick for this project is 220mm x 220mm x 100mm;
- The compaction/compression pressure of the machine was 10MN/m^2
- It was assumed the internal pressure/stress of the mould is distributed evenly.

2.2. Design Calculations

The design calculations for each component of the machine were done and base on the results, the materials were selected and the construction was executed. The design calculations for the following elements were carried out: The Mould, Rammer & Ejector Plates, Rammer and Struts, Hydraulic Beam, Main Columns, Hydraulic Cylinder and Hydraulic Power Pum. The details design calculations are contained in M.B. Umar's Work [8]

- **The Mould**

The distributed load intensity (ω), cross sectional modulus of the mould wall (Z), the Maximum Bending moment (M_{max}) and Maximum Stress on the mould wall were all calculated. The maximum deflection was also calculated. The factor of safety for the machine was determined also.

- **Rammer and Ejector Plates**

The same calculations were done for the Rammer and the Ejector Plates.

- **Rammer and Ejector Struts**

The sectional second moment of area, radius of gyration, slenderness radius, and the crippling load were all calculated. The maximum bending moment, sectional modulus, and bending stress were calculated for the hydraulic cylinder beam. Likewise the following calculations were carried out for the hopper viz the weight of the hopper, the reaction due to hydraulic cylinder force, the resultant moment (which is the sum of the resultant moments of the upper rectangular part of the hopper and the lower trapezium part) and maximum stress on the columns.

2.3. Selection of the Hydraulic Cylinder and Power Pump

The hydraulic cylinder and power point were selected after the necessary calculations like the cylinder caliber (internal diameter), cylinder stroke, speed and pump discharge, speed, pressure, power, torque respectively.

2.4. Electric Motor Selection

The electric motor is standard component and its selection was done after defining the followings:

- Power requirement of the hydraulic pump
- Shaft rotational speed requirement of the hydraulic pump
- Torque requirement of the hydraulic pump
- Weather and other environmental conditions of the site of application

  The selection was done in accordance with the National Electrical Manufacturers Association (NEMA) Standard Publication MG-1-2010 [9].

2.5. Fabrication Processes of the Machine

The summary of the fabrication processes is presented in table 2.1 below.

Table 2.1 summery of components fabrication and tools

S/N	COMPONENT	DESCRIPTION	EQUIPMENT/TOOL USED
1	mould	150 by 240mm box open at top and bottom. Made from welded 8mm low carbon steel plate	Abrasive cut-off disc Milling machine and SMAW
2	feeder	150 by 240mm box open at top and bottom. Made from 4mm metal sheet	Abrasive cut-off disc and SMAW
3	Rammer/Ejector	Metal plate 150 by 240mm, 15mm thick welded to a U-shaped strut made from 75PFC	Oxy-acetylene cutting torch, abrasive grinding, milling and SMAW
4	Hopper	500 by 500mm, 200mm high upper box welded to 300mm high lower frustum of pyramid made from 1mm sheet metal	Guillotine machine, sheet bending machine and SMAW
5	Frame	Framework of welded structural steel made from 75PFC and 35mm angle bar 570 by 700mm, 1312mm high.	Abrasive cut-off disc, drilling machine and SMAW.
6	Guide rods	Steel rods 35mm diameter 800mm long, threaded at both ends	Abrasive cut-off disc and lath machine
7	Rammer bar/Ejector bar	500mm long 75PFC with holes and 50mm flat bar brackets	Abrasive cut-off disc, drilling machine and SMAW.
8	Hydraulic cylinder bar	500mm long 75PFC with round holes and rectangular holes	Abrasive cut-off disc, drilling machine, milling machine and SMAW.
9	Pump-motor base	Rectangular base frame 570 by 225mm made of 75PFC, 35mm angle bars and 10mm thick metal plate	Abrasive cut-off disc, drilling machine and SMAW.
10	Pump bracket	L-shaped bracket 150 by 120mm 150mm high made from 10mm thick steel plate with holes	Abrasive cut-off disc, drilling machine, lath machine and SMAW.
11	Hydraulic cylinder bracket	Steel plate 120 by 100mm with round holes and rectangular hole	Abrasive cut-off disc, drilling machine, milling and SMAW.
12	Ejector latch	Flat bar 325mm long 50mm wide by 5mm thick with holes and cut out	Abrasive cut-off disc and drilling machine.

However, all the components of the hydraulic system are standard/adopted engineering components. These are: the Hydraulic Cylinder, Hydraulic Pump, Control Valve, Oil Tank and Filter, Hydraulics Hoses, hydraulic hoses' fittings and Electric Motor.

The fabricated multipurpose brick/block making machine is presented in fig. 2.1 below.

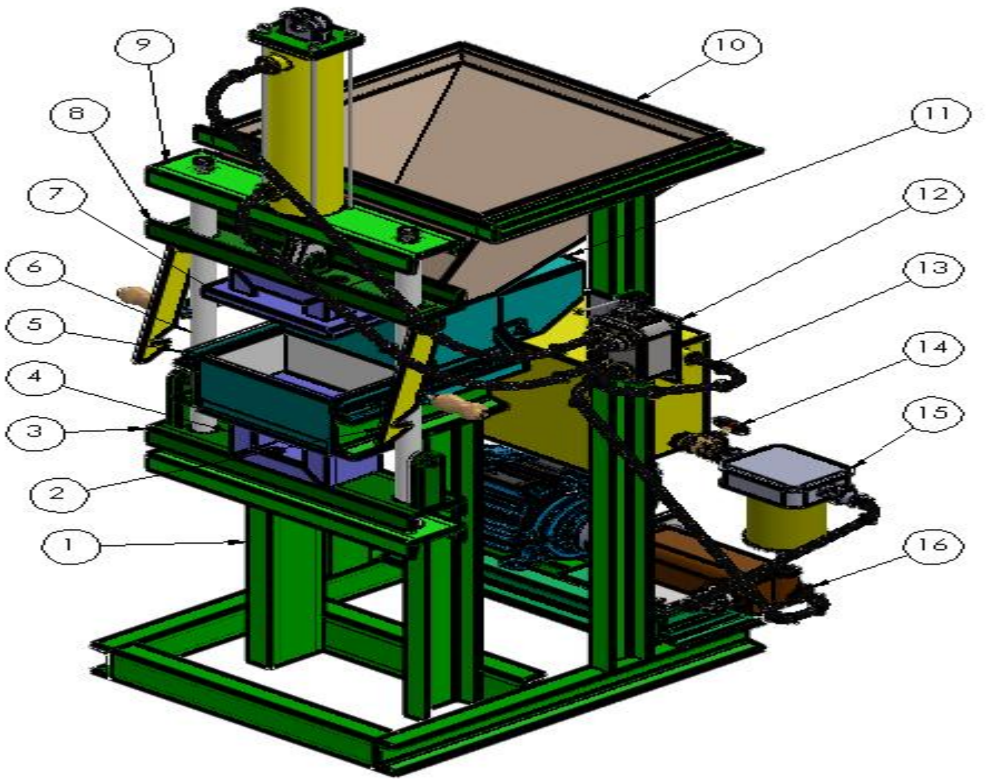

Fig. 2.1 Multipurpose Brick/Block Moulding Machine (3D CAD)

1. Main frame	2. Ejector latch	3. Ejector bar	4.Ejector
5. Mould	6. Guide rod	7. Rammer	8. Rammer Bar
9. Hydraulic cylinder bar	10. Hopper	11. Feeder	12. Control valve
13. Hydraulic oil tank	14. Oil supply valve	15. Oil filter	16. Hydraulic pump

2.6. The Cost Implication (Cost Analysis)

The cost of the machine comprises the cost of materials, the cost of production (labour costs) and transportation. The break down is presented in table 2.2

Table 2.2 Cost Breakdown

S/N	Item Description	Quantity	U/M	unit cost(₦)	Amount (₦)
1	100PFC C-channel	14	m	1,600.00	22,400.00
2	75PFC C-channel	14	m	1,200.00	16,800.00
3	35 x 5 equal angle	14	m	500.00	7,000.00
4	50 x 5 flat bar	21	m	200.00	4,200.00
5	8mm low carbon steel sheet	1	m^2	5,500.00	5,500.00
6	4mm low carbon steel sheet	1.2	m^2	3,000.00	3,600.00
7	15mm low carbon steel plate	0.2	m^2	12,000.00	2,400.00
8	1mm low carbon steel sheet	20	m^2	200.00	4,000.00
9	25mmØ polished rod	2	m	2,500.00	5,000.00
10	M24 Hex hd bolts and nuts	6	pcs	220.00	1,320.00
11	M8 Hex hd bolts 20mm long & nuts	35	pcs	30.00	1,050.00
12	M10 stud 1000mm long	6	pcs	125.00	750.00

13	12Hp, 3phs electric motor	1	pc	22,000.00	22,000.00
14	jaw coupling	1	set	5,000.00	5,000.00
15	220GPM, 45MPa Hydraulic Pump	1	pc	45,000.00	45,000.00
16	150 x 1000mm Hydraulic cylinder	1	pc	9,000.00	9,000.00
17	12mmØ, high pressure flexible hose	5	pcs	3,000.00	15,000.00
18	20mmØ, high pressure flexible hose	2	pcs	4,200.00	8,400.00
19	12mmØ, hydraulic hose fittings	15	pcs	320.00	4,800.00
20	20mmØ, hydraulic hose fittings	4	pcs	300.00	1,200.00
21	directional control valve	1	pc	12,000.00	12,000.00
22	hydraulics oil tank	1	pc	3,500.00	3,500.00
23	hydraulics oil filter	1	pc	4,200.00	4,200.00
24	1" gate valve	1	pc	500.00	500.00
25	1" pipe fittings	6	pcs	120.00	720.00
26	2.5mm^2, 4 core flexible cable	5	m	850.00	4,250.00
27	ball bearings (203)	6	pcs	300.00	1,800.00
28	welding electrodes	2	pkts	3,000.00	6,000.00
29	abrasive cutting discs	10	pcs	550.00	5,500.00
30	abrasive grinding discs	5	pcs	500.00	2,500.00
31	hack saw blades	5	pcs	300.00	1,500.00
32	hydraulic oil	15	lts	400.00	6,000.00
	Total				**232,890.00**
	tooling/labour cost				
33	machining				18,000.00
34	welding and fitting				25,000.00
35	Transportation				11,000.00
	Total				**54,000.00**
	Grand total				**286,890.00**

2.7. TESTING (Brick/Block Production Processes)

2.7.1. Testing Procedures

i) The materials used were soil, sand, cement, water and shovel. The selection of the soil for the production of the compressed earth brick (CEB) was in accordance with laid down guidelines [10]. One of such guidelines is that all soil types considered good for road construction are also good for making CEB. Therefore, the soil used was obtained from a road construction borrow site.

ii) The soil lump was crushed using wooden poll and then sieved to remove lumps and stones bigger than 5mm, because big stones and lumps will necessitate higher compression force according to P. Odul et al [11]

iii) Water was added to the soil by sprinkling and then mixed thoroughly with shovel until it was homogeneously damp (fig. 2.2)

FIG 2.2: Earth mix just after mixing

iv) The damp soil mix was then covered with a polythene sheet and allowed to soak for three days (fig 2.3) (as per ARS 674: 1996) [7]. This is to ensure that every lump is well permeated by the water.

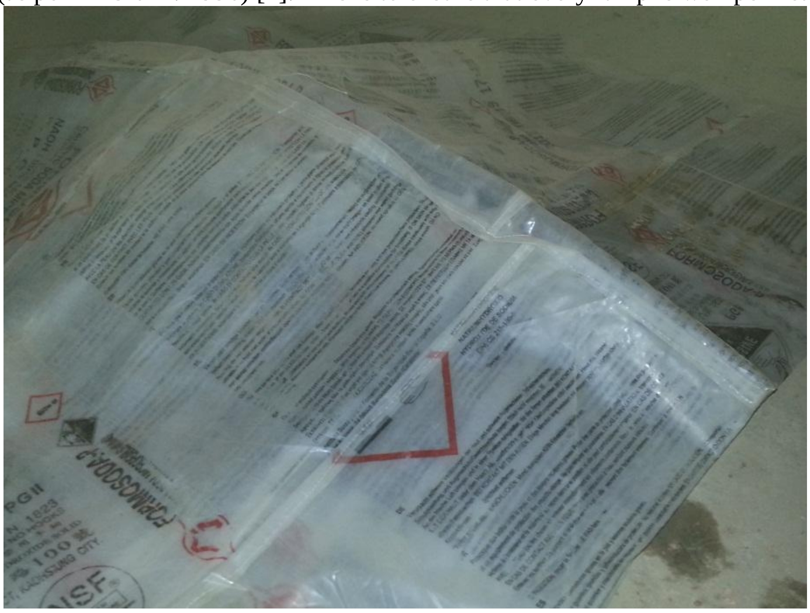

Figure 2.3 Soil Mix covered after mixing to soak

Then thereafter, the bricks were produced. The machine was operated under the following conditions:

1. Compression Pressure: 10Mpa
2. Moisture content: 6%
3. Curing time: 7days
4. Mould size (length x width x height): 235mm x 148mm x 150mm.

2.7.2. The brick production processes

The production of the bricks was carried out following the steps below.

1. The hydraulic oil tank was checked to ensure adequate oil level
2. The oil supply valve to the hydraulic pump was fully opened
3. The electric motor was then powered
4. Feeder was positioned directly under the hoper
5. Using shovel, the mix was fed to the hoper
6. Holding the feeder handle, the feeder was moved to a position above the mould and then the feeder was shaken back and forth to make sure that the mould was well filled (fig. 2.4)

Figure 2.4 Soil Mix being fed into Mould from hopper

7. By depressing the lever of the directional control valve, the rammer was lowered into the mould and therefore compressing the soil to its final density.
8. Using the same lever but this time upward, the compressed soil block is now ejected
9. Using palms of both hands (fig. 2.5) the *Green Block* was removed from the machine to curing area.
10. The cycle was repeated for other blocks

Figure 2.5 Compressed Soil Block lifted to curing yard

The same procedures were followed in the production of the concrete blocks. (fig. 2.6 and fig. 2.7)

Figure 2.6 Concrete Mix

Figure 2.7 Concrete Block

2.7.3. Determination of the Mechanical and Physical properties of the bricks/blocks: The mechanical properties examined were: the compressive strength, bulk density, moisture content, compression ratio using the ASTM C 67 standard. The physical properties (squareness, surface smoothness/flatness, dimensional uniformity/accuracy) were also examined. For the bulk density determination, twelve (12) bricks were used, while for the compressive strength two (2) sets of seven bricks were used for both dry and wet conditions.

III. RESULTS AND DISCUSSION

3.1. Results: The results of the bulk density and compressive strength are presented in tables 3.1 and 3.2 respectively.

Table 3.1 Bulk Density and Physical Characteristics

TRIAL NUMBER	PRODUCTION PERIOD (s)	BLOCK HIGHT (m)	WEIGHT (kg)	VOLUME (m^3)	BULK DENSITY (kg/m^3)
1	14	0.0778	4.9177	0.00268	1833
2	12	0.0758	4.6998	0.00261	1798
3	12	0.0769	4.9059	0.00265	1850
4	13	0.0770	4.9176	0.00266	1852
5	15	0.0768	4.7591	0.00265	1797
6	12	0.0790	4.9009	0.00272	1799
7	13	0.0779	4.8918	0.00269	1821
8	14	0.0791	4.8935	0.00273	1794
9	12	0.0763	4.7466	0.00263	1804
10	13	0.0755	4.7280	0.00260	1816
11	12	0.0772	4.8159	0.00266	1809
12	15	0.0780	4.9518	0.00269	1841
AVERAGE	**13**	**0.0773**	**4.8440**	**0.00266**	**1818**

Table 3.2 The Compressive Strength

	Wet		**Dry**	
S/N	Max load @ failure (KN)	Compressive strength (N/mm^2)	Max load @ failure (KN)	Compressive Strength (N/mm^2)
1	96.98	2.79	249.01	7.16
2	95.43	2.74	251.21	7.22
3	97.67	2.81	248.99	7.16
4	96.19	2.77	253.07	7.28
5	95.98	2.76	249.18	7.16
6	98.07	2.82	250.25	7.20
7	95.79	2.75	248.59	7.15
average	96.59	**2.78**	250.04	**7.19**

3.2. Discussions

3.2.1 Compression Pressure

The hydraulic pressure of the system was maintained at 10MPa by means of adjusting the set-point of the Pressure Relief Valve (PRV) on the hydraulic power pump, and monitored through the Pressure Gauge as shown on Fig 3.1. This pressure is obtained at the motor speed of 1,450rpm.

Compression pressure (as per African Regional Standards for Compressed Earth Blocks ARS 674: 1996) is classified as follows: very low pressure 1 to 2 N/mm^2, low pressure 2 to 4 N/mm^2, medium pressure 4 to 6 N/mm^2, high pressure 6 to 10 N/mm^2, hyper-pressure 10 to 20 N/mm^2 and mega-pressure 20 N/mm^2 and over.

The size of this machine fall within the light hydraulic brick machine category, which usually provides high compression pressure (6 to 10 N/mm^2).

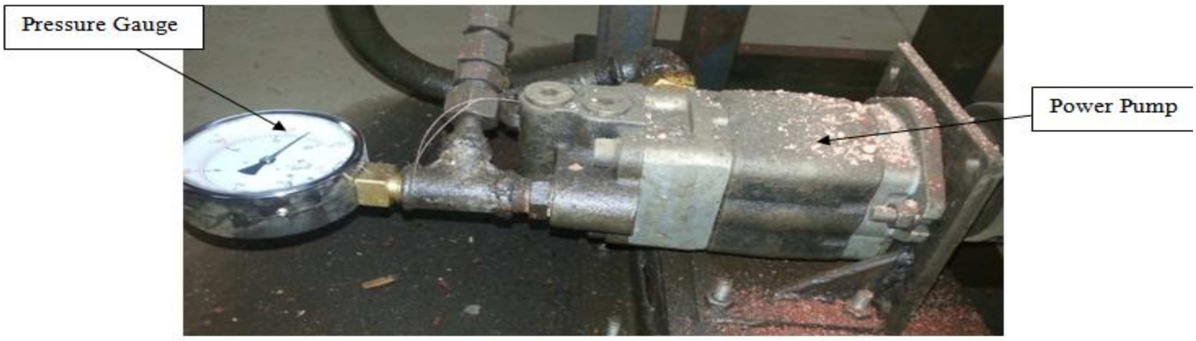

Figure 3.1 Hydraulic Power Pump with Pressure Gauge

3.2.2 Bulk Density

Dry density of the produced block is often the primary measure of performance of block machine [10]. The higher the bulk density of the block, the stronger the block is [10]. The bulk density of each of the twelve samples is presented in Table 3.1 and it was obtained by dividing the weight of the block by its volume. The average bulk density of the block is 1818kg/m^3 which is approximately 1,800kg/m^3. Although the most desirable CSB density is 2,000kg/m^3[12], 1,800kg/m^3 is also adequate for most applications [10]. Besides, this density can be improved by adjusting sand content and moisture content of the mix [10].

3.2.3 Production Rate

The production rate is a direct function of the *Capacity* of the power pump as well as the ability of the operator. The average production period of a block was 13seconds as presented in table 3.1. Therefore, in an eight-hour working day the average total bricks produce was:

$$Production\ rate\ /day = \frac{60 \times 60 \times 8}{13} = 2{,}215 \text{ bricks per day}$$

Compared with the design production capacity of 3,100 brick per day (section 2 above), this production rate is less than the desired. However, this rate can be boosted by increasing motor speed or by modifying the machine to produce two or more bricks at the same time.

3.2.4 Moisture Content

Moisture content, taken as a percentage of solid material by weight is usually within the range 2-10% [10]. For this work, 6% was used.

3.2.5 Compression Ratio

The compression ratio, which is a measure of how well the soil is compressed, is the change in volume of the compressed soil as compared to the volume of the uncompressed soil.

The compression ratio of the machine was 0.52. This is important in selecting the mould size for a given target of compressed block size. For example, if 100mm height of block is desired, then the Mould must be at least 200mm high for this soil type.

3.2.6 Compressive Strength

Compressive strength is one of the most important characteristics of all masonry units. The ASTM C46 standard procedure was used to measure the compressive strength of the bricks and blocks and the results are presented in table 3.2. The tests were carried out on two sets of seven specimens under two different conditions of *dry* and *wet*. This is because in practice, the CEBs are used under wet and dry conditions, hence their strength under the two conditions are important.

The *wet compressive strength* was 2.78N/mm^2 while the *dry compressive strength* was 7.19N/mm^2.
African Regional Standards for Compressed Earth Blocks ARS 674: 1996 - Compressed Earth Blocks Technical Specifications for Ordinary Compressed Earth Blocks recommends 3N/mm^2 and 6N/mm^2 as minimum wet and dry compressive strength respectively [5]. While, Nigerian Building and Road Research Institute (NBRRI) propose 1.65N/mm2 as minimum wet compressive strength for CEB [7]. Therefore, the bricks meet the laid down standards.

3.2.7 Dimensional Parameters

1. **Squareness of the block:** The dry compressed blocks were checked for squareness with a Try Square as shown in Figure 3.2 and it was found that all adjacent sides are square (i.e.90^o) to each other. In other words all opposite sides are parallel to each other.

Figure 3.2 Dry Block being checked with Try Square

2. **Dimensional uniformity of the block:** All dimensions measured with Vanier Calliper of the dry blocks (fig. 3.3) were consistent for all the produced samples with the exception of block height, which is also within the allowable limit of dimensional accuracy of ±2mm.

Figure 3.3 Dry Block being measured with Vanier Calipers

3. **Dimensional accuracy:** The Produced samples were measured at different points to ascertain consistency within the same sample. It was found that the differences between them are less than a millimetre, except also in the height dimension. The height discrepancy is controlled by adjusting inclination of rammer.

IV. CONCLUSION AND RECOMMENDATION

4.1 Conclusion

- A multipurpose brick/block making machine was designed in accordance with the standard design calculations and it was then constructed using simple fabrication processes. Thereafter, the machine was used to produce affordable and quality bricks and blocks in line with the African Regional Standard for compressed earth blocks ARS 674: 1996 [5] and the Nigerian Building and Road Research Institute(NBRRI) standard.
- The cost of producing the machine was two hundred and eighty six thousand, eight hundred and ninety naira (N286,890:00) only. This is very cheap compared to the similar machine (Hydroform CEB machine) that costs about six million naira (6,000,000:00) only.
- The actual brick production rate was two thousand, two hundred and fifteen (2,215) pieces per day. This is lower than the designed rate of three thousand and hundred (3,100) pieces per day. However, this can be boosted by increasing the motor's speed or modifying the mould to produce two (2) or more bricks/blocks simultaneously.

4.2. Recommendation

- In order to be able to produce hollow masonry units, the mould has to be modified to a movable mould that will accommodate pallet.
- The machine could be automated especially the feeding and evacuation components (mechanism). This will improve its performance and the safety of the operator.
- This machine can be modified such that it can have bigger mould and a means of feeding and compaction of the mix in lifts, preferably automatically. This should be made simple and not expensive.

REFERENCES

[1]. Chuku L. (2014) *Addressing Housing Deficit In Nigeria*, http://www.pmnewsnigeria.com/2014/01/16/addressing-housing-deficit. accessed on the (26/02/2014 09:17)

[2]. Montgomery D. E. (2002) *Dynamically-compacted cement stabilized soil blocks for low-cost walling*, School of Engineering,University of Warwick, UK (PhD theses)

[3]. http://www.thefreedictionary.com/block

[4]. "Concrete Block Vs. Brick | eHow.com"http://www.ehow.com/info_7943641_concrete-block-vs-brick.html

[5]. Adam E. A. and Agib A. R. (2001) *Compressed Stabilised Earth Block Manufacture in Sudan*, UNESCO, Paris, France

[6]. Ajao K., Lawal A., Onaolabo N., and Eniayenkan E. (2012) *Development and preliminary testing of a compressed laterite soil brick machine*, Annals of faculty of engineering, Hunedoara, Romania International Journal of Engineering ISSN 1584-2665

[7]. Akelere F., and Akhire N. (2013) *Design and Construction of a Three- Mould Hydraulic Interlocking Brick Moulding Machine*, Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS) 4(3): 527-532, www. jeteas.scholarlinkresearch.org

[8]. Umar M.B. (2014), *Design, Fabrication and Testing of a Multipurpose Brick/Block Making Machine*, a thesis submitted to the Department of Mechanical Engineering, Nigerian Defence Academy, Kaduna, Nigeria

[9]. *Motor Efficiency, Selection, and Management*, A Guidebook for Industrial Efficiency Programs, September 2013. *Publication of* Consortium for Energy Efficiency, Boston, USA. www.motorsmatter.org

[10]. Ryder G.H. (2002), *Strength of Materials*, Macmillan Publishers India Limited

[11]. Odul p., Guillaud H., Joffroy T., and ATerre C.R. - EAG (1995) *Compressed Earth Blocks: Vol II Manual of design and construction*, Deutsche Gesellschaftfür Technische Zusammenarbeit (GTZ), GmbH, Eschborn. Germany. Pg 10 – 18

[12]. *How concrete block is made*, http://www.madehow.com/Volume-3/Concrete-Block.html

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Biomass Briquette Production: A Propagation of Non-Convention Technology and Future of Pollution Free Thermal Energy Sources

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Abstract: *Biomass briquettes are a biofuel substitute to coal and charcoal. Briquettes are mostly used in the developing world where cooking fuels are not as easily available. Briquettes are used to heat industrial boilers in order to produce electricity from steam. The briquettes are con-fired with coal in order to create the heat supplied to the boiler. People have been using biomass briquettes since before recorded history. Biomass briquettes are made from agriculture waste and are a replacement for fossils fuels such as oil or coal, and can be used to heat boiler in manufacturing plants. Biomass briquettes are a renewable source of energy and avoid adding fossils carbon to the atmosphere. The extrusion production technology of briquettes is the process of extrusion screw wastes (straw, sunflower husks, buckwheat, etc.) or finely shredded wood waste (sawdust) under high pressure. There is a tremendous scope to bring down the waste of convention energy sources to a considerable level through the development, propagation of non-convention briquettes technology i.e. briquettes machine , briquettes plant, biomass briquettes plant for production of agro residue briquettes to meet thermal energy requirement . Therefore this substitute energy medium is given national priority as appears to be the only permanent solution into restriction of the national laws and avoid pollutions.*

Key words: *Biofuel, Briquettes Machine, Briquettes Plant, Calorific Value, Incentives*

I. INTRODUCTION

The legacy foundation has developed a set of technique to produce biomass briquettes through artisanal production in rural villages that can be used for heating and cooking. These techniques were recently pioneered by vicuna national park in eastern democratic republic of Congo, following the massive destruction of the mountain gorilla habitat for charcoal. The economics of two countries i.e. India and China are rapidly increasing due to cheap ways of harnessing electricity and emitting large amounts of carbon dioxide. The Kyoto protocol attempted to regulate the emissions of the three different worlds, but there were disagreements to which country should be penalized for emissions based on its previous and future emissions. The United States has been the largest emitter but china has recently become the largest per capita. The United States had emitted a rigorous amount of carbon dioxide during its development and the developing nations argue that they should not be forced to meet the requirements. At the lower end, the undeveloped nations believe that they have little responsibility for what has been done to the carbon dioxide levels.

The major use of biomass briquettes in India is industrial applications usually to produce steam. A lot of conversions of boilers from FO to biomass briquettes have happened over the past decade. A vast majority of those projects are registered under CDM under Kyoto protocol, which allows for users to get carbon credits the use of biomass briquettes is strongly encouraged by issuing carbon credits. One carbon credit is equal to one free ton of carbon dioxide to be emitted into the atmosphere. India has started to replace charcoal with biomass briquettes in regards to boiler fuel, especially in the southern parts of the country because the biomass briquettes can created domestically, depending on the availability of land. Therefore, constantly rising fuel prices will be less influential in an economy if sources of fuel can be easily produced domestically. Lehar Fuel Tech Pvt. Ltd is approved by Indian renewable energy development agency (IREDA), is one of the largest briquetting machine manufactures in India.

Fig. 1 Different types of Briquettes

II. ADVANTAGES OF USING BRIQUETTES COMPARED TO OTHER SOLID FUELS

- Briquettes are cheaper than coal.
- Oil, coal or lignite, once used, cannot be replaced.
- There is no sulfur in briquettes, thus does not pollutes the environment.
- Biomass briquettes have a higher practical thermal value.
- Briquettes have much lower ash content (2-10% as compared to 20-40% in coal).
- Combustion is more uniform compared to coal
- Briquettes are usually produced near the consumption centers and supplies do not depend on erratic transport from long distances.
- Briquettes give much higher boiler efficiency because of low moisture and higher density.

III. ADVANTAGES OF SETTING UP BRIQUETTES PLANT PROJECT

- High sulfur content of oil and coal, when burnt, pollutes the environment.
- There is no fly ash when burning briquettes.
- Briquettes have consistent quality, have high burning efficiency, and are ideally sized for complete combustion.
- Combustion is more uniform compared to coal and boiler response to changes in steam requirement is faster due to higher quantity of volatile matter in briquettes.
- Compared to fire wood or loose biomass, briquettes give much higher boiler efficiency because of low moisture and higher density.
- Briquettes, are easy to store, pack and hygienic to handle.

IV. BRIQUETTES CAN REPLACE FOLLOWING CONVENTIONAL FUELS

- Diesel
- Kerosene
- Furnace oil
- Lignite
- Coal
- Firewood

Calorific Value:

One of the most important characteristics of a fuel is its calorific value, that is the amount of energy per kg it gives off when burnt. The calorific value can thus be used to calculate the competitiveness of a processed fuel in a given market situation. There is a range of other factors, such as ease of handling, burning characteristics etc., which also influence the market value, but calorific value is probably the most important factor and should be recognized when selecting the raw material input.

V. KEY FEATURES OF THE BRIQUETTES PLANT PROJECT

- High profitability
- Excellent growth potentiality
- Ready market
- Wide variety and easy availability of agro-waste from various crops

- Short gestation and quick returns
- Employment potentiality
- Conversion of natural resources into hi-tech energy and maintenance of ecological balance.

VI. Raw Materials Used To Briquette with Different Calorific Values

Table no. 1

Groundnut shell	4524 k	3.80
Baggasse	4380 k	1.80
Castor seed Shell	3860 k	8.00
Saw dust briquette	3898 k	8.20
Cotton Stalks / chips	4252 k	3.00
Bamboo dust	4160 k	8.00
Coffee husk	4045 k	5.30
Tobacco waste	2910 k	31.50
Tea waste	4237 k	3.80
Paddy straw	3469 k	15.50
Mustard straw	4200 k	3.40
Mustard shell	4300 k	3.70
Wheat straw	4100 k	8.00
Sunflower stalk	4300 k	4.30
Jute waste	4428 k	3.00
Palm husk	3900 k	4.90
Soya bean husk	4170 k	4.10
Sugarcane	3996 k	5.00
Barks wood	1270 k	4.40
Forestry waste	3000 k	7.00
Coir pitch	4146 k	9.10
Rice husk	3200 k	21.20
Wood chips	4785 k	1.20
Others	3700 k	APX

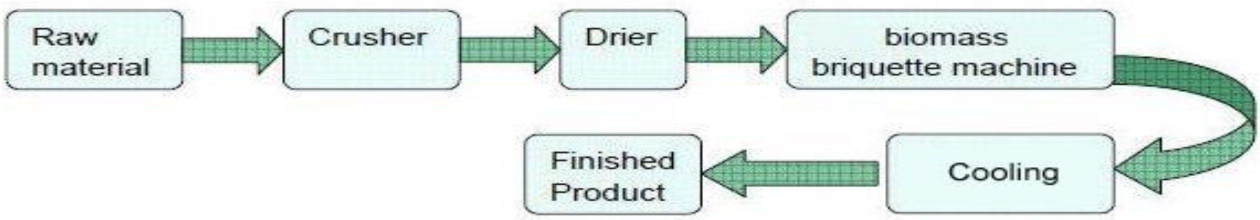
VII. MANUFACTURING PROCESS

This project is called biomass briquetting project and is simply a process of converting agro waste and forestry waste into biomass briquettes/bio coal. The biomass briquetting is the best renewable source of energy for healthy environment and economy. It's a complete eco friendly project.

All materials containing lignite and cellulose are suitable for densification. Successful test have been carried out with variety of materials from saw dust, sander dust, secondary pieces of wood, tree barks and twigs, pine needles, wild grass, coffee husk, sunflower waste, rice husks, groundnut shell, almonds and cotton stalks, sugarcane baggasse, leaves and trash. The above sectors can be briquetted individually or in combination depending on their availability and blending properties. Main concept of this project is to produce the material as a bio-coal, which is made from the wastages. We cannot destroy the wastage totally. But we can use it with the help of briquetting plant and produce the briquettes, which ultimately produce the energy. The use of these cheap fertilizers gives low yield as compared to the modern fertilizer available however the major quantity of press mud goes just as waste. The briquette made from press mud after drying and briquetting have calorific value 4000 Kcal. /Kg Approximately.

We can use such above wastage as an input to the briquetting plant machinery to produce white coal and the non conventional source of energy.

Production Processes:



Production Processes Flow Chart

Screw Press and Piston Press Technologies:

High compaction technology or binder less technology consists of the piston press and the screw press. Most of the units currently installed in India are the reciprocating type where the biomass is pressed in a die by a reciprocating ram at a very high pressure. In a screw extruder press, the biomass is extruded continuously by a screw through a heated taper die. In a piston press the wear of the contact parts e.g., the ram and die is less compared to the wear of the screw and die in a screw extruder press. The power consumption in the former is less than that of the latter. But in terms of briquette quality and production procedure screw press is definitely superior to the piston press technology. The central hole incorporated into the briquettes produced by a screw extruder helps to achieve uniform and efficient combustion and, also, these briquettes can be carbonized.
Table 2 shows a comparison between a screw extruder and a piston press.

Table 2 Comparison of a Screw Extruder and a Piston Press

	Piston press	Screw extruder
Optimum moisture content of raw material	10-15%	8-9%
Wear of contact parts	low in case of ram and die	high in case of screw
Output from the machine	in strokes	continuous
Power consumption	50 kWh/ton	60 kWh/ton
Density of briquette	1-1.2 gm/cm³	1-1.4 gm/cm³
Maintenance	high	low
Combustion performance of briquettes	not so good	very good
Carbonization to charcoal	not possible	makes good charcoal
Suitability in gasifies	not suitable	suitable
Homogeneity of briquettes	non-homogeneous	homogeneous

Parameters of fuel briquettes made by extrusion from sawdust:

Parameter	Value
Briquette density, t/m³	1,0-1,2
Heat content, MJ/kg	19.3-20.5
Ash content, %	0,5-1,5

(MJ = Mega joules. 3.6 MJ equals 1 kWh.)

Fig.2 Reciprocating Type Machine

Following Industries Can Make Maximum Use Of Briquettes:

- Ceramic and Refractory Industry
- Solvent Extraction Plant
- Chemical Units
- Dyeing Plants
- Milk Plants

- Food Processing Industries
- Vegetable Plants
- Spinning Mill
- Lamination Industries
- Leather Industries
- Brick Making Units
- Other Industries having Thermal Applications
- Gasifies system in Thermal
- Textile Units

VIII. ECONOMICAL THAN OTHER FUELS

It is more economical than other fuels because it contains low moisture, low ash high density. It is very easy for handling, transporting storage. It is cheaper than heavy furnace oil, steam coal fire wood etc.

IX. TYPICAL COST ANALYSIS

A typical cost analysis with materials which are available in dry form and do not therefore require drying but do need grinding prior to briquetting is given below. The potential types of biomass under this category are rice husk, coffee husk and groundnut shells.

The below given analysis is based on a screw press costing Rs.9.0 lac. Plants with less than two machines are not recommended. However, plants with more machines will definitely have better profitability and advantages of scale of operation can be derived.

Basis:
Two machines each 750 kg/hr
Production capacity = 1.5 T/hr (20 hrs/day operation)

Operating days per year	300	
Operating hours per year	6000	
Capacity utilization	85%	
Raw material	8000	TPY
Moisture losses	350	TPY
Briquettes produced	7650	TPY
Briquettes consumed (Dryer)	600	TPY
Saleable production	7050	TPY
Infrastructural facilities		
Power	1 5 0	kW
Land area	3000	m²
Operational shed area	240	m²
Briquetting storage (covered area)	250	m²
Investments	**In Rs.(lac)**	
Installed cost of plant & machinery (based on 9.0 lac for each machine)	52.0	
	3.0	
Land	4.2	
Building	59.2	
Total investment	7.5	
Working capital		
Cost of production	**In (Rs./tonne)**	
Power	136.70	
Manpower	67.50	
Water	8.00	
Maintenance (including consumables)	76.70	
Administrative overheads	43.00	

Depreciation (Plant 10% Building 5%)	74.10	
Subtotal	406.00	
Financial cost	91.50	
Cost of production	497.50 = Rs. 500/- per tonne	
Overall cost of production per year	Rs. 38.25 lac	
Profitability		
Basis:		
Cost of raw material	Rs. 500/- per tonne	
Net sale price of briquettes	Rs. 1450/- per tonne	
		In Rs.(lac)
Total sales	(1450 x 7050)	102.22
Production cost	(500 x 7650)	38.25
Raw material	(500 x 8000)	40.00
Gross profit before taxes		23.97
Pay-back period		**2.5 years**

X. INCENTIVES BY THE GOVERNMENT

The Government of India has announced series of incentives for promoting this project for installing such plants to the entire printers engaged in developing alternative energy source.

The major incentives are:

- **100% Depreciation:** The total value of plant and machinery is allowed to be depreciated in the first year.
- **Excise Exemption:** The solid fuel briquettes are completely exempted from Excise duty. The Government is also considering exemption in the case of plant and machinery.
- **Sales Tax Exemption:** The various states like Madhya Pradesh, Maharashtra, Rajasthan, Thailand, Delhi & Pondicherry have exempted solid fuels briquettes from sales tax. Other states are also considering the same and many states and offering sales tax exemption in backward area.
- **No Licenses:** The whole industry of non conventional energy sources has been exempted for obtaining any license.
- Income tax Exemption for first five years.
- The Central and State Government give subsidies.
- Low rate of interest from Government financial institutions.

XI. FUTURE SCOPE OF WORK

Our main task is to stop and minimize the carbon emission as far as possible while producing briquettes by blending with some other material in order to save the environment from toxic Sulphur pollutants.

XII. CONCLUSIONS

Thus briquettes can be used in any appliances meant for burning wood or coal. However, certain changes in operating parameters especially the distribution of primary and secondary air will have to be incorporated into the conversion. One should first understand the specific characteristics of briquetted biomass before taking steps to make changes in appliances. With a view to improving the briquetting scene in India, the Indian Renewable Energy Development Agency (IREDA) - a finance granting agency has financed many briquetting projects, all of which are using piston presses for briquetting purposes. But the fact remains that these are not being used efficiently because of their technical flaws and also due to a lack of understanding of biomass characteristics. Holding meetings with entrepreneurs at different levels, providing technical back-up cells and educating entrepreneurs have to some extent helped some plants to achieve profitability and holds out hope of reviving the briquetting sector.

India is the only country where the briquetting sector is growing gradually in spite of some failures. As a result of a few successes and IREDA's promotional efforts, a number of entrepreneurs are confidently investing in biomass briquetting. These entrepreneurs are also making strenuous efforts to improve both the production process and the technology.

REFERENCES

[1] "Feed Biomass." Biomass.net. Web. 30 Nov. 2010.
[2] "Biomass Briquettes for Green Electricity Production." Bionomicfuel.com. 4 May 2009. Web. 30 Nov. 2010.
[3] Chohfi, Cortez, Luengo, Rocha, and Juan Miguel. "Technology to Produce High Energy Biomass Briquettes." Techtp.com. Web. 30 Nov. 2010.
[4] Mani, Sokhansanj, and L.G. Tabil. "Evaluation of compaction equations applied to four biomass species." University of Saskatchewan College of Engineering. Web. 30 Nov. 2010.
[5] "Biomass Briquetting: Technology and Practices - Introduction." Centre for Ecological Sciences INDIAN INSTITUTE OF SCIENCE BANGALORE. Web. 04 Dec. 2010.
[6] Ramesh Man Singh. "History of Bio-Briquetting." brgcnn.net. 2008. Web. 30 November 2010.
[7] "Biomass Briquetting: Technology and Practices - Introduction." Centre for Ecological Sciences INDIAN INSTITUTE OF SCIENCE BANGALORE. Web. 04 Dec. 2010.
[8] PRABIR, B. and BUTLER, J. and LEON, M., "Biomass co-firing options on the emission reduction and electricity generation costs in coal-fired power plants", Renewable Energy, 36 (2011), 282-288. doi:10.1016/j.renene.2010.06.039
[9] PRABIR, B. and BUTLER, J. and LEON, M., "Biomass co-firing options on the emission reduction and electricity generation costs in coal-fired power plants", Renewable Energy, 36 (2011), 282-288. doi:10.1016/j.renene.2010.06.039
[10] "Biomass Briquette." Www.gcmachines.com. Web. 30 Nov. 2010.
[11] Yugo Isobe, Kimiko Yamada, Qingyue Wang, Kazuhiko Sakamoto, Iwao Uchiyama, Tsuguo Mizoguchi and Yanrong Zhou. "Measurement of Indoor Sulfur Dioxide Emission from Coal–Biomass Briquettes." springerlink.com. Web. 30 November 2010.

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Effect of Power Deviation Ratio on the Selection of Sites for a Wind Power Generation System

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***ABSTRACT**: Wind energy is one of the most important energy among the renewable energy sources in today's world. Realizing the importance of renewable energy, this paper focuses on selecting sites to harvest electrical power from wind energy as the demand of electricity is on increase rapidly. In this work, precisely, seven different regions of Bangladesh with high average of yearly wind speed are investigated. The results of the investigations show the relation between Unit Electricity Cost of a typical site with the power deviation ratio of generating power with respect to average load of that site. This relation helps to select a site to set up wind power generation system not only considering high average speed of wind and high average generated power as key-factors but also to consider power deviation ratio of the site in order to justify the system economically.*
***Keywords:** BOS, LCCA, Power Deviation Ratio, TSR, UEC.*

I. INTRODUCTION

Power is the pre-condition for social and economic development. But currently consumers cannot be provided with uninterrupted and quality power supply due to inadequate generation of electricity compared to the national demand. In 1971, 3% of the total population in Bangladesh had access to electricity. Total installed electricity capacity by December, 2014, is 10,817 MW of which 5,880 MW (54%) comes from public sectors and 4,937 MW (46%) comes from private sectors of Bangladesh [1]. By 2014 only 55.20% of total population of Bangladesh had access to electricity [2]. This statistic of consumers of electricity clearly shows that some percentage of total population of Bangladesh still cannot access electricity due to the shortage of power generation. To resolve the present shortfall and to meet the increasing demand for electricity, the government has taken an initiative to increase generation (installed) capacity to 13735 MW by 2015[3].

Power generation is Bangladesh was almost mono-fuel dependent, meaning indigenous natural gas considering it's apparent huge availability. But 89% of power previously used to come from natural gas and the rest is from liquid fuel, coal and hydropower [3]. But by burning fossil fuel emits carbon di oxide, nitrogen oxide, sulphur di oxide and other toxic materials and gases into our atmosphere directly causing environmental degradation and health hazards.

Renewable energy helps in reducing energy shortage, environmental degradation. In recent years, the development of renewable energy is one of the important strategies adopted as part of Fuel Diversification Program. Renewable Energy Policy has been approved in 2008. Through this policy the government commits to facilitate both public and private investment in renewable energy projects to substitute indigenous non-renewable energy supplies and boost up contributions of existing renewable energy like solar, hydro, wind energy based electricity productions. The policy targets to be able to generate 5% of the total generation of electricity from renewable sources by 2015 and 10% of the same by 2020 [3].

Wind energy is one of the main resources among renewable sources. Site selection of a country is the main challenge to set up a wind power generation station. Usually sites having high wind speeds are considered for the development of wind power generation station. But it has been found that selection of a site depending on high wind speed is not always economically feasible. Power deviation ratio plays a vital role in this regard and so in this paper seven different sites or regions of Bangladesh having high annual average wind speed are taken to demonstrate this phenomenon. The annual average wind speed profile of the sites are obtained by averaging the wind speeds over last ten years. The deviations of generating wind power are investigated with respect to the loads of the respective regions. In this work, average power of the respective sites are considered as their loads. Unit electricity cost (UEC) of wind power generation system over twenty years of life cycle of these eight regions are also computed. The results of these investigations depicts that the Unit Electricity Cost (UEC) of the power station of a typical site increases with the increase of the power deviation ratio of generating power of that site and vice-versa. This means that the high wind speed of a selected region may not be consistent over a particular time period and may vary and thus producing varying power which in turn varies the deviation of power with respect to average power i.e. our load for that particular site or region.

II. STATISTICS OF WIND SPEED

Seven sites considered for the purpose of analysis are, Barisal, Chittagong, Cox's Bazar, Dhaka, Jessore, Khepupara and Syedpur. The Statistics of monthly wind speeds of the regions are computed from averaging the monthly wind speeds over last ten years. These statistics are demonstrated in Table I and also shown graphically in Fig. 01.

Table I: Statistical Data of Wind Speed in m/s

Months	*Barisal*	*Chittagong*	*Cox's Bazar*	*Dhaka*	*Jessore*	*Khepupara*	*Syedpur*
January	5.31	8.83	6.66	4.53	8.24	5.63	6.17
February	5.73	10.05	7.94	4.97	8.69	6.06	7.91
March	6.39	10.28	7.67	5.99	10.77	7.71	7.67
April	7.23	10.4	8.21	5.61	11.87	8.24	6.62
May	7.19	10.08	7.85	5.52	12.2	8.16	6.35
June	6.17	11.03	7.86	4.59	11.18	8.34	6.33
July	5.7	11	7.13	4.82	9.98	7.77	6.35
August	5.42	9.8	7.7	4.59	9.84	7.94	6.42
September	6.26	8.9	7.29	5.42	9.63	7.94	6.17
October	5.81	7.63	6.77	5.43	11.54	6.6	6.68
November	4.86	8	6.32	4.35	8.72	4.76	6.06
December	3.69	7.75	6.27	4.07	6.83	5.28	5.87
Yearly avg. in m/s	5.81	9.48	7.31	4.99	9.96	7.04	6.55

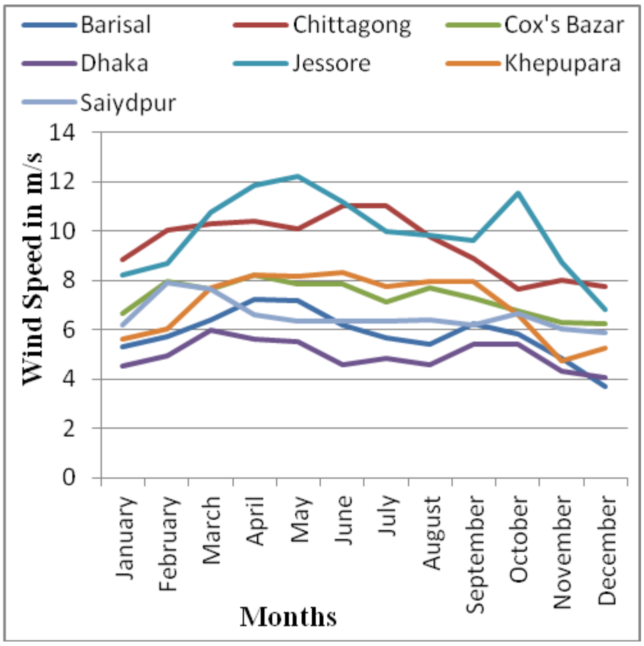


Figure 01: Wind speed variation in different months of various sites

The bar diagram of the comparison of annual average wind speed of the sites is shown in Fig. 02 and from this figure it can be seen that highest average wind speed 9.96 m/s is in Jessore where Chittagong come in second highest with average wind speed of 9.48 m/s. Dhaka the capital of Bangladesh has the lowest average wind speed of 4.99 m/s among these sites.

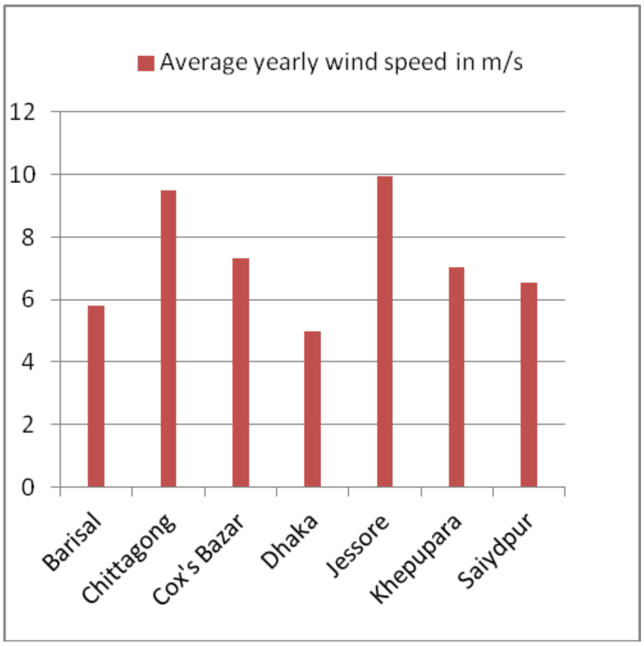


Figure 02: Comparison of annual average wind speed of various sites.

III. MODELING OF WIND POWER GENERATION SYSTEM

Setup of wind power generation system depends on the modeling of wind turbine and the sizing of batteries which are discussed below:

3.1 WIND TURBINE MODELING

The wind turbine considered is this paper has mechanical power (P_m) captured by the blades is described below [4]:

$$P_m = \frac{1}{2} C_p(\beta, \lambda)\rho\pi R^2 V_{wind}^3 \quad (1)$$

where, $C_p$is a rotor power coefficient, β is a blade pitch angle, λ is a tip-speed ratio(TSR), ρ is an air density, R is the radius of the wind turbine blade and V_{wind} is a wind speed. The rotor power coefficient is defined by the fraction of the available wind power that can be transformed to mechanical power by a rotor [5]. This rotor power coefficient (C_p) depends on the rotor blade aerodynamics, which is the function of a blade pitch angle (β) and a TSR (λ) [6], [7]. The type of a wind turbine rotor may also be another factor affecting the rotor power coefficient (C_p). However, the C_p of [7] in which a general blade type was assumed is used in this study for the sake of simplicity [6].

$$C_p = (0.44 - 0.0167\beta)\ Sin\ \frac{\pi(\lambda - 2)}{13 - 0.3\beta} - 0.00184(\lambda - 2)\ \beta \quad (2)$$

The maximum value of $C_p$can be of 44%. For the simplicity, C_p's value is considered as 30% in this study. The wind turbine specifications [8] used for the aid of analysis in this paper, are given the following Table II.

Table II: Parameters and Specification of the Wind Turbine Model

Parameter name	*Value*	*Unit*
Rated Power	600	Watt
Rotor diameter	1.73	M
Start-up wind speed	2.5	m/s
Rated wind speed	12	m/s
Survival wind speed	35	m/s
Tower height	6	m
Air density	1.225	Kg/m^3

The mechanical power (P_m) captured by the wind turbine does not fully convert to electrical power due to several losses occurring during the conversion in the machine. So taking into account the power losses, to obtain output electrical power of the generator from the mechanical wind power, the mechanical power ought to be multiplied by a factor named efficiency (η) of the generator. The electrical output power (P_e) of wind generator is described below:

$$P_{e,gen} = \eta P_m \quad (3)$$

here, the generator efficiency (η) is considered 78% in this study. The average power (P_{avg}) over a particular time period of a particular site is computed as follows:

$$P_{avg} = \frac{1}{n}\sum_{n=1}^{12} P_{e,gen}(n) \quad (4)$$

where, *n* is the number of months of a year in this study. The output powers of the generator of the seven sites under consideration is computed using equation (3) and the average powers of the sites are found using the equation (4). For comparative analysis of the powers of the sites, the data are given in Table III as follows:

Table III: Generated and average generated powers (in Watt) of seven sites

Months	*Barisal*	*Chittagong*	*Cox's Bazar*	*Dhaka*	*Jessore*	*Khepupara*	*Syedpur*
January	16.056	73.8306	31.6794	9.9689	59.9979	19.1372	25.1889
February	20.1752	108.856	53.6804	13.1651	70.3742	23.8656	53.0742
March	27.9806	116.502	48.3883	23.0481	133.9681	49.1493	48.3883
April	40.5293	120.6297	59.3449	18.934	179.352	59.9979	31.112
May	39.8603	109.8337	51.8756	18.0373	194.7304	58.2673	27.4584
June	25.1889	143.9066	52.0741	10.3703	149.8579	62.2089	27.1998
July	19.86	142.7356	38.8707	12.0087	106.5972	50.3057	27.4584
August	17.0747	100.9328	48.9583	10.3703	102.1738	53.6804	28.3765
September	26.3074	75.6004	41.5467	17.0747	95.7708	53.6804	25.1889
October	21.0321	47.6352	33.2752	17.1693	164.8055	30.8309	31.9657
November	12.3101	54.9065	27.0711	8.8272	71.1056	11.5658	23.8656
December	5.3881	49.9182	26.4336	7.23	34.1677	15.7854	21.6904
Yearly avg. Power in Watt	22.6469	95.4406	42.7665	13.8503	113.5751	40.7062	30.9139

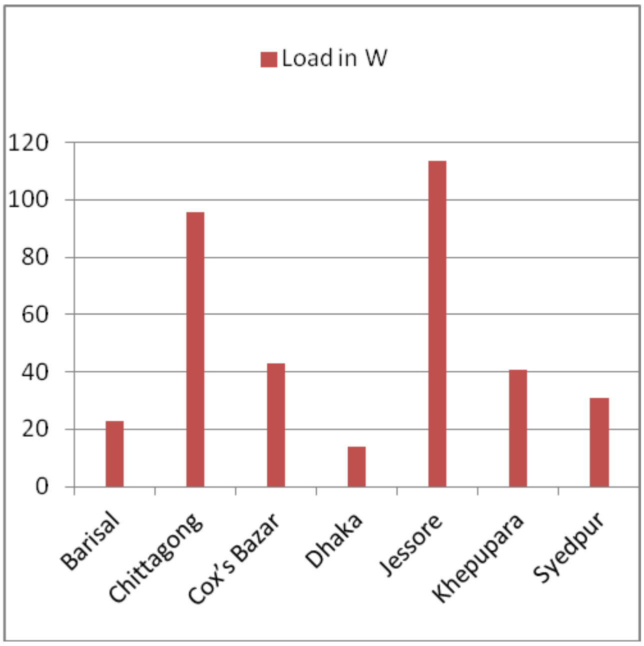


Figure 03 : Comparison of annual average power (i.e. also load in this study) of seven sites

The load (P_{load}) of a site is assumed to be equal to the produced average electrical power (P_{avg}) , for the sake of simplicity of this work and expressed mathematically as follows:

$$P_{load} = P_{avg} \quad (5)$$

For clear and comparative understanding, the annual average power which is also happen to be the load as discussed above, of the sites are plotted in a bar diagram Fig. 03 from where it becomes obvious that the highest annual average wind power is produced in Jessore and after Jessore, Chittagong has the second highest annual average wind power. Dhaka has minimum average power of 13.8503 W among these sites.

The output power of the wind generator varies with the variation of wind speed which causes power deviation. The papers prime find outs is the relation between unit electricity cost with the power deviation ratio of a particular site. This power deviation ratio over a particular time period of a site is the difference between the maximum power produced by the wind generator and the minimum power produced by the same, to the average load of that site. It is expressed in percentage. The produced powers are found using equation number (3). The definition of power deviation ratio is expressed mathematically by the following equation:

$$\text{Power Deviation Ratio} = \frac{P_{e\,(max)} - P_{e\,(min)}}{P_{load}} \times 100 \quad (6)$$

where, $P_{e\,(max)}$, $P_{e\,(min)}$ is the maximum and minimum electrical powers respectively, produced by the wind generator over a particular time interval of a site. The greater the numerator of the ratio with respect to P_{load}, the greater is the Power deviation ratio. The power deviation ratios of seven sites under consideration are calculated using equation (6) are presented in Fig. 04.

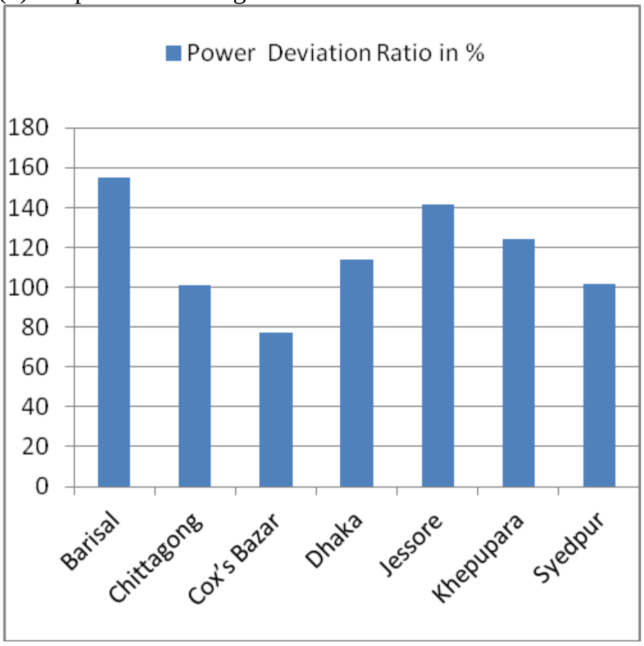


Figure 04: Power Deviation Ratio of seven sites

3.2 BATTERY SIZING

The generated and demanded energy (E_{gen} , E_{dem}) over a month period can be written in terms of the generated wind power and the power demand as follows:

$$E_{gen}(n) = P_{e.gen}(n)\,\Delta T \quad (7)$$

$$E_{dem}(n) = P_{e.dem}(n)\,\Delta T \quad (8)$$

where, $P_{e.gen}$ and $P_{e.dem}$ are the power generated by a specific wind turbine and power demand, respectively, of a site. n is the sampling time (months of a year), and ΔT is the time between the samples (in this case one month).

$$\Delta E(n) = E_{gen}(n) - E_{dem}(n) \quad (9)$$

On an average month, the battery is required to cycle between the positive and negative peaks of the energy curve obtained using equation (9). Therefore, the battery should at least have a capacity equal to the difference between the positive and negative peaks of the energy curve. For this type of application batteries designed specifically for cycling should be used. These batteries have a life time about 1500 cycles, and in order to obtain this life time, they should not be cycled through more than 80% of their rated capacity [9]. Hence, the number of batteries required for the needed storage capacity can be found as follows [10]:

Required Storage Capacity $= \Delta E(n)_{max} - \Delta E(n)_{min}$ (10)

Number of batteries, $N_b = \frac{required\ storage\ capacity}{(0.8)(rated\ capacity\ of\ each\ battery)}$ (11)

The rated capacity of each battery is defined as follows:

Rated capacity of battery = $V_b I_b$ (12)

where, V_b is the voltage of the battery, I_b is the ampere-hour of the battery. In this study 12V, 200Ah battery ratings are considered. The numbers of battery needed in seven different sites are list in Table IV.

Table IV: List of Number of batteries of seven sites

Region	*Total number of battery needed*	*Number of battery per Watt load*
Barisal	14	0.618186
Chittagong	37	0.387676
Cox's Bazar	13	0.303976
Dhaka	06	0.433204
Jessore	61	0.53709
Khepupara	19	0.466759
Syedpur	12	0.388175

IV. UNIT ELECTRICITY COST (UEC) ANALYSIS

Unit Electricity Cost (UEC) is the cost which is required to produce per kWh electricity. To calculate UEC, the total Life Cycle Cost Analysis (LCCA) of the power system has to be assessed. LCC covers the total cost of a power source in three phases: construction phase, operational phase and decommissioning phase. The construction phase includes the initial investment cost. Operational phase contains the fuel cost and the cost incurred due to operation and maintenance. The decommissioning phase covers the cost related to termination of the project and disposal of the equipment. All these costs are summed up to provide the total life cycle cost of the project. The overall cost incurred over the lifetime is then converted into unit cost per kWh of energy.

As Life Cycle Cost Analysis comprises not only the initial cost of a project but also all future costs for the entire operation of a system, the Net Present Value (NPV) of the components has to be taken into account. For this reason, all future costs are discounted in LCCA to their equivalent value in the present economy and the present worth of the costs is calculated. Thus the LCC analysis takes into account the changing value of money as well as cost escalations due to inflation.

The total annual cost for the wind power generation system is obtained considering the price of each component and the installation and other costs known as " Balance of System Cost" (BOS cost) given in Table V. In this study the BOS cost is taken as 25% of the cost of wind turbine. Therefore, to account for this cost, the cost of wind turbine is multiplied by 1.25 [10].

Table V: System component ratings and costs

Component	*Rating*	*Price (BDT)*	*BOS cost*
Wind Turbine	1 kW	37,000	25% of price
Deep Cycle Battery	2.4 kWh	17500	0

.

To obtain the compound interest factor needed for calculating the annual cost [11], an interest rate of 6% was used. Also, a life expectancy of 20 years was assumed for the wind turbine [12] and a life expectancy of 4 years for the batteries. For simplicity of the study, single wind turbine is used in this power generation system.

Present value of 20 years of wind turbines :

C_{wind}= *(1.25)(Wind turbine cost in BDT/Turbine)* (13)

Present value of 20 years of maintenance of wind power generation system :

C_{main}=*(1.56 BDT/kWh)(Wind power generated kWh/Turbine/day)(365days/year)(11.4699 years compound interest factor)* (14)

Present value of the cost of batteries for 20 years :

$C_{battery}$= *(No. of batteries) (17500 BDT/ battery) (5 instalments over 20 years)* (15)

Present value of total capital cost :

$C_{capital} = C_{wind} + C_{battery}$ (16)

Present value of depreciation of the components of the wind power generation system over 5 years assuming a 30% tax bracket and an interest rate of 6% :

$C_{Dep.} = [(C_{capital})\ (4.213\ \text{compound interest factor})\ (0.3)]/5$ (17)

Present value of actual cost of the power system :

$C_{actual} = C_{capital} + C_{main} - C_{Dep.}$ (18)

Unit Electricity Cost :

UEC = Cost/kWh

$= [(C_{actual})\ (0.08718\ \text{compound interest factor})]\ /\ (\text{Annual average wind generation in kWh})$ (19)

UEC of seven sites under consideration in this paper is calculated using equations from (13) to (19) and given in the Table VI.

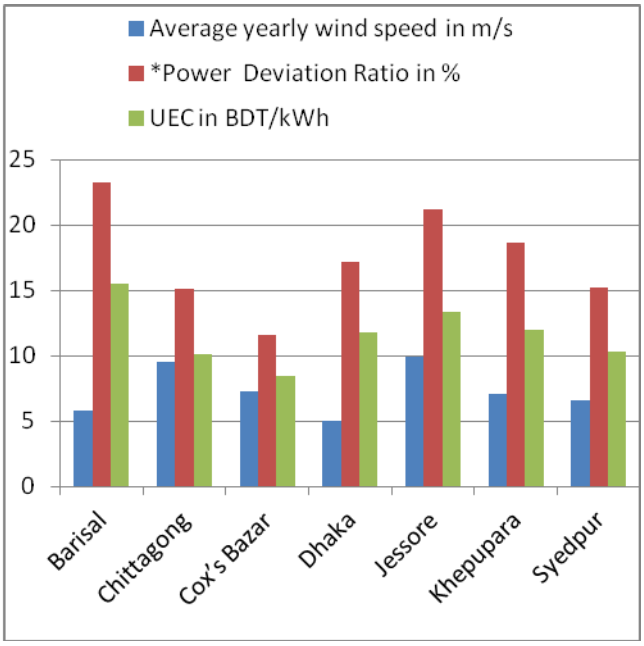
Table VI: Cost analysis of seven sites and UEC

Sites	C_{wind} (BDT)	C_{main} (BDT)	$C_{battery}$ (BDT)	$C_{capital}$ (BDT)	$C_{Dep.}$ (BDT)	C_{actual} (BDT)	UEC (BDT/kWh)
Barisal	46250	106490	1225000	1271250	321350	1056400	15.4743
Chittagong	46250	448790	3237500	3283750	830070	2902500	10.0885
Cox's Bazar	46250	201100	1137500	1183750	299230	1085600	8.4211
Dhaka	46250	65128	525000	571250	144400	491980	11.7836
Jessore	46250	534060	5337500	5383750	1360900	4556900	13.3100
Khepupara	46250	191410	1662500	1708750	431940	1468200	11.9653
Syedpur	46250	145370	1050000	1096250	277110	964510	10.3500

V. RESULTS AND DISCUSSIONS

For better understanding of the results obtained so far and to comment about them a comparison of annual average wind speed, power deviation ratio and UEC of the seven sites under consideration are plotted in Fig. 05. Only the power deviation ratios in Fig. 05, are reduced by 80% from their actual value (shown in Fig. 04) with an intention to provide better visual understanding of the pattern of the ratios. Therefore, the values of the ratios are multiplied with 0.2 and then plotted. But other parameters of the same figure, like annual average wind speeds and UECs are plotted with their actual values.

Among the seven sites, in Jessore the highest annual average wind speed flows with a value of 9.96 m/s and the next best site with high average wind speed is Chittagong where an average of 9.48 m/s of wind flows. The average wind speed of Cox's Bazaar is 7.31 m/s. These are top three regions with high average wind speeds among the sites chosen for this study. A general concept of choosing a site to construct a wind power station is that a location with high wind speed record is good for the purpose to generate greater power. Though this concept is highly appreciable, but to setup a power station which is economically also good would be a better idea. As can be seen from Fig. 05, Jessore has highest average wind speed among Chittagong and Cox's Bazar. But to produce electricity using wind power in Jessore, 13.31 BDT/kWh is required where in Chittagong UEC of 10. 9 BDT/kWh and in Cox's Bazaar 8.42 BDT/kWh are required. Where there is highest average wind speed is in Jessore, it requires more costs than costs requires in Chittagong and Cox's Bazaar. On the other hand also it is obvious that among these three regions meaning Jessore, Chittagong, Cox's bazaar, Cox's Bazaar has the lowest average wind speed but also with lowest UEC. So only considering the high wind speed sites for wind power generation system may not be economically fruitful.



*The Power deviation ratio is reduced by 80% from actual value

Figure 05: Comparison of annual average wind speed, power deviation ratios and UECs of seven different sites.

With a motivation to find a condition for selecting a site or region appropriate to construct a wind power generation system, a term named power deviation ratio is taken into account in this paper. In a particular site, wind speed may vary time to time causing variation in power generation which then varies the power deviation ratio with respect to the load of that site. An important relation between power deviation ratio and UEC of a particular site can be quoted from the Fig. 05 which is, with the increase in power deviation ratio of a site, UEC increases and vice-versa. Barisal has an average wind speed of 5.81 m/s and power deviation of this region is highest among other regions under consideration which is about 155.17% (actual value). But second highest power deviation of 141.37% occurs in Jessore where Jessore is said to have highest average wind speed. From Fig. 05, it can be seen that lower is the power deviation ratio of a site, the lower is the UEC. In our study Cox's Bazaar has the lowest power deviation ratio as well as lowest UEC and also has a good average wind speed and that is why this site is suitable to build a wind power generation station rather than Jessore, as Jessore has highest average wind speed, but it's power deviation ratio is also very high and also has high cost/kWh among the sites under consideration.

VI. CONCLUSION

This paper focused in figuring out the conditions appropriate for the selection of a site or region to setup a wind power generation system and also justifies the approach economically. For the selection of the site, as the high speed of wind is highly recommended, the power deviation ratio of the site needs to be equally evaluated to produce power at as much as low cost per kWh. This paper's prime findout is the relation of Power Deviation Ratio of a site with the Unite Electricity Cost (UEC) of that site. It is clear from the results and discussions that for a particular site, with the increase of power deviation ratio, UEC increases and with decrease in power deviation ratio, the UEC decreases.

Wind energy can be put to a variety of uses, especially for wind pumps, hybrid electricity generating systems with wind as one of the energy sources, small battery chargers at isolated places and electricity inputs to local grids in some coastal areas or the bay islands. To mention some practical applications, wind energy in Bangladesh could be used in shrimp production, fish or poultry firming, salt, ice production, fish-mill industries, hatcheries, domestic applications and vegetable irrigation - all using decentralized electricity. Wind energy is a clean renewable energy source cheaper to maintain, saves fuel and can give decentralized energy. We should make maximum use of it.

REFERENCES

[1] Bangladesh Power Development Board website, available at: https://www.bpdb.gov.bd
[2] Bangladesh Energy Situation website, available at: https://energypedia.info/wiki/Bangladesh_Energy_Situation
[3] Power Division, Ministry of Power, Energy and Mineral Resources, Government of the People's Republic of Bangladesh website, available at: www.powerdivision.gov.bd

[4] Sungwoo, Bae; Kwasinski,A.”Dynamic Modeling and Operation Strategy for a Microgrid With Wind and Photovoltaic Resources” ,*IEEE Transactions onSmart Grid, Vol. 3, Issue: 4*,2012, pp. 1867-1876.
[5] M.R. Patel, *Wind and Solar Power System*(Boca Raton, FL: CRC Press; 1999)
[6] S.-K. Kim, J.-H. Jeon, C.-H. Cho, J.-B. Ahn, and S.-H. Kwon, “Dynamic modeling and control of a grid-connected hybrid generation system with versatile power transfer,” *IEEE Trans. Ind. Electron*., *vol. 55, no. 4*, Apr. 2008, pp. 1677-1688.
[7] A. Murdoch, J.R. Winkelmn, S.H. Javid, and R.S. Barton, “Control design and performance analysis of a 6 MW wind turbine-generator,” *IEEE Trans. Power Appl. Syst., vol. PAS-102, no. 5*, May 1983, pp. 1340-1347.
[8] “Wenzhou Nova New Energy Co. Ltd” manufacturer of wind turbines available at: http://www. novanewenergy.com
[9] D. Linden (Editor), *Handbook of Batteries, Second Edition* (McGraw Hill, Inc., New York, 1994)
[10] W.D.Kellogg, M.H.Nehrir, G. Venkataramanan,V. Gerez, “Generation unit sizing and cost analysis for stand-alone wind, photovoltaic, and hybrid wind/PV systems” **,** *IEEE Transactions on Energy Conversion, Vol. 13, Issue:1*,1998, pp. 70-75.
[11] F. Stermole, and J. Stermole, *Economic Evaluation and Investment Decision Methods* (Investment Evaluation Corporation, 1993)
[12] J. Schaeffer, *Solar Living Source Book* (Chelsea Green Publishing Company, 1994)

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Optimization of Flexural Prediction for Ribbed Floors in Bending, Shear and Deflection

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ABSTRACT: The flexural prediction for concrete ribbed floors has been assessed using the minimum weight approach and mathematical techniques for optimization. Results indicate that although both the BS8110 (1997) and EC2 (2008) are reliable, they are quite expensive and cost can be further reduced as they currently encourage abuse. The BS8110 (1997) and EC2 (2008) were found to be under-estimated by about 27 and 19 percent respectively.

Keywords: optimization; ribbed slab; bending; deflection; reinforced concrete

I. INTRODUCTION

Reinforced concrete is a strong durable building material that can be formed into many varied shapes and sizes ranging from a simple rectangular column, to a slender curved dome. Its utility and versatility is achieved by combining the best features of concrete and steel. Thus when they are combined, the steel is able to provide the tensile strength and probably some of the shear strength while the concrete, strong in compression, protects the steel to give durability and fire resistance. The tensile strength of concrete is only about 10 percent of the compressive strength. Hence, nearly all reinforced concrete structures are designed on the assumption that the concrete does not resist any tensile forces. Reinforcement is designed to carry these tensile forces, which are transferred by bond between the interfaces of the two materials (Mosley and Bungney, 1990).

In long span, solid reinforced concrete slabs of lengths greater than 5 meters, the self-weight becomes excessive when compared to the applied dead and imposed loads, resulting in an uneconomic method of construction. One major way of overcoming this problem is to use ribbed slabs. A ribbed slab is a slab which voids have been introduced to the underside to reduce dead weight and increase the efficiency of the concrete section. A slightly deeper section is required but these stiffer floors facilitate longer spans and provision of holes. These longer spans are economic in the range of 8 to 12metres. The saving of materials tends to be offset by some complications in formwork (BS8110, 1997).

When a structure is loaded, it will respond in a manner which depends on the type and magnitude of the load and the strength and stiffness of the structure. The satisfaction of these responses depends on the requirements which must be satisfied. Such requirements might include safety of the structure against collapse, limitation on damage or on deflection or any of a range of other criteria. These requirements are the limit state requirements (Melchers, 1987).

Slabs are major structural elements in structures, other than beams and columns. Standardized and optimized slabs can significantly enhance safety and durability of structures. This requires special techniques to achieve standardized and optimized slabs which can satisfy all the important design standards. These techniques enable the design of the most optimized floors. Structural floor systems made of reinforced concrete are required to efficiently transmit the floor loads to the vertical systems through shear, bending and torsion resisting capacities. In addition to these requirements of strength, they are required to satisfy the deformation criteria also in terms of low deflection and crack width (Melchers, 1987).

This work elaborates the results obtained from the analytical study carried out on ribbed floor system via obtaining the most optimum ribbed slabs design using the BS 8110 (1985; 1997) and EC2 (2008) design requirements and propose a comprehensive design using an optimization technique for one of the most commonly used slabs in building construction i.e ribbed slabs. An objective function was developed for the purpose of achieving an optimum slab design which will fulfill the entire BS 8110 (1985; 1997) and EC2 (2008) design requirements and simultaneously save construction cost.

II. BACKGROUND OF RIBBED/HOLLOW SLABS.

Ribbed slabs used herein refer to singly reinforced concrete slabs with hollow blocks or voids in them. These types of structural plate systems can minimize formwork complexity by using standard modular, reusable formwork. Ribbed slab floors are very adaptable for accommodating a range of service openings. According to BS8110; 1:1997, hollow or solid blocks may be of any suitable material. When required to contribute to the structural strength of a slab, slabs should be made of concrete or burnt clay; Have a characteristic strength of at least 14N/mm^2, measured on the net section, when axially loaded in the direction of compressive stress in the slab. When made of fired brick earth, clay or shale, conform to BS3921 (1985), BS EN772-1 (2000), BS EN 772-3 (1998) and BS EN772-7 (1998).

2.1 Slabs with Permanent Blocks

The clear distance between ribs should not be more than 500mm. The width of the rib will be determined by consideration of cover, bar spacing and fire requirements. But the depth of the rib excluding the topping should not exceed four times the width. If the blocks are suitably manufactured and have adequate strength they can be considered to contribute to the strength of the slab in the design calculations, but in many designs no such allowance is made. These permanent blocks which are capable of contributing to the structural strength if it can be jointed with cement-sand mortar. During construction the hollow tiles should be well soaked in water prior to placing the concrete, otherwise shrinkage cracking of the top concrete flange is liable to occur. This probably develops strength for topping (Mohammed, 2006).

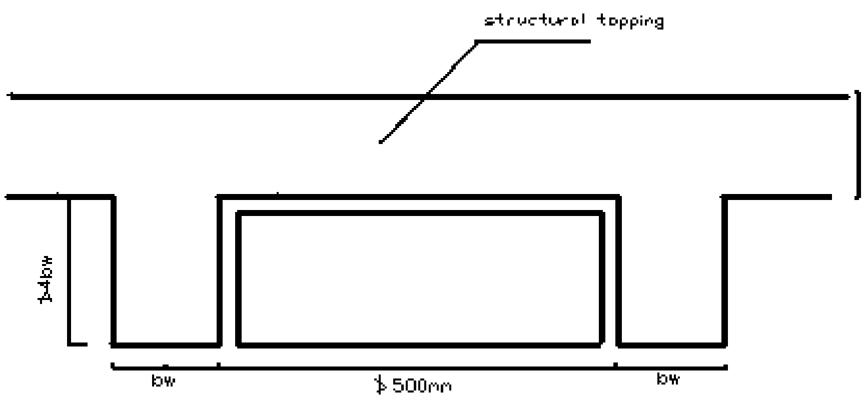

Fig 1: Permanent Blocks Contributing to Structural Strength. (Source: Mohammed, 2006).

2.2 Concept of Optimization

The concept of optimization is basic to much of what we do in our daily lives: a desire to do better or be the best in one field or another. In engineering we wish to produce the best possible result with the available resources. The term optimization has been used in operations management, operations research, and engineering for decades. The idea is to use mathematical techniques to arrive at the best solution, given what is being optimized (cost, profit, or time, for instance). To optimize a manufacturing system means that the effort to find best solutions focuses on finding the most effective use of resources over time. In a highly competitive modern world it is no longer sufficient to design a system whose performance of the required task is just satisfactory, it is essential to design the best system. Thus in modern design we must use tools which provide the desired results in a timely and economical fashion (Vanderplaats, 2009).

Optimization, or Mathematical Programming, refers to choosing the best element from some set of available alternatives (Yang, 2008). In mathematical programming, this means solving problems in which one seeks to minimize or maximize a real function by systematically choosing the values of real or integer variables from within an allowed set. More generally, it means finding best available values of some objective function given a defined domain, including a variety of different types of objective functions and different types of domains.

An optimization problem may be represented in the following way (Avriel, 2003):

Given: a function f: A $\longrightarrow$ R from some set A to the real numbers

Sought: an element x_0 in A such that $f(x_0) \leq f(x)$ for all x in A (minimization) or such that $f(x_0) \geq f(x)$ for all x in A (maximization).

A is some subset of the Euclidean space R^n, often specified by a set of constraints, equalities or inequalities that the members of *A* have to satisfy. The domain of *A* of *f* is called the *search space* or the *choice set*, while the elements of *A* are called *feasible solutions*. The *f* function is called an objective function. A feasible solution that maximizes (or minimizes, if that is the goal) the objective function is called an *optimal solution.*

Generally, when the feasible region, or the objective function of the problem does not present convexity, there may be several local minima and maxima, where a *local minimum* x^* is defined as a point for which there exists some $\delta > 0$ so that for all x such that

$\| x - x^* \| \leq \delta;$

The expression

$f(x^*) \leq f(x)$

Holds; that is to say, on some region around x^* all of the function values are greater than or equal to the value at that point. Local maxima are defined similarly (Avriel, 2003).

2.3 Multi-Objective Optimization

Adding more than one objective to an optimization problem adds complexity. For example, if you wanted to optimize a structural design, you would want a design that is both light and rigid. Since these two objectives conflict, a trade-off exists. There will be one lightest design, one stiffest design, and an infinite number of designs that are some compromise of weight and stiffness. This set of trade-off designs is known as a Pareto set. The curve created plotting weight against stiffness of the best designs is known as the Pareto frontier. A design is judged to be Pareto optimal if it is not dominated by other designs: a Pareto optimal design must be better than another design in at least one aspect. If it is worse than another design in all respects, then it is dominated and is not Pareto optimal (Papalambros and Wilde, 2000).

2.4 Multi-Modal Optimization

Optimization problems are often multi-modal, that is they possess multiple good solutions (Papalambros and Wilde, 2000). They could all be globally good (same cost function value) or there could be a mix of globally good and locally good solutions. Obtaining all (or at least some of) the multiple solutions is the goal of a multi-modal optimizer. Classical optimization techniques due to their iterative approach do not perform satisfactorily when they are used to obtain multiple solutions, since it is not guaranteed that different solutions will be obtained even with different starting points in multiple runs of the algorithm. Evolutionary Algorithms are however a very popular approach to obtain multiple solutions in a multi-modal optimization task (Papalambros and Wilde, 2000).

2.5 Analytical Characterization of Optima

The extreme value theorem of Karl Weierstrass states that if a real-valued function f is continuous in the closed and bounded interval $[a,b]$, then f must attain its maximum and minimum value, each at least once. That is, there exist numbers c and d in $[a,b]$ such that (Jerome, 1986):

$f(\mathrm{c}) \geq f(x) \geq f(\mathrm{d})$ for all $x \in [a,b]$.

A related theorem is the boundedness theorem which states that a continuous function f in the closed interval $[a,b]$ is bounded on that interval. That is, there exist real numbers m and M such that:

$m \leq f(x) \leq M$ for all $x \in [a,b]$.

The extreme value theorem enriches the boundedness theorem by saying that not only is the function bounded, but it also attains its least upper bound as its maximum and its greatest lower bound as its minimum (Jerome, 1986).

The satisfiability problem, also called the feasibility problem, is just the problem of finding any feasible solution at all without regard to objective value. This can be regarded as the special case of mathematical optimization where the objective value is the same for every solution, and thus any solution is optimal (Elster, 1993).

Many optimization algorithms need to start from a feasible point. One way to obtain such a point is to relax the feasibility conditions using a slack variable; with enough slack, any starting point is feasible. Then, minimize that slack variable until slack is null or negative (Elster, 1993).

Fermat's theorem states that optima of unconstrained problems are found at stationary points, where the first derivative or the gradient of the objective function is zero. More generally, they may be found at critical points, where the first derivative or gradient of the objective function is zero or is undefined, or on the boundary of the choice set. An equation stating that the first derivative equals zero at an interior optimum is sometimes called a 'first-order condition'.

Optima of inequality-constrained problems are instead found by the Lagrange multiplier method. This method calculates a system of inequalities called the 'Karush-Kuhn-Tucker conditions' or 'complementary slackness conditions', which may then be used to calculate the optimum.

While the first derivative test identifies points that might be optima, it cannot distinguish a point which is a minimum from one that is a maximum or one that is neither. When the objective function is twice differentiable, these cases can be distinguished by checking the second derivative or the matrix of second derivatives (called the Hessian matrix) in unconstrained problems, or a matrix of second derivatives of the objective function and the constraints called the bordered Hessian. The conditions that distinguish maxima and minima from other stationary points are sometimes called 'second-order conditions' (Papalambros and Wilde, 2000).

III. METHODOLOGY

3.1 Concept of Lagranges Multipliers Method

This is a popular optimization method. In mathematical optimization, the method of Lagrange multipliers (named after Joseph Louis Lagrange) provides a strategy for finding the maximum/minimum of a function subject to constraints (Arfken, 1985).

Consider the optimization problem

$f(x, y)$

Subject to $g(x, y) = c$

A new variable (λ) called a Lagrange multiplier is introduced, and the Lagrange function is defined by

$$\Lambda(x, y, \lambda) = f(x, y) + \lambda \cdot (g(x, y) - c)$$

(λ may be either added or subtracted). If (x,y) is a maximum for the original constrained problem, then there exists a λ such that (x,y,λ) is a stationary point for the Lagrange function (stationary points are those points where the partial derivatives of Λ are zero). However, not all stationary points yield a solution of the original problem. Thus, the method of Lagrange multipliers yields a necessary condition for optimality in constrained problems (Arfken, 1985).

Consider the two-dimensional problem introduced above:

Maximize $f(x, y)$

Subject to $g(x, y) = c$

We can visualize contours of f given by

$$f(x, y) = d$$

For various values of d, and the contour of g given by $g(x,y) = c$.

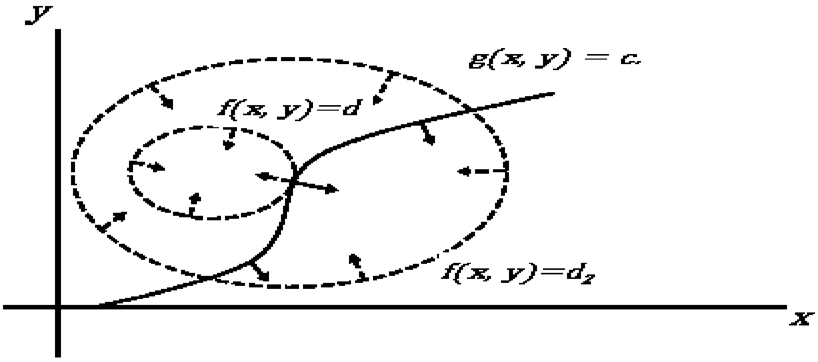

Figure 2: Continuous line showing constraint $g(x, y) = c$. (Source: Arfken, 1985)

The dotted lines are the contours of $f(x, y)$. The point where the continuous line touches the dotted line tangentially is our solution.

Suppose we walk along the contour line with $g = c$. In general the contour lines of f and g may be distinct, so following the contour line for $g = c$ one could intersect with or cross the contour lines of f. This is equivalent to saying that while moving along the contour line for $g = c$ the value of f can vary. Only when the contour line for $g = c$ meets contour lines of f tangentially, we do not increase or decrease the value of f — that is, when the contour lines touch but do not cross. The contour lines of f and g touch when the tangent vectors of the contour lines are parallel. Since the gradient of a function is perpendicular to the contour lines, this is the same as saying that the gradients of f and g are parallel (Arfken, 1985).

Thus we want points (x,y) where $g(x,y) = c$ and

$$\nabla_{x,y} f = -\lambda \nabla_{x,y} g,$$

Where

$$\nabla_{x,y} f = (\partial f/\partial x, \partial f/\partial y)$$

And

$$\nabla_{x,y} g = (\partial g/\partial x, \partial g/\partial y)$$

are the respective gradients. The constant λ is required because although the two gradient vectors are parallel, the magnitudes of the gradient vectors are generally not equal.

To incorporate these conditions into one equation, we introduce an auxiliary function:

$$\Lambda(x, y, \lambda) = f(x, y) + \lambda \cdot (g(x, y) - c)$$

and solve

$$\nabla_{x,y,\lambda} \Lambda(x, y, \lambda) = 0.$$

This is the method of Lagrange multipliers. Note that $\nabla_{\lambda} \Lambda(x, y, \lambda) = 0$ implies $g(x, y) = c$.

3.2 Design Procedure

A ribbed slab floor will be adequately designed to comfortably support a given design load using the BS8110 (1985; 1997) and EC2 (2008) code. Using the ultimate moment of resistance of singly reinforced concrete slabs, the optimization technique will thus be formulated. The goal here is to obtain the most cost effective, smallest and most reliable ribbed concrete slab section. It is important to note here that in order to achieve the optimum section, the major variables to be taken into consideration will be the height of slab, effective depth, area of reinforcing steel, and depth of concrete in compression. Also, member size restrictions will not be imposed.

IV. ANALYSIS AND DESIGN OF A CONTINOUS RIBBED/HOLLOW SLAB

A sample floor slab, consists of several units of ribbed slab, is simply supported at the ends. The effective span is 5.0 m, while the chosen characteristic dead load including finishes and partition is 1.5KN/m^2 and the characteristic live load is 2.0 kN/m². The distance of the center to the center of the ribs is 300 mm, concrete strength f_{cu} = 30N/mm^2, and characteristic reinforcement, f_y = 460N/mm^2

4.1 Optimization Process

The optimization of the above designed ribbed floor will thus be commenced using minimum weight approach and the Lagrange's Multipliers Method. The target or aim as earlier mentioned will be to choose the most cost effective, smallest, and most effective concrete section and reinforcement. The major variables to be considered will be the height of slab, effective depth, area of reinforcing steel, and depth of concrete in compression.

Since optimization definitely focuses on quantity of materials to be used, the cost function will consist of the total sum of the cost of each material multiplied by its unit volume.

$$\text{Cost } (f) = C_c V_c + C_s V_s \quad (1)$$

Where V_c is total volume of section minus volume of steel

$$V_c = b \times d \times h - A_s \quad (2)$$

$$= b \times d \times h - A_s \times h$$

Since a unit volume is being considered, $h = 1$

$$= bd - A_s$$

But $A_s = \rho bd$

$$= bd - \rho bd \quad (3)$$

Since $d_s = \rho d$

$$= b(d - \rho d) = b(d - d_s) V_s = \rho bd = A_s \times 1 \quad (4)$$

$$\text{Cost} = C_c V_c + C_s V_s$$

$$= C_c b(d - d_s) + C_s \rho bd \quad (5)$$

$$\text{Let } D = -d_s / d \quad (6)$$

Dividing through by C_c

$$f = C_c b(1 + D)d + C_s \rho bd \quad (7)$$

$$\text{But } d = \sqrt{\frac{M_U}{Kb}} \quad (8)$$

$$f = C_c b(1 + D)d + C_s \rho b \sqrt{\frac{M_U}{Kb}}$$

$$f = C_c b(1 + D)\sqrt{\frac{M_U}{Kb}} + C_s \rho b \sqrt{\frac{M_U}{Kb}} \quad (9)$$

$$f = b\sqrt{\frac{M_U}{Kb}} \; [\,(C_c(1 + D)/C_c) + C_s\rho / C_c\,]\, C_c$$
(10)

Let $R = C_s / C_c$
(11)

$$f = b\sqrt{\frac{M_U}{Kb}} \; [\,(1 + D) + R\rho\,]\, C_c$$
(12)

$$f = \sqrt{\frac{b\,M_U}{K}} \; [\,(1 + D) + R\rho\,]\, C_c$$
(13)

C_c, b and M_U are considered constants, since C_c, b and d will remain constant for the slab under consideration. Therefore:

$$f = \left(\frac{1}{\sqrt{K}}\right) [\,(1 + D) + R\rho\,]$$
(14)

Problem is then presented thus :

Minimize $f = \left(\frac{1}{\sqrt{K}}\right) [\,(1 + D) + R\rho\,]$

Subject to

$$0.4 f_{cu}\, bx\,(d - \tfrac{x}{2}) = M_U$$
(15)

$$0.95 f_y\, A_s(d - \tfrac{x}{2}) = M_U \qquad \text{(BS8110, 1997)}$$
(16)

$$0.87 f_y\, A_s(d - \tfrac{x}{2}) = M_U \qquad \text{(EC2, 2008)}$$
(16a)

Where the value of ρ is restricted by BS8110 (1997) code and EC2 (2008) specifications for singly reinforced concrete slabs, the constraint is presented as:

$\rho_1 < \rho < \rho_U$

Equations (15), (16) and (17) are the ultimate moment of resistance of singly reinforced concrete sections presented in terms of concrete and steel strengths respectively according to BS8110 (1997) and EC (2008).

Since $M_U = K\,bd^2$
(17)

Where $K = \left(\frac{0.4 f_{cu}\, x}{d} - \frac{0.4 f_{cu}\, x^2}{2d^2}\right)$

Substituting equation (15)into (16)

$$0.4 f_{cu}\, bx\,(d - \tfrac{x}{2}) = 0.95 f_y\, A_s(d - \tfrac{x}{2}) \qquad \text{(BS8110, 1997)}$$

$$0.4 f_{cu}\, bx\,(d - \tfrac{x}{2}) = 0.87 f_y\, A_s(d - \tfrac{x}{2}) \qquad \text{(EC2, 2008)}$$

$$0.4 f_{cu}\, bx = 0.95 f_y\, A_s \qquad \text{(BS8110, 1997)}$$

$$0.4 f_{cu}\, bx = 0.87 f_y\, A_s \qquad \text{(EC2, 2008)}$$

$$x = \frac{0.95 f_y A_s}{0.4 f_{cu}\, b} \qquad \text{(BS8110, 1997)}$$
(18)

$$x = \frac{0.87 f_y A_s}{0.4 f_{cu}\, b} \qquad \text{(EC2, 2008)}$$
(18a)

$$x = \frac{2.37 f_y\, \rho d}{f_{cu}} \qquad \text{(BS8110, 1997)}$$
(19)

$$x = \frac{2.17\, f_y\, \rho d}{f_{cu}}$$ (EC2, 2008)

(19a)

Substituting equation (19)into (16)

$$M_U = 0.95 f_y\, \rho b d \left(d - \frac{2.37\, f_y\, \rho d}{2 \times f_{cu}}\right)$$ (BS8110, 1997) (20)

$$M_U = 0.87 f_y\, \rho b d \left(d - \frac{2.175\, f_y\, \rho d}{2 \times f_{cu}}\right)$$ (EC2, 2008) (20a)

$$M_U = 0.95 f_y\, \rho b d \left(d - \frac{1.1875\, f_y\, \rho d}{f_{cu}}\right)$$ (BS8110, 1997) (21)

$$M_U = 0.87 f_y\, \rho b d \left(d - \frac{1.0875\, f_y\, \rho d}{f_{cu}}\right)$$ (EC2, 2008) (21a)

Since $M_U = K bd^2$, Therefore

$$K bd^2 = 0.95 f_y\, \rho b d^2 \left(1 - \frac{1.1875\, f_y\, \rho}{f_{cu}}\right)$$ (BS8110, 1997)

$$K bd^2 = 0.87 f_y\, \rho b d^2 \left(1 - \frac{1.0875\, f_y\, \rho}{f_{cu}}\right)$$ (EC2, 2008)

$$K = 0.95 f_y\, \rho \left(1 - \frac{1.1875\, f_y\, \rho}{f_{cu}}\right)$$ (BS8110, 1997) (22)

$$K = 0.87 f_y\, \rho \left(1 - \frac{1.0875\, f_y\, \rho}{f_{cu}}\right)$$ (EC2, 2008) (22a)

$$K = 0.95 f_y\, \rho - \frac{1.128\, f_y^2\, \rho^2}{f_{cu}}$$ (BS8110, 1997) (23)

$$K = 0.87 f_y\, \rho - \frac{0.946\, f_y^2\, \rho^2}{f_{cu}}$$ (EC2, 2008) (23a)

Dividing both sides by K

$$1 = \frac{0.95 f_y\, \rho}{K} - \frac{1.128\, f_y^2\, \rho^2}{K\, f_{cu}}$$ (BS8110, 1997)

$$1 = \frac{0.87\, f_y\, \rho}{K} - \frac{0.946\, f_y^2\, \rho^2}{K\, f_{cu}}$$ (EC2, 2008)

$$1 - \frac{0.95\, f_y\, \rho}{K} + \frac{1.128\, f_y^2\, \rho^2}{K\, f_{cu}} = 0$$ (BS8110, 1997) (24)

$$1 - \frac{0.87\, f_y\, \rho}{K} + \frac{0.946\, f_y^2\, \rho^2}{K\, f_{cu}} = 0$$ (EC2, 2008)

(24a)

Now let $\gamma_1 = 0.95 f_y$ (BS8110, 1997)

(25)

$$\gamma_1 = 0.87 f_y$$ (EC2, 2008)

(25a)

$$\gamma_2 = \frac{1.128\, f_y^2}{f_{cu}}$$ (BS8110, 1997)

(26)

$$\square_2 = \frac{0.946\, \square_{\square}^{2}}{\square_{\square\square}}$$ (EC2, 2008)

(26a)

Thus equation (24) becomes:

$$1 - \frac{\square_\square\, \rho}{K} + \frac{\square_\square\, \rho^2}{K} = 0$$

(27)

4.2 Applying Lagranges Multipliers Method

$$L = \left(\frac{1}{\sqrt{K}}\right) [\, (1 + D) + R\rho\,] - \lambda \left[1 - \frac{\square_\square\, \rho}{K} + \frac{\square_\square\, \rho^2}{K}\right]$$

(28)

Now let $(1 + D) = Q$

$$L = \left(\frac{1}{\sqrt{K}}\right)[Q + R\rho] - \lambda\left[1 - \frac{\square_{\square}\rho}{K} + \frac{\square_{\square}\rho^2}{K}\right]$$

(29)

L is then partially differentiated separately by ρ and K

$$\frac{\partial L}{\partial \rho} = \left(\frac{1}{\sqrt{K}}\right) - \lambda\left[0 - \frac{\square_{\square}}{K} + \frac{2\square_{\square}\rho}{K}\right] = 0$$

(30)

$$\frac{\partial L}{\partial K} = -\frac{Q + R\rho}{2K\sqrt{K}} - \lambda\left[0 + \frac{\square_{\square}\rho}{K^2} - \frac{\square_{\square}\rho^2}{K^2}\right] = 0$$

(31)

From equation (30)

$$\left(\frac{1}{\sqrt{K}}\right) = \lambda\left[0 - \frac{\square_{\square}}{K} + \frac{2\square_{\square}\rho}{K}\right]$$

$$\left(\frac{1}{\sqrt{K}}\right) = \frac{\lambda}{K(2\square_{\square}\rho - \square_{\square})}$$

(32)

$$\lambda = \left(\frac{K}{\sqrt{K}}\right)(2\square_{\square}\rho - \square_{\square})^{-1}$$

$$\lambda = \frac{\sqrt{K}}{2\square_{\square}\rho - \square_{\square}}$$

(33)

From equation (31)

$$\frac{Q + R\rho}{2K\sqrt{K}} = -\lambda\left[\frac{\square_{\square}\rho}{K^2} - \frac{\square_{\square}\rho^2}{K^2}\right]$$

$$\frac{Q + R\rho}{2K\sqrt{K}} = \frac{\lambda}{K^2(\square_{\square}\rho^2 - \square_{\square}\rho)}$$

(34)

$$\frac{(Q + R\rho)\sqrt{K}}{2} = \lambda(\square_{\square}\rho^2 - \square_{\square}\rho)$$

(35)

Substituting λ from equation (33) into (35)

$$\frac{(Q + R\rho)\sqrt{K}}{2} = \frac{\sqrt{K}(\square_{\square}\rho^2 - \square_{\square}\rho)}{(2\square_{\square}\rho - \square_{\square})}$$

(36)

$$(Q + R\rho)(2\square_{\square}\rho - \square_{\square}) = 2(\square_{\square}\rho^2 - \square_{\square}\rho)$$

(37)

$$2\square_{\square}Q\rho - \square_{\square}Q + 2\square_{\square}R\rho^2 - \square_{\square}R\rho = 2\square_{\square}\rho^2 - 2\square_{\square}\rho$$

$$2\square_{\square}Q\rho - \square_{\square}Q + 2\square_{\square}R\rho^2 - \square_{\square}R\rho - 2\square_{\square}\rho^2 + 2\square_{\square}\rho = 0$$

(38)

$$\rho = \frac{\square_{\square}Q}{(2Q\square_{\square} + R\square_{\square})}$$

(39)

Dividing through by Q $\square_{\square}$

$$\rho = \frac{1}{\left[\frac{R}{Q} + 2\frac{\square_{\square}}{\square_{\square}}\right]}$$

(40)

Recall $\square_{\square} = 0.95\square_{\square}$ (BS8110,1997)

$\square_{\square} = 0.87\square_{\square}$ (EC2, 2008)

$\square_{\square} = \frac{1.128\,\square_{\square}^2}{\square_{\square\square}}$ (BS8110,1997)

$\square_{\square} = \frac{0.946\,\square_{\square}^2}{\square_{\square\square}}$ (EC2, 2008)

Therefore,

$$\rho^{m}_{opt} = \left[\frac{R}{(1+D)} + \left(\frac{2.37\ \square_{\square}}{\square_{\square\square}}\right)\right]^{-1}$$ (BS8110, 1997)

(41)

$$\rho^{m}_{opt} = \left[\frac{R}{(1+D)} + \left(\frac{2.17\ \square_{\square}}{\square_{\square\square}}\right)\right]^{-1}$$ (EC2, 2008)

(41a)

From equation (27)

$$1 = \frac{\square_{\square}\,\rho - \square_{\square}\,\rho^{2}}{K}$$

$$K^{m}_{opt} = \square_{\square}\,\rho - \square_{\square}\,\rho^{2}$$

(42)

To optimize K, we obtain its partial derivative with respect to its principal variables R and D

$$\frac{\partial K^{m}_{opt}}{\partial R} = \square_{\square}\frac{\partial \rho^{m}_{opt}}{\partial R} - 2\,\square_{\square}\,\rho^{m}_{opt}\frac{\partial \rho^{m}_{opt}}{\partial R} = 0$$

$$\frac{\partial K^{m}_{opt}}{\partial R} = \left(\square_{\square} - 2\,\square_{\square}\,\rho^{m}_{opt}\right)\frac{\square\rho^{\square}_{\square\square\square}}{\square R}$$

(43)

$$\frac{\square K^{\square}_{\square\square\square}}{\square D} = \square_{1}\frac{\square\rho^{\square}_{\square\square\square}}{\square D} - 2\,\square_{2}\,\rho^{\square}_{\square\square\square}\frac{\square\rho^{\square}_{\square\square\square}}{\square D} = 0$$

$$\frac{\square K^{\square}_{\square\square\square}}{\square D} = \left(\square_{\square} - 2\,\square_{\square}\,\rho^{m}_{opt}\right)\frac{\partial \rho^{m}_{opt}}{\partial D}$$

(44)

From equation (41)

$$\frac{\partial \rho^{m}_{opt}}{\partial R} = \frac{\partial\left[\frac{R}{(1+D)} + \left(\frac{2.37\ \square_{\square}}{\square_{\square\square}}\right)\right]^{-1}}{\partial R}$$ (BS8110, 1997)

$$\frac{\partial \rho^{m}_{opt}}{\partial R} = \frac{\partial\left[\frac{R}{(1+D)} + \left(\frac{2.17\ \square_{\square}}{\square_{\square\square}}\right)\right]^{-1}}{\partial R}$$ (EC2, 2008)

$$\frac{\partial \rho^{m}_{opt}}{\partial R} = -\left[\frac{R}{(1+D)} + \left(\frac{2.37\ \square_{\square}}{\square_{\square\square}}\right)\right]^{-2}(1+D)^{-1} = 0$$ (BS8110, 1997)

(45)

$$\frac{\partial \rho^{m}_{opt}}{\partial R} = -\left[\frac{R}{(1+D)} + \left(\frac{2.17\ \square_{\square}}{\square_{\square\square}}\right)\right]^{-2}(1+D)^{-1} = 0$$ (EC2, 2008)

(45a)

$$\frac{\square\rho^{\square}_{\square\square\square}}{\square D} = \frac{\partial\left[\frac{R}{(1+D)} + \left(\frac{2.37\ \square_{\square}}{\square_{\square\square}}\right)\right]^{-1}}{\partial D}$$ (BS8110, 1997)

$$\frac{\square\rho^{\square}_{\square\square\square}}{\square D} = \frac{\partial\left[\frac{R}{(1+D)} + \left(\frac{2.17\ \square_{\square}}{\square_{\square\square}}\right)\right]^{-1}}{\partial D}$$ (EC2, 2008)

$$\frac{\square\rho^{\square}_{\square\square\square}}{\square D} = +\left[\frac{R}{(1+D)} + \left(\frac{2.37\ \square_{\square}}{\square_{\square\square}}\right)\right]^{-2}\frac{R}{(1+D)^{2}} = 0$$ (BS8110, 1997)

(46)

$$\frac{\square\rho^{\square}_{\square\square\square}}{\square D} = +\left[\frac{R}{(1+D)} + \left(\frac{2.17\ \square_{\square}}{\square_{\square\square}}\right)\right]^{-2}\frac{R}{(1+D)^{2}} = 0$$ (EC2, 2008)

(46a)

But $\frac{\partial \rho^{m}_{opt}}{\partial R} = \frac{\partial \rho^{m}_{opt}}{\partial D} = 0$

Therefore equating equation (45) to (46)

For (BS8110, 1997),

$$-\left[\frac{R}{(1+D)}+\left(\frac{2.37\,\square_{\square}}{\square_{\square\square}}\right)\right]^{-2}(1+D)^{-1}=+\left[\frac{R}{(1+D)}+\left(\frac{2.37\,\square_{\square}}{\square_{\square\square}}\right)\right]^{-2}\frac{R}{(1+D)^{2}}$$

For (EC2, 2008),

$$-\left[\frac{R}{(1+D)}+\left(\frac{2.17\,\square_{\square}}{\square_{\square\square}}\right)\right]^{-2}(1+D)^{-1}=+\left[\frac{R}{(1+D)}+\left(\frac{2.17\,\square_{\square}}{\square_{\square\square}}\right)\right]^{-2}\frac{R}{(1+D)^{2}}$$

$$-(1+D)^{-1}=\frac{R}{(1+D)^{2}}$$

(47)

$$R(1+D)=-(1+D)^{2}$$

$$R=-(1+D)$$

(48)

Substituting equation (48) into (41)

$$\rho^{m}_{opt}=\left(\frac{2.37\,\square_{\square}}{\square_{\square\square}}-1\right)^{-1}$$ (BS8110, 1997)

(49)

$$\rho^{m}_{opt}=\left(\frac{2.17\,\square_{\square}}{\square_{\square\square}}-1\right)^{-1}$$ (EC2, 2008)

(49a)

$$\rho^{m}_{opt}=\frac{\square_{\square\square}}{(2.37\,\square_{\square}-\square_{\square\square})}$$ (BS8110, 1997)

(50)

$$\rho^{m}_{opt}=\frac{\square_{\square\square}}{(2.17\,\square_{\square}-\square_{\square\square})}$$ (EC2, 2008)

(50a)

Substituting equation (50) into (42)

$$K^{\square}_{\square\square\square}=\frac{0.95\square_{\square}\,\square_{\square\square}}{(2.37\,\square_{\square}-\square_{\square\square})}-\frac{1.128\,\square^{2}_{\square}\,\square^{2}_{\square\square}}{\square_{\square\square}\,(2.37\,\square_{\square}-\square_{\square\square})^{2}}$$ (BS8110, 1997)

(51)

$$K^{\square}_{\square\square\square}=\frac{0.87\square_{\square}\,\square_{\square\square}}{(2.17\,\square_{\square}-\square_{\square\square})}-\frac{0.946\,\square^{2}_{\square}\,\square^{2}_{\square\square}}{\square_{\square\square}\,(2.17\,\square_{\square}-\square_{\square\square})^{2}}$$ (EC2, 2008)

(51a)

$$K^{\square}_{\square\square\square}=\frac{0.95\square_{\square}\,\square_{\square\square}\,(2.37\,\square_{\square}-\square_{\square\square})-1.128\,\square^{2}_{\square}\,\square_{\square\square}}{(2.37\,\square_{\square}-\square_{\square\square})^{2}}$$ (BS8110, 1997) (52)

$$K^{\square}_{\square\square\square}=\frac{0.87\square_{\square}\,\square_{\square\square}\,(2.17\,\square_{\square}-\square_{\square\square})-0.87\square^{2}_{\square}\,\square_{\square\square}}{(2.17\,\square_{\square}-\square_{\square\square})^{2}}$$ (EC2, 2008) (52a)

$$K^{\square}_{\square\square\square}=\frac{2.25\,\square^{2}_{\square}\,\square_{\square\square}-0.95\,\square_{\square}\,\square^{2}_{\square\square}-1.128\,\square^{2}_{\square}\,\square_{\square\square}}{(2.37\,\square_{\square}-\square_{\square\square})^{2}}$$ (BS8110, 1997)

$$K^{\square}_{\square\square\square}=\frac{1.8879\,\square^{2}_{\square}\,\square_{\square\square}-0.87\,\square_{\square}\,\square^{2}_{\square\square}-0.946\,\square^{2}_{\square}\,\square_{\square\square}}{(2.17\,\square_{\square}-\square_{\square\square})^{2}}$$ (EC2, 2008)

$$K^{\square}_{\square\square\square}=\frac{\square_{\square}\,f_{\square\square}\,(1.12\,\square_{\square}-0.95\square_{\square\square})}{(2.37\,\square_{\square}-\square_{\square\square})^{2}}$$ (BS8110, 1997)

(53)

$$K^{\square}_{\square\square\square}=\frac{\square_{\square}\,f_{\square\square}\,(0.942\,\square_{\square}-0.87\square_{\square\square})}{(2.17\,\square_{\square}-\square_{\square\square})^{2}}$$ (EC2, 2008)

(53a)

Thus the optimum values of the reinforcement ratio and the parameter K can be derived for any combination of reinforcement and concrete strengths from equations (50) and (53) respectively using BS8110, (1997) and EC2 (2008).

4.3 Results of Lagranges Multipliers Optimization Technique

Having successfully derived the formula for K, it is now obvious that the under-estimations for the various combinations of concrete strength and steel strength can be obtained by substituting each value of K into the ultimate moment of resistance formulae. Using the above derived formulae, the ribbed floor slab designed on page (25) can now be optimized. From that problem, the respective steel and concrete strengths were:-

f_y = 460N/mm^2 and,

f_{cu} = 30N/mm^2

Therefore from equation (53)

$$K^{□}_{□□□} = \frac{(460 \times 30)\left((1.12 \times 460) - (0.95 \times 30)\right)}{\left((2.37 \times 460) - 30\right)^2} \qquad \text{(BS8110, 1997)}$$

$$= 5.97537042$$

From equation (17)

$$M_u = Kbd^2$$

$$M_u = 5.97537042bd^2 \qquad (54)$$

The ultimate moment for a singly reinforced concrete section is given by BS8110 (1997) as :

$$M_u = 0.156\, bd^2 □_{□□}$$

(55)

In order to evaluate the resistance moment, equation (55) is represented as :

$$M_u = 0.156\, bd^2 □_{□□}\, □_{□}$$

(56)

Equating equation (56) to (54)

$$0.156\, bd^2 □_{□□}\, □_{□} = 5.97537042bd^2$$

$$□_{□} = \frac{5.97537042}{0.156\, □_{□□}} \qquad (57)$$

But $□_{□□}$ = 30N/mm^2 , therefore

$$□_{□} = \frac{5.97537042}{0.156 \times 30}$$

$$□_{□} = 1.276788551$$

(58)

Therefore, for a singly reinforced concrete section made up of grade 30 concrete and steel strength of 460N/mm^2, the ultimate method of resistance is under-estimated by about 27.679 percent using the BS8110 (1997).

The amount of reduction in the value of under-estimation as indicated in BS8110 (1997) simply shows the quantitative value of the quality control and cost savings associated with it. The value of $□_o$ can be obtained for the other reinforced ribbed floor slab concrete sections with various combinations of steel and concrete strengths. An objective function value of less than 1 signifies the degree of effectiveness of the optimization technique used. The value of D has been taken as 0.06 as an example.

Also, steel strengths of 250N/mm^2 and 460N/mm^2 will be used by BS8110 (1997) as they are more recognized by the code though EC2 (2008) will use steel strengths of 250N/mm^2 and 500N/mm^2. Other steel strengths may also be used.

Table 1: Data for Percentage Under-Estimation for Various Singly Reinforced Ribbed Slab Concrete Sections Using BS8110 (1997).

S/NO	Steel strength (f_y) N/mm^2	Concrete strength (f_{cu}) N/mm^2	K^m_{opt}	$□_o$	Percentage Under-estimation	Objective Function (f)
		20	3.981617437	1.276159435	27.6159	0.51266
		25	4.972927866	1.275109709	27.5110	0.45440

1	250	30	5.961481481	1.273820829	27.3821	0.41098
		40	7.927765607	1.270475258	27.0475	0.34921
		50	9.874917709	1.266015091	26.6015	0.30623
		60	11.7966012	1.260320641	26.0321	0.27385
2	460	20	3.985792558	1.277497615	27.7498	0.52102
		25	4.98098076	1.277174554	27.7175	0.46380
		30	5.97537042	1.276788511	27.6789	0.42136
		40	7.961121098	1.275820689	27.5821	0.36137
		50	9.941719533	1.274579427	27.4579	0.32002
		60	11.91574158	1.273049314	27.3049	0.28919

Table 2: Data for Percentage Under-Estimation for Various Singly Reinforced Ribbed Slab Concrete Sections Using EC2 (2008).

S/NO	Steel strength (f_y) N/mm^2	Concrete strength (f_{cu}) N/mm^2	$K^m{}_{opt}$	$\square_o$	Percentage Under-estimation	Objective Function (f)
1	250	20	3.985256748	1.193190643	19.3191	0.51065
		25	4.976778921	1.192042855	19.2043	0.45220
		30	5.965020821	1.190622918	19.0623	0.40860
		40	7.928516621	1.186903686	18.6904	0.34649
		50	9.868844856	1.181897588	18.1898	0.30317
		60	11.77803431	1.175452526	17.5453	0.27046
2	500	20	3.990389914	1.194727519	19.4728	0.52067
		25	4.986761303	1.194433845	19.4434	0.46348
		30	5.98234541	1.19408092	19.4081	0.42106
		40	7.970513496	1.193190643	19.3191	0.36109
		50	9.953557843	1.192042855	19.2043	0.31975
		60	11.93004164	1.190622918	19.0623	0.28893

V. CONCLUSION AND RECOMMENDATION

From the results, it is obvious that optimization is possible as the current ultimate limit allowed by BS8110 (1997) and EC2 (2008) favors structure reliability over cost minimization. As observed in table 1 and 2 above, an under-estimation of averagely about 27 percent was deduced using BS8110 (1997) while the EC2 (2008) had a lesser under-estimation percentage value of about 19 percent. For a major construction project, optimization could greatly reduce cost in terms of material usage.

It is also important to note that the under-estimation allowed by the British standard code and the EC2 (2008) create accommodation for uncertainties in engineering design like human errors, variations in material strength and variations in wind loading. It also ensures that high expense is traded by safety and reliability of the structure.

REFERENCES

[1] Arfken G.: "Lagrange Multipliers in Mathematical Methods for Physicists", 3rd edition, Orlando, FL: Academic Press, pp. 945-950, 1985.

[2] Avriel M.: "Nonlinear Programming", *Analysis and Methods,* Dover Publishing, 2003.

[3] BS8110: "British Standard Institution: The structural use of concrete:" *Parts 1, 2, and 3*. Her Majesty's stationary office, London, 1997.

[4] EC 2 Eurocode 2: "Part 1.1": *Design of Concrete Structures*. European Committee for Standardization, Brussels, 2008.

[5] Elster K. H.: "Modern Mathematical Methods of Optimization", *Vch Publishing*, 1993.

[6] Fischer S. D., Jerome J. W.: "The existence, characterization and essential uniqueness of L_∞ external problems", Trans. Amer. Math. Soc., 187 (1974), pp. 391–404

[7] Melchers R. E.: "Structural Reliability Analysis and Prediction". *Ellis Horwood Series in Engineering, Cooper Strut,* West Sussex, England, 1987.

[8] Mohammed A. A.: "How high could buildings made of Ribbed or Flat slab construction without shear walls be built?" *Addis Ababa University Press*. 2006, pp 5-7.

[9] Mosley W. H. and Bungey J. H.: "Reinforced concrete design Fourth edition", *Macmillan press limited*, 1990, pp 193-195.

[10] Papalambros P. S, and D. J. Wilde D. J.: "Principles of Optimal Design", *Modeling and Computation*, Cambridge University Press, 2000.

[11] Vanderplaats G. N.: Numerical Optimization techniques for Engineering Designs with Applications", VMA Engineering, McGraw-Hill Companies January 1st 1984.

[12] Yang X. S.: "Introduction to Mathematical Optimization", *From Linear Programming to Metaheuristics*, Cambridge Int. Science Publishing, 2008.

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Investigating the transitional state between circular plates and shallow spherical shells

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ABSTRACT: *The stiffness of circular plates can be increased by inducing a rise at the center of these plates; this rise converts the circular plates from two-dimensional stiffness elements into three-dimensional stiffness elements. This slight change in the geometry shifts the state of stresses from mainly bending stresses to tensile-compressive stresses. The rise at the center of a circular plate is increased gradually to the point where a shell element is formed. This paper focuses on this particular transition between the plate elements to the shell element which is called the transitional rise. Several finite element models were used to identify the transitional rise given fixed parameters. Stresses and deflections are also studied for each case. An optimized approach was used to minimize the cost and improve the serviceability of the structural elements. In this present study, numerous analyses were conducted using the finite element methodology on shell model. Finite element mesh was established for each different rise value starting from zero (plate). The rise is increased gradually to the point where shell stiffness becomes insensitive to the increase in the rise. An empirical relationship was established between the transition state of the plate/shell elements and relevant geometrical parameters. Parametric study is also conducted using several loading cases.*

Keywords: *Spherical shells, circular plates, transition state, optimization*

I. INTRODUCTION

Plates and shells have several important civil engineering applications. They are used as structural elements, roofs, domes, and water tanks. Also for industrial purposes plates and shells are used extensively in many applications including machines, gas vessels and cans. Introducing a rise at the center of a circular plate will increase the stiffness of the plate. As the rise becomes large enough, the plate will change into a shallow spherical shell, and consequently the strength of the plate increases substantially to a point where the rate of increase in strength becomes insignificant. This particular rise (apex) is referred to here as the Transitional Rise ɳ. This study also focused on the other parameters that may have any effect on the transitional rise ɳ.

Many researchers explored the difference between plates and shells, but most of their work produced solutions for stresses and deformations for symmetrically loaded plates and shells. The finite element method nowadays becomes widely used and much commercial software became available in the market. The new advances in computer hardware especially the processing power made it much easier to use the finite element method in engineering applications.

AlNasra conducted several experimental tests on reinforced concrete square plates loaded at the center. The central deflection is measured at each load level until failure. The plates showed concaved shapes before failure. The plates eventually failed by punching shear [1, 2]

In order to build a circular roof, there are two major choices; a circular plate or a spherical shell in the shape of a dome. Taking into consideration many factors one may go for a plate which might be characterized as an element of large thickness that uses more material, exhibiting large deflection under loads, and consequently generating cracks. The other available choice is to use a full-height spherical shell which is characterized by relatively thin element covering large space. Nevertheless, the construction cost of a spherical roof is higher than the plate. Developing a small rise in the center of the plate, one can take advantage of both plates and shells. A small rise at the middle of a circular plate can be induced making a concaved shape. This rise can change the state of stresses and the serviceability of the structural element. The finite element method can be used to determine the values of stresses and deflection at a given value of the rise and under given load case. A gradual increase in the rise makes the plate behaves like a shell. The value of the rise that makes the plate becomes a full blast shell is called the transitional rise based on the calculated values of stresses and deformations

Circular plates and spherical shells were studied intensively in the past using either numerical methods or experimental techniques subjected to different cases of loading. The bending solution of simply supported circular plates with uniformly distributed load produces the max deflection at the middle of the plate as follows [3, 4, 5, 6, 7]:

$W_{max} = (P_o a^4 (5+\nu)) / (64 D (1+\nu))$ (1)

Where,
P_o = uniformly distributed load
a= radius of plate
ν = Poison's ratio
D = flexural rigidity of plate.

$D = Et^3 / (12 (1-\nu^2))$ (2)

Where,
E = modulus of elasticity
t = thickness of plate
Then

$Po = [(64 D (1+\nu)) / (a^3 (5+\nu))] (w_{max}/a)$ (3)

Equation 3 relates the uniformly distributed load with the deflection at the center of a plate in what is known as small deflection theory. Several researchers also worked on the derivation of the large deflection theory of plates. The derivation is based on simply supported circular plates which in turns helped in understanding the post bucking behavior of circular plates. Equation (4) relates the uniformly distributed load on a simply supported circular plate with the total deflection at the center of the plate [8, 9, 10].

$$P_o = \frac{8}{3}\frac{E}{(1-\nu)}\frac{t}{a}\left(\frac{W_{max}}{a}\right)^3 + \frac{64D(1+\nu)}{a^3(5+\nu)}\frac{W_{max}}{a} \quad (4)$$

As a case study, a plot of the applied uniformly distributed load Po and the deflection equations is shown in Fig. (1) for the following constants:
E= 200,000 MPa
ν = 0.3
a=1000 mm
t=10.0mm

Figure (1) shows that the first portion of the curves can be used satisfactorily to calculate the central deflection by the small deflection theory (SDT). As the central deflection increases the small deflection theory becomes inappropriate while the large deflection theory (LDT) can give satisfactory results at any central deflection range. The early portion of this curve will be used to study the plate behavior. The remainder of the curve shows rapid divergence between the large deflection theory (LDT) and the small deflection theory (SDT). Another point than can be made out of these curves, that the stiffness of the plate increases at a higher rate as the maximum central deflection increases, a preparation for shell behavior. Figure (2) shows the relationship between $1/P_o$ and the maximum central deflection $W_{max.}$ The first portion of the curve represents the plate behavior, and the rest represent the shallow shell behavior. A tangent can be drawn out of the first portion of the curve, which intersects the tangent drawn out of the second portion of the curve at a point denoted by ɳ as shown. The intersection of these two tangents is taken as the point of shifting behavior between plate and shallow shell, at which the rise is called the transition rise (TR). .

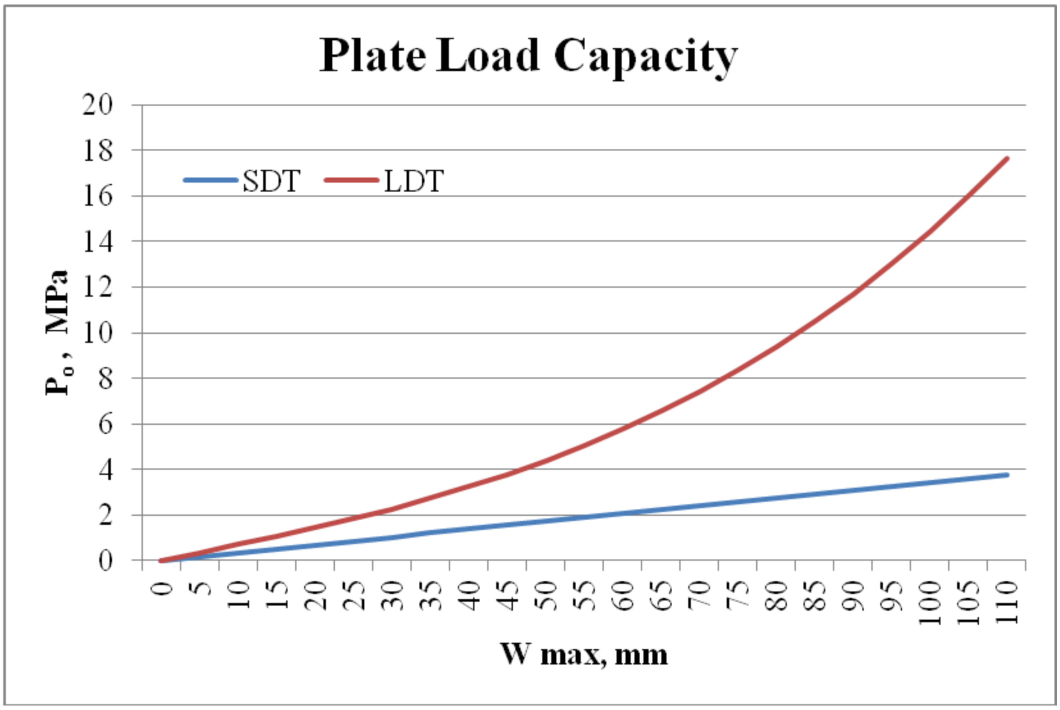

Figure 1: Load deflection relationship of simply supported plate.

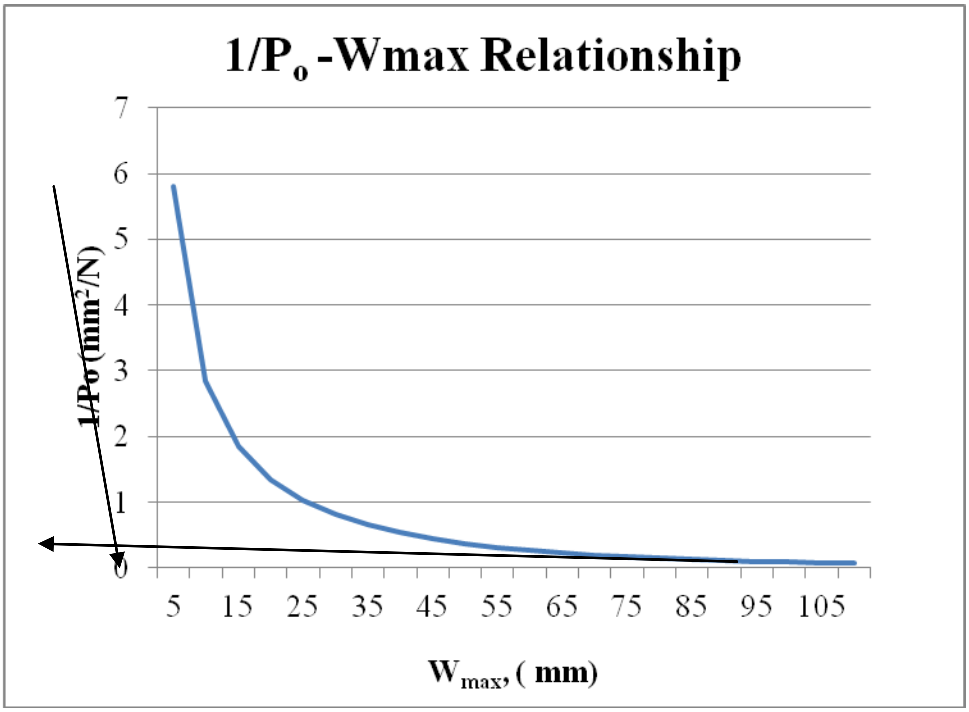

Figure 2: Locating the transition rise

II. PLATE-SHELL THEORY

The finite element method is used to measure the deflection as the applied load increases. This method measures the stresses and deflection with appropriate accuracy. Plates and shells elements can be brick eight elements, rectangular elements, triangular elements or trapezoidal elements. At all cases the equilibrium and compatibility must always be satisfied in the analysis of the finite element model. Several finite element software are widely available and can be easily used with acceptable accuracy. For this study STAAD program was used. Figure (3) shows typical finite element model for plates and shells used. The plate/shell is divided into circles of equal spacing. The number of circles and sectors were selected proportionally to give meaningful outputs. The accuracy of the output depends on the number of segments used. Common rules that are widely acceptable among researchers when using this type of elements are; element aspect ratio should not be excessive, and each individual element should not be distorted. The preferable aspect ratio is 1:1 but it should not exceed 4:1. Also angles between any two adjacent sides within any element should be around 90 degrees but less than 180 degrees [11].

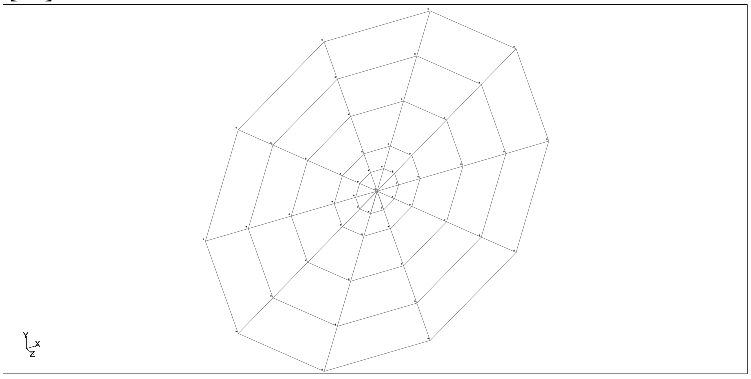

Figure 3: Finite element typical mesh

The types of supports used in this research are the ones that allow horizontal translation and rotation, while the vertical movement is restrained. This type of support suits the boundary condition of the membrane element, which is responsible of carrying the major part of the load in the large deflection theory. For analytical purposes, plates and shells used in this study are made of concrete, making the output easier to compare with experimental results [12, 13].

It was convenient to start the analysis with plate of zero height of apex. The height of apex is increased gradually by two centimeter increment until the change in deflection due to applied load reached a well specified tolerance range. Models of three, four, five, six, seven and eight meter diameter plates were used. The thickness-diameter ratio in the order of 0.010, 0.012, 0.014, 0.016, 0.018, 0.020, 0.022, and 0.024 were also used for each plate/shell diameter. In other words, for the plate of 3 m diameter, 8 different thicknesses of 6 mm increment were considered (30.0, 36.0, 42.0, 48.0, 54.0, 60.0, 66.0, and 72.0 mm).

Four different type of loading were used in this study, including uniformly distributed pressure, concentrated load at the center of the plate/shell element, ring loads, and hydrostatic pressure load as shown in Fig.(4). Each type of loading is used within the finite element model. Loads were increased gradually in some specific cases.

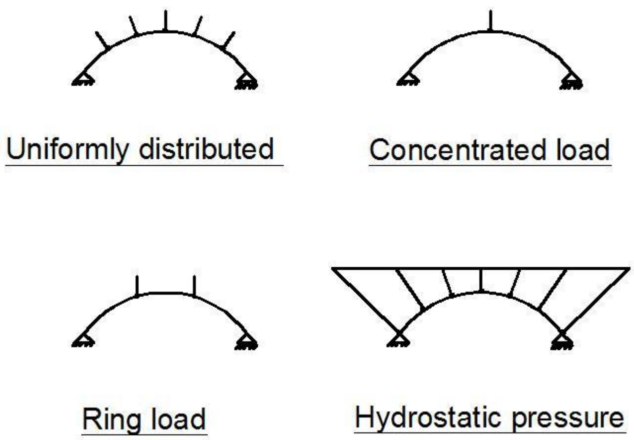

Figure 4: Load cases used in this study

For analytical purposes, the level of stress in the plate/shell element was controlled and bounded by the modulus of rupture of concrete. The concrete compressive strength is taken here to be 30 MPa, and the modulus of rupture for this type of concrete is taken as 4.3 MPa according to the local codes and confirmed by experimental data. In the case of the uniformly distributed load, the maximum stress can be calculated according to the following formula:-

$$\sigma_{r-max} = \sigma_{\theta-max} = \frac{3(3+\vartheta)}{32} Po\left(\frac{D}{t}\right)^2 \quad (5)$$

Large number of data were generated and analyzed. Several graphs were generated too. Only small portion of the results will be presented in this study. Some typical results will be shown. Figure 5 shows a typical rise – central deflection relationships. This graph shows also that the transition rise to be 66.1 mm at which the plate element will shift behavior to shell element. This graph is developed for uniformly distributed load, diameter of 3 m, and thickness – diameter ratio of 0.010.

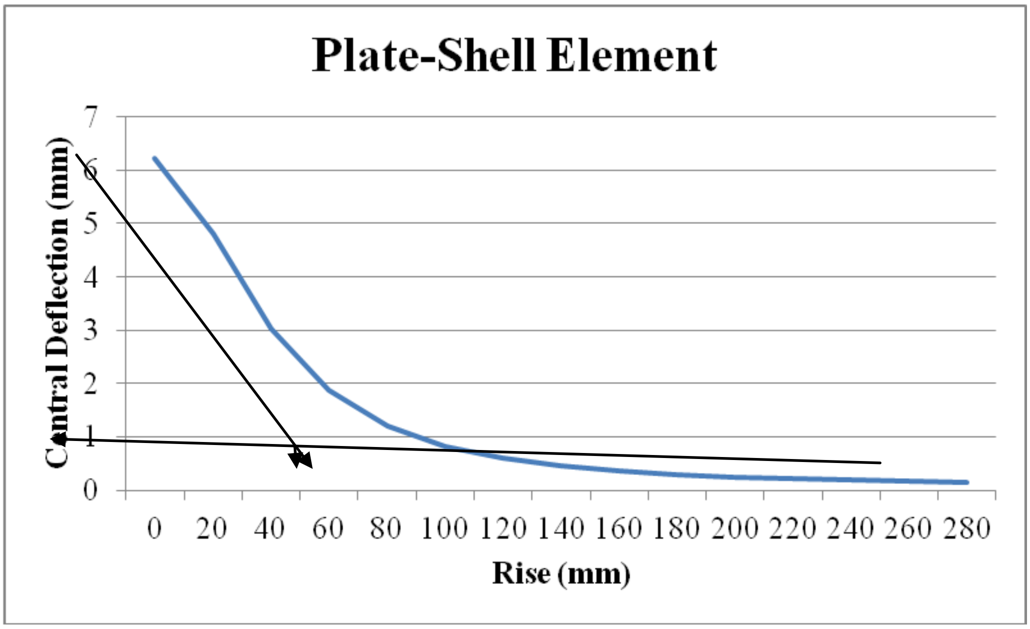

Figure 5: Typical rise – central deflection relationship

III. EFFECT OF LOAD INTENSITY ON THE TRANSITION RISE

Table 1 shows the effect of the applied load on the transition rise. The other parameters are kept constant in order to draw a meaningful conclusion. All of the plates/shells used in this particular part are of 3 m diameter, and thickness of 30 mm. The table also shows that the increase in the applied load has no effect on the value transition rise. Each unique load type has its own value of transition rise.

Table 1: Transition rise values

Load (KN)	Load Type		
	Concentrated Load	Ring Load	Water Pressure Load
1.0	66.8	64.6	63.4
1.5	66.8	64.6	63.4
2.0	66.8	64.6	63.4
2.5	66.8	64.6	63.4
3.0	66.8	64.6	63.4
3.5	66.8	64.6	63.4

IV. EFFECT OF THE PLATE/SHELL THICKNESS ON THE VALUE OF THE TRANSITION RISE

Several hundreds of cases were studied and analyzed in order to draw a meaningful conclusion that relates the variation of the plate/shell thickness with the value of the transition rise. Table (2) shows a summary of these findings. Table (2) shows only a sample of the data collected for a given plate/shell diameter of 3.0 m loaded by uniformly distributed load type. The same type of data were collected for other 5 different diameters considered in this study for each different load type, a total of 24 similar tables of 192 different load cases.

Table 2: Effect of plate/shell thickness on the value of the transition rise

Thickness-Diameter ratio (t/D)	Thickness (mm)	Transition Rise (mm)	Transition Rise – Diameter ratio (TR/D)	Transition Rise – Thickness ratio (TR/t)
0.010	30.0	66.1	0.022033	2.203333
0.012	36.0	77.9	0.025967	2.163889
0.014	42.0	88.1	0.029367	2.097619
0.016	48.0	102.4	0.034133	2.133333
0.018	54.0	115.1	0.038367	2.131481
0.020	60.0	131.8	0.043933	2.196667
0.022	66.0	144.5	0.048167	2.189394
0.024	72.0	159.5	0.053167	2.215278

Table (2) also shows that the value of the transition rise – plate/shell thickness ratio does not vary significantly, and considered almost constant oscillating around the value of 2.12. This conclusion takes into consideration all cases considered. The average value is also found to be 2.12. Among all the cases studied and analyzed the ratio of the value of the transition rise (ɳ) to the plate/shell thickness can be represented by the following formula

$$\eta/t = 2.12\,(1 \pm 5\%) \qquad (6)$$

Figure 6 shows the plate/shell thickness and the value of the transition rise ɳ. The increase in plate/shell thickness increases the value of the transition rise. These values are calculated for the plate/shell thickness of 30 mm through 72 mm.

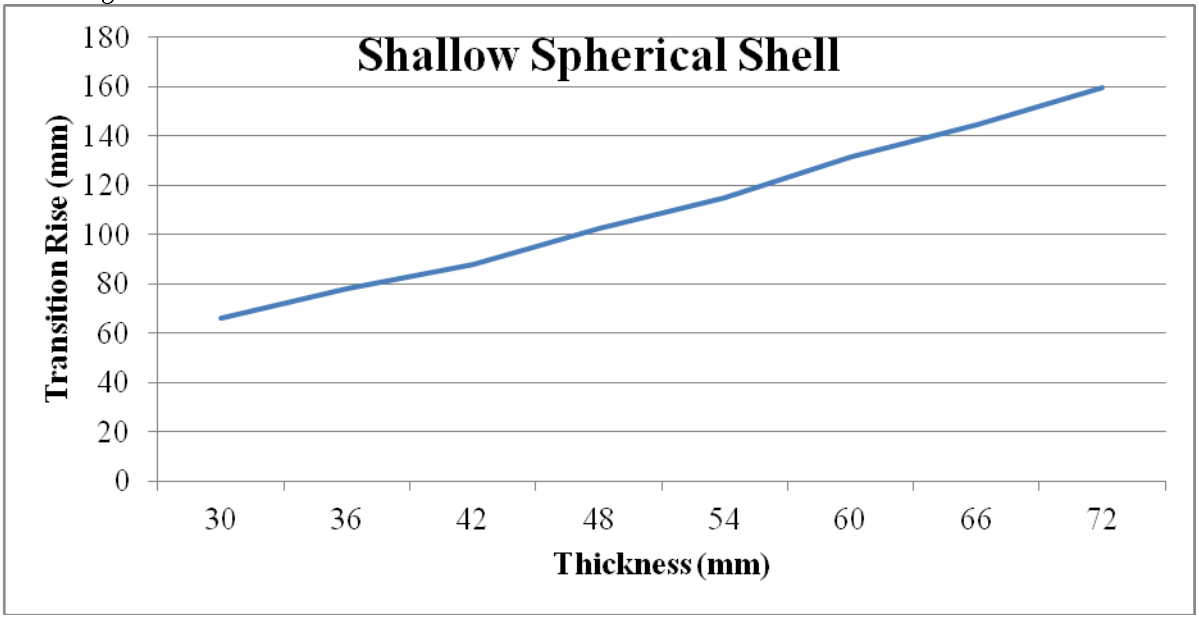

Figure 6: Transition rise-thickness relationship for shallow spherical shell

V. CONCLUSIONS

Large number of cases was studied using the finite element method. The study focused on the shift between plate element behaviors to shallow shell element behavior. Rigorous parametric study was conducted to study the effect of several plate/shell parameters on the value of the transition rise. One of the main conclusions out of this study is that the value of the transition rise – thickness ratio is almost constant with 5% variations and measured to be 2.12. The shallow shell diameter has no effect on the value of the transition rise. The value of the transition rise is not sensitive to either the level of loading nor is it sensitive to the type of loading.

REFERENCES

[1] M. Al-Nasra, A. Najmi, I. Duweib, " Effective Use of Space Swimmer Bars in Reinforced Concrete Flat Slabs", *International Journal of Engineering Sciences and Research Technology, Vol. 2 No. 2*, February 2013, ISSN: 2277-9655, 2013

[2] M. AL-Nasra, I. Duweib, A. Najmi, "The Use of Pyramid Swimmer Bars as Punching Shear Reinforcement in Reinforced Concrete Flat Slabs", *Journal of Civil Engineering Research, Vol. 3, No. 2, 2013, PP 75-80*, DOI: 10.5923/J.JCE.20130302.02, March, 2013.

[3] Eduard Ventsel and Theodor Krauthammer, *Thin Plates and Shells Theory, Analysis, and Applications* (Marcel Dekker, Inc., ISBN: 0-8247-0575-0, 2001)

[4] Rudolph Sziland, *Theory and Analysis of Plates, Classical and Numerical Methods* (Prentice Hall 1974)
[5] SP Timoshenko and Woinowsky-Krieger K *Theory of Plates and Shells* (McGraw-Hill, 1959).
[6] M.L. Bucalem and K.J. Bathe, "Finite Element Analysis of Shell Structures," *Archives of Computational Methods in Engineering, State of the art reviews, Vol. 4, 1*, 3-61, 1997
[7] A. C. Ugural, *Stresses in plates and shells* (New York, *McGraw Hill, 1981*)
[8] El-Sobky H., Singace A. A. and Petsios M., "Mode of Collapse and Energy Absorption Characteristics of Constrained Frusta under Axial Impact Loading", *International Journal of Mechanical Sciences., Vol. 43,* No. 3, pp. 743-757, 2001.
[9] S. Ways, "Bending of Circular Plates with Large Deflections," *Trans. ASME, 56, No. 8,* PP 627-636, 1934
[10] A.J. Sadowski and J.M. Rotter, "Solid or shell finite elements to model thick cylindrical tubes and shells under global bending," *International Journal of Mechanical Sciences*, 74, 143-153. DOI: http://dx.doi.org/10.1016/j.ijmecsci.2013.05.008, 2008
[11] S. Reese, "A large deformation solid-shell concept based on reduced integration with hourglass stabilization," *International Journal of Numerical Methods in Engineering*, vol. 69, no. 8, pp. 1671–1716, 2007
[12] M. Schwarze and S. Reese, "A reduced integration solid-shell finite element based on the EAS and the ANS concept - geometrically linear problems," *International Journal for Numerical Methods in Engineering*, vol. 80, no. 10, pp. 1322–1355, 2009.
[13] R. Hauptmann, S. Doll, M. Harnau, and K. Schweizerhof, "'solid-shell' elements with linear and quadratic shape functions at large deformations with nearly incompressible materials," *Computers & Structures, vol. 79, no. 18*, pp. 1671–1685, 2001.

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Modelling of Transmitter & Receiver for VSAT Communication System

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ABSTRACT— *The Satellite communication is an essential part of telecommunication systems which carrying large amount of data (internet, e-mail) and telephone traffic in addition to TV signals. Very small aperture terminal (VSAT) is widely used for these purpose. This paper aims to provide the framework of VSAT technology in the evolving context of satellite communications in terms of network configuration, services, economics and operational aspects. This paper presents the modelling and simulation aspects of communication blocks of VSAT which can be used in different types of network topology. This paper also includes the numerical results simulated by MATLAB.*
KEYWORDS— *VSAT, HPA, LNA, Satellite Transponder, Star, Mesh*

I. INTRODUCTION

VSAT, now a well established acronym for Very Small Aperture Terminal, was initially a trademark for a small earth station marketed in the 1980s by Telecom General in the USA. VSAT refers to receive or transmit terminals installed at dispersed sites connecting to a central hub via satellite using small diameter antenna dishes (0.6 to 3.8 meter). The majority of VSAT antennas range from 75 cm to 1.2 m. VSATs provide the vital communication link required to set up a satellite based communication network. VSAT systems can be configured for bi-directional or receive-only operation. VSATs can support any communication requirement be it voice, data, or video conferencing. Data rates typically range from 56 kbit/s up to 4 Mbit/s. VSATs access satellite(s) in geosynchronous orbit to relay data from small remote earth stations (terminals) to other terminals (in mesh topology) or master earth station "hubs" (in star topology).

The organization of this paper is as follows- Section II conducts VSAT Satellite Communication System. Section III describes VSAT topology. Section IV shows VSAT frequency band. Section V describes VSAT transmitter & receiver part. Section VI illustrate the simulation results. Section VII resembles link budget Calculation. Finally, Section VIII provides some concluding remarks.

II. VSAT SATELLITE COMMUNICATION SYSTEM

Fig1shows the block diagram of basic VSAT satellite communication system. Satellite communication system consists of many earth stations on the ground and these are linked with a satellite in space [2]. The user is connected to the Earth station through a terrestrial network and this terrestrial network may be a telephone switch or dedicated link to earth station. The user generates a baseband signal that is processed through a terrestrial network and transmitted to a satellite at the earth station. The satellite transponder consists of a large number of repeaters in space which receives the modulated RF carrier in its uplink frequency spectrum from all the earth station in the network, amplifies these carriers and retransmits them back to the earth stations in the downlink frequency spectrum [8]. To avoid the interference, downlink spectrum should be different from uplink frequency spectrum. The signal at the receiving earth station is processed to get back the baseband signal, It is sent to the end user through a terrestrial network.

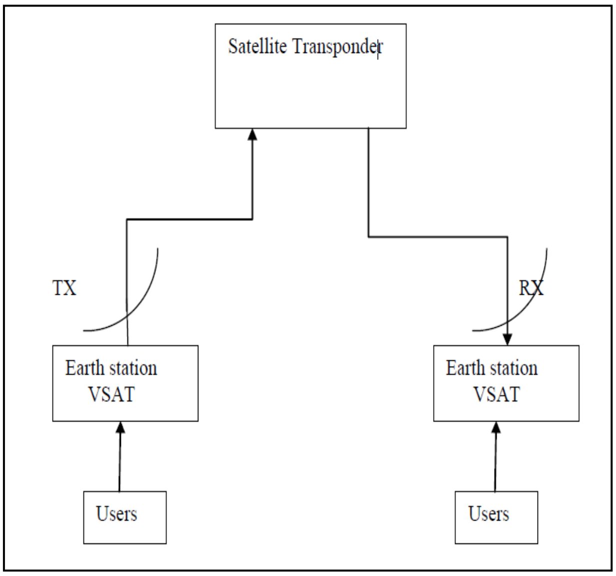

Fig. 1 Basic Satellite communication System

The basic block diagram of an VSAT earth-station Transmitter is as shown in fig 2. The baseband signal from the terrestrial network is processed through modulator and then it is converted to uplink frequency [2],[3]. Finally it is amplified by high power amplifier and directed towards the appropriate part of antenna. The block diagram of an VSAT earth station receiver is as shown in fig 3. The signal received from the satellite is processed through LNA (Low Noise Amplifier). Then it is down-converted and demodulated. Thus the original baseband signal is obtained.

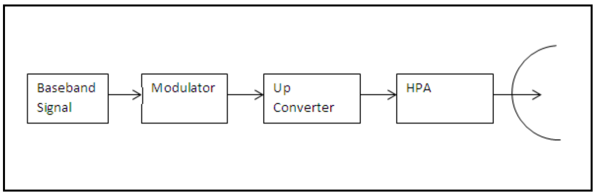

Fig. 2 Block diagram of VSAT Earth Station Transmitter

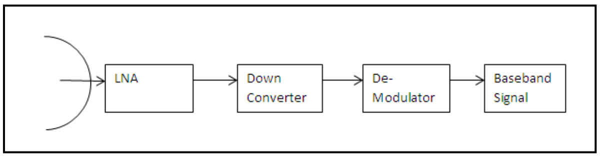

Fig. 3 Block diagram of VSAT Earth Station Receiver

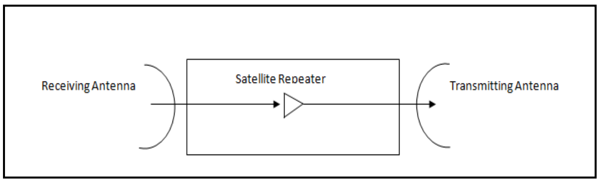

Fig. 4 Block Diagram of Satellite transponder

III. VSAT TOPOLOGY

STAR

The hub station controls and monitors can communicate with a large number of dispersed VSATs. Generally, the Data Terminal Equipment and 3 hub antenna is in the range of 6-11m in diameter [1]. Since all VSATs communicate with the central hub station only, this network is more suitable for centralized data applications.

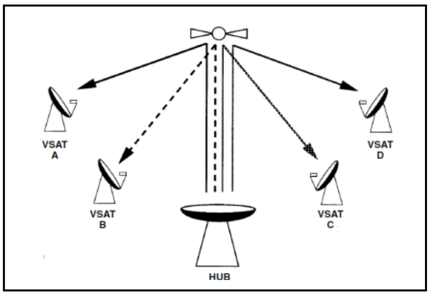

Fig. 5 Star Topology

Mesh

A group of VSATs communicate directly with any other VSAT in the network without going through a central hub. A hub station in a mesh network performs only the monitoring and control functions. These networks are more suitable for telephony applications[6].

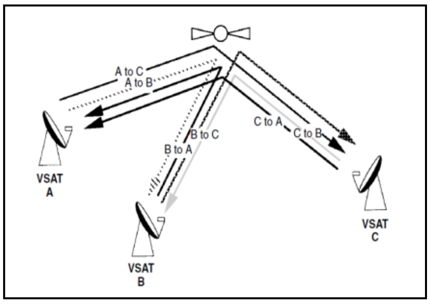

Fig. 6 Mesh Topology

Hybrid Network

In practice usually using hybrid networks, where a part of the network operates on a star topology while some sites operate on a mesh topology, thereby accruing benefits of both topologies.

IV. VSAT FREQUENCY BAND

TABLE I. VSAT FREQUENCY BAND

SI No.	Band	Uplink Range(GHZ)	Downlink range(GHZ)
1	C Band	5.925-6.425	3.700-4.200
2	Ex C Band	6.725-7.025	4.500-4.800
3	Ku Band	14.00-14.50	10.95-11.70
4	Ka Band	30.00	20.00

TABLE II. ADVANTAGE & DISADVANTAGE OF DIFFERENT BAND

Band	Advantage	Disadvantage
C Band	Broad footprint, Little rain fade	Interference , Large antenna & amplifier.
Ex-C Band	Broad footprint, Little rain fade, Less Interference.	Weak signals, Large antenna size, Large amplifier.
Ku Band	Focused Footprint, Less Terrestrial interference, Smaller antenna, Smaller Amplifiers.	Interference due to rain.
Ka Band	Focused Footprint, Less Terrestrial interference, Smaller antenna, Smaller Amplifiers.	Interference due to rain.

V. VSAT TRANSMITTER & RECEIVER PART

A. *Transmitter Part*

Modulator

Modulators are responsible for converting the digital data into IF Signals. We have used a QPSK modulator [5]. The mathematical analysis shows that QPSK can be used either to double the data rate compared with a BPSK system while maintaining the *same* bandwidth of the signal, or to maintain the data-rate of BPSK but halving the bandwidth needed. In this latter case, the BER of QPSK is exactly the same as the BER of BPSK - and deciding differently is a common confusion when considering or describing QPSK. The transmitted carrier can undergo numbers of phase changes.

Up Converter

An up-converter amplifies & converts the frequency (IF to RF), that is received from the modulator. This is then passed on to the power amplifier for further amplification and transmission. A block up converter (BUC) is used in the transmission (uplink) of satellite signals. Modern BUCs convert from the L band to Ku band, C band and Ka band. Older BUCs convert from a 70 MHz intermediate frequency (IF) to Ku band or C band.

B. *Receiver Part*

HPA

The Power Amplifier is used for amplifying the Up converter RF signal before being fed into the Antenna system. The Amplifier can be either Mounted on the Antenna system or could be placed in the Indoor Rack. The amplification is required to send the up stream signals to the Satellite. There are four basic types of electronic amplifier: the voltage amplifier, the current amplifier, the trans-conductance amplifier, and the trans-resistance amplifier.

LNA

The signal that travels from the satellite would have become weak due to various atmospheric issues, the signal strength is reduced to a few watts hence the signal need to pass through an equipment that will increase the signal strength from a few watts to several Kilowatts [10]. Usually LNA require less operating voltage in the range of 2-10 V.LNA require supply current in the range of mA, the supply current require for LNA is dependent on the its design and the application for which it has to be used. The Frequency Range of LNA operation is very wide. They can operate from 500 kHz to 50 GHz [14]. The temperature range where a LNA operates best is usually -30 to +50 C. Noise figure is also one of the important factors which determines the efficiency of a particular LNA. Low noise figure results in better reception of signal. With the low noise figure LNA must have high gain for the processing of signal into post circuit. If the LNA doesn't have high gain then the signal will be affected in by noise in LNA circuit itself and
maybe attenuated so high gain of LNA is the important parameter of LNA.

Down Converter

A down converter amplifies and converts the frequency (RF to IF), which is received from the low noise amplifier. This is then passed on to the demodulator [9]. A low-noise block down-converter (or LNB) is the receiving device mounted on satellite dishes used for satellite TV reception, which collects the radio waves from the dish. Also called a low noise block, LNC (for low-noise converter), or even LND (for low-noise down-converter), the device is sometimes wrongly called an LNA (low-noise amplifier) [15].

Demodulator

Demodulator is responsible for converting the IF signals into digital format. This is understood by the networking components like Routers, Switches, Telephone systems, etc. and the same is then fed into the computer.

VI. SIMULATION RESULT

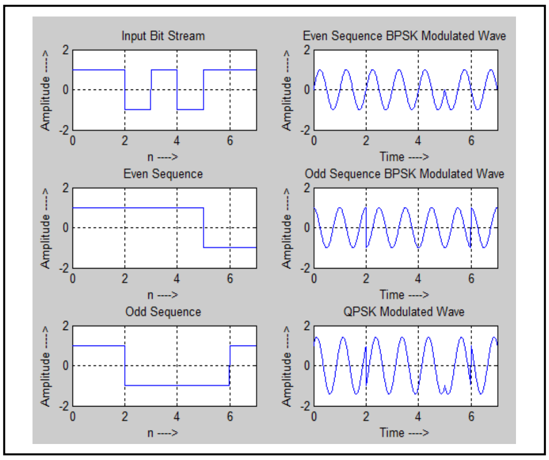

Fig. 7 QPSK modulated Output

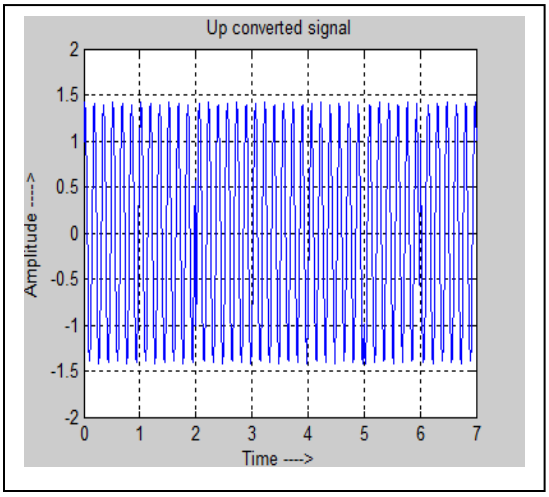

Fig. 8 Up Converted Signal

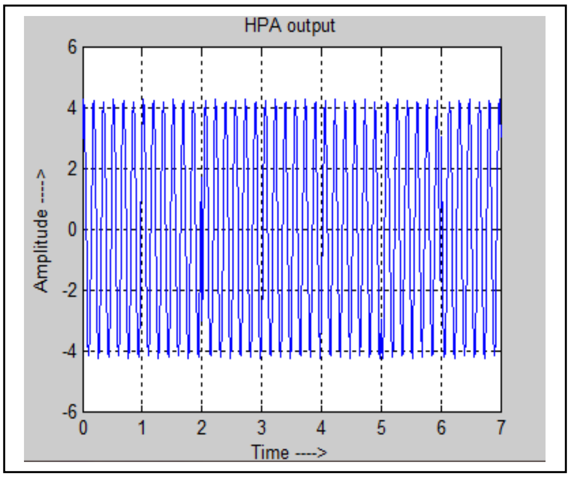

Fig. 9 HPA output

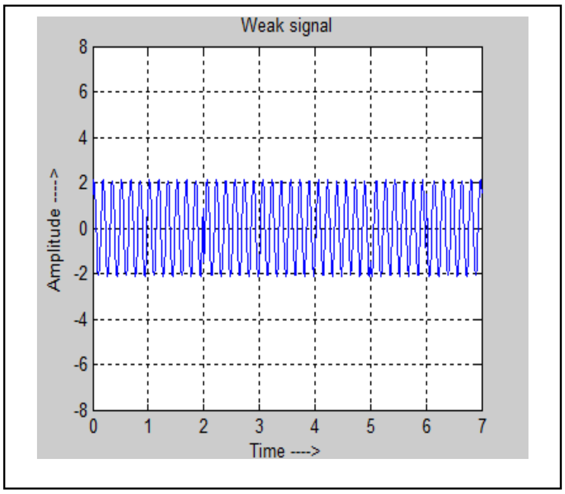

Fig. 10 Weak Signal

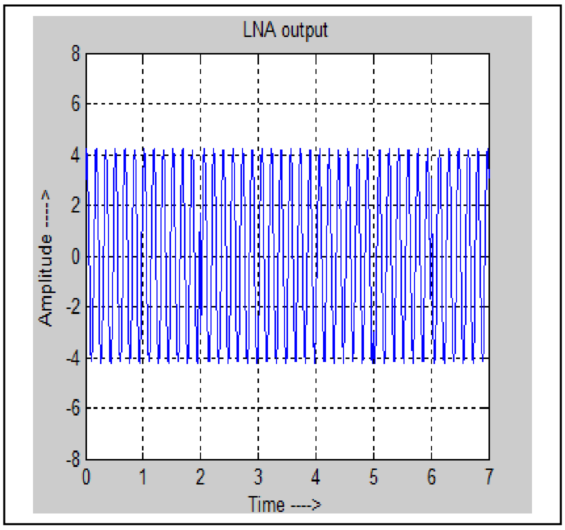

Fig. 11 LNA output

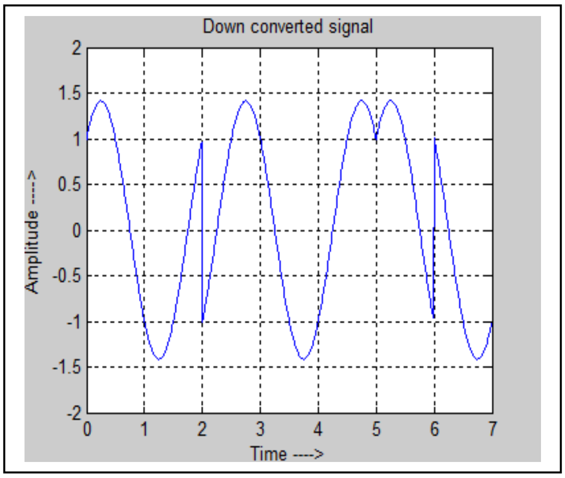

Fig. 12 Down converted Signal

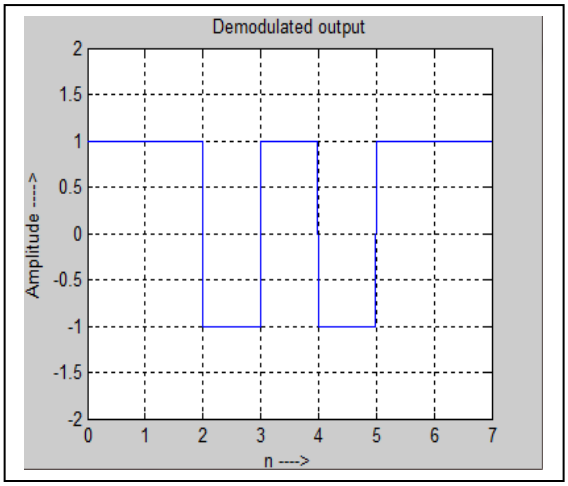

Fig 13 Demodulated Output

VII. LINK BUDGET CALCULATIONS

The link between the satellite and Earth station is governed by the basic microwave radio link equation [11],[12]:

$$P_r = \frac{P_t G_t G_r C^2}{4 \pi^2 R^2 f^2}$$

Where P_r is power received by the receiving antenna: Pt is the power applied to the transmitting antenna: G t is the gain of the transmitting antenna, Gr is gain of the receiving antenna, C is the speed of light (c = 3 x 10 8 m/s): R is the range (path length) in meters: and f is the frequency in hertz .Almost all link calculations are performed after converting from products and ratios to decibels. This uses the unit popular unit of decibels, thus converting the equation (1) into decibels. It has the form of a power balance as $P_r = P_t + G_t + G_r$ –Path-loss [13] . All link budgets require knowledge of the free space path loss between the earth station and the satellite and the noise powers in the operating bandwidth[16]. Free space Path loss:

$$L_p = 20 \log (4\pi R / \lambda).$$

Gain of the antenna is given by –

$$G = \frac{4 \pi \eta A}{\lambda^2} = \eta (\frac{\pi D}{\lambda^2})$$

Where η is the antenna efficiency, A is the effective area, and λ is the wavelength.

VIII. CONCLUSION

A comparison of costs between a VSAT network and a leased line network reveals that a VSAT network offers significant savings over a two to three years timeframe. This does not take into account the cost of downtime, inclusion of which would result in the VSAT network being much more cost - effective. Pay-by-mile concept in case of leased line sends the costs spiralling upwards. More so if the locations to be linked are dispersed all over the country. Compare this to VSATs where the distance has nothing to do with the cost. Additionally, in case of VSATs, the service charges depend on the bandwidth which is allocated to your network in line with your requirements. Whereas with a leased line you get a dedicated circuit in multiples of 64Kbps whether you need that amount of bandwidth or not.

REFERENCES

[1] M. H. Hadjitheodosiou, Frances P. Coakley and Barry G. Evans, *Next Generation Multi service VSAT Networks*, July 2, 1997 .

[2] T. Pratt, C. Bostian , J.Allnutt, *Satellite Communication,* John Wiley and Sons, 2nd Edition.

[3] Theodore S. Rappaport, *Wireless Communications*, Principles and Practice, Prentice – Hall of India Private Limited, 2nd Edition.

[4] Sanjay Sharma *Wireless and Cellular Communications*, S. K. Kataria and Sons 2nd edition, Jan 2007.

[5] R . E. Ziemer and W. H. Tranter *Principle of communications Systems, Modulation and Noise*, Published by Jaico Publishing House.

[6] G´erard Maral *VSAT Networks*,Published by John Wiley & Sons Ltd

[7] Robert M. Gagliardi Satellite Communication CBS publishers & Distributors.

[8] Tri T. Ha *Satellite Digital Communication,* McGraw-Hill publishing Company

[9] Gerben W. de Jong, Domine M. W. Leenaerts, *Fellow, IEEE*, and Edwin van der Heijden *A Fully Integrated Ka-Band VSAT Down-Converter* ,IEEE Journal Of Solid-State Circuits, Vol. 48, No. 7, July 2013

[10] Kosei Nishimura and Futoshi Kuroki *Connection between Microstrip Circuits in Transmitter and Receiver of VSAT Systems*, Proceedings of Asia-Pacific Microwave Conference 2010.

[11] F. Michael Naderi ,William W. Wu *Advanced Satellite Concepts for Future Generation VSAT Networks,* 0 163-6804/88/00 13-000 1 $0 1 .OO ' 1988 IEEE.

[12] Paolo Amadesi The Role Of VSATs & Other Small Satellite Terminals *In The Evolving Telecommunications Environent,* EUTELSAT Tour Maine Montpamasse 33, Ave du Maine 75755 Paris Cedex 15 France

[13] Aderemi A. Atayero, Matthew K. Luka and Adeyemi A. Alatishe, *Satellite Link Design: A Tutorial*‖,International Journal of Electrical and Computer Sciences IJECS-IJENS Vol: 11 No:04, August 2011.

[14] Howard Hausman, *Fundamentals of Satellite Communications, Part-2*‖, Hauppauge, NY 11788,January 22, 2009.

[15] Charan Langton, Intuitive Guide to Principles of Communications‖, copyright 1998 and 2002

[16] Basari, Development of Simple Antenna System for Land Mobile Satellite Communications, Doctoral Dissertation, February, 2011.

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Effect of Power System Parameters on Transient Stability Studies

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ABSTRACT: *Transient stability studies play a vital role in providing secured operating configurations in power system networks. This paper shows an investigation of the effects of some key power system parameters on transient stability. The parameters for which this analysis is carried out include fault location, load increment, machine damping factor, fault clearing time and generator synchronous speed. The analysis has been carried out on a 7-bus test system for an electric utility company. From this analysis, the impact of these parameters on power system transient stability has been highlighted.*

Keywords-*fault location; load increment; machine damping factor; fault clearing time; generator synchronous speed.*

I. INTRODUCTION

The definition of stability includes a number of factors that may be involved: the load carried before a fault occurs, the type of fault and its location in the system, the time required to clear the fault, the change in steady state operating angles when the faulted portion of the system is removed from service, and the moment of inertia of the rotating machines at each end of the system. Stability, then, is the ability of a system to continue to operate without loss of load when any reasonable system change or disturbance occurs. The transient stability is one of the important constraints in the planning and maintenance of a secured power system operation. Transient stability is concerned with the ability of the power system to maintain synchronism when subjected to severe perturbations. These perturbations can be faults such as: a short circuit on a transmission line, loss of a generator, loss of load, gain of load or loss of a portion of transmission network [1][2].

II. BACKGROUND OF STUDY

Transient stability analysis is used to investigate the stability of power system under sudden and large disturbances, and plays an important role in maintaining security of power system operation. Some studies have been carried out to evaluate the effects of parameters that influence transient stability in a power system.

Adepoju [3] carried out a study to evaluate the Critical Clearing Time (CCT) of the Nigerian 330kV transmission system. This research work demonstrated that determination of appropriate CCTs for the Nigerian power system will enhance the operation of the system by limiting the effects of faults on the power system. The CCTs for three-phase faults of circuit breakers installed on the Nigerian 330kV transmission grid, which can serve as reference data for the use of power system experts and researchers,were established. Investigationof the damping of electromechanical oscillations using Power System Stabilizers (PSS) was carried out [4]. The study simulated the behavior of PSS on Automatic Voltage Regulator (AVR) and excitation system. It also developed an algorithm to investigate the transient and dynamic stability of the power systems. This was with a view to providing information of damping rotor oscillations of synchronous generators. Baseer [5] focused on the improvement of the transient stability of the Western System Coordinating Council9-Bus System with fixed compensation on various lines and optimal location using trajectory sensitivity analysis for better results. In order to improve the transient stability margin further series Flexible AC Transmission System (FACTS) devicewas implemented. A fuzzy controlled, Thyristor Controlled Series Compensation (TCSC) devices were used and the results highlighted the effectiveness of the application of a TCSC in improving the transient stability of power systems especially with regards to damping of the system.

Singh [6] focused on the comparative performance of Static Var Compensator (SVC) and Unified Power Flow Controller (UPFC) for the improvement of transient stability of multi-machine system. The UPFC is more effective FACTS device for controlling active and reactive power flow in a transmission line and power oscillation damping by controlling its series and shunt parameters. Simulations were carried out in MATLAB /Simulink environment for multi-machine system to analyze effects of SVC and UPFC on transient stability performance of the system. The performance of UPFC was compared with SVC. The simulation results demonstrate the effective and robustness of the proposed UPFC for transient stability improvement of the system. This paper, however, investigates the effects of some key power system parameters on transient stability of the system. These parameters include the effect of fault location within the system, effect of load increment on the system, effect of damping factor of the synchronous machines within the system and effect of the fault clearing time on the stability of the system.

III. METHODOLOGY

The initiation of fault and its removal by circuit breakers in a power system shows that the system is going through a fault with change in the system configuration in three stages: pre-fault, fault and post-fault stages. The dynamics of the power system during fault and post-fault periods are nonlinear and the exact solution is too complex. In transient stability studies, particularly, those involving short periods of analysis in the order of a second or less, a synchronous machine can be represented by a voltage source behind transient reactance that is constant in magnitude but changes its angular position [7]. This representation neglects the effects of saliency and assumes constant flux linkage and small change in speed. The voltage behind the transient reactance is determined from the following equation [8].

$$E_i = V_i + jX_d I_i \tag{1}$$

where

E_i = voltage behind transient reactance

V_i = machine terminal voltage

X_d = direct axis transient reactance

I_i = machine terminal current

The rotor mechanical dynamics are represented by the following equations

$$2H\frac{d\omega}{dt} = T_m - T_e - D\omega \tag{2}$$

$$\frac{d\delta}{dt} = \omega \tag{3}$$

where

H = per unit inertia constant

D = damping coefficient

ω = rotor angle of the generator

δ = angular speed of the generator

T_m = mechanical torque input

T_e = electrical torque output

Numerical integration techniques are used to solve the swing equation for multi-machine stability problems. The Modified Euler's method is used to compute machine power angles and speeds in this research work. The real electrical power output of each machine is computed by the following equations.

$$P_e = \text{Real}\left[E_n I_n^*\right], n = 1, 2, ..., m \quad (4)$$

$$P_e = \sum_{j=1}^{n} |E_i||E_j||Y_{ij}| \cos\left(\theta_{ij} - \delta_i - \delta_j\right) \quad (5)$$

Equations (1) to (5) are very crucial for transient stability studies, because they are used to calculate the output power of each machine in the power system. The individual models of the generators and the system load given by the differential and algebraic equations have been stated. These equations, together, form a complete mathematical model of the system, which, when solved numerically, simulate the system behaviors.

IV. SIMULATION OF RESULTS

This section presents computer simulations with the program developed in the MATLAB software environment. The analysis has been carried out on a 7-bus test system for an electric utility company shown in Figure 1. It consists of seven (7) buses, three (3) synchronous generators, four (4) loads and seven (7) transmission lines.

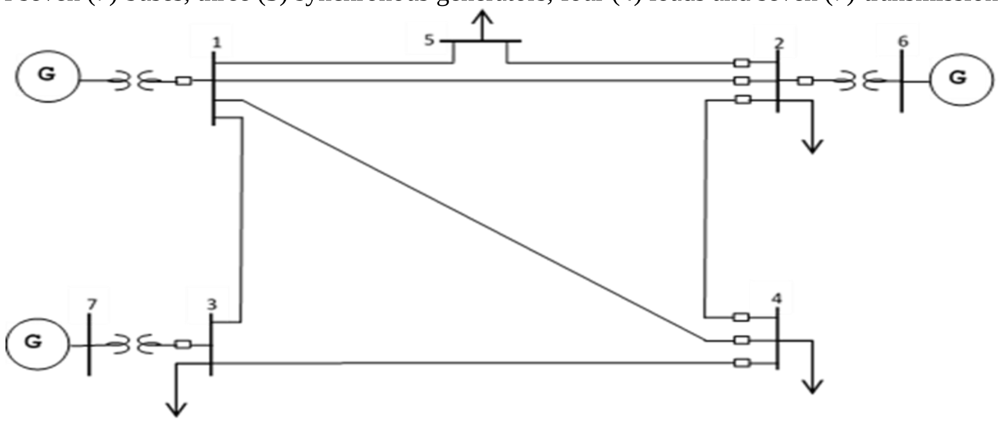

Figure 1: Single-line diagram of the test system for an electric utility company

4.1 Effect of fault location

This sub-section analyzes the effect of fault location in transient stability. A three-phase fault is simulated at two different locations, one close to the generating station and the other one far from the generating station. Figure 2 shows the angular positions of the generators with the generator at bus 1 as reference, when a three phase fault occurred at bus 1 and the fault was cleared at the critical clearing time by removal of line 1-2. The critical clearing time for this case is 242ms(see Table 1). The generators swing together to show stable equilibrium. Figure 3 shows the angular positions of the machines when a three phase fault occurred at bus 4 and the fault was cleared at the critical clearing time by removal of line 2-4. The CCT for this case is 271ms(see Table 1). The generators swing together to show stable equilibrium. It is observed that the critical clearing time of the fault on bus 1 is lower than that of bus 4. This shows that when faults close to the generating station are cleared, the system returns to stability more rapidly than those on lines further away from the station.

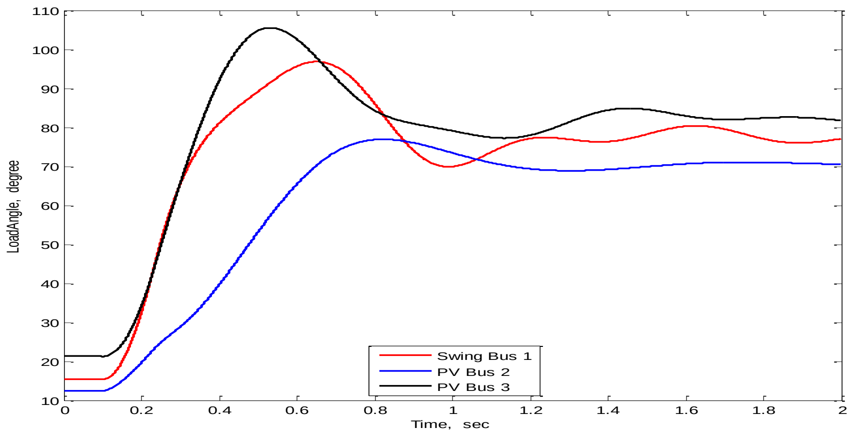

Figure 2. Rotor angle response with fault on bus 1

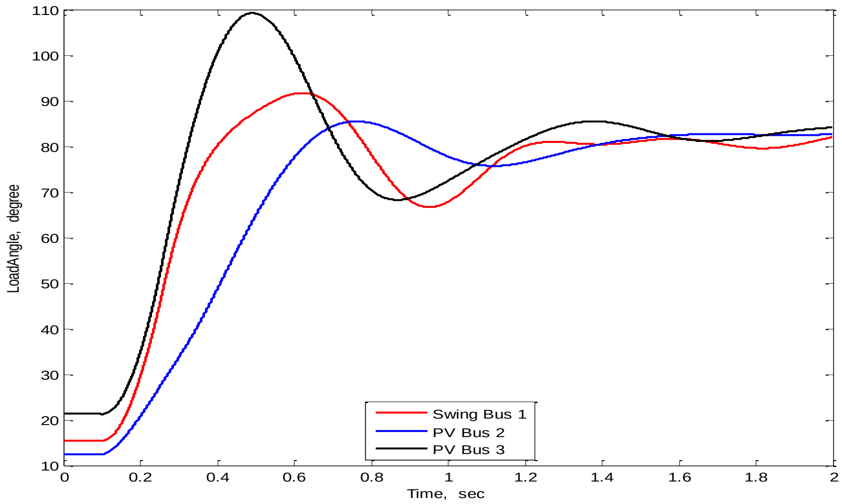

Figure 3. Rotor angle response with fault on bus 4

4.2 Effect of damping factor on the system stability.

The machine damping factor represents the natural damping of the system. This sub-section considers the effect of damping factor on the transient stability evaluation. Figure 4 and Figure 5 show the rotor angle behavior with and without damping coefficient for a three phase fault on bus 1. When a fault occurs, the rotor angles of the generators will begin to oscillate and will eventually either converge or diverge depending on the system configuration. The damping factor prevents the growth of oscillations. Machines within the system that are properly damped regain synchronism when the fault is cleared. However, those that are poorly damped wereobserved to be unstable with their rotor angles continuously diverging. When the fault is cleared, the speed is continuously increasing and system is not able to retain stability due to the lack of proper damping.

4.1 **Effect of fault clearing time**

In order to know the effect of fault clearing time on transient stability, a disturbance in the form of a three phase fault was simulated at some buses and different lines removed to determine the stability or otherwise of the power system. The critical clearing time, which is a measure of the stability, was determined by varying the fault clearing times. The stability and instability of the power system at a given fault is determined by the behavior of the generators in the system. If the rotor angles of the generators diverge, the system is unstable and if otherwise, the system is stable.

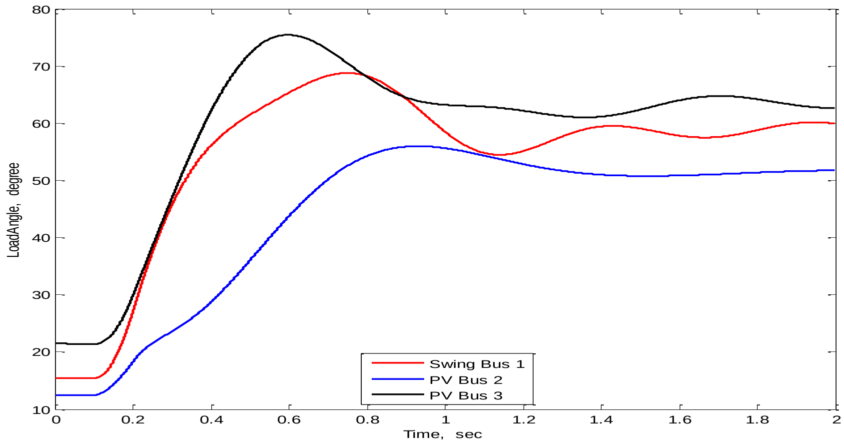

Figure 4. Rotor angle oscillations when the system is properly damped

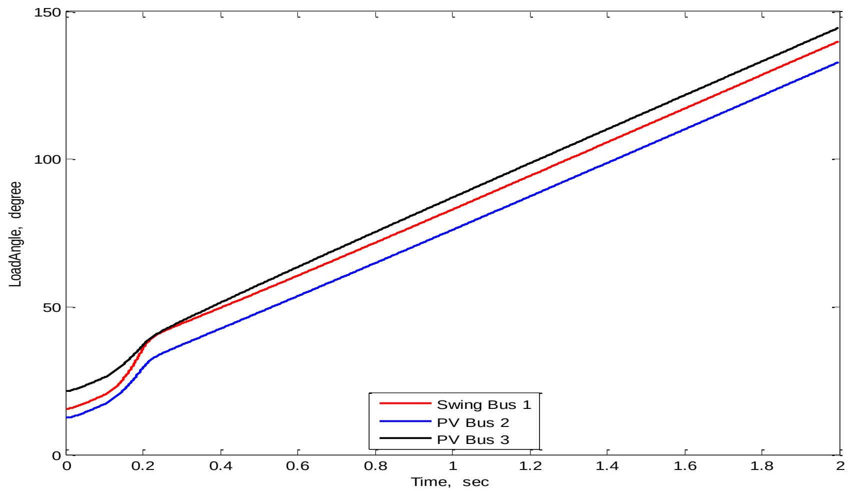

Figure 5. Rotor angle oscillations when the system is poorly damped

Figure 6 show the angular positions of the generators with the generator at bus 1 as reference when a three phase fault occurred at bus 2 and the fault was cleared at the critical clearing time by the removal of line 2-4. The generators swing together to show stable equilibrium. Figure 7 shows the angular positions of the machines for a clearing time greater than the critical clearing time. In this case, the clearing time increased beyond the critical clearing time and the machines lost synchronism as seen in the figure.

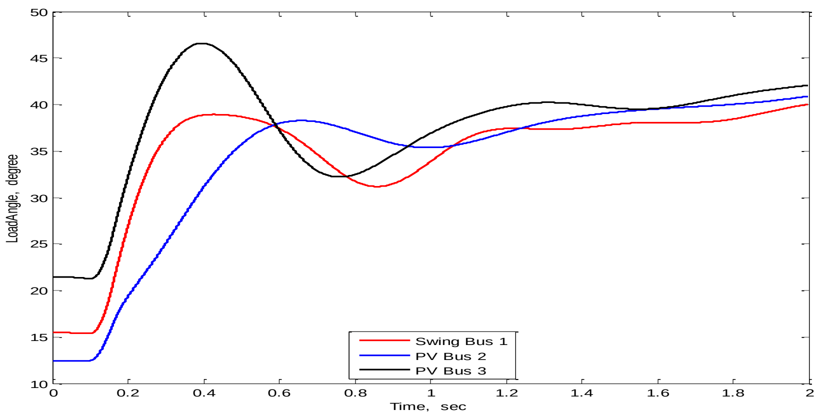

Figure 6. Generator rotor angle response for fault cleared at the critical clearing time

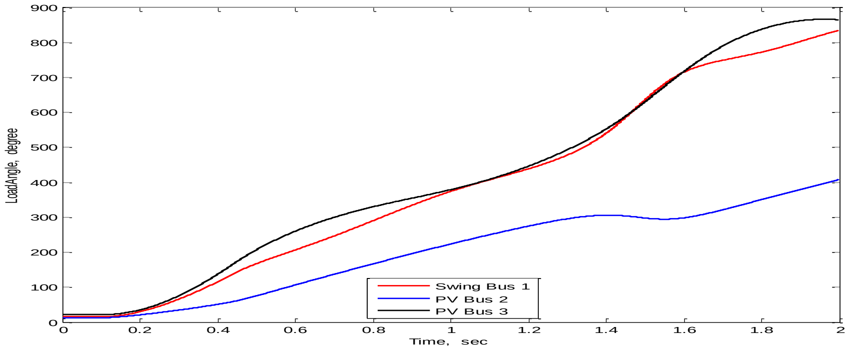

Figure 7. Generator rotor angle response for fault cleared after the critical clearing time

Further simulations were carried out at different locations and it was observed that if faults are cleared rapidly the angular deviation is less and the system stability is assured. The angular deviation increases if the fault clearing time increases and ultimately if the fault is cleared after the critical clearing time, the system will lose synchronism. Table 1 shows the critical clearing times in millisecond for different fault location in the 7-bus test of the electric utility company.

Table 1: Critical clearing times for faults at different locations in the 7-bus test system

Faulted bus	Line opened	Critical clearing time (ms)
1	1-2	242
2	2-4	271
3	1-3	225
4	1-4	315

4.2 **Effect of load increment.**

The objective of this sub-section is to investigate the impact of load increment on the Critical Clearing Time (CCT).For this reason, active load at all buses in the 7-bussystem are increased from the base value by 10%, 20%, 30% and 40%. Real example of this case is electrical peak load ofenergy consumption.In order to evaluate the effects of load variation on the transient stability of the system, a three-phase fault was simulated at bus 1 with the opening of line 1–2 to clear the fault. Table 4.2 show the impact of the load increment on the CCT. It was observed for this particular case that as the load increased within certain range, the CCT decreased. Increment of the load beyond certain limit caused the machines' rotor angle to diverge continuously leading to loss of synchronism and hence, instability. In order to maintain the stability of the system within certain range of the load increment, power generation has to increase while the voltage at all buses has to drop.

TABLE 2 Critical clearing times with load increment

Load increment (%)	Base value	10	20	30	40
Total load increment (MW)	1400	1540	1680	1820	1960
Critical clearing time (ms)	347	309	271	237	199

4.3 Effect of fault on the synchronous speed

This sub-section is aimed at investigating the response of the generator synchronous speed in relation to the mechanical power input, electrical power output, power angle and the damping of the generator when a fault occurs in the system. Consider a three phase fault on bus 1, which is cleared by opening line 1-2.

In the steady-state, the generators in a power system network operate at equilibrium corresponding to the mechanical power input P_m being equal to the electrical power output P_e. When a fault occurs in the system, the initial configuration of the system will be lost and since P_m is constant, then P_m will become greater than P_e. An excess of the mechanical input P_m over the electrical output P_e accelerates the rotor, thereby storing excess kinetic energy, and the power angle increases. With increase in the power angle, the electrical power P_e will begin to increase until it matches the mechanical power input P_m. At this point, with the fault cleared, the accelerating power becomes zero but the rotor is still running above synchronous speed; hence the power angle and the electrical power P_e will continue to increase. Now $P_m < P_e$, causing the rotor to decelerate toward synchronous speed until the power angle reaches its critical value. The rotor angle will continue to oscillate back and forth at its natural frequency and the damping present in the generators will cause the oscillations to eventually subside. Figure 8 depicts the deviation from the synchronous speed when the system is perturbed and the eventual return to synchronous speed when the fault was cleared.

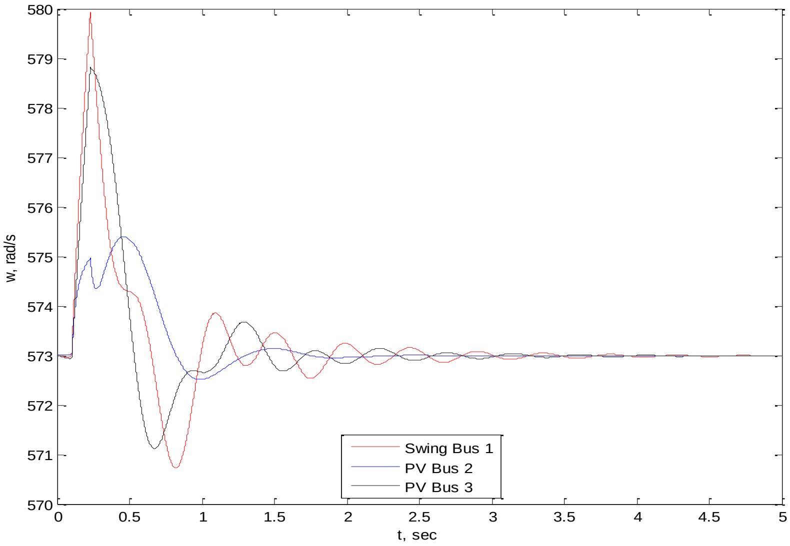

Figure 8. The generators' synchronous speed response when a three phase fault occur

V. CONCLUSION

Transient Stability Analysis is a major investigation into the operation of power systems due to the increasing stress on power system networks. The main goal of this analysis is to gather critical information, such as CCT of the circuit breakers for faults in the system, effect of location of fault within a power system network, effect of operating machines that are poorly damped, effect of load increment on the CCT and effect of fault on the synchronous speed of machines in the system. This information can aid protection engineer make an informed decision when designing protection scheme for a power system. This paper presents a transient stability analysis of 7-bus test system for an electric utility company using the MATLAB software package. To analyze the effects of these parameters on the system stability, a three-phase fault was applied at different locations in the system. The stability of the system has been observed based on the simulation graphs of the generators' swing curves and generators' synchronous speed. The simulation results showed that the critical clearing time decreases as the fault location becomes closer to the power generating station.

The results obtained from this study, confirmed and established the findings in previous stability studies regarding these parameters.

REFERENCES

[1] Kundur, P and J. Paserba. 2004. Definition and classification of power system stability. IEEE Trans. on Power Systems.19, 2, pp. 1387-1401.

[2] Abdul, M.M. 2002. A new method of transient stability assessment by using a simple energy margin function. Second International Conference on Electrical and Computer Engineering Dhaka, Bangladesh.pp. 24–27, 26-28.

[3] Adepoju, G.A; Tijani M.A. 2013. Critical Clearing Time Evaluation of Nigerian 330kV Transmission System. American Journal of Electrical Power and Energy Systems.Vol. 2, No. 6, pp. 123-128. doi: 10.11648/j.epes.20130206.11

[4] Funso, K.A. and M.O. Omoigui. 2012. Investigation of the Damping of Electromechanical Oscillations Using Power System Stabilizers (PSS) in Nigerian 330 kV Electrical Network. Electrical and Electronic Engineering 2(4): 236-244.?

[5] Baseer, M.A. 2014. Transient Stability Improvement of Multi-machine Power System using Fuzzy Controlled TCSC. IOSR Journal of Electrical and Electronics Engineering (IOSR -JEEE) e -ISSN: 2278 -1676, p-ISSN: 2320-3331, Volume 9, Issue 1 Ver. I, P 28-40.

[6] Singh, S; A, Ram; N, Goel;, P, Kumar. 2013. Transient Stability Enhancement of Multi-Machine System Using FACTS Controllers. International Journal of Engineering Science and Innovative Technology (IJESIT) Volume 2, Issue 2.

[7] Saadat, H. 1999. Power System Analysis. McGraw-Hill, New York, USA, 1999.

[8] Wang, X; S, Yonghua, and I. Malcolm. Modern Power System Analysis. Springer, New York, USA, 2008.

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DC / DC Converter for the conditioning of the photovoltaic energy - modeling and command strategy

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ABSTRACT: *Demand for energy, especially electricity, throughout the world, is increasingly growing rapidly. Renewable energy: wind, solar, geothermal, and hydroelectric and biomass provides substantial benefits for our climate, our health, and our economy. However it needs more investigations in terms of research. A special attention should be given on the optimization of energy production and its own integration in grids especially when the resources become multiple. The contribution of our researches is to study the technical and physical aspects to optimize the energy management in a multi-source system dedicated to rural area applications. The multi-source system is based on photovoltaic panels, wind turbine, solar PV and storage batteries. In this paper, we present the modeling and simulation of the part composed of photovoltaic source and its DC / DC converter.*

Keywords - *Renewable energy, PV generator, Chopper, MLI, Backstepping.*

I. INTRODUCTION

The introduction Demand for electrical energy, throughout the world, is increasingly growing rapidly. This demand must be satisfy within a framework that does not aggress the environment. So many researches has been developed. Most of these researches has been focused on the optimization of the renewable energy production and its integration with electrical systems [1]. In addition, to satisfy this energy need, research has taken many paths [1][2], especially when sources of renewable energy become multiple.

The contribution of this paper is to study a multi-source system composed by a wind, photovoltaic (PV) panels and the batteries in order to inject the energy produced in an island or rural electric network.

The proposed configuration is shown in Figure 1.

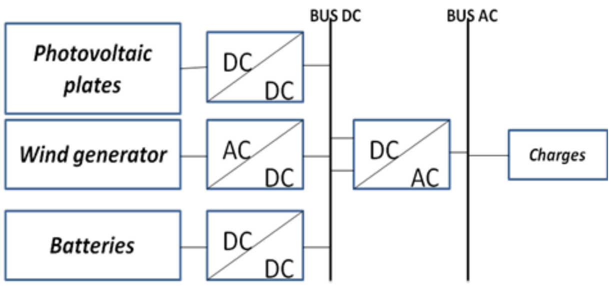

Figure 1: Configuration of global system.

Static charge represents common and fixed loads which are essential for a client. The dynamic charge represents additional loads to the usual ones, They have a fluctuating character. For the work conduct, we propose, as a first step, to consider separately the different blocks of the chosen structure, in a second step, to study the whole structure and how it can be affected by the integration of the blocks. Thus, we study in this article the floor composed of photovoltaic generator connected with the DC / DC converter. To command the switches (IGBTs) states, which are the heart of the DC / DC converter , the backstepping approach is used [3]. This approach control is non linear and can be adapted to the real functioning conditions, especially if we consider the variation of the output voltage of the photovoltaic field. Note that, an inverter (see fig. 1) is powered by the DC bus. Its output voltage value is given by $V_{AC\,eff} = \frac{\sqrt{2}}{2}.\alpha.V_{DC}$ and should be equal to 380V,with α is a variable coefficient of the command of the inverter and must be between 0 and 1.So, the DC bus voltage, noted V_{DC}, must be equal at least to 538V. our choice consists that α=0.4. This leads that we choose 800 V as a value of the DC bus voltage. After modeling the PV generator and the chopper, we use Matlab/Simulink software, to simulate different parts of the system.

II. MODELING SYSTEM

The studied system consists of a PV generator, a Boost chopper and a DC bus. Using the backstepping strategy, the chopper is controlled by a square signal with a varying duty cycle as a function of the measured output voltage of the PV. Figure 2 shows the block diagram of the floor.

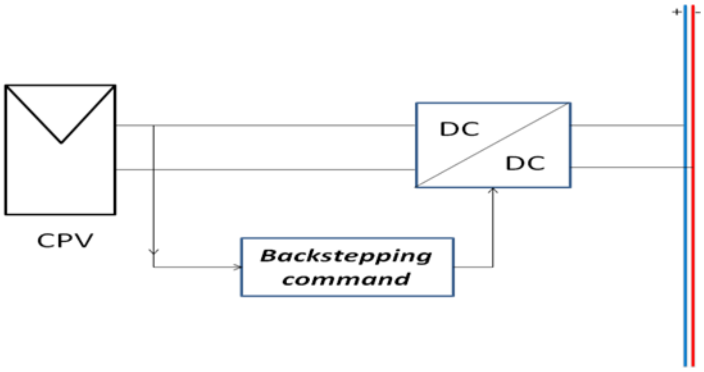

Figure 2. Studied floor structure

1- Model of photovoltaic plate

There are many models of PV which vary in complexity and accuracy [4][6]. For our study we use The model presented in Figure 3. This can faithfully reproduce the dynamic behavior of a photovoltaic generator

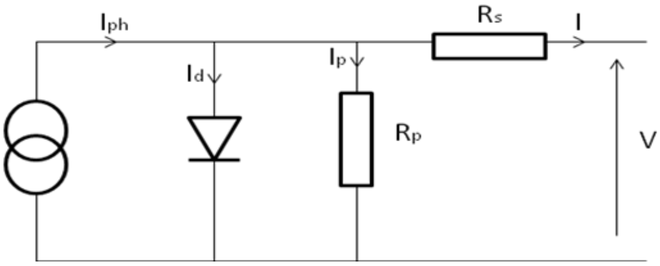

Figure 3. Model of photovoltaic plate

The electrical current output of the used model is mathematically described by:

$$I_d = I_{cc}\left(e^{\frac{qV}{nkT}} - 1\right) \qquad (1)$$

Where: Icc is the current in the reverse bias diode, q is the electron charge (1.6 10-19C), K is the Boltzmann constant (1.38 10-23J / K), n is the diode ideality factor it is between 1 and 2, T is the temperature in K of the junction.

The electrical current output of the used model is:

$$I = I_{PH} - I_{cc}\left(e^{\frac{V+I.R_S}{nV_T}} - 1\right) - \frac{V+I.R_S}{R_P} \qquad (2)$$

To increase the current value of the PV output; we use a mixed combination of several plates in series and parallel. This forms a matrix with Ns lines and Np columns; we connect the plates in a way to have Np groups of Ns PV. The Np groups are connected in parallel and the Ns are connected in series. This configuration leads to a global model presented in Figure 4.

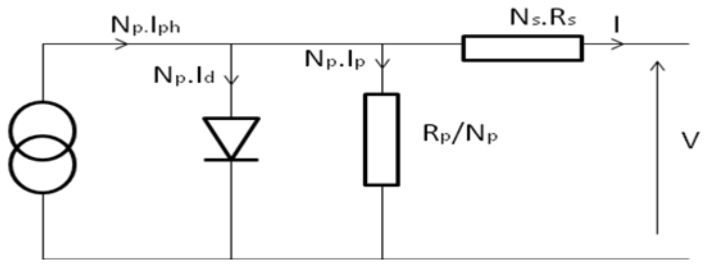

Figure 4. Model of photovoltaic fieled (CPV)

Finally, the expression of the PV field current is written as follows:

$$I = N_p.I_{ph} - N_p.I_d - N_p.N_s\left(\frac{V + I.R_S}{R_P}\right) \qquad (3)$$

2- Model of the boost chopper

The static converter chosen for this application is the boost chopper because of the voltage generated by the photovoltaic field value is lower than the voltage supplied by the DC bus. To achieve this, several structures can be used. Based on the performance criteria, the structure chosen for this study[6], is mounted around a double boost as shown in the figure below.

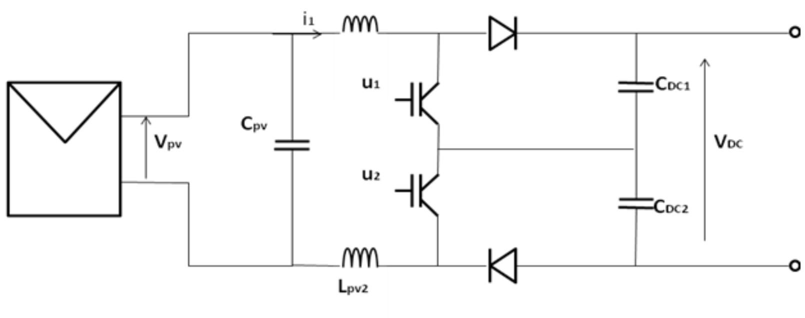

Figure 5: Structure of double boost.

Double boost is composed on two DC/DC converters connected in parallel, the output voltage is the sum of the voltages across each capacitor C_{DC1} and C_{DC2}.

u1 and u2 are the switches controls respectively (IGBT) forming the heart of the structure. Each command is moved from the other one by a half of the chopping period (T / 2)[7]. This configuration reduces the study of the control of the overall system to that of a single switch, since the command of one switch is derived from the other one by a simple shift of T / 2 . Therefore, the differential equations governing the DC/DC converter are [8]:

$$\begin{cases} L.\dfrac{di_1}{dt} = V_{pv} - (1-u)V_{DC} & (4.1) \\ C.\dfrac{dV_{DC}}{dt} = 2(1-u).i_1 - \dfrac{2}{R}.V_{DC} & (4.2) \end{cases} \quad (4)$$

With $L = L_1 + L_2$, $C = C_1 + C_2$ and i_1 and V_{DC} are respectively the input current and the output voltage for the system.

This system is nonlinear, it has a triangular form, where the V_{DC} Output has to follow the reference signal imposed by the DC bus and it is about 800V. Following the backstepping technique a controller is designed in two steps, since the controlled system (4) is a two-order [9][10][11].

- **<u>In the first step,</u>** we set $\varepsilon_1 = V_{DC} - V_{co}$ (5), with V_{co} the voltage setpoint. The derivative of the equation (5) takes the form:

$$\dot{\varepsilon}_1 = \dot{V}_{DC} - \dot{V}_{co} \qquad (6)$$

$$\dot{\varepsilon}_1 = \frac{2(1-u)}{C} i_1 - \frac{2}{RC} V_{DC} - \dot{V}_{co} \qquad (7)$$

Supposing that i_1 is the effective command of the system, and seeking the stability of the first lyapunov function which impose that $\dot{\varepsilon}_1$ takes the form $\dot{\varepsilon}_1 = -K_1 \varepsilon_1$, with $K_1 > 0$ is a design constant. Thus, the control law for the sub system (4.2) is given by:

$$i_1 = \alpha_1 = \frac{-K_1.C.\varepsilon_1 + \frac{2}{R}.V_{DC} + C.\dot{V}_{co}}{2(1-u)} \qquad (8)$$

To ensure the stability of the first sub-system described by (4.2), α_1 is considered as the desired value for i_1.

α_1 is called the first stabilization function.

- **<u>In the second step,</u>** Considering the overall system (4.1) and (4.2), the new error is defined as: $\varepsilon_2 = i_1 - \alpha_1$ (9).

We try, subsequently, to converge its value to zero just as ε_1. Replacing $i_1 = \varepsilon_2 + \alpha_1$ in equation (7) we obtain :

$$\dot{\varepsilon}_1 = -K_1.\varepsilon_1 + \frac{2(1-u)}{C}.\varepsilon_2 \qquad (10)$$

and :

$$\dot{\varepsilon}_2 = \frac{V_{pv}}{L} - \left(\frac{1-u}{L} - \frac{4}{R^2.C.(1-u)}\right).V_{DC} + \frac{C.K_1{}^2.\varepsilon_1}{1-u} + 2.K_1.\varepsilon_2 - \frac{4.i_1}{R.C} - \frac{C}{2(1-U)}.\dot{V}_{co} - \frac{\dot{u}.\alpha_1}{2(1-u)} \qquad (11)$$

Introducing the equations (10) and (11), the derivative of the Lyapunov function shown in equation (12), on the one hand, and on the other hand, respecting the condition of stability of the system imposed by the method ($\dot{V}_2$ must be strictly negative) we obtain the relation (15) :

$$V_2 = \frac{1}{2}\varepsilon_1{}^2 + \frac{1}{2}\varepsilon_2{}^2 \qquad (12)$$

$$\dot{V}_2 = \varepsilon_1.\dot{\varepsilon_1} + \varepsilon_2.\dot{\varepsilon_2} \qquad (13)$$

$$\dot{V}_2 = -k_1\varepsilon_1{}^2 - k_2\varepsilon_2{}^2 + \varepsilon_2\left(k_2.\varepsilon_2 + \frac{2(1-u)}{C}\varepsilon_1 + \dot{\varepsilon_2}\right) \qquad (14)$$

With k1 and k2 two positive coefficients representing design constants.

$$k_2.\varepsilon_2 + \frac{2(1-u)}{C}\varepsilon_1 + \dot{\varepsilon_2} = 0 \qquad (15)$$

Finally we obtain the below equation managing the control of the overall system:

$$\dot{u} = \frac{2(1-u)}{\alpha_1}.\left(\frac{V_{pv}}{L} - \left(\frac{1-u}{L} - \frac{4}{R^2.C.(1-u)}\right).V_{DC} + \left(\frac{C.K_1{}^2}{1-u} + \frac{2(1-u)}{C}\right).\varepsilon_1 + (2.K_1 + K_2).\varepsilon_2 - \frac{4.i_1}{R.C} - \frac{C}{2(1-U)}.\dot{V}_{co}\right) \qquad (16)$$

When the errors represented by ε_1 and ε_2 tend to zero, the form of the differential equation of the command (16) becomes: $\dot{u} = \frac{R.(1-u)^2(V_{pv}-(1-u)V_{co})}{L.V_{co}}$ (17)

We are dealing with a system that has two equilibrium points (solutions): $u_1 = 1$ and $u_2 = 1 - \frac{V_{pv}}{V_{co}}$. Only the solution u_2 that might make sense in the command, since u_1 presents a unified duty cycle. This allows us to write the control law as follows:

$$\dot{u} = \frac{R.(1-u)^2(u-u_2)}{L} \qquad (18)$$

However u_2 is an unstable equilibrium point, as we can see from equation (18) [12]. this is due to the nature of the boost chopper.

2.1- Indirect output voltage control

As the control of the output voltage led to an unstable system. An indirect approach to command is on to control the input current i_1 with a setpoint current I_{co}. The latter can be calculated from Equation 4 in the steady state, it is written as follows: $I_{co} = \frac{V_{co}^2}{R.V_{PV}}$ (19)

Following the same steps described above for calculating the command law, we arrive at the following result :

$$\dot{u} = \frac{1-u}{\alpha}\left[\left(\frac{1-u}{L} - \frac{K_1^2.L}{1-u}\right)\varepsilon_1 + (-K_1 - K_2)\varepsilon_2 - \frac{2}{R.C}V_{DC} - \frac{2(1-u)}{C}i_1 + \frac{L}{1-u}\dot{I}_{co}\right] \qquad (20)$$

With :

$$\varepsilon_1 = i_1 - I_{co} \qquad (21)$$

$$\varepsilon_2 = V_{DC} - \alpha \qquad (22)$$

$$\alpha = \frac{K_1.L.\varepsilon_1 + V_{PV} - L.\dot{I}_{co}}{1-u} \qquad (23)$$

When, this time, the errors represented by ε_1 and ε_2 tend to zero, the form of the differential equation of the command becomes: $\dot{u} = \frac{2(1-u)}{V_{PV}.R.C}((1-u)^2.R.I_{co} - V_{PV})$ (24)

Equation (24) admits three equilibrium points which are : u_1=1, $u_2 = 1-\sqrt{\frac{V_{PV}}{R.I_{co}}}$ and $u_3 = 1+\sqrt{\frac{V_{PV}}{R.I_{co}}}$. only u_2 has meaning in the command, the Equation (24) in the vicinity of equilibrium u_2 becomes: $\dot{u} = \frac{4(u_2-u)}{RC}$ (25).

This solution clearly shows that u_2 is an equilibrium point asymptotically stable.

This command ensures satisfactory results only when the converter model and the DC bus are well known and with fixed parameters. The problem is that these conditions are encountered very little in reality, that's why an adaptive version of the command described above is required.

2.2- Adaptative command

Its mathematical formalism is based on the variable change shown by equation (26) : $\theta = \frac{1}{R}$ (26).

Where R is the resistance model symbolizing the DC bus. Thus the relation (19) becomes:

$$I_{co} = \frac{V_{co}^2}{V_{PV}}.\theta \quad , \quad \hat{I}_{co} = \frac{V_{co}^2}{V_{PV}}.\hat{\theta} \qquad (27)$$

The main aim of this command, which also obeys the same strategy as the previous one, is to find an optimal value for θ to stretch the value of an additional error rated $\tilde{\theta} = \theta - \hat{\theta}$ to zero, while treating the other two errors already studied. $\hat{\theta}$ is the estimated value of θ. the mathematical expressions of the two other errors which have be minimize are obtained by the same procedure as before.

- **In the first step ,** we are interested ,in first time , with the error defined by equation (21) .Thus, the first stabilizing function, denoted α_1 is obtained either: $\alpha_1 = \frac{K_1.L.\varepsilon_1 + V_{PV} - L\dot{I}_{co}}{(1-u)}$ (28)

  Then in a second time, we pay attention on the error described by equation (22).

- **The aim of the second step** is the introduction of the Lyapunov function with three errors ($\tilde{\theta}$, ε_1,ε_2) previously defined in order to properly calculate the command u and the estimated value denoted $\hat{\theta}$. This is translated by the function below. $V = \frac{1}{2}\varepsilon_1^2 + \frac{1}{2}\varepsilon_2^2 + \frac{1}{2.\gamma}\tilde{\theta}^2$ (29) , with γ is a positif coefficient.

let $\dot{V}$ derivated function of V : $\dot{V} = \varepsilon_1.\dot{\varepsilon}_1 + \varepsilon_2.\dot{\varepsilon}_2 + \frac{1}{\gamma}\tilde{\theta}.\dot{\hat{\theta}}$ (30).

Calculation of $\dot{\varepsilon}_1$ and $\dot{\varepsilon}_2$ is based on the equations (21) and (22) and they are :

$$\dot{\varepsilon}_1 = -K_1.\varepsilon_1 - \frac{1-u}{L}.\varepsilon_2 \qquad (31)$$

$$\dot{\varepsilon}_2 = \frac{2(1-u)}{C}i_1 - \frac{2.\tilde{\theta}}{C}V_{DC} - \frac{2.\hat{\theta}}{C}V_{DC} + \frac{\dot{u}.\alpha}{1-u} + \frac{L.\ddot{I}_{co}}{1-u} - \frac{K_1^2.L.\varepsilon_1}{1-u} - K_2.\varepsilon_2 \qquad (32)$$

Introducing (31) and (32) into (30) we obtain:

$$\dot{V}_2 = -k_1\varepsilon_1{}^2 - k_2\varepsilon_2{}^2 + \varepsilon_2\left(k_2.\varepsilon_2 + \frac{2(1-u)}{C}\varepsilon_1 + \dot{\varepsilon}_2 + \frac{2}{C}V_{DC}.\varepsilon_2\right) + \tilde{\theta}(-\frac{2}{C}V_{DC}.\varepsilon_2 + \frac{1}{\gamma}\dot{\hat{\theta}}) \quad (33)$$

Then the insertion of the new expression (32) into (33) leads to the following equation:

$$\dot{V}_2 = -k_1\varepsilon_1{}^2 - k_2\varepsilon_2{}^2 + \varepsilon_2\left((K_1 + K_2)\varepsilon_2 + \frac{2(1-u)}{C}i_1 + \frac{2.\hat{\theta}}{C}V_{DC} + \frac{K_1^2.L}{1-u}\varepsilon_1 + \frac{\dot{u}.\alpha}{1-u}\right) + \tilde{\theta}(-\frac{2}{C}V_{DC}.\varepsilon_2 + \frac{1}{\gamma}\dot{\hat{\theta}}) \quad (34)$$

In the end, respect of the stability condition of the Lyapunov function requires the following:

$$\dot{\hat{\theta}} = \frac{2.\gamma}{C}V_{DC}.\varepsilon_2 \quad (35)$$

$$\dot{u} = -\frac{(1-u)}{\alpha}.\left((K_1 + K_2)\varepsilon_2 + \frac{2(1-u)}{C}i_1 + \frac{2.\hat{\theta}}{C}V_{DC} + \frac{K_1^2.L}{1-u}\varepsilon_1 - \frac{L}{1-u}I'_{co}\right) \quad (36)$$

When, this time, the errors represented by ε_1, $\varepsilon_2$and $\tilde{\theta}$ tend to zero, the form of the differential equation of the command becomes : $\dot{u} = \frac{2.\theta.(1-u)}{C.V_{pv}}(\frac{(1-u)^2}{\theta}I_{co} - V_{PV})$ (37)

Note that the zero of this function is the same as that of the previous function, thus $u_2 = 1 - \sqrt{\frac{V_{PV}}{R.I_{co}}}$,

Hence the expression of the command : $\dot{u} = \frac{4.\theta(u_2-u)}{C}$ (38)

III- SIMULATION AND DISCUSSION

The goal is, using a double-Boost converter controlled by the backsteeping strategy, to adapt the output of a photovoltaic field (CPV) to a fixed voltage of 800V imposed by the DC bus. In order to test the performance of the controller designed previously, we have applied a real signal measured from a (CPV), to a simulated model of a double boost chopper associated to the controller. This simulation is carried out under the Matlab / Simulink environment according to the experimental setting of figure 6.

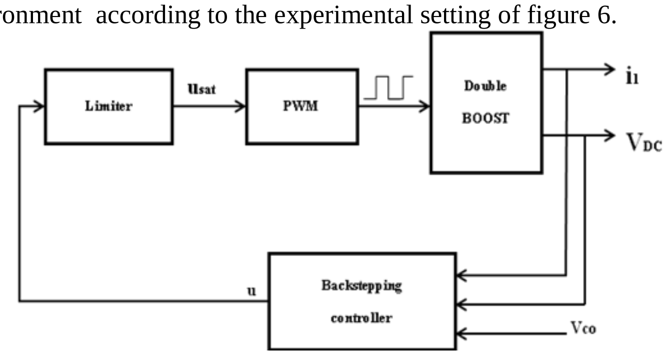

Figure 6: principle of the simulation

The (CPV) is composed of sixteen solar panels in series controlled by an MPPT algorithm (Maximum Power Point Tracking) called Perturb and Observ (P & O) that extracts the maximum power of each panel on the (CPV)[6][13]. The shape of the output (figure 7) of this (CPV), which is applied to our simulated model, was measured and recorded for a period of 10 hours (from 8 hours to 18 hours).

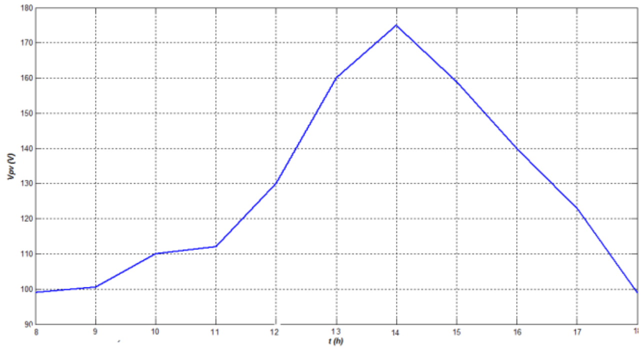

Figure 7 : Input Voltage Vpv

The parameters of the double boost, and the backsteeping controller used , for our simulation studies, are summarized in the table below

Variable	Valeur
C_1, C_2	600µF
L_1, L_2	100mH
F	20 kHz
R	10 Ω
K_1	20
K_2	40
γ	$10e^{-7}$
V_{co}	800V

Table 1 : parameters of the system.

The results of the simulation is shown in Figures 8, 9 and 10.

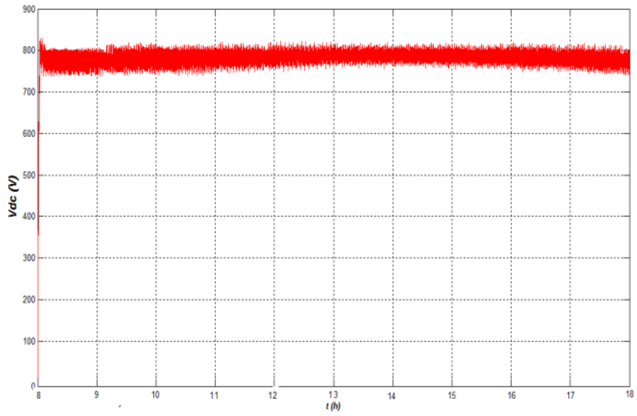

Figure 8 : output voltage of the double boost

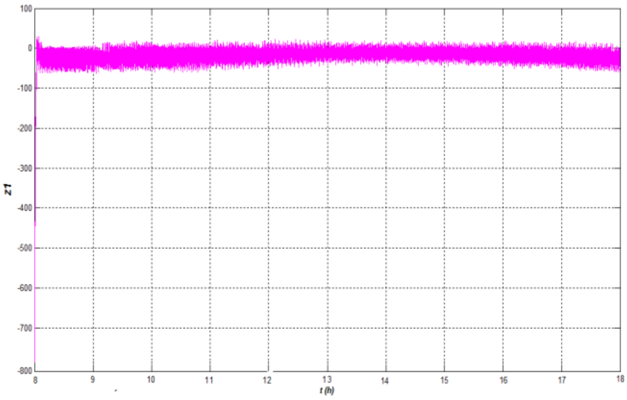

Figure 9 : representation of the evolution of the error z1

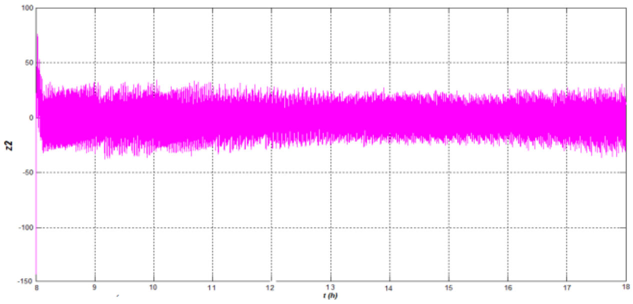

Figure 10 : representation of the evolution of the error z2

Figure 8 shows the voltage output of the chopper, which is the system output, and it is fixed, with a good stability, around the 800 V, despite the variation of the chopper signal input generated by (PV Field). Note that the 800 V is the desired value and represents the DC bus voltage, In addition, as we can see, the oscillatory phenomenon is mastered and understated, see disappeared; compared to the old structure of the chopper presented in [14].

Figures 9 and 10, respectively represent, the shape of errors ε_1 and ε_2 .Note that the actual trajectories converge to the desired trajectory and errors ε_1 and ε_2 tend to zero. These results lead us to consider the system as robust to adverse consequences, caused by changes in the input voltage from the (PV Field) depending on weather conditions.

IV- CONCLUSION AND PERSPECTIVE

Thanks to the adaptive command based on the backsteeping strategy, the voltage output of a double boost chopper is fixed with a good stability to a required value. The chopper is used to adapt and regulate the output of a PV field to a DC bus voltage. The set made up of the chopper, the controller and the PV field represents a mesh in a multisource system of renewable energy. the obtained results are encouraging and we plan to apply the same approach to control and adjust the output of a wind turbine to the DC bus.

REFERENCES

[1] M.A Tankari, 'Système multi-sources de production d'énergie électrique', Thèse Université Le Havre 2010

[2] A. H. Bagdadee 'Using A Battery Storage Wind / PV Hybrid Power Supply System Based Stand-Alone PSO To Determine The Most Appropriate', AJER, Vol.-03, Issue-08, pp.234-242, 2014.

[3] M. Ghamgui, N. Yeganefar, J.P. Gaubert, D.Mehdi '.Backstepping controller approach for a boost DC-DC converter for photovoltaic power, STA 2010

[4] A. Mellit, M. Benghanem and S.A. Kalogirou, 'Modeling and Simulating of a Stand-Alone Photovoltaic System Using an Adaptive Artificial Neural Network: Proposition for a New Sizing Procedure', Renewable Energy, Vol. 32, N°2, pp. 237 - 258, 2007.

[5] S. NDOYE, Ibrahima LY, F.I. BARRO and G. SISSOKO'Modélisation et simulation sous matlab/simulink de la chaine

d'alimentation d'une station relais de télécommunications en énergie solaire photovoltaïque dans une zone isolée du réseau électrique',J .Sci .Vol .9,N°2 2009.

[6] K. Kassmi, M. Hamdaoui and F. Olivié' Conception et modélisation d'un système photovoltaïque adapté par une commande MPPT analogique' ., 2007.

[7] Michel Pinard' Convertisseurs et Electronique de Puissance', thèse, Dunod, 2007.

[8] Guang Yi Cao, «Mathematical Models of Dc-Dc Converters», Journal of Zhejiang University, pp263-270, China, 2009

[9] A.Houari 'contribution à l'étude de micro-réseaux autonomes alimentés par des sources photovoltaïques',Thèse université lorraine,2012.

[10] H. El Fadil., F. Giri, and H.Ouadi .“Adaptive Sliding Mode Control of PWM Boost DC-DC Converters”. In Proceedings of IEEE International Conference on Control Applications (CCA'06), Munich, Germany,October 4-6, 2006, pp. 3151-3156.

[11] H.El Fadil, F. Giri, O. EIMagueri and F.Z. Chaoui, "Control of DC-DC power converters in the presence of coil magnetic saturation," Control Engineering Practice, Elsevier Journal, pp. 849-862, 2009

[12] H.ELFadil and F. Giri, "Backstepping based control of PWM DC-DC boostpower converters," International Journal of Power Engineering, pp. 479-485,2007

[13] P.Vital Rao, Dr.K.R.Sudha, S.Prameela Devi 'Incremental conductance (IncCond) algorithm for Maximum Power Operating Point (MPOP) of Photo-Voltaic (PV) power generation system', AJER, Vol.-02, Issue-12, pp-334-342, 2013.

[14] Z.Sabiri, N. Machkour, Elm. Kheddioui, M.B. Camara, B.Dakyo "DC / DC converters for Photovoltaic Applications- Modeling and Simulations” proceeding conference IRSEC ouarzazate-17-19 october 2014.

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Remediation of Disorders in Writing Ability of the Slow Learners in Vi Standard Taught Under Activity Centred Teaching of English

Rajendran Muthiah

ABSTRACT: The study examines how far the Activity Centred teaching of English is effective in remediating the mistakes committed in written expression in English by the slow learners in Standard VI of a Government High School in Tamil Nadu State in India. Using an already standardised tool prepared to test writing ability in English, a Pre Diagnostic test was conducted to identify the disorders committed by the slow learning pupils. The marks secured by 24 slow learners were recorded. Then activities were introduced in teaching for developing all the four basic skills in English for a month. The single group design was adopted for the study. The Post Diagnostic test was conducted and the marks secured by all the pupils were recorded. The 't' test was applied. It was found that there was significant difference in the remediation of mistakes in the written expression in English.

*KEY WORDS: **Communicative Skills**: Speaking and Writing, the active, productive and expressive skills in language learning are Communicative Skills.*

1. **Disorder in Language**: It is the child's persistent, specific language difficulty
2. **Diagnostic Test**: It is the test which assesses the strengths and weaknesses of a learner.
3. **Remediation**: It is the strategy or re-teaching to tackle deficiency in learners of a second language.
4. **Morphology**: A study of the system of rules for combining the smallest units of language into words.
5. **Orthography**: It is a system of spelling in a language.
6. **Jargon:** words and expressions which are special to a subject in a language.

PURPOSE OF THE STUDY

The purpose of the study is to examine the mistakes committed by the slow learning pupils of VI Standard in their written expression in English and remedy those mistakes after teaching them through Activity Centred Teaching of English.

I. INTRODUCTION

Writing skill is an expressive language ability. This skill begins with toddler's drawing and scribbling as they try to write. Children communicate their ideas and concepts about the world through writing and drawing (Sandra Levey & Susan Polirstok,2011). Children in India learn English as a second language from the Pre K.G class (Kinder Garten) itself. Hand writing books are introduced from L.K.G (Lower Kinder Garten) and when they reach VI Standard, the children with average intelligence practise writing words and sentences in their Handwriting Books. Practice is given to write paragraphs, summaries and essays in Composition Notebooks and in their English Notebooks. The slow learners in a class need special guidance in letter formation and in the mechanics of writing like handwriting, spelling, capitalisation, punctuation, word order and sentence constructions.

A good writer is a good reader. The best technique for rectifying grammatical faults is intensive drilling that is oral drilling and then written exercise. In all the activities introduced under Activity Centred Teaching, the pupils listen to teacher's reading of words and sentences on charts. The pupils are drilled to read next. Then the teacher (researcher) asks comprehension questions. The pupils give oral answers. Then they are asked to write words, phrases and sentences in their Handwriting Books supplied by the teacher. Handwriting can be developed through regular practice with the teacher's attention to the size and shape of the letters and spacing between words etc. Writing is a skill that grows by exercise and not by knowing the rules and meanings of words (Vallabi, J.E, 2013).

Writing involves motor skills such as handwriting and cognitive skills such as arranging ideas (Bose,M.N.K,2005).Even the minimal development of writing requires a high level of abstraction (Thirumalai, S,2003). Activities like the following can be used in the class: 1. Answering questions (textual or general) in writing . 2. Filling in forms such as Bank Pay-in-slips, Money-Order forms, application forms etc. 3. Writing Captions for the pictures cut out of magazines or newspapers 4.Pronunciation Drills to avoid orthographical errors 5. Dictation of words and sentences 6. Controlled Writing, guided writing and free writing stages 7. Workbook exercises (filling in the spellings of words, linking sentences with connectors, rearranging jumbled sentences into a logical paragraph) 8. Recalling and writing the words 9. Writing proverbs from library books 10. Practising simple cursive writing 11. Language Games 12. Delayed Copying Technique 13. Task involved copying and so on.

According to Bacon, “Writing makes an exact man”. Semantic Skills, Syntactical skills and motor skills develop writing skill. In this study, a Pre-Diagnostic Test in Writing was conducted using a standardised tool. For 20 working days, all the activities were conducted to the 24 slow learning pupils in Standard VI , a regional language medium class in Govt. Higher Secondary School, Ponnur Village in 2014 , June. The class teacher himself was trained and instructed by the researcher to conduct all the activities. Handwriting Notebooks and pens were supplied to all the 24 pupils. 12 were boys and 12 were girls. At the end of the month, the Post Diagnostic Test on Writing was conducted to all the pupils at the same time. It was attempted to verify whether the mistakes committed in the pretest were how far rectified.

II. REVIEW OF RELATED STUDIES

Studying on “ Simple ways to Assess the Writing skills of students with learning Disabilities”, Stephen Isaacson of Portland States Univesity (1996) has stated that the Writing Process can be analysed through Observational and self-observational check lists. The writing product can be evaluated on five product factors: Fluency, Content, Conventions, Syntax and Vocabulary. Writing samples should also be assessed across a variety of purposes for writing to give a complete picture of a student’s writing performance across different text structures and genres. From their study on “ Students’ Mistakes and Errors in English Writing: Implications for Pedagogy”, Harunur Rashid Khan and Md. Zahid Akter (2011)
have found that students commit more mistakes in spelling to pronoun. Their Sentence Level mistakes indicate a poor command of syntactic accuracy. Word and Sentence level mistakes appear to be quite alarming underpinning innovative means of teaching to improve current state of student writing in English at their primary and secondary level.

Nirmala,Y,(2013) studied on “ Teaching Writing Using Picture Stories as Tool at the High School Level”. The learners became familiar with the genre of story writing, use of punctuation, usage of tenses, prepositions and so on. This was the result of a short-term teaching session. If such teaching would be imparted for a longer period, undoubtedly their writing skill will improve substantially.

Kelu (1990) worked on ‘ Some Socio-Familial Correlates of Basic
Language Skills in the Mother tongue of Secondary School Pupils of Kerala’ and found that (I) parental income, occupation and education, socio-economic status and socio-familial status were positively correlated with listening comprehension, handwriting speed & vocabulary, (ii) Achievement in hand writing quality was facilitated by parental income, parental occupation, family acceptance of education facility for learning at home and total socio-familial status, (iii) Socio-familial status, cultural level of neighbourhood, family acceptance of education, learning facilities at home and parental occupation were found to be significantly differentiating high, average and low achievers in language skills .

Chidambaram, K,(2005) made a study on the Learning Process of English by Higher Secondary Students with reference to Dharmapuri District in Tamil Nadu. Writing is the process of conveying one's thought through written symbols. It is a difficult process. The writing skill includes:

ability to shape the letters,

ability to convert the ideas using the written symbols,

ability to write without grammatical errors,

ability to present and organize in a readable fashion, etc.

All these four skills of language are the bases for communication. Hence, they form the base for the language proficiency-the ability to use the knowledge in different tasks. Make adjustment and amendment to avoid errors in writing; students may practise to write stories, and the errors in the written items may be spotted. Then the reasons for the occurrence of errors should be indicated to the students. Further, editing training should also be given to the students. To avoid orthographical errors, appropriate pronunciation drills should be given to the students. By preventing the L1 sounds in their L2 pronunciation, the spelling errors can be minimized in the learners writings .

Sakthivel, K,(2014) studied on “Influence of Multimedia Technology in English Language Teaching” and found that at present the decreased students’ reading competence has become a major concern for reason that textual words are replaced by sound and image, handwriting by keyboard input. The over-application of multimedia technology would worsen the situation. The Computer Screen can’t Substitute the Blackboard. Most of the teachers take the computer screen as the blackboard. They have input exercises, questions, answers and teaching plans into the computer and display them step by step, without taking down anything on the blackboard or even the title of a lesson. It is known that teachers are supposed to stimulate situations based on teaching and make the students to communicate in English. In addition to this, traditional writing on blackboard is concise and teachers can continue the practice .

Sunkyoung Yoon, et al (2002), studied on “The Evolution of Asian ESL students perceptions of Grammar: Case Studies of nine learners” and arrived at the following conclusions: Grammar is not important for general communication but important for academic purpose. Grammar is not important for Speaking but important for Writing.

Trudy Wallace et al (2004) studied on “Teaching Speaking, Listening and Writing” and concluded that note-taking, identifying a central idea, outlining, drafting and editing are writing acts. Computers can be both harmful and helpful in writing and learning to write. Students can be encouraged to write by saying one in ten million can attain the status of a great writer who is long influential and long remembered. Direct contacts with professional writers such as novelists and news reporters may be inspirational. Inquiry and discovery also inspire great writing .

Gay Ivey and Marianne I. Baker (2004) studied on “ Phonics Instruction for Older Students? Just Say No” and reached the conclusions: Some struggling readers need to think more about the structure of words. An interactive and connected approach, such as word study, enables students to manipulate key words from their reading and begin extending generalizations to unfamiliar words, thereby strengthening not only reading skills but also writing and spelling skills. Instruction to facilitate word knowledge begins with high-interest, easy reading and pulls high-utility words directly from the pages of students' current texts .

III. SIGNIFICANCE OF THE STUDY

With the invention of Smart phones, tablets, laptops and so on, practice of writing has gone down in schools. Writing is vital for learning and for future success in life. Many children struggle to meet the standards expected by school and those needed for later life. In most of the schools, Copy writing books are not used. The teachers should change strategies to teach writing. Word-forming, Sentence combining, Summarization, Writing down the central idea of a paragraph, Fill- in with responding expression in a conversation, etc must be taught at high school level. Students should be enabled to monitor and manage their own writing. Peer group writing helps them get immediate feedback. In each peer group, there should be one bright student and one dull learner. Less- skilled and more -skilled writers learn from each other. There is chance for corrosion and erosion of one’s voice (speaking skill)
saved in a Compact Disc. But the written words of great writers live for ever inspiring and enlightening the oncoming generations. So without quoting any reason, the teachers and the pupils together initiate steps to strengthen their writing skill. Instead of thrusting cumbersome tasks for writing, interesting activities which teach all the skills in an integrated manner should be introduced .

OBJECTIVES

To identify the disorders of the slow learning pupils in written English expression and involve them in activities of learning English for remediating those
disorders.

HYPOTHESIS

There is no significant difference in the remediation of the disorders in writing ability in English of the slow learners in VI Standard .

METHODS AND MATERIALS

Activity Centred Teaching of English is used in an Experimental Study.

SAMPLE

24 pupils of which 12 each are boys and girls in VI Standard, Tamil Medium Class in Government Higher Secondary School, Mamandur,Thiruvannamalai District. They were in the age group 11+.

DESIGN

One Group Design

T_1 ------------------------ T_2 Mean Gain = Mean of Post test (T_2) – Mean of Pretest (T_1)

TOOLS

1. A Verbal Intelligence Test 2. A Diagnostic Test in Writing Skill

STATISTICS

To study the significance of the difference in means between the Pretest and the Post test means of a small sample (Single Group) due to the effect of a method of teaching, the independent variable, where N= 24

Pretest Scores	Post test Scores
Mean, $M_1 = \Sigma X_1 / N$	Mean, $M_2 = \sum X_2/N$
$S.D = \sqrt{\sum x_1^2 / N}$	$S.D = \sqrt{\sum x_2^2 / N}$
Mean Deviation, $x_1 = X_1 - M_1$	$x_2 = X_2 - M_2$
$S.E_{M1} = S.D / \sqrt{N} = \sigma_{M1}$	$S.E_{M2} = S.D / \sqrt{N} = \sigma_{M2}$

$$S.E_{DM} = \sqrt{\sigma_{M1}^2 + \sigma_{M2}^2}$$

$$t = M_1 - M_2 / S.E_{DM}.$$

Significance of t-value is found out at 0.01 levels for df = 24-2

PROCEDURE

Testing of Intelligence

Intelligence Quotient (IQ) is the ratio between Mental Age and Chronological Age, multiplied by 100. If a child of 12 years old could solve problems which 50% of nine-year olds could solve, his IQ would be (9/12) x 100. That is 75. So he is a Slow Learner.

Wechsler's scales have subscales (ten basic sub-tests) to test different abilities which make intelligence. The sub-scales covering the age range 5-16 are as follows:

The first five are "Verbal Scale" and the last five are "Performance Scale". **1.** General Information **2.** General Comprehension **3.** Arithmetic **4.** Similarities **5**. Vocabulary **6.** Picture Completion **7**. Picture Arrangement **8.** Block Design **9.** Object Assembly **10**. Coding.

Spearman maintains that in the measurement of any ability, there enter two independent factors : 1. General Factor 2. Specific Factor, which varies within one individual from one ability to another. According to the " Multiple Factor" theory of intelligence, a number of more or less general or group factors, such as linguistic ability, mechanical ability, and memory make their relatively independent contribution to " General Intelligence".

Identification of Slow Learners

The Content of Verbal Intelligence tests are loaded with varieties of verbal materials such as,

1. Vocabulary Tests (The subject has to give the meanings of words or phrases)
2. Memory Tests (This includes recall and recognition type of items)
3. Comprehension Tests (The subject has to understand and react to given situations)
4. Information Tests (The subject's knowledge about the things around is tested)
5. Association Tests (The subject has to point out similarities and dissimilarities Between two or more concepts)
6. Reasoning Tests (The subject's ability to reason logically, analytically, synthesisingly, inductively or deductively)

Verbal tests are linguistic in nature. The subjects should have adequate knowledge and skill of the language which is used in the test. As these tests give importance to 'Verbal Intelligence', these tests are nicknamed as tests of 'Scholastic Aptitude Verbal Tests'. Verbal tests are popular because a person's expression of thoughts and ideas in his verbal and written responses, power of reasoning and abstract thinking can be reasonably measured.

In the beginning of the twentieth century, children were classified according to their 'rate of learning',as:

I.Q between 110 and above	...... Superior
90 to 110	.......Average
80 to 90	.......Dull/Normal
70 to 80	.......Borderline
Below 70	.... Feebleminded

In the past, psychologists held that slow learning was directly related to intellectual ability. But recent studies reveal that heredity alone is not responsible for the backwardness of the child. Environment contributes significantly to the scholastic achievement of the child. The low achiever is a slow learner and he finds it difficult to keep pace with the normal child in his school work. All Promotion to the next higher class, free Admission by private study certificate under Education For All Scheme and unfilled vacancies of teachers for years together enhance the percentage of slow learners in each class up to 30%.

Schools should have plenty of extra-curricular activities and teach various art forms, which activates the brain and improve students' performance. But in most of the Government-run schools, there are no skilled coaches to games and sports, no music teachers, tailoring teachers, craft teachers, bakers and caterers for attracting the slow learners. Learning experience in classrooms has activities like explaining, memorising, reciting, repetition of the answers and writing them in notebooks. The curriculum is designed for the above average learners and the syllabus is restructured to produce results in School final classes. Schools fail to identify the slow learners at an early stage well before the VIII standard and take remedial steps to activate their brains.

Slow learners show a characteristic weakness in thinking capacity, finding out relationships, similarity, familiarity, reasoning, observing characteristics of objects, poor development of concept, language, verbal ability, making sentences and number concepts. They are poor in forming abstractions specifically in non-verbal tasks such as matching shapes, drawing figures, completing rigs and puzzles, remembering patterns and so on. The children should therefore be taught using thinking and problem- solving practical activities.

Slow Learners have to go over material more times before it is fixed in their minds, and more frequent revision is required to prevent forgetting. They have poorer powers of retention than average children. Their weakness in attention causes poor memory. They are restless and distractible. Failures in a subject make them dislike it. To improve their memory, the teacher has to make meaningful associations, links and generalisations. For example to teach the word, 'night', the teacher first makes the sequence of letters: n-i-g-h-t. The teacher then makes visual display, speaks, asks the students to write it down, links it with 'light', 'sight', 'fright' etc. Words must be taught by suitable actions. The slow learners can learn by understanding and then they need more repetition, revision, and practice to retain. Language is essentially a skill like singing, dancing, swimming, painting , drawing, writing etc. These skills are performed after acquiring them. When these skills are learnt, mistakes are committed and rectified. Rectification of mistakes in a language are called remediation. Diagnostic evaluation reveals specific mistakes of a student in a subject.

In this study, it is attempted to identify the slow learners psychologically from an entire class consisting more than a hundred students. A Verbal Intelligence Test with twenty questions each on the Classifications such as Verbal Oddity, Verbal Similarity, Similar-Opposite Words, Verbal Analogy, Scrambling of Word Order and Sentence, Completion(Completion Analogy) were framed choosing the vocabulary from the text books of III, IV, V and VI Standards. Some of the words from the Pre K.G, LKG and UKG books were also collected. Children come to acquire a lot of vocabulary through television now-a-days.

If Practical Intelligence Kits are used to identify the slow learners whose I.Q range fall between 70 and 90, It will take months to complete the test for all the 100 children in VI Standard by a single researcher. Further the welfare governments all over the world are not afford to buy Practical Testing Kits to all the schools in developing countries. In this digitalised world, a teacher in a remote village can construct Verbal Intelligence test in English or in Mother Tongue, conduct the test in an hour's time, correct the scripts in an hour, separate the scripts which have scores/marks between 3 and 30, use statistical formulae to work out I.Qs and identify the slow learners whose I.Qs are between 70 and 90 in the forenoon session or in the afternoon session of the school and immediately he can start the intervention or remedial teaching programmes. In this study, the standard deviation of the normal distribution of the marks of all the 100 students was 15. The pupils whose raw scores out of 100 fell between 5 and 25 have been identified as slow learners. Other Classifications such as Sentence Completion, Proverbs, Logical Reasoning, Syllogisms, Inferential Conclusions, Syntactic Inference and Pedigrees were avoided in the construction of the intelligence test. The test then would be very difficult to VI Standard children and and they will hate to appear for tests thereafter.

The following formulae were used to find out Item Difficulty, Discrimination Value, Z-score and the I.Q score.

Item Difficulty / Item Difficulty Index = R x 100 / T,
Discrimination Value = $R_u - R_L$ / 1/2T

$$\text{Z Score} = \frac{\text{Raw score} - \text{Mean score}}{\text{Standard Deviation}} = \frac{\bar{X} - M}{\sigma}$$

I.Q. Score = σ z + 100

An Intelligence Test must not only be Objective, Reliable, and Valid, but it must also enable the user to compare different children, irrespective of school or locality or test used. When the test enables the user/researcher/teacher to do this, it is said to be standardised. The researcher has a standardised instrument to test the linguistic Intelligence of children in VI Standard.

Items with Difficulty Value 0.2 to 0.8 and Discrimination Index 0.2 and above were chosen

TABLE 1: Calculation of I.Q Scores from Raw Scores of the slow learners

from the Try-out Test of Intelligence given to Pupils in VI Standard

Govt. Higher Secondary school, Mamandur.Thiruvannamalai Dist.

Serial Number	Raw Scores(X) in descending order	Z-Score= X – M/ σ	I.Q Score= 15z + 100= x + 100	T-Score= 10z + 50
75	25	-0.67	90	43
76	24	-0.73	89	43
77	23	-0.8	88	42
78	23	-0.8	88	42
79	22	-0.86	87	41
80	18	-1.13	82	39
81	15	-1.13	80	39
82	15	-1.13	80	39
83	15	-1.13	80	39
84	15	-1.13	80	39
85	14	-1.4	79	36
86	14	-1.4	79	36
87	14	-1.4	79	36
88	14	-1.4	79	36
89	13	-1.46	78	35
90	13	-1.46	78	35
91	12	-1.53	77	35
92	12	-1.53	77	35
93	12	-1.53	77	35
94	11	-1.6	76	34
95	9	-1.73	74	33
96	8	-1.78	73	32
97	7	-1.86	72	31
98	5	-2.0	70	30

Out of the 30 slow learners present in VI Standard, only 12 boys and 12 girls were selected to make the sample balanced. When the Standard Deviation of the distribution of the scores in the intelligence test lies between 12 and 18, the formula , I.Q = σz+100 can be used to identify the slow learners whose I.Qs fall between 70 an The tool to test the writing ability was taken 24 copies. All of them were arranged to sit in a hall. The Pre-Diagnostic test in writing was conducted in a peaceful atmosphere. If the students wanted clarifications in their mother tongue,l about the instructions, translation into mother tongue was made. The slow learners do not use punctuation marks like comma, exclamation mark, apostrophe and quotation marks. Most of them fail to fill in right letters in the given blanks in a word. In identifying phrase and clause, they need total re-teaching. Some students score some marks in prepositions. They score marks in filling the blanks with adjectives. In using articles, they show average performance.

A few students write the negative forms of verbs correctly, when the meaning of the question was translated in to their mother tongue. They need teaching about transitive and intransitive verbs. They are poor in identifying the pattern/structure of the sentence. In identifying the tenses (only three simple tenses) of the sentences, they are good. In giving the opposite word, odd word, and rhyming word, they are a little better. Once the meaning of the question is said in their mother tongue, they do the exercises easily.

These 24 pupils were separated from the class in their English period and told to sit in a separate room. The researcher taught them for a month introducing activities to develop writing ability. All of them were supplied with a handwriting notebook to practise writing at home and in the class. Every day, they wrote words or phrases or sentences in the Handwriting Notebooks. The researcher corrected the notebooks by keeping the pupils beside him during the lunch interval. Simple Cursive Writing was practised. At the end of the month, the Post Diagnostic Test was conducted for all of them at the same time. Means of the pretest and post test were found and the mean difference was tested for significance in the remediation of mistakes. Several activities involving writing exercises were given .

A few of the exercises are given here.

I. Match each word with a word from the box and write it in your Handwriting Book.

1. Thunder	2. Torrential	3. Down
4. Heat	5. Hail	6. Snow
7. Gale		

Ex: 5. Hail stones

Stones drift storm rain wave warning pour

II. Show up Flash cards which have opposite words of the underlined words. and write them in Copying notebook. (Students are supplied with flashcards)

1. It is a <u>huge</u> mountain 2. It is very difficult to <u>conquer</u> China.
3. Don't donate <u>dirty</u> clothes. 4. He is a very <u>kind</u> minister
5. I have no <u>aversion</u> to anybody. 6. He is an <u>obedient</u> boy.

III. Match functions and expressions and write them down in your Notebook.

1. Seeking Permission	a) May be.
2. Expressing possibility	b) By all means
3. Granting Permission	c) Do you mind me taking this seat?
4. Politeness	d) Do you mind me taking this seat?
5. Parting	e) Could I help you please?

These kinds of activities and similar ones were introduced in the class.

Table 2: Difference in Mean Scores between the Pretest and Post test Scores

Test	N	Mean	σ	Obtained 't'	Table't' at 0.01 level	Significant or Not Significant
Pretest	24	13.6	2.34	9.02	2.82	S
Post test	24	20.1	2.64			

There is significant difference in the mean gain of the slow learners in VI Standard (Tamil Medium of Instruction). There is better remediation of mistakes in the speaking ability of the slow learners after teaching under Activity Centred Approach to teach English.

The difference in mean scores is graphically explained here.

Pre test Mean	Post test Mean
13.6	20.1

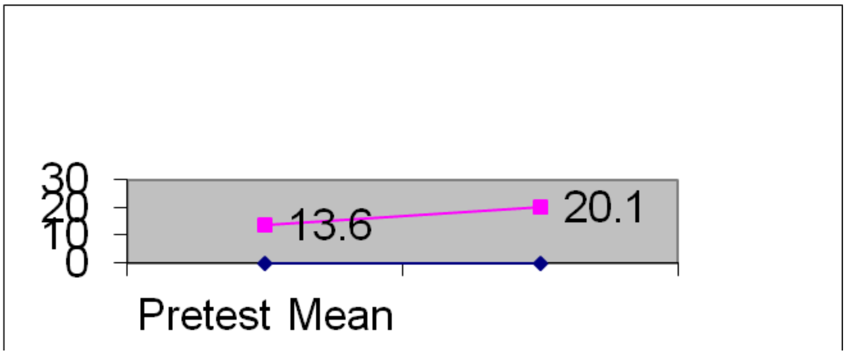

Figure 1: Difference in remediation of mistakes in the writing skill of the slow learners in VI standard.

IV. DISCUSSION

There was good improvement in using the Punctuation marks in the post test. In spelling exercise, groups of words with similar affixes were taught together. Students use their memory skills for mastering the spelling of words as they have this habit in learning their first language. In understanding the phrases and clauses, in the use of prepositions, adjectives, articles, negative forms of verbs, transitive and intransitive verbs, in understanding the tenses, patterns of sentences, there was improvement. Forming compound words was difficult for them. Arranging the letters in meaningful words is difficult for them. In writing a second language, they have to put down on paper the conventional symbols of the writing system that represents the utterances they have in mind and also they have to select and organise ideas, facts and experiences. Writing is a complex thinking process. The mechanics of writing, at the beginning level is taught in three stages, namely Manipulation, Structuring and Communication. Manipulation consists in the psychomotor ability to form the letters of the alphabet. At the pre-primary and primary levels, the second language learners practise cursive writing, upper and lower case letters, alphabetizing, basic spelling patterns of English, rules for capitalisation and word and sentence punctuation. In the stage of Structuring, the learners understand how words combine to form sentences and the rules which govern them. They organise the letters into words, words into phrases and sentences. In the Communication stage, the learners are able to select the appropriate structures and vocabulary to produce simple and correct paragraphs. Writing should be performed on a daily basis. At the high school level, there should be a lot of writing practice. Practice alone will make the ESL learners perfect in life.

Stephen Isaacson (1996) has stated that the writing process should be analysed
Through self-observation check list for five factors: Fluency, Content, convention, Syntax and Vocabulary. The pupils of VI Standard must be guided to correct their mistakes themselves in spelling, punctuation, word-order and so on by consulting the textbook, grammar book or the dictionary.

Harunur Rashid Khan and Md. Zahid Auter (2011) have suggested that innovative methods should be used to remediate disorders in writing. Activity Centred Method is the suitable one for remediating the disorders in writing of the slow learners. Nirmala, Y (2013) has suggested to use picture stories to remediate disorders in punctuation, use of tenses, preposition and so on. Kelu (1990) suggested that parental occupation, education and status of the family influence the handwriting, listening comprehension and vocabulary of the pupils. The teachers of English in remote villages and hills must be supported financially and by frequent refresher courses for passing on the new knowledge to their students. Chidambaram, K (2005) has stated that writing skill involves the abilities to shape the letters, convert the ideas using the written symbols, write without grammatical errors and to present and organise in a readable fashion. Pronunciation drills should be given to avoid orthographical errors. Sakthivel K(2014), has warned that the overuse of multimedia technology by teachers and students have affected adversely the handwriting and spelling of the students. Sank Young Yoon et al (2002) have found that grammar teaching is more important for writing than for speaking. At present, students are drilled in saying conventional expressions for certain functions. Too much grammatical definitions and jargons are not given in teaching.

V. RESULT

There is significant difference in remediation of disorders in the writing ability of the slow learners after teaching several writing exercises under Activity Centred Teaching of English.

VI. CONCLUSION:

Meaningful repetition of the exercises given in the tool by the teacher and the students will take up pupils of the slow learning category to the next higher level, the average category. Some of them may be climbing up the ladder to reach the superior category.

REFERENCES

[1]. Levey Sandra, and Polirstok Susan,(2011), Language Development, Sage Publications, New Delhi-110044. Pp243-270
[2]. Vallabi, J.E,(2013), Teaching of English, Neelkamal Publications Pvt.Ltd. New Delhi-110063, pp 29-31 & 308 to 333.
[3]. Bose, M.N.K,(2005), A Text Book of English Language Teaching for Indian
[4]. Students. New Century Book House (P) Ltd.Chennai-600098. Pp57-59,73-75
[5]. Thirumalai, S(2003), " Speech and Writing". www.languageinindia.com
[6]. Stephen Isaacson of Portland States Univesity (1996), " Simple ways to
[7]. assess writing skills of students with learning disabilities".
[8]. Harunur Rashid Khan and Md. Zahid Akter (2011) from East West University,
[9]. Nirmala, Y,(2013), " Teaching Writing Using Picture Stories as Tools at the High School Level: The Movement from Othe Regulation to Self Regulation". The English and Foreign Languages University, Hyderabad. " Language in India", Volume 13:2, Feb 2013.
[10]. Robert J. Gregory(2006), " Psychological Testing". Pearson Education,Delhi-92. Pp 183-313.
[11]. Nagarajan, K and Srinivasan, R(2003). Research Methodology in Education, Ram Publishers, Chennai-93.pp 122.141
[12]. Bhandarkar, K.M, (2007), Statistics in Education, Neelkamal Publications , Hyderabad, pp 247-259
[13]. Harmer, Jeremy.,(1983), The Practice of English Language Teaching. Longmans, London. p p. 29 – 197
[14]. Anne Anastasi and Susana Urbina**(2003),** Psychological Testing7th edition.New Delhi: Prentice Hall of India Pvt.Ltd.pp 64-67
[15]. Chidambaram, K(2005), " A Study on the Learning Process of English by Higher
[16]. Secondary Students with Special Reference to Dharmapuri District in Tamil Nadu". Language in India. Volume: 5. http://www.languageinindia.com/dec2005/chidambaramthesis/htm/
[17]. Sakthivel*, K,(2014), "*Influence of Multimedia Teaching in EL Teaching" http://www.slideshare.net/sakthivelkrishnan/Influence of Multimedia- technology-in E-L-Teaching" Kelu,(1990), " Some Socio-familial Correlates of Basic Language Skills in the Mother Tongue of Secondary School Pupils of Kerala", 10-chapter 2.pdf. 'Theoretical Foundations of Reading"
[18]. Yoon, Sunkyoung, Hoshi Kyoko and Zhao Hong, (The Evolution of Asian ESL
i. Students' Perceptions of Grammar: Case Studies of 9 Learners".
ii. Carleton Papers in Applied Language Studies, Carleton University,
iii. April 2004.
iv. 6_The_Evolution_of_Asian_ESL_Students_Yoon_Hoshi_Zhao.pdf
[19]. Trudy Wallace, Winifred E. Stariba and Herbert J. Walberg,(2004), "Teaching
a. Speaking, Listening and Writing", International Academy Education,
b. Curtin University of Technology in Perth, Australia.
[20]. http://www.Curtin.edu.an/curtin/dept/smec/iae
[21]. Ivey, Gay and Baker, Marriane," Phonics Instruction for other Students? Just
i. Say No". "*2014 ASCD Conference on Educational Leadership*",
ii. Orlando Fla, Volume Number 61, pp 35-39.

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Availability and Utilization of Ict Facilities for Teaching and Learning of Vocational and Technical Education in Yobe State Technical Colleges.

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ABSTRACT : *This study examines the availability and utilization, the benefits and challenges of ICT facilities in teaching and learning vocational and technical education in Yobe state technical college. Descriptive survey design was used for the study. The study revealed that ICT facilities were lacking in technical colleges. Teachers and Students exposure to ICT facilities was low. The study revealed that some of the benefits of using ICT in technical college include making teaching and learning interesting; helping teacher to be up to date in enhancing the quality of work of both teachers and students. Despite these benefits, the study revealed some of the challenges facing ICT as: irregular power supply; inadequate computer literate teachers; inadequate ICT facilities. It was therefore, recommended that Yobe state government should increase the funding of education sector to cater for ICT programme in technical colleges and there should be periodic training for teachers on ICT computer skills acquisition.*

I. INTRODUCTION

Information and Communication Technologies (ICT) have become key tools and had a revolutionary impact on how we see the world and how we live. Today, the place of ICTs in education and the world in general cannot be undermined. Modern day businesses are conducted and facilitated through the use of telephones, fax machines and computer communication networks through the internet. The phenomenon has given birth to the contemporary e-commerce, e-government, e-machine, e-banking and e-education among others.

According to Bamidele (2006), ICT is a revolution that involves the use of computers, internet and other telecommunication technology in every aspect of human endeavour. Ozoji in Jimoh (2007) defined ICT as the handling and processing of information (text, images, graphs, instruction, etc) for use, by means of electronic and communication devices such as computers, cameras, telephone. Similarly, Ofodu (2007) also define ICT as electronic or computerized devices, assisted by human and interactive materials that can be used for a wide range of teaching and learning as well as for personal use. From these definitions, ICT could be defined as processing and sharing of information using all kinds of technologies for the manipulation and communication of information.

Aribasala (2006), posited that ICT are increasingly playing an important role in organizations and in society's ability to produce, access, adopt and apply information. They are however being heralded as the tools for the post-industrial age and the foundations for a knowledge economy due to their ability to facilitate the transfer and acquisition of knowledge. Stressing the importance of the use of ICT in schools, Olorunsola (2007), posited that through ICT, some educational needs have been met; it changes the needs of education as well as the potential processes.

Looking at the role of education in the national building and the population explosion in technical colleges these days, the use ICT in the teaching and learning process becomes imperative. This is because its adoption by teachers will enhance effective teaching. Issues like good course organization, effective classroom management, self-study collaborative learning, tax oriented activities, and effective communication between the actors of teaching-learning process and research activities will be enhanced by the use of ICT based technology. Teaching and learning has gone beyond the teacher standing in front of a group of pupils and disseminating information to them without the students' adequate participation (Ajayi, 2008).

The various ICT facilities used in the teaching and learning process in technical colleges according to Babajide and Bolaji (2003), Bryers (2004), Bamidele (2006) and Ofodu (2007) include; radio, television, computers, overhead projectors, optical fibres, fax machines, CD-Rom, internet, electronic notice board, slides, digital multimedia, video/VCD machine and so on. It appears some of these facilities are not sufficiently provided for teaching and learning process in the technical colleges. This might account for why teachers are not making use of them in their teaching. According to Ajayi (2008) the use of these facilities involves various methods which include systematized feedback system, computer-based operation/network, video conferencing and audio conferencing; internet/worldwide websites and computer assisted instruction. It should be stressed that the effective use of the various methods of ICT in teaching and learning depends on the availability of these facilities and teachers competences in using them.

There are developments in the Nigerian education sector which indicate some level of ICT application in technical colleges teaching and learning processes. The Federal Government of Nigeria, in the National Policy on Education (Federal Republic of Nigeria, 2004), recognizes the prominent role of ICTs in the modern world, and has integrated ICTs in to education in Nigeria. To actualize the goal, the National Policy on Education (2004) states that, government will provide basic infrastructure and training at the primary level, at the junior secondary level, computer education has been made a pre-vocational elective and is a vocational elective at the senior secondary level.

Vocational and technical education as a discipline requires adequate instructional facilities such as the ICT so as to make teaching and learning more effective. Use of ICT will also simplify abstract concepts through relevant examples by using internet facilities. It is evident that we live in a time of rapid technological change which modernized every aspect of our lives; be it social, physical and intellectual. These technological changes also affected the way we teach and learn.

To improve technical education is essential to the creation of effective human capital in any country (Evoh, 2007). The need for ICT in technical colleges cannot be overemphasized in this technology-driven age, every one requires ICT competence in order to gain and share information. Organizations are finding it's very necessary to train and retrain their employees to establish or increase their knowledge of computer and other ICT facilities (Adomi and Anie, 2006; Tyler, 1998). This calls for early acquisition of ICT skills by the technical colleges students.

The ability to use computers effectively has become an essential part of every one's education. Skills such as book keeping, clerical and administrative work, and science/technological disciplines now constitute a separate sets of computerized practices that form the core IT skills package; spreadsheets, word processors, database, CorelDraw, etc. (Raffel and Whitworth) (2002). The demand for computer/ICT literacy is increasing because employees realize that computer can be a threat to their jobs, and the only way to enhance job security is to become computer literate with the high demand for computer literacy, the teaching and learning of these skills is a concern among professionals (Ochroye, n.d.). ICT application will prove beneficial in improving educational system and giving students a better education. A technologically advanced workforce will lead to ICT growth in Yobe State technical colleges, with the potential to improve educational performance, telecommunication, media communication and skilled ICT professionals who will be well-equipped to solve ICT problems in the state and the country at large. The government said it will provide necessary infrastructure and training for the integration of ICTs in technical colleges system.

Okebukola, (1997), cited by Aduwa-Ogiegbaen and Myamu, (2005), concludes that computer is not part of classroom technology in more than ninety (90) percent of Nigerian public schools. This implies that the chalkboard and textbook continues to dominate classroom activities in most Nigerian secondary schools.

The Federal Ministry of Education has launched an ICT-driven project known as school net www.snng.org (Federal Republic of Nigeria, 2006; Adomi 2005; Okebukola, 2004), which was intended to equip all schools in Nigeria with computers and communication technologies. In June 2003, at the African submit of the world economic forum held in Durban, South Africa, the New Partnership for African Development (NEPAD) launched the e-schools, initiative, intended to equip all African high schools with ICT equipment including computers, radio and television sets, phones and fax machines, communication equipment, scanners, digital cameras and copiers among other things. It is meant to connect African students to the internet and to impart ICT skills to young Africans in the primary, secondary and technical colleges, to harness ICT to improve, enrich, and expand education in African countries (Aginam, 2006).

Various ICT tools are used in teaching and learning process in technical colleges. For this research, as an example, Computer Aided Instruction (CAI) was used as an example of ICT tools used in teaching.

Computer Aided Instruction (CAI) is a self-learning technique, usually offline/online, involving integration of the student with programmed instructional materials. It's an interactive instruction technique where a computer is used to present the instructional material and monitor the learning that takes place. Opportunities provided by CAI in the classroom are in the area of drill and practice, tutorials, simulations, demonstrations, designing, data collection and retrieval, analysis of games, which are essential competences for technical teachers.

As technology improves, educational capability increases correspondingly. The emergence of inexpensive computer technology and mass storage media, including optical video disc, compact disc, has given instructional technologist (teachers) better tool with which to work. Computer compact disc and flash memory are used to store large amount of information (data), such as encyclopedias or motion pictures. A teacher who is interested in a particular topic-say semi-conductor devices, can first scan an electronic encyclopedia, and then view at the touch of a button. All these can be achieved through the use of Computer Aided Instruction.

According to Ajayi (2008), the effective utilization of ICT in teaching and learning depends on the availability of these facilities and teachers competence in using them. Observation has shown that there are no functional ICT facilities in most technical colleges in Yobe state and this hampers the teacher ability to use them for teaching and learning. Also lack of adequate computer literate teachers, irregular power supply and inadequate funding are another set of obstacle militating against effective utilization of ICT facilities in teaching and learning of vocational and technical education in Yobe state technical colleges. Therefore there is need to address such problems by providing adequate ICT facilities and training needs of the teachers to effectively utilize it in teaching and learning process.

Research Question

The study answered the following questions:

i. To what level are the ICT facilities available for teaching and learning of Vocational and technical education in Yobe state technical colleges?
ii. To what level are the teachers and students in technical colleges use ICT facilities in teaching-learning of vocational and technical education?
iii. What are the perceived benefits of ICT in teaching and learning in technical colleges?
iv. What are the challenges facing ICT facilities in technical colleges in Yobe state?

Hypotheses

The following hypotheses were tested at 0.05 level of significance:

HO_1: There is no significant difference in ICT facilities available for teaching and learning of Vocational and technical education in Yobe state technical colleges.

HO_2: There is no significant difference in the teachers and students in technical colleges use ICT facilities in teaching-learning of vocational and technical education.

HO_3: There is no significant difference in the perceived benefits of ICT in teaching and learning in technical colleges.

HO_4: There is no significant difference in the challenges facing ICT facilities in technical colleges in Yobe state.

Research Design

The study employed descriptive survey design. According to Sambo (2005), a survey research design is one in which group of people or items are studied by collecting and analyzing data from only a few people or items considered being representative of the entire group.

The instrument for data collection is a self-designed questionnaire tagged "ICT in technical colleges, (ICTTC)". The instrument was validated by research experts in both Technical Education Department of Federal College of Education (Technical) Potiskum and It has four items rated scale i.e. Strongly Agreed = (SA), Agreed = (A), Strongly Disagreed (SD), Disagreed (D)

The questionnaire was administered to the respondents through personal contact which allow for explanation if the need arises. The completed instrument was collected back by the researcher. Data collected was analyzed using mean and standard deviation.

II. RESULT AND DISCUSSION

Research Question 1:

To what level are ICT facilities available for teaching and learning of vocational and technical education in Yobe state technical colleges?

Table 1: mean response of technical teachers/students on availability of ICT facilities.

S/N	Item Statement	Mean	Remarks
1.	There are enough computers to teach students.	2.35	Disagreed
2.	Television sets are available for teaching students.	2.36	Disagreed
3.	There are projectors for teaching students.	2.98	Agreed
4.	The school is connected to the internet.	2.82	Agreed
5.	Disc player is available for teaching students.	2.72	Agreed
6.	There are film strips for teaching students.	2.15	Disagreed
7.	CCTV are available for teaching students.	2.21	Disagreed
	Grand Mean	**2.51**	

Table one showed the response obtained from teachers/students on availability of ICT facilities in technical colleges. The respondents agreed that facilities like projectors, disc player and internet connectivity were made available. While facilities like computers, film strips, and CCTV are not adequately available because their mean response is less than 2.50 which is the cutoff point. Based on the calculated grand mean of 2.51 obtained, it showed that the respondents agreed that ICT facilities are to some extent available.

Research Question 2:

To what level are teachers and students in technical colleges exposed to the use of ICT facilities?

Table 2: Mean responses of teachers /students on their exposure to ICT

S/N	Item Statement	Mean	Remarks
1.	There are functional ICT facilities owned by the school Cafe.	3.13	Agreed
2.	Teachers are exposed to the use of ICT facilities in teaching students.	2.41	Disagreed
3.	Teachers use computer to teach technical education to students.	2.41	Disagreed
4.	Students are given opportunities to use ICT facilities in the class/laboratories.	1.96	Disagreed
5.	Training is organized for teachers on the use of ICT facilities.	2.21	Disagreed
6.	Training is organized for student on the use of ICT facilities.	2.09	Disagreed
	Grand Mean	**2.30**	

Table 2 showed that the mean response obtained from teacher/students on exposure to ICT facilities in vocational technical colleges in Yobe state. The respondents agreed with item 1 because the mean response 3.13 which signifies that there are functional ICT facilities, but disagreed with item 2- 6 because the mean responses are less than 2.5. The grand mean signifies that teachers/students were not exposed to ICT facilities.

Research Question 3:

What are the perceived benefits of ICT facilities in technical colleges?

Table 3: Mean response of student/teachers on benefits of ICT facilities in technical colleges.

S/N	Item statement	Mean	Remarks
1.	ICT helps in making teaching-learning more effective.	2.89	Agreed
2.	ICT enhances quality of work of both teacher/students	2.86	Agreed
3.	ICT makes teachers to be up to date in their various disciplines.	3.01	Agreed
4.	ICT enhances efficiency of workers.	2.91	Agreed
5.	ICT helps teachers to share information with colleagues in other parts of the country.	2.81	Agreed
6.	ICT helps student to share information with colleagues in other parts of the country.	2.78	Agreed
	Grand Mean	**2.88**	

Table 3 showed the mean responses of students/teachers on the perceived benefits of ICT facilities in secondary schools of Potiskum local government. The respondents agreed with all the items because none of the mean response is below the cutoff point of 2.50 and the grand mean is 2.88.

Research Question 4:

What are the challenges facing ICT facilities in technical colleges in Yobe?

Table 4: Mean response of students/teachers on the challenges facing ICT facilities in technical colleges.

S/N	Item statement	Mean	Remarks
1.	Moat secondary schools lack computer literate teachers.	3.24	Agreed
2.	There is lack of ICT laboratories in the schools.	2.99	Agreed
3.	Irregular power supply hinders the use of ICT facilities where they available.	3.53	Agreed
4.	The cost of purchasing computers is high for schools.	3.52	Agreed

5.	There are inadequate facilities like computer to support the full application of ICT.	3.53	Agreed
6.	Lack of adequate funds hinders school from embracing ICT.	3.44	Disagreed
	Grand Mean	**3.38**	

Table 4 showed the mean response of students/teachers on the challenges facing ICT facilities in secondary schools of Potiskum local government. The respondents agreed with all the items 1-6 of table 4 because the mean responses of each item is great than the cutoff point of 2.50, which showed the grand mean of 3.88 to indicates that the respondents agreed with the listed items as the major challenges facing ICT facilities.

Major Findings of the study.

Findings of the study are presented according to the purpose of the study and research questions. From the results obtained, respondents agreed that;

(1) ICT facilities such as computer, television sets, CCTV, etc. are not adequately available in secondary schools.
(2) Teachers and students level of exposure to the use of ICT in secondary schools is inadequate.
(3) The perceived benefits of using ICT in schools include making teaching and learning more effective, enhancing the quality of work of both teacher and students; help teachers to be up-to-date, etc.
(4) Irregular power supply is a challenge facing the application of ICT in secondary schools, all the schools in the sampled area lacks adequate number of computer literate teachers.

III. CONCLUSION

It is clear that the education sector of Yobe state and the country at large has no smooth running of education system. In fact, all levels of education are plagued with catalogue of problems ranging from underfunding to mismanagement. If the educational sector of our schools throughout the state is to maintain maximum standards, it should be provided with adequate funds, infrastructural facilities in term of modern classrooms equipped with electronic computer system which are connected to the internet and highly qualified personnel that can effectively, utilize these resources.

Finally, our secondary school students should be given the best in education with modern facilities which will in turn draw out the best in every student and ensure the utility of these students to the development of Potiskum, Yobe state, and the country at large.

5.5 Limitation of the Study

Limitations of the study were:

(1) Language barrier i.e. inability of the students to comprehend the concepts in some of the items in the questionnaire. This calls for translation into understandable languages.
(2) The researcher faces some setbacks in distribution and retrieval of the questionnaires due to security situations characterized by security barricades all over the township due frequent attack by the sect called Boko Haram.

5.6 Recommendation

Based on the investigations carried out on topic, the following recommendations are made:

(1) ICT equipment and facilities should be made available to all technical colleges.
(2) Government should encourage and put in place policies to attract international codes and nongovernmental organizations (NGOs) to invest on ICT related projects in secondary schools.
(3) Teachers that are not ICT compliance should be encouraged by the secondary school administrators to study further in order to meet up with new demand of ICT literate teacher.
(4) Attention should be paid to the deforming state of facilities in our secondary school. Also ICT system and facilities like laboratory should be provided in secondary school in Yobe state.

REFERENCES

[1]. Adinam, E. (2006). Nepad scores students' ICT education Africa low. Vanguard. Available: http://www.Vanuardngr.com/articles/2002/features/technology/tec527092006.html.

[2]. Adonni, EE., & Anie, S.O. (2006). An assessement of computer literacy skills of professionals in Nigerian university libraries library H.Tech News 23(2):10-14.

[3]. Adowa-Ogiegaben, S.E; & Iyamu, E.O.S. (2005). Using information and communication technology in secondary schools in Nigeria. Educational technology & society 8 (1), 104-112

[4]. AICTA (2001), Development of Information and Communication technology (ICT) in Education Retrieved in 21st August 2004 from http://www/CCTD/6/R/index.Htm.
[5]. Ajayi, I.A. (2008). Towards effective use of information and communication technology for teaching in Nigeria colleges of education. Asian J. mf.techno 7(5): 210-214.
[6]. Aribasala, J.O. (2006). Role of information and communication technology in globalization in Agagu A.A. (ed). Information and community technology and computer applications. Abuja: Panof press pp. 68-76.
[7]. Babajide, VFT and Bolaji, O.A. (2003). Perception of lectures and service teachers towards the use of communication media in teaching pore and applied science related disciple 44th Annual STAN conference proceedings PP. 33-36.
[8]. Bamidele, S.O. (2006). Development of modern ICT and internet system. In Agagu A.A. (ed). Information and communication technology and computer applications. Abuja; pamof pree pp. 1-3.
[9]. Evoh, C.J. (2007). Policy networks and the transformation of secondary education through ICTs in Africa: the prospects and challenges of the NEPAD E-Schools initiative. International journal of Education and Development using information and communication technology (IJEDICT) 3 (1), 64-84. Available: http://ijedict.dec.uwi.edu/include/getdoc.php?id=2198 & article =272 & mode =pdf
[10]. Federal Republic of Nigeria (2006). National Policy on Education. 4th ed. Lagos: Nigerian educational research and development council.
[11]. Olorunsola, E.O. (2007). Information communication technology. A tool for effective management in Nigerian Universities. Educ. Focosi (1): 80-87.
[12]. Raffael, P. & Whitworth, A. (2002). Information fluency: critically examining ICT education now library world 103 (1182/1183): 427-35.
[13]. World Bank (2002). Information & Communication Technologies. A world Bank group strategy; Washington, D.C. The world Bank Group.

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Design and Performance Analysis of a C Band Micro-strip Patch Feed Reflector Antenna and Link Budget Optimization

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ABSTRACT : *This paper deals with the design and performance analysis of a very small size, low-cost, low-profile, high gain and high directivity C Band Micro strip Patch Feed Reflector Antenna considering the link budget optimization. The proposed antenna system has a gain of -4.45dB, directivity of 7.062dBi, return loss of -16.817327dB at 5.532 GHz and -15.998dB at 6.532GHz, Voltage Standing Wave Ratio (VSWR) of 1.338 at 5.5302GHz and 1.3766 at 6.5309 GHz, at C band it operates in two regions with bandwidth of 184MHz (5.4431 to 5.6275GHz) and 422MHz (6.3356 to 6.7576 GHz). The resonant frequencies of the antenna are 5.532GHzand 6.532GHz. The proposed antenna system can be used for C-band like satellite communications transmissions, VSAT, Wi-Fi, weather radar systems, medical applications and other wireless systems. The antenna system is designed and simulated in the CST Microwave Studio. Link budget optimization is performed in order to analyze the critical factors in the transmission chain and to optimize the performance characteristics. The link budget determines what size antenna is to use, power requirements and in general, the overall customer satisfaction.*

KEYWORDS *- Reflector antenna, C band, link budget optimization, gain, satellite communications, VSAT.*

I. INTRODUCTION

With the change of era new technologies are getting familiarity in satellite communications. Due to the drastic growth of modern satellite communication technology, the use of small antennas have increased due to their low-cost, low-profile, high gain and high directivity. Antennas for mobile communications are widely presented in books and papers in the last decade as presented in [1-3]. Global Mobile Satellite Communications: For Maritime, Land and Aeronautical Applications are illustrated in [4]. The satellite link is much like terrestrial microwave radio relay link with the advantage of not requiring as many re-transmitters as are required in the terrestrial link. Transmission of signals over a satellite communication link requires Line-of-Sight (LoS) communication. Link analysis basically relates the transmit power and the receive power [9]. The communication link between a satellite and the Earth Station (ES) is exposed to a lot of impairments such as free space path loss, rain loss, pointing loss and atmospheric attenuations etc. [10]. The organization of this paper is as follows – Section II conducts the antenna architecture. Section III illustrates the simulation results. Section IV reveals the result analysis. Section V conducts link budget analysis. Section VI resembles System Noise. Section VII shows link budget calculation. Section VIII conducts the cost calculation of the proposed antenna system. Finally, Section IX provides some concluding remarks.

II. ANTENNA ARCHITECTURE

The copper(annealed) lossy metal is used as substrate for the reflector. The relative permeability (μ_r) and electrical conductivity of the substrate material are 1.0 and 5.8e+007 (S/m) respectively. The reflector diameter is 100mm with 1mm thickness . A micro strip patch antenna is placed at distance of 9mm from the reflector surface without any electrical conduction. FR-4 lossy material is used for substrate and copper(annealed) as ground plane. The length of substrate is 41.33mm and width is 52.66mm.The patch length is 20.66mm and width is 26.33mm.The excitation signal is applied at the patch feed line. Fig 1 shows the structure of the C Band Micro strip Patch Feed Reflector Antenna.

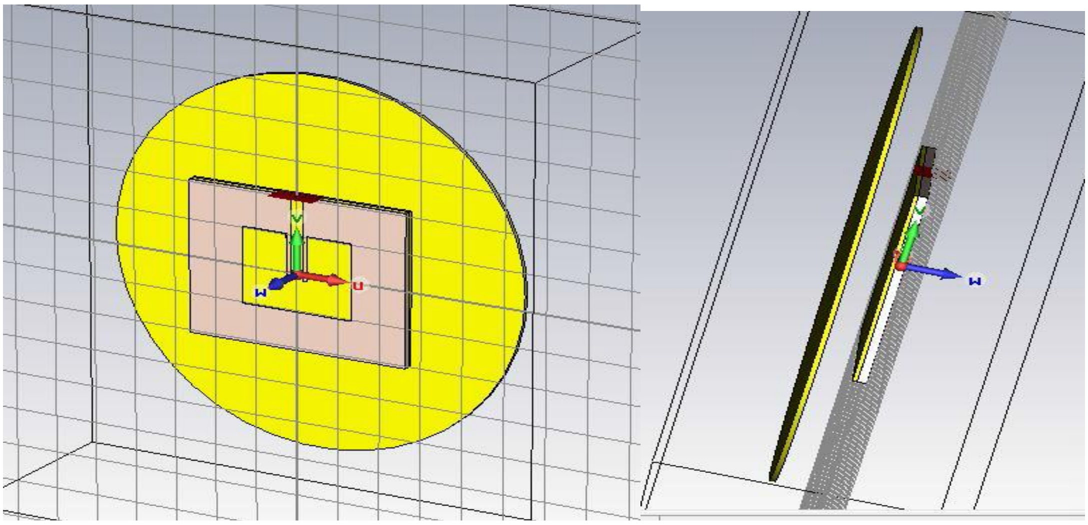

Fig. 1. Structure of C Band Micro-strip Patch Feed Reflector Antenna

III. SIMULATION RESULT

3.1 Electric & Magnetic Field Distribution

Electric & Magnetic field distribution of the C Band Micro-strip Patch Feed Reflector Antenna is given below:

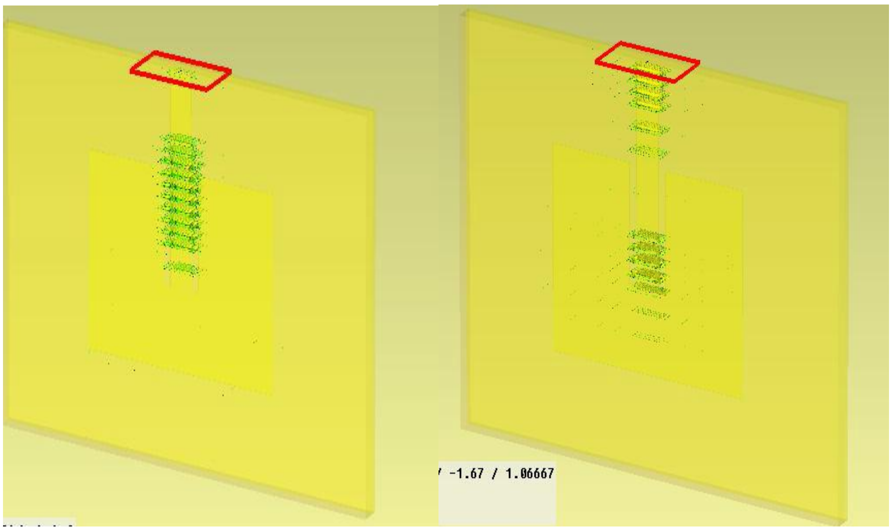

Fig. 2. Electric & Magnetic field distribution of the C Band Micro-strip Patch Feed Reflector Antenna

3.2 Voltage Standing Wave Ratio (VSWR) & Return Loss

Fig. 3 shows the graph of VSWR vs. Frequency. From this figure it can be seen that the VSWR value is very near to the unity which is mostly expected. The VSWR value of the antenna is 1.338 at 5.5302GHz and 1.3766 at 6.5309 GHz respectively.

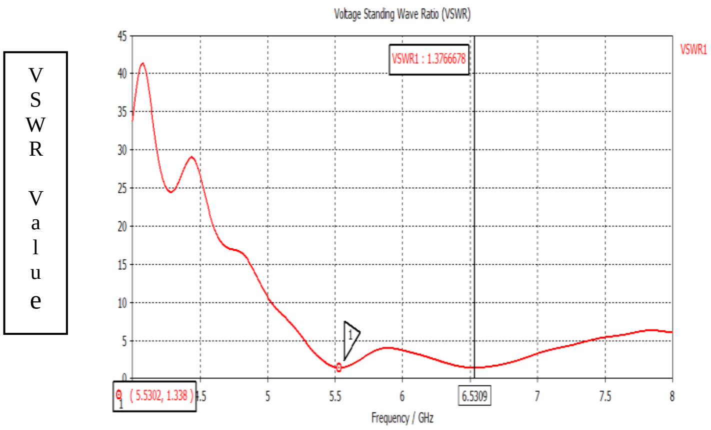

Fig. 3. VSWR vs. Frequency curve of the C Band Micro-strip Patch Feed Reflector Antenna

Fig. 4 shows the graph of return loss vs. frequency. From this figure we can observe the bandwidth of the antenna. The bandwidth of the antenna is 184MHz which operates in C band (5.4431 to 5.6275GHz) at 5.532GHz and 422MHzwhich operates in C band (6.3356 to 6.7576 GHz) at 6.532 GHz. The value of return loss is -16.817327dB at 5.532 GHz and -15.998dB at 6.532GHz.

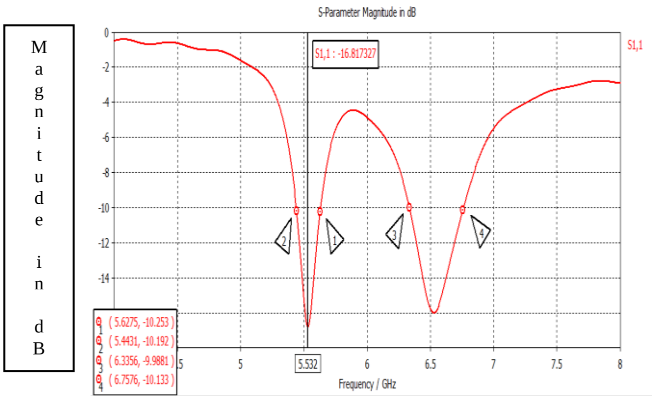

Fig. 4. Return loss of the C Band Micro-strip Patch Feed Reflector Antenna

3.3 Farfield Radiation Pattern (2D), Gain Pattern and Antenna Efficiency

Fig. 5 shows the far-field directivity pattern of the Proposed antenna. The radiation pattern of the antenna is bidirectional. From this figure it can be seen that the directivity and gain of the antenna is about 7.062 dBi and -4.45 dB respectively. The radiation efficiency is -11.52 dB

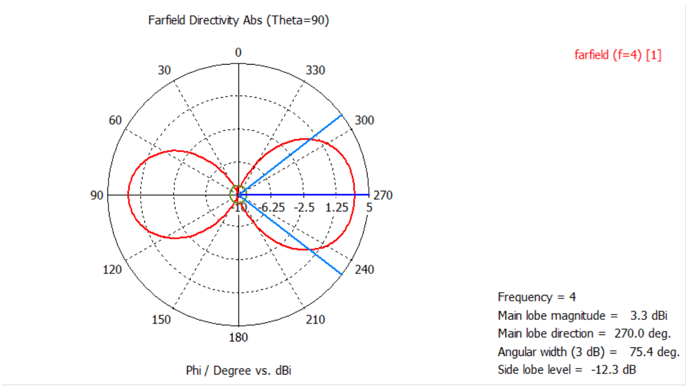

Fig. 5. Far-field directivity pattern of the C Band Micro-strip Patch Feed Reflector Antenna

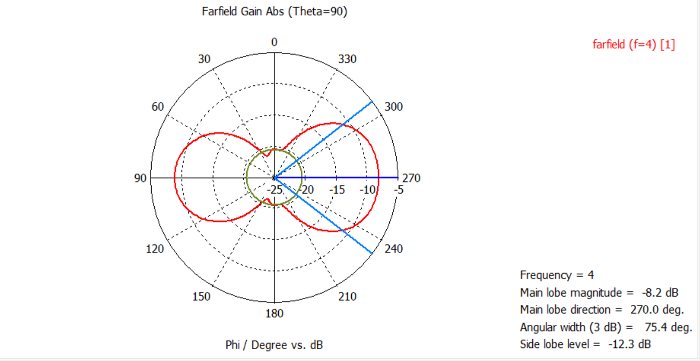

Fig. 6. Far-field gain pattern of the C Band Micros-trip Patch Feed Reflector Antenna

IV. RESULT ANALYSIS

VSWR, return loss, far-field radiation pattern, antenna gain, directivity and antenna efficiency of the proposed antenna system show reasonable characteristics. The performance of the antenna is quite good. This antenna can be used in C band applications for its effective performance.

Table I. Proposed C Band Microstrip Patch Feed Reflector Antenna parameters and their values at a glance

Designed Micro strip Patch Feed C Band Reflector Antenna Parameters	Simulation Results
VSWR	1.338
Return Loss (in dB)	-16.817327 dB
Gain (in dB)	4.45dB
Directivity (in dBi)	7.062 dBi
Bandwidth (MHz)	C Band : 184 MHz &422 MHz

The results in the Table I reveal that the proposed C Band Micro-strip Patch Feed Reflector Antenna system is useful for C band applications like VSAT Communication, satellite communications transmissions, Wi-Fi, cordless telephones, weather radar systems, medical applications and other wireless systems.

V. LINK BUDGET ANALYSIS

The Satellite link is much like the terrestrial microwave radio relay link with the advantage of not requiring as many re-transmitter as are required in the terrestrial link. Transmission of Signal over a satellite communication link requires Line-of-Sight (LoS) Communication. Line analysis basically relates the transmit power & receive power. Basic transmission parameters are – flux density, received power, antenna gain, noise power, figure of merit etc.A link consists three parts namely transmitter, receiver & media. The two main items that are associated with transmitter are flux density & EIRP. A measure of the amount of energy that is received at a distance *r* from a transmitter of gain G_t & transmitter power P_t watts is the flux density which is given by –

$$\phi = \frac{P_t G_t}{4 \pi R^2} \ [\mathrm{W/m^2}] \qquad (1)$$

Where P_tG_t is called the Effective Isotropic Radiated power or EIRP which is closely associated with a radiating source or a transmitter & a subset of flux density.

Fig. 7 shows that flux density decreases as square of the distance. The plot has been made between 400 ton40000 km for distance and the corresponding flux density lies between near about 10^{-9} to 10^{-13} W/ m^2 . The constant parameters are P_t = 20 W, G_t = 22 dB.

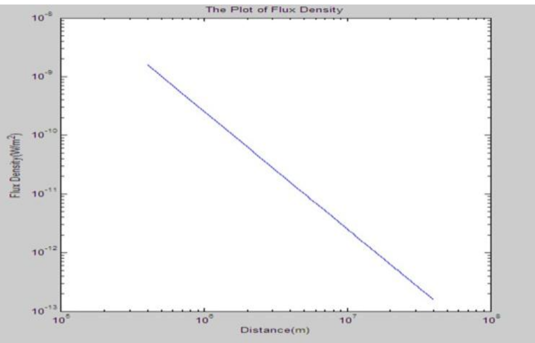

Fig. 7. Graphical representation of flux density

For an ideal receiver antenna of aperture area A, the total received power at the receiver is given by –

$$P_r = \phi \times A = \frac{P_t G_t A}{4\pi R^2} \text{ [W]} \quad (2)$$

A practical antenna with physical aperture A will not deliver this power as some energy will be reflected and some will be absorbed by lossy elements. Thus the actual power received will be-

$$P_r = \eta A \times \phi \text{ [W]} \quad (3)$$

where, η is the antenna efficiency and A is referred to as the effective collecting area of the antenna. The antenna
efficiency accounts for all losses between the incident wave-front and the antenna output port. An antenna of maximum gain G_r is related to its effective area by the following equation –

$$G_r = \frac{\eta 4\pi A}{\lambda^2} \quad (4)$$

where, λ is the wavelength of the received signal.
Rearranging equation (4) and substituting in (3) we get –

$$P_r = \frac{P_t G_t G_r}{\left(4\pi R / \lambda \right)^2} \text{ [W]} \quad (5)$$

From Fig. 8 it is seen that received power remains almost constant for GEO due to its longer distance which is above 35786 km above the earth surface. Here, the ranges of different orbits are taken as- LEO→500-1500km, MEO→5000-10000km, GEO→36000-41000km while the values of constant parameters of equation (5) are P_t = 20 W, G_t = 22dB, G_r 52.3 dB, f = 11 GHz.

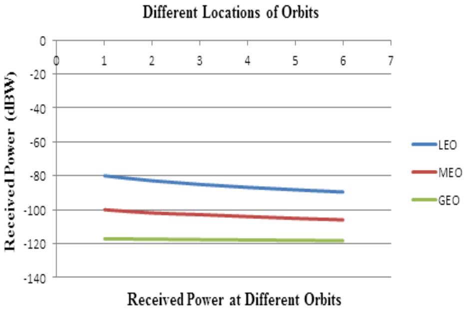

Fig. 8 Received Power at different orbits

For a parabolic antenna of diameter D, equation (4) can be rewritten as –

$$G_r = \eta \frac{\pi^2 D^2}{\lambda^2} \quad (6)$$

The variation in antenna gain for a range of transmission frequencies that are employed in satellite communications is shown below assuming an efficiency of 60%.

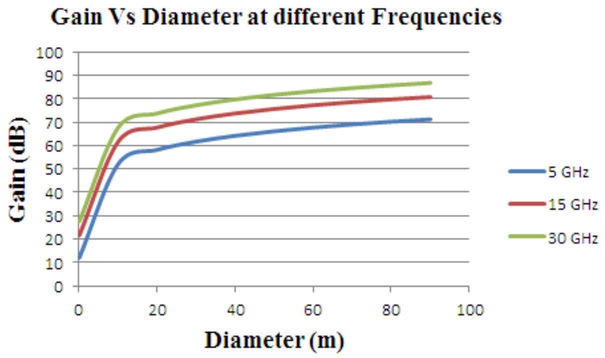

Fig. 9 Illustration of gain Vs diameter at different frequencies

The above figure resembles that highest frequency shows maximum gain while the lowest one illustrates the lowest gain as the gain is directly proportional to the square of the frequency.

VI. SYSTEM NOISE

6.1 Noise Power

The Thermal noise power P_n delivered to the optimam load by the thermal noise source of resistance R at temperature T is given by –

$$P_n = K T_p B_n \tag{7}$$

Where K – Boltzman Constant = 1.38 x 10^{-23} J/K, Tp – Noise temperature in Kelvin & B_n – Noise bandwidth in Hz.

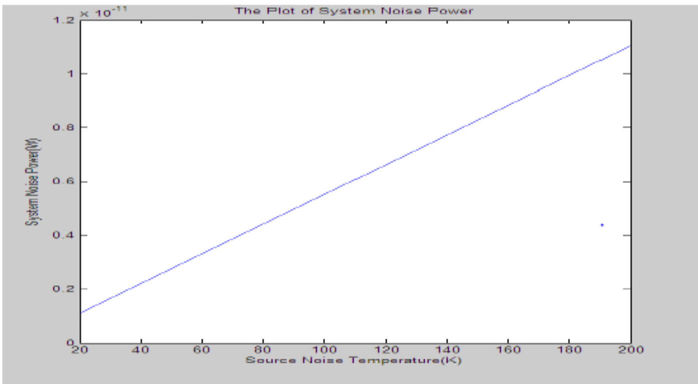

Fig. 10 Demonstration of system noise power

Since the system noise power is directly proportional to the system noise temperature so the noise power will increase as the temperature increases.

6.2 Figure of Merit

The figure of merit is introduced to describe the capability of an earth station or satellite to receive the signal. Since the C/N is the ratio of Signal Power to noise power, we have that –

$$C/N = \frac{P_r}{P_n} = \frac{P_t G_t G_r}{\left(4\pi/\lambda\right)^2} \tag{8}$$

$$\text{i.e.} \quad \frac{C}{N} = f\left(\frac{G_r}{T_s}\right)$$

The ratio G_r/T_s is known as figure of merit which indicates the quality of receiving satellite earth station & it is measured in dB/K.

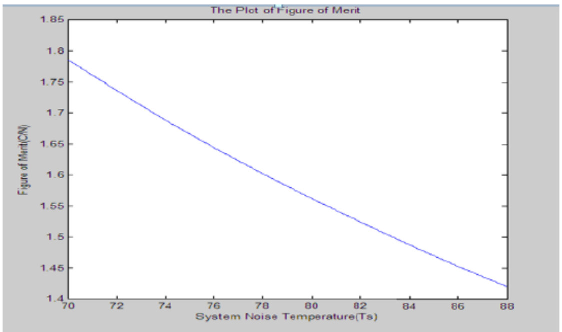

Fig. 11 Realization of Figure of Merit

Since the figure of merit is inversely proportional to the system noise temperature, so the figure of merit will decrease as the system noise increases. Here P_t = 20 W, G_t = 22 dB, R = 39000 Km, f = 4.15 GHz, B = 4 GHz, G_r = 10,000 – 100,000.

VII. LINK BUDGET CALCULATION

The results obtained from the link budget calculator are shown below [11]-

7.1 Uplink Budget

Uplink frequency GHz	5.5
Uplink antenna diameter m	0.1
Uplink antenna aperture efficiency e.g. 0.65	0.65
Uplink antenna transmit gain dBi	13.3369523
Uplink antenna, power at the feed W	200
Uplink EIRP dBW	36.3472523
Range (35778 - 41679) km	1000
Uplink path loss dB	167.257253
Uplink pfd at satellite dBW/m^2	-94.653082
Bandwidth Hz	184000000
Satellite uplink G/T dB/K	-5.3
Uplink C/N dB	9.7418203

7.2 Downlink Budget

Downlink frequency GHz	4
Downlink receive antenna diameter m	.1
Downlink receive antenna aperture efficiency e.g. 0.65	0.65
Downlink system noise temperature (antenna+LNA) K	270.43
Downlink receive antenna gain dBi	10.5708984
Downlink receive antenna G/T dB/K	-13.749650
Downlink satellite EIRP dBW	55.59
Downlink path loss dB	164.491199
Downlink C/N dB	23.3009716

VIII. COST CALCULATION

Large antennas are expensive to construct and install, with costs exceeding \$1M for 30-m diameter fully steerable antennas [12]. The cost of large fully steerable antennas has been quoted as [13]-

$$\text{Cost} = \$\ y(D)^{2.7} \tag{9}$$

Where, D is the diameter of the antenna aperture in feet. The constant y in equation (1) depends on the currency used and inflation, but might typically be around five U.S. dollars in the early 1980s. The diameter of the proposed Micro-strip Patch Feed C Band Reflector Antenna aperture is 100 mm i.e.; 0.32808 feet which in turn gives-

$$\begin{aligned}\text{Cost} &= \$\ y(D)^{2.7} \\ &= \$\ \{5 \times (0.32808)^{2.7}\} \\ &= \$\ 0.2467\end{aligned}$$

IX. CONCLUSION

The design of a C Band Micro-strip Patch Feed Reflector Antenna and its performance analysis for C band along with the link budget optimization has been demonstrated in this paper. The simulation results of the proposed antenna system resemble very good performance. Also the cost calculation reveals that our proposed antenna system is cost effective. In this paper, CST Microwave Studio software has been used for all the simulations which provide effective and satisfactory results. The proposed antenna system provides high gain, directivity, efficiency and bandwidth. It also shows very low value in case of VSWR which is near about unity that satisfies the antenna specification.

REFERENCES

[1] Basari, *Development of simple antenna system for land mobile satellite communications*, Doctoral Dissertation, Feb. 2011.
[2] S. Ohmori, H. Wakana, and S. Kawase, *Mobile satellite communications*, Artech House, Norwood, MA, USA, 1998.
[3] J.H. Lodge, Mobile satellite communication systems: toward global personal communications, *IEEE Commun. Mag., vol. 29, no. 11*, pp. 24–30, Nov. 1991.
[4] S.D. Ilcev, Global mobile satellite communications: For Maritime, Land and Aeronautical Applications, *Springer*, Dordrecht, the Netherlands, 2005.
[5] Adel M. Abdin, 12 GHz Planar Array Antenna for SatelliteCommunication, *PIERS Online, Vol. 4, No. 4*, 2008..
[6] Monojit Mitra, *Satellite Communication*, ISBN: 978-81-203-2786-3.
[7] Tri T. Ha., *Digital Satellite Communications*, 2nd edition, McGraw Hill, Copyright©1990, ISBN-13: 978-0-07-007752-2..
[8] Howard Hausman, Fundamentals of Satellite Communications, Part- 2, Hauppauge, NY 11788, Jan. 22, 2009.
[9] Aderemi A. Atayero, Matthew K. Luka and Adeyemi A. Alatishe, Satellite link design: A Tutorial, *International Journal of Electrical and Computer Sciences, Vol: 11 No: 04*, Aug.2011.
[10] Charan Langton. (2002) Intuitive Guide to Principles of Communications, copyright 1998 and 2002. [Online]. Available*:* http://www.Complextoreal.com/
[11] Satellite Link Budget Calculator. [Online] Available:http://www.satsig.net/ linkbugt.htm/
[12] Timothy Pratt et al., *Satellite Communications*, ISBN: 9971-513-226.
[13] N.E. Feldman, The link from a communications satellite to a small ground terminal, *Microwave journal*, 7, 39-44, 1964.

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Analysis of Torque Convertor Using Two Masses for Medium Duty Vehicles

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ABSTRACT: *A mechanical torque converting transmission producing an output with variable controllable speed torque characteristics which compares a rotary input shaft adapted for attachment to the rotary power source connected to a main shaft. This invention relates to a mechanism transferring torque from one rotating shaft to another and in particular to a transmission mechanism that will enable an engine or motor to deliver power to a load at optimum torque and speed levels. Control can be utilize to activate or deactivate the clutch also change the phase relationship of the driven eccentric masses device in order to vary the transmission output under varying load condition. Infinitely variable transmission system plays a crucial role in order to guarantee the overall vehicle performance in different working conditions. The relationship between the stress and transmission which is based on the results of two different mass strategies with dynamometer and motor is constructed to test the transmission to speed the results of those tests which shows the efficient at low input torque levels. A virtual verification process is described focusing on the model based engineering which allows reducing the number of prototypes and hence lower cost and development time.*

Keywords - *Infinitely Variable Transmission, Novel Cam, Velocity Theorem, Positive Drive.*

I. INTRODUCTION

The purpose of this design project was to improve upon an existing infinitely variable transmission design for use in Automobile. An infinitely variable transmission is a new design of transmission which utilizes moments produced by rotating offset masses to transfer torque, while varying output speed, from the engine to the output shaft. In an effort to design a reliable and efficient infinitely variable transmission, all components from the existing infinitely variable transmission were analyzed in detail and modified accordingly.

The linear IVT is solving the problem in modern automobile industry to develop new generation in vehicle to sustain. The input and output ratio in traction the linear IVT parameters to sustain the limited Two masses profile and masses the IVT infinity check the depending upon various load condition in gear, clutch, Two masses and Two masses follower. The superior in automobile cycle, the linear IVT dissolve input speed to the shaft traction to the output shaft to the transmission solver transmission ratio. The different investigators presents the background and theory related to the IVT, considers alternative designs, and presents the final design. It also outlines improvements for the IVT which will be installed in automobiles.

A two masses-based infinitely variable transmission system allows a user to vary the speed between input & output progressively from one positive value to another. Unlike, conventional transmissions the selection of gears is not restricted to a finite number of ratios. The two masses-based infinitely variable transmission systems can be used in automobile drive applications to improve performance, economy & functionality.

II. OBJECTIVE OF PROJECT

1. To Design & Development of Infinitely variable transmission based on Torque convertor mechanism
2. Testing and Trial To derive the following performance characteristics :
   a) Torque Vs Speed
   b) Output Power Vs Speed
   c) Efficiency Vs Speed.
3. Manufacturing of torque convertor using IVT system

III. RESEARCH METHODOLOGY

1. Review of literature regarding the work done.
2. Analytical design of IVT.
3. Manufacturing and assembly of the Actual testing set-up.
4. Perform experimental testing on IVT with different two masses.
5. Result and Discussion.

IV. ANALYTICAL ANALYSIS

4.1 Design of Mass-01:

The mass -01 is a link that is subjected to direct tensile load in the form of pull = 48 N material selection

Table 1: Mass No.1 Material

Material Designation	Tensile Strength (N/mm^2)	Yield Strength (N/mm^2)
EN9	600	380

Check for failure of mass under direct tensile load at the eye end. This is the portion where the lever pin fits, the cross sectional area at this point is 288 mm2 now

FT = LOAD /AREA

Ft act = 48/288

= 0.166/mm^2

AS FT ACT < FT ALL

The link is safe under tensile load

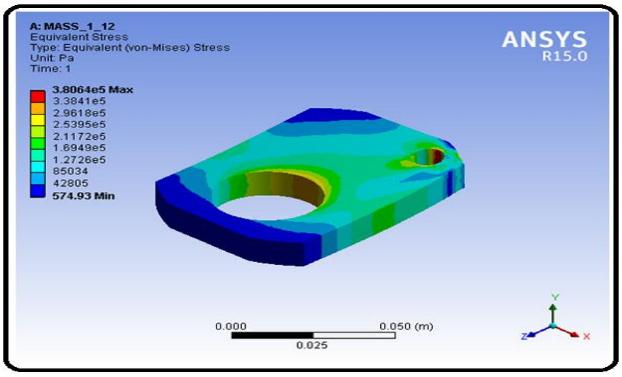


Fig. 1: FEA Analysis of Mass No-1

Table 2: FEA Results Mass No. 1

Sr. No	Thickness (mm)	Deformation (m)	Stress (Max) N/m^2
1	4	3.1398*10-7	1.1923
2	6	2.0927*10-7	8.246
3	8	1.5693*10-7	5.896
4	10	1.2553*10-7	4.811
5	12	1.0456*10-7	3.8064

4.2 Design of Mass-02:
The mass -02 is a link that is subjected to direct tensile load in the form of pull = 48 N Material Selection:

Table 3: Mass No.2 Material

Material Designation	Tensile Strength (N/mm^2)	Yield Strength (N/mm^2)
EN9	600	380

Check for failure of mass under direct tensile load at the eye end. This is the portion where the lever pin fits, the cross sectional area at this point is 576 mm2 now
FT = LOAD /AREA

$$Ft\ act = 48/576 = 0.0833\ N/mm^2$$

AS FT ACT < FT ALL

The Mass Number-2 is safe under tensile load.

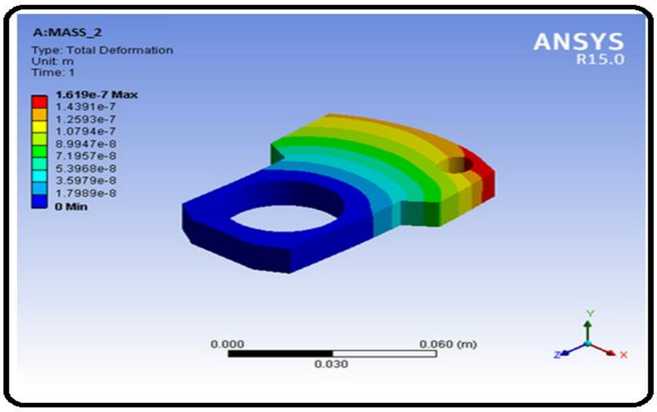


Fig.2: FEA Analysis Mass No.2

Table 4: FEA Results Mass No.2

Sr. No	Thickness (mm)	Deformation (m)	Stress (Max) N/m^2
1	4	4.8732*10-7	1.4766
2	6	3.248*10-7	0.5983
3	8	2.429*10-7	0.72404
4	10	1.944*10-7	0.57489
5	12	1.619*10-7	0.48529

4.3 Analytical results:
The maximum torque is given by the formula:

$$\mathbf{T = m * \omega^2 * R_{CG} * D_{(lobe\ offset)}} \ldots\ldots\ldots. (1)$$

Where,

T	:	Maximum torque (N-m)
m	:	Masse (kg)
$\boldsymbol{\omega^2}$	:	Angular acceleration (m/s^2)
$\mathbf{R_{CG}}$	:	Radius of offset mass
$\mathbf{D_{(lobe\ offset)}}$	:	Radius of lobe

Table 5: Analytical results

Sr. No	Speed	Angular Speed		Torque
	(rpm)	(w)	(w^2)	(N-m)
1	380	39.79	1583.4	0.10
2	520	54.45	2965	0.18
3	535	56.02	3138.6	0.19
4	650	68.07	4632.9	0.28
5	850	89.01	7922.6	0.48
6	1050	109.9	12089.5	0.73

V. EXPERIMENTAL RESULTS

The following test results will be derived from the test and trial on IVT Drive.

Table 6: Experimental Results

Sr. No	Weight	Radius of Pulley	Speed	Angular speed	Torque
	(kg)	(m)	(rpm)	(w)	(N-m)
1	0.1	0.0375	2100	219.905	0.037
2	0.15	0.0375	1960	205.245	0.055
3	0.2	0.0375	1750	183.254	0.074
4	0.25	0.0375	1600	167.547	0.092
5	0.3	0.0375	1250	130.896	0.110
6	0.35	0.0375	1050	109.953	0.129
7	0.5	0.0375	810	84.8205	0.184
8	0.6	0.0375	650	68.0658	0.221
9	0.7	0.0375	535	56.0234	0.258
10	0.8	0.0375	520	54.4527	0.294
11	1	0.0375	380	39.7923	0.368

VI. SUMMARY OF RESULT

The result correlation summarized as show in table 7

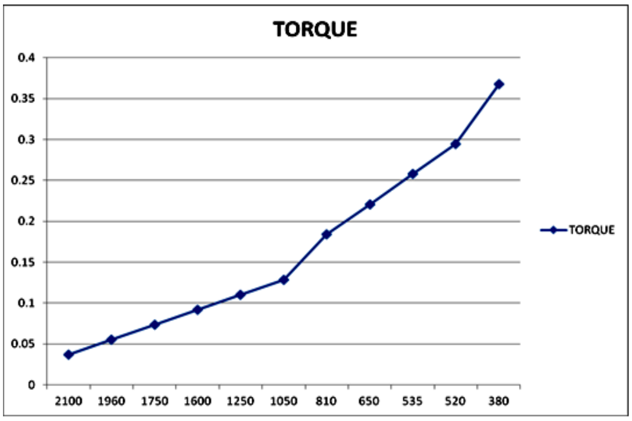
Table 7: Summary of result correlation

Sr.No	Speed	Analytical Results Torque (N-m)	Experimental results Torque (N-m)	% error
1	650	0.2793	0.2207	5
2	535	0.1892	0.2575	6
3	520	0.1787	0.2800	10

The error in prediction of IVT by theoretical analysis is the range of 3 to 4% and experimental analysis 5 to 20%. The propose method is confirmed by the comparing it with result of FEA and Experimental result. This is a in well agreement the acceptable limit ±10%.

1] Torque Vs Speed Characteristics:

The following test results will be derived from the test and trial on IVT Drive:



Graph No: 1. Torque Vs Speed Characteristics

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VIII. CONCLUSION

The IVT is infinity variable transmission of input speed to the output speed in torque convert ratio will be change. In two masses like Rectangular shape, irregular shape, the input shaft given the specific speed motor to the output result is varying different masses to determine torque converter by the Infinitely Variable Transmission (IVT). The speed difference ratios are design criteria of IVT and development in torque in the mass moment and convert different masses in linear speed.

The error in prediction of torque converter by theoretical analysis is in the range of 3 % to 15% and experimental analysis it is the range of 5 % to 20 %. The proposed method is confirmed by comparing it with results of FEA results and experimental results. The proposed method is found to be simple and accurate. The IVT is newly concept in Light and Medium vehicle on automobile industries is development research they are torque convertor in various masses with different input speed to very output speed to give the more efficient in output power.

REFERENCES

Journal Papers:

[1] Dr. N. Arunkumar, *Infinitely Variable Transmission Using Four Bar Mechanism, International Journal of Engineering Science and Technology (IJEST) 2014; 6(4):170-176*

[2] Derek F. Lahr, Dennis W. Hong, *The Operation And Kinematic Analysis Of A Novel Cam-Based Infinitely Variable Transmission, ASME 2006 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference September 10-13, 2006, Philadelphia, Pennsylvania, USA.*

[3] Gregory F. Hickman, *Kinematic Modeling and Analysis of a Cam Based CVT For a Capstone Design Project Experience, Proceedings of the 2013 ASEE North-Central Section Conference, American Society for Engineering Education.*

[4] Amjad M. Abood, *A Novel Cam-Based Infinitly Variable Transmission, Journal Of K Erbala University, 2010; 8(4): 61-74*

[5] *Giuseppe Carbone, Modelling, Optimization and verification of power split infinitely variable transmissions, Ph.D. Dissertation, Northwestern University, 2009.*

[6] Ranbir Singh, *a brief review of transmission in automobiles, International Journal of Latest Research in Science and Technology, 2012; 1(2) :222-226*

[7] Konstantin Ivanovo, *A CAD Design of a New Planetary Gear Transmission, International Journal Of Innovative Technology and Research, 2014; 4(2):1063-1067.*

[8] F.G. Benitez, J.M. Madrigal, J.M. del Castillo, *Infinitely variable transmission of Ratcheting drive type based on one-way clutches, Journal of Mechanical Design, July 2004; 126:.673-682.*

[9] F.A. Fitz, P.B. Pires, *A geared infinitely variable transmission for automotive applications, SAE paper no. 910407, 1991:1-7*

[10] S. Matsumoto, N. Inoue, Y. Tsukada, *Continuously variable transmission for Bicycles, United States Patent Application 20030221892, 2003.*

[11] Douglas Magyari, *Infinitely Variable Transmission in Patent Application Publication, on 01 November, 1999.*

[12] Peter Eichenberger, *Dual Range Infinitely Variable Transmission, Patent Application Publication, on 07 July, 1988.*

[13] Wayne Paul Bishop, *Positive Drive Infinitely Variable Transmission, Patent Application Publication, 04 Auguest, 2011.*
[14] Lohr, Charles, Stevenson, *Gregory, Infinitely Variable Transmissions, Methods, Assemblies, Subassemblies and Components, Patent Application Publication, 10 December, 2009.*
[15] Dieter Hahne, *Infinitely Variable Transmission for Automotive Vehicle Driveline, Patent Application Publication, on 21 February, 1984.*
[16] Paul K. Coronel, *Dual Concentric Positively Infinitely Variable Rotary Motion Transmission, Patent Application Publication, on 16 November, 1992.*
[17] Brian S. *Andersen presented paper on An Investigation of a Positive Engagement Continuously Variable Transmission, Brigham Young University, Harry Valentine, August 2005.*
[18] E. Faulring, *The cobotic hand controller: Design, control and analysis of a novel haptic display, Ph.D. Dissertation, Northwestern University, 2005.*

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Research Paper Open Access

Computer Aided Design and Comparative Study of Copper and Aluminium Conductor Wound Distribution Transformer

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ABSTRACT: *This paper describes design and performance analysis for copper and aluminium conductor wound distribution transformers using computer programs. The different parts of the transformer are designed by developing a MATLAB program according to designing algorithm. The design data sheets have been prepared from program outputs and working performances for different KVA ratings with various loading have been analyzed. This study also represents a comprehensive comparison of designing and performance of copper and aluminium windings. It can influence the selection of copper against aluminium windings for distribution transformer. This study establishes the high rate of performance calculation and provides the ability to carry out logical decisions.*

KEYWORDS*- Copper and aluminium wound, Distribution transformer, Maximum efficiency, MATLAB coding*.

I. INTRODUCTION

The application of transformer in power transmission and distribution is vital for the proper use of power and it is impossible to think of a large power system without transformers. So the designing of transformer is very important for proper power management. The manual design procedure is time consuming, needs more manpower and accuracy level is lower. The objective of this research work is to accomplish a computer aided design of distribution transformer. This design procedure enables us to analyze the performance and it represents a comprehensive comparison of copper and aluminium windings. From this study we will be able to determine how to obtain better performance of transformer. It also establishes the high rate of performance calculation and provides the ability to carry out logical decisions for the selection of proper winding material. For this reason an engineer has to take in to the consideration of several factors such as losses, efficiency, voltage regulation etc. This study represents a computer aided design using MATLAB and the use of the result of coding to analyze the performance for both copper and aluminium windings of transformer.

II. DESIGN OF TRANSFORMER

Transformers may be designed to make one of the following quantities as minimum.
(i)Total Volume, (ii) Total weight, (iii) Total cost and (iv) Total losses.
In general, these requirements are contradictory [1] and it is normally possible to satisfy only one of them. All these quantities vary large core with ratio r = $Ø_m/AT$. If we choose a high value of r, the flux becomes larger and consequently a large core cross-section is needed which results in higher volume, weight and cost of iron and also gives a higher iron loss. On the other hand, owing to decrease in the value of AT, The volume, weight and cost of copper required decrease and also I^2R losses decrease. Thus we conclude that the value of r is a controlling factor for the above mentioned quantities:
Let us consider a single phase transformer. In KVA output is:
$Q = 2.22fB_m\delta K_w A_w A_i \times 10^{-3} = 2.22fB_m A_c A_i \times 10^{-3}$

Assuming that the flux and current densities are constant, we see that for a transformer of given rating the product A_cA_i is constant.
Let this product $A_cA_i = M^2$ (1)
The optimum design problem is, therefore, that of determining the minimum value of total cost.
Now, $r = Ø_m/AT$ and $Ø_m = D_mA_i$ and $AT = K_wA_w/2 = \delta A_c/2$

$$r = \frac{2B_m A_i}{\delta A_c} \text{ or, } \frac{A_i}{A_c} = \frac{\delta}{2B_m} r = \beta \quad (2)$$

Where β is a function of r only as B_m and δ are constant.

Thus from (1) and (2) we have
$Ai = M\sqrt{\beta}$ and $Ac = M/\sqrt{\beta}$

Let C_t = total cost of transformer active materials, C_i = Total cost of iron, and
C_c = total cost of conductor
$C_t = C_i + C_c = C_iG_i + C_cG_c$
$= c_ig_iI_iA_i + c_vg_cL_{mt}A_c$
Where C_i and C_c are the specific costs of iron and copper respectively.
Now, $C_t = c_ig_iI_iA_i\, M\sqrt{\beta} + c_cg_cL_{mt}\, M/\sqrt{\beta}$
Differentiating C_t with respect to β,
$dC_t/d\beta = 0.5\, c_ig_iI_iA_i\, M\beta^{-0.5} - 0.5c_cg_cL_{mt}\, M\beta^{-1.5}$
For minimum cost, $dC_t/d\beta = 0$
$c_ig_iI_i = c_cg_cL_{mt}\beta^{-1}$
$C_i = C_c$
Hence, for minimum total cost, the cost of iron must equal the cost of conductor.
Now $G_i/G_e = c_c/c_i$, for minimum cost
Knowing the value of specific costs of iron and conductor the ratio of weight of iron to conductor can be determined. Similar conditions apply to other quantities e.g. for minimum volume of transformer,
Volume of iron = Volume of conductor
$G_i/g_i = G_c/g_c$ i.e. $G_i/G_c = g_i/g_c$
For minimum weight of transformer,
Weight of iron = Weight of conductor i.e. $G_i = G_c$
For minimum losses in transformer i.e., for maximum efficiency [2],
Iron loss = I^2R loss in the conductor or, $Ps = x^2\, P_c$
Total losses at full load = $P_i + P_c$
At any fraction x of full load, the total losses are $P_i + x^2P_c$
If Q is the output at full load, the output at fraction x of the full load is xQ.
Efficiency at output xQ, $\eta_x = \frac{xQ}{xQ + Pi + x^2 Pc}$

This efficiency is maximum, when $d\eta_c/dx = 0$
Differentiating we have, $d\eta_c/dx = \frac{(xQ+Pi+x^2Pc)Q - xQ(Q+2xPc)}{(xQ+Pi+x^2Pc)^2}$

For maximum efficiency, $(xQ + Pi + x^2\, PC)Q - xQ(Q + 2xPc) = 0$
Or, $Pi = x^2Pc$
So, the maximum efficiency is obtained, when the variable losses are equal to the constant losses.
$P_i/P_c = P_iG_i/P_cG_c$
$x^2 = P_iG_i/P_cG_c$
or, $G_i/G_c = x^2P_c/P_i$ for maximum efficiency. Now, knowing the values of densities in iron and copper the specific losses p_i and p_c can be determined and the value of x i.e., the fraction of full load where the maximum efficiency occurs depends upon the service conditions of the transformer and is, therefore, known. Thus ratio G_i/G_c is known to get the core area for maximum efficiency [2].

III. MATLAB CODING, DESIGN PROBLEM AND PROGRAM OUTPUT

This research work implements a MATLAB program for designing distribution transformers and analyzing their working performance. Here we design a 25 KVA, 11000/433 V, 50 Hz, 3 phase, delta/star, core type, oil immersed natural cooled distribution type transformer. The transformer is provided with 5% tapping on the HV side. Program Outputs for 25 KVA Transformer:

****
CORE DESIGN OF THE TRANSFORMER
****
The KVA rating of the transformer is 25.000000 KVA
Voltage per turn Et 2.25 V
Line frequency: 50.000000 Hz
The number of phase of transformer: 3
Flux in the core is 0.010135 Wb
Flux density: 1.0000 Wb/m^2
The net iron area is 0.010135 m^2
Stacking factor is 0.900000
Gross iron area is: 0.011261 m^2
Type of core is Cruciform
Diameter of the core is 0.1345 m
The dimension is: 0.114 X 0.071

****
WINDOW DIMENSION OF THE TRANSFORMER
****
Primary winding voltage is: 11.000000 KV
Current density: 2.30 A/mm^2
Window space factor is: 0.195
Modified window space factor is: 0.180
Area of the window: 0.035785 m^2
Ratio height to width of window is 2.5
Height of the window is 0.299
The calculated height and width of the window are 0.299 m and 0.120 m
The modified height and width of the window are 0.300 m and 0.120 m
Distance between adjacent cores is 0.255 m

****
YOKE DESIGN OF THE TRANSFORMER
****
Area of the yoke is 15 to 25 percent larger than the core (0.010135 m^2) of the transformer
The ratio-area of the yoke to limbs is 1.20
Flux density in the yoke 0.833333 Wb/m^2
Area of the yoke is 0.012162 m^2
Gross area of the yoke is 0.013514 m^2
Select the section of the yoke is rectangular
The depth of the yoke is 0.1140 m
Height of the yoke 0.1185 m

************************************ ********
OVERALL DIMENSION OF THE TRANSFORMER
****
Distance between adjacent cores centers 0.255 m
Height of the frame is 0.537 m
Width of the frame is 0.623 m
Depth of the frame 0.114 m

****
LOW VOLTAGE WINDING

****
Secondary line voltage is 433.00 V
Connection type is star
Phase voltage is 249.993 V
Turn per phase is 111
Secondary current per phase is 33.334 A
Current density in secondary phase is 2.30 A/mm^2
Total area of secondary conductor is 14.493 mm^2
Area of each conductor is 14.493 mm^2
Dimension of the conductor is 7.500 X 2.000
Modified area of the conductor is 15.000 mm^2
Modified current density in secondary phase is 2.22 A/mm^2
Covering of conductor is 0.500 mm
Dimension of the conductor with covering is 8.000 X 2.500
The number of layer is used is 6
Turns along the axial depth is 19
Axial depth of the LV winding is 152.000 mm
Clearance is 74.000 mm
Thickness of the pressboard cylinders is 0.500 mm
Radial depth of the LV winding is 16.000 mm
The insulation for the circumscribing circle is 0.500 mm
The insulation between LV winding and core is 1.500 mm
Diameter of the circumscribing circle is 0.135 mm
Inside diameter is 138.031 mm
Outside diameter is 170.031 mm

****
HIGH VOLTAGE WINDING DESIGN OF THE TRANSFORMER
****
Primary line voltage is 11000.00 V
Connection type is delta
Primary phase voltage is 11000.000 V
Primary turn per phase is 4884
Tapping is considered here
Percentage of tapping is 5.000 percent
Primary turn per phase with 5.000 tapping is 5128
Actual number of turn per phase 5128
Cross over winding is used here
The value of voltage per coil is 1500.000 V
Number of coil is 7
Modified number of coil is 8
Modified value of voltage per coil is 1375.000 V
Turns per coil is 641 Number of normal coil is 7
Turns for the normal coil are 672
Reinforced turns in remaining 1 coil is 424
Total turn is 5128
Number of layers 24
Number of turn per layer 28
Primary current per phase is 0.758 A
Current density in primary conductor is 2.400 A/mm^2
Area of primary conductor is 0.316 mm^2
Calculated Diameter of the primary conductor is 0.634Standard value of the diameter proper insulation is 0.805 mm
Modified area of primary conductor is 0.322 mm^2
Modified current density in the primary conductor is 2.355 A/mm^2 Axial depth of one coil is 22.540(mm)
Space between adjacent coils (mm) is 5.0

Axial length of the coil (mm) is 220.320
Clearance is 39.840(mm)
The thickness of insulation is 0.300
Radial depth of the coil is 26.220(mm)
Thickness of the insulation between low voltage and high voltage is 14.900(mm)
Inside diameter of the HV is 199.831(mm)
Outside diameter of the HV is 252.271(mm)

For Copper Transformers:

****
RESISTANCE DESIGN OF THE TRANSFORMER
****
Mean diameter of the HV winding is 226.051(mm)
Length of mean turn in HV winding is 0.710
Resistivity of material is 0.0210
Resistance is the high voltage side is 226.4125
Mean diameter of low voltage winding is 154.031(mm)
Length of mean turn in LV winding is 0.484(mm)
Resistivity of material of low voltage winding is 0.0210
Resistance in the low voltage side is 0.0752
Resistance referred to primary side is 371.9966(ohm)
Per unit resistance is 0.0256

****
CALCULATION OF LEAKAGE REACTANCE OF THE TRANSFORMER
****
Mean diameter of winding is 195.151(mm)
Length of mean turn of winding is 0.613(m)
Mean axial length of winding is 186.160(mm)
Leakage reactance referred to primary side is 898.100(ohm)
Per unit leakage reactance is 0.062
Per unit impedance is 0.067

****
CALCULATION OF LOSSES OF THE TRANSFORMER
****
I^2*R Loss is 640.490(W)
Copper Loss is 640.490(W)
The Percentage of Stray Loss is 15.000
I^2*R Loss including Stray Loss is 736.564
Density of Lamination is 7600.000(kg/m^2)
Weight of the 3.000 Limbs is 69.324(kg)
Specific Core Loss is 1.200(W/kg)
Core Loss in the Limbs is 83.189(W)
Weight of the 2.000 Yokes is 115.182(kg)
Specific Core Loss is 0.850(W/kg)
Core Loss in the Yokes is 97.905(W)
Total Core Loss is 181.094(W)

****
CALCULATION OF EFFICIENCY OF THE TRANSFORMER
****
Total Loss is 917.658 (W)
Efficiency of the Transformer is 96.46
Condition for Maximum Efficiency is 0.50

****
NO LOAD CURRENT CALCULATION OF THE TRANSFORMER
****
Value "at" of Core corresponding to the flux density (1.000 Wb/m^2) in Core is 120.00(A/m)
Value "at" of Core corresponding to the flux density (0.833 Wb/m^2) in yoke is 80.00(A/m)
Total Magnetizing Current is 207.690(A)
Magnetizing mmf per phase is 69.230(A)
Magnetizing Current is 0.01002(A)
Loss component of no load Current is 0.00549(A)
No load Current is 0.01143(A)
No load Current as a percentage of full load current is 1.5(A)

For Aluminium Transformers:

****
RESISTANCE DESIGN OF THE TRANSFORMER
****
Mean diameter of the HV winding is 226.051(mm)
Length of mean turn in HV winding is 0.710
Resistivity of material is 0.0300
Resistance is the high voltage side is 323.4465
Mean diameter of low voltage winding is 154.031(mm)
Length of mean turn in LV winding is 0.484(mm)
Resistivity of material of low voltage winding is 0.0300
Resistance in the low voltage side is 0.1074
Resistance referred to primary side is 531.4238(ohm)
Per unit resistance is 0.0366

****
CALCULATION OF LEAKAGE REACTANCE OF THE TRANSFORMER
****
Mean diameter of winding is 195.151(mm)
Length of mean turn of winding is 0.613(m)
Mean axial length of winding is 186.160(mm)
Leakage reactance referred to primary side is 898.100(ohm)
Per unit leakage reactance is 0.062
Per unit impedance is 0.072

****
CALCULATION OF LOSSES OF THE TRANSFORMER
****
I^2*R Loss is 914.986(W)
Copper Loss is 914.986(W)
The Percentage of Stray Loss is 15.000
I^2*R Loss including Stray Loss is 1052.234
Density of Lamination is 7600.000(kg/m^2)
Weight of the 3.000 Limbs is 69.324(kg)
Specific Core Loss is 1.200(W/kg)
Core Loss in the Limbs is 83.189(W)
Weight of the 2.000 Yokes is 115.182(kg)
Specific Core Loss is 0.850(W/kg)
Core Loss in the Yokes is 97.905(W)
Total Core Loss is 181.094(W)

****
CALCULATION OF EFFICIENCY OF THE TRANSFORMER
****
Total Loss is 1233.328 (W)
Efficiency of the Transformer is 95.30
Condition for Maximum Efficiency is 0.41

****
NO LOAD CURRENT CALCULATION OF THE TRANSFORMER
****
Value "at" of Core corresponding to the flux density (1.000 Wb/m^2) in Core is 120.00(A/m)
Value "at" of Core corresponding to the flux density (0.833 Wb/m^2) in yoke is 80.00(A/m)
Total Magnetizing Current is 207.690(A)
Magnetizing mmf per phase is 69.230(A)
Magnetizing Current is 0.01002(A)
Loss component of no load Current is 0.00549(A)
No load Current is 0.01143(A)
No load Current as a percentage of full load current is 1.5(A)

IV. COMPARATIVE STUDY AND ANALYSIS

The effect of variation of percentage of I^2R loss on KVA ratings of transformer has been shown in Fig.1. In this observation the value of transformer KVA rating is varied from 5 KVA to 100 KVA with the variation of percentage of I^2R loss has been observed. The value of percentage I^2R loss is higher when the KVA rating is lower and vice versa. The value of percentage of I^2R loss is decreased with increasing of KVA rating. This observation is same for both copper and aluminium winding transformer but I^2R loss of aluminium wound transformer is higher than that of copper wound transformer for same KVA rating.

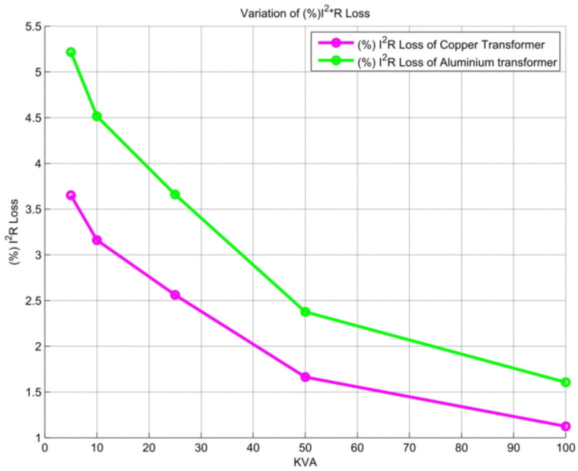

Figure 1**:** Transformer KVA Rating vs. Percentage of I^2R Losses for both Copper and Aluminium Wound Transformer

The effect of variation of efficiency on KVA ratings of transformer has been shown in Fig 2. In this observation the value of transformer KVA rating is varied from 5 KVA to 100 KVA and the variation of all-day efficiency has been observed. The value efficiency is higher when the KVA rating is higher and vice versa. The value of efficiency is increased with increasing of KVA rating. This observation is same for both copper and aluminium winding transformer but efficiency of aluminium wound transformer is lower than that of copper wound transformer for same KVA rating. It is seen that 93.5% to 98.2% all-day efficiency has been achieved for aluminium winding transformer and 94.9% to 98.5% all-day efficiency has been achieved for copper winding transformer.

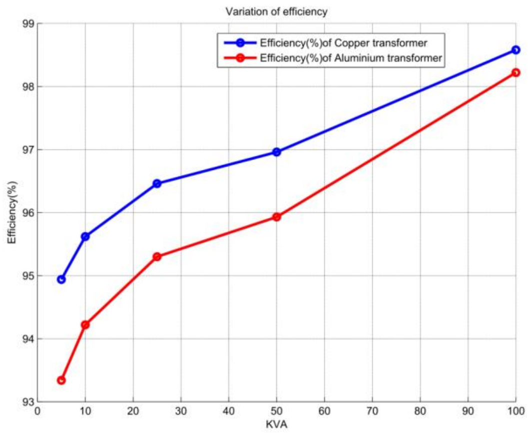

Figure 2: Transformer KVA Rating vs. Percentage of I^2R Losses for both Copper and Aluminium Wound Transformer

The effect of variation of loading causes the variation of I^2R loss of transformer. The graph of variation of I^2R loss for copper winding transformer is shown in Fig.3 and the graph of variation of I^2R loss for aluminium winding transformer is shown in Fig.4. In this observation the value of percentage of KVA loading changes from 10% to 100% for KVA ratings varied from 5 KVA to 100 KVA. The value of I^2R loss is lower when the percentage of KVA loading is lower and vice versa. The value of I^2R loss is increased with increasing of percentage of KVA loading. This observation is same for both copper and aluminium winding transformer but I^2R loss of aluminium transformer is higher than that of copper transformer for same percentage of KVA loading.

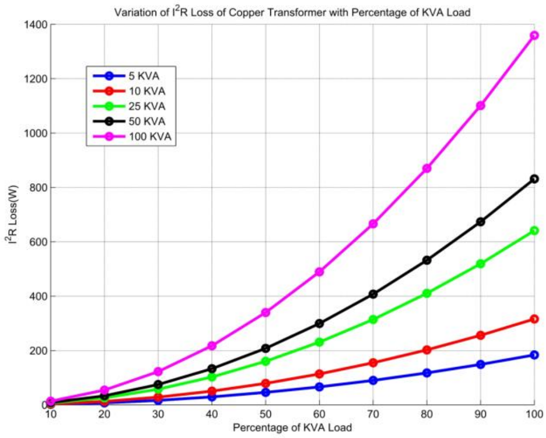

Figure 3: I^2R Loss of Copper Wound Transformer vs. Percentage of KVA Load

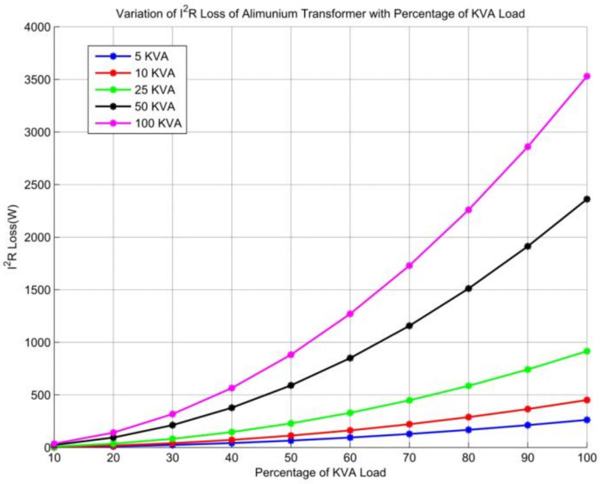

Figure 4: I^2R Loss of Aluminium Wound Transformer vs. Percentage of KVA Load

The effect of variation of transformer efficiency with loading the value of percentage of KVA loading changes from 10% to 100% for KVA ratings varied from 5 KVA to 100 KVA. The value of percentage of I^2R loss is increased with increasing of percentage of KVA loading. The core loss remains constant for different loading. Efficiency was maximum when copper loss and core loss was equal. This observation is same for both copper and aluminium wound transformer but efficiency of aluminium wound transformer is lower than that of copper wound transformer for same percentage of KVA loading. Fig.5 shows the effect of loading on copper wound transformer and Fig.6 shows the effect of loading on aluminium wound transformer.

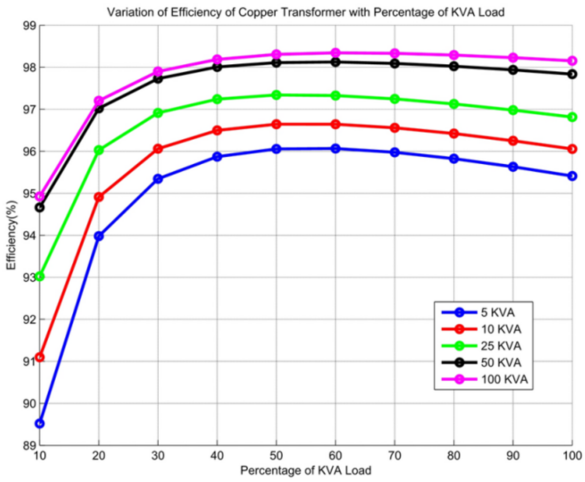

Figure 5: Variation of Efficiency vs. Loading of Copper Wound Transformer

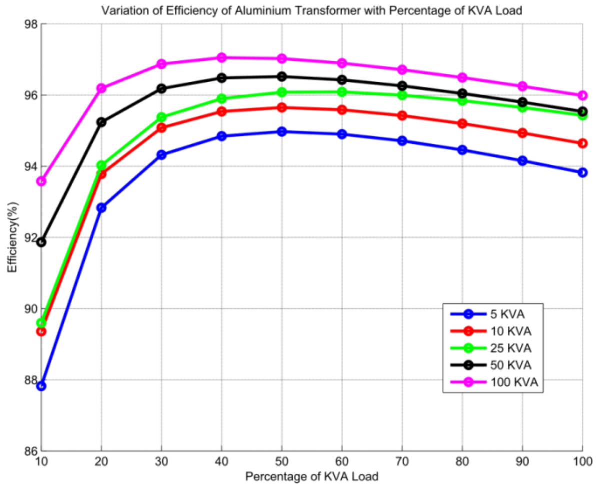

Figure 6: Variation of Efficiency vs. Loading of Aluminium Wound Transformer

Voltage regulation is increased with increasing of percentage KVA load. In this observation the value of KVA load is varied from 10% to 100 % whereas KVA ratings are considered from 5 KVA to 100 KVA. Fig.7 shows the variation of voltage regulation for different loading of copper transformer and Fig.8 shows the variation of voltage regulation for different load of aluminium transformer. Voltage regulation of aluminium transformer is higher than that of copper transformer for same percentage KVA loading. Here we use 0.8 lagging power factor.

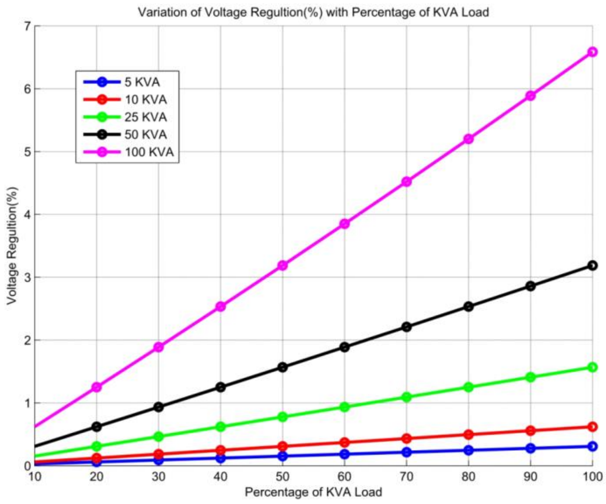

Figure 7: Voltage Regulation vs. KVA Load of Copper Wound Transformer

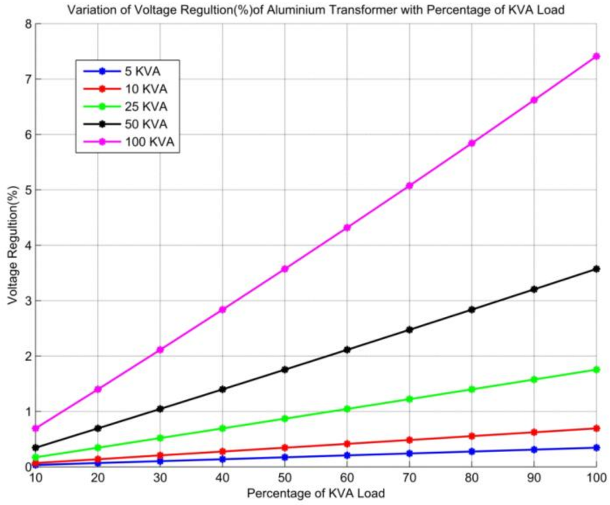

Figure 8: Voltage Regulation vs. KVA Load of Aluminium Wound Transformer

Efficiency is increased with increasing of power factor (lagging). In this observation the value of power factor is varied from 0.7 to 1.00 whereas KVA ratings are considered from 5 KVA to 100 KVA. Fig.9 shows the variation of efficiency for different power factor of copper wound transformer and Fig.10 shows the variation of efficiency for different power factor of aluminium wound transformer.

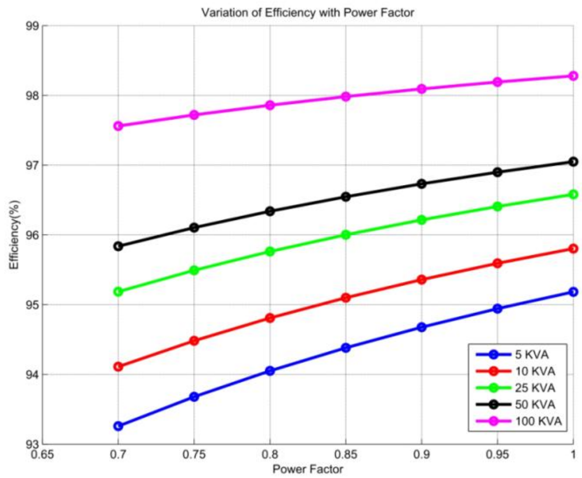

Figure 9: Efficiency vs. power factor of copper wound transformer

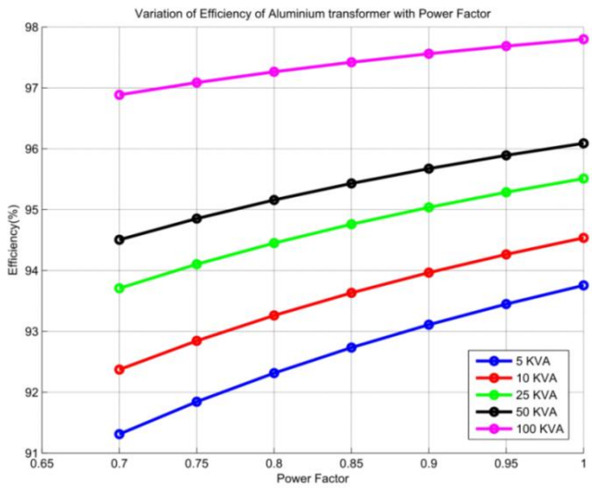

Figure 10: Efficiency vs. Power Factor of Aluminium Wound Transformer

V. CONCLUSION

This paper implements a MATLAB program for designing distribution transformers and analyzing their working performance. It represents a comparative study based on the analysis of program outputs for the selection of copper against aluminium windings for distribution transformers. This research work has not only been of interest to transformer designers, but the comparison of copper and aluminium conductor wound distribution transformers has been discussed.The advantages of use of MATLAB program for the design of transformer may be summed up as:

i. It is easily accessible to engineers with little experience in transformer engineering.
ii. The high rate of performing calculation at reasonable cost can be obtained.
iii. It eliminates a large number of non-useful combinations of design parameters.
iv. The results are highly accurate and reliable.
v. It can design a series of machines having different ratings to fit into a given frame size.
vi. It is capable of taking logical decisions and save man hour of the design engineers.
vii. The outputs can be integrated for further analysis.

The design data sheets have been prepared and these results have been observed for performance analysis. From the program outputs, it was observed that the better performance can be achieved for higher KVA ratings of transformer. Design data sheet is used in graphical representation to show the performance variation at different ratings. Performance has been also analyzed for various KVA loading and load power factor. It is usually tried to operate the transformer at close to full load condition because maximum efficiency of transformer has been achieved in this condition.

Although the variation characteristics were same for copper and aluminium winding transformer, the working performance of both transformers were not equal. The variation of physical properties of copper and aluminium conductors offer higher losses for aluminium windings and greater efficiency for copper windings. The summary of analysis helps the designer to compare the performance of copper and aluminium windings. By calculating the windings volume using the program, the total cost can be obtained for desired efficiency. Aluminium wound transformer needs more conductors (greater volume) to obtain the same efficiency as like copper windings transformer that may increase the cost. But aluminium conductor is cheaper than copper thus the overall cost analysis vs. efficiency may be dissimilar for different KVA ratings. Since many factors are related for the design of transformer thus the selection of winding material between aluminium and copper is not an easy task.

VI. ACKNOWLEDGEMENTS

Foremost, we would like to express our sincere gratitude to our supervisor Mr. Dilip Kumar Sarker, Associate Professor, Dept. of Electrical & Electronic Engineering, Pabna University of Science & Technology, for his patience, motivation, enthusiasm and immense knowledge. His guidance helped us in all the time of research and writing of this thesis. We could not have imagined having a better supervisor and mentor for our research work.

REFERENCES

[1] Easwarlal, C., Palanisamy, V., Sanavullah, M. Y. and Gopila, M.,"Graphical estimation of optimum weights of iron and copper of a Transformer", *PEDES 06 IEEE International conference*, New Delhi, 2006, pp. 1-5.

[2] A.K. Sawheny & Chakrabarti, *A course in electrical machine design*. (Dhanpati Rai and sons, 1984).

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Fabrication and Performance Evaluation of a Pedal Driven Pulverizing and Sieving Machine for Dewatered Grated Cassava

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ABSTRACT : *The traditional method of pulverizing and sieving cassava lump in garri production is very tedious, time consuming, unhygienic and consequently with low efficiency. The need to eliminate drudgery in the traditional method, will involves the mechanization of pulverizing and sieving process. This paper presents the fabrication and performance evaluation of a pedal driven pulverizing and sieving machine for dewatered grated cassava. The machine was designed to be driven like a bicycle, which sends rotary motion to the system. It was made to accept cassava lumps through the hopper to the pulveriser, which rotates at a speed greater than that of the lump, thereby breaking it into smaller particles. The performance of the machine increases with increase in the amount of cassava lump inserted into the machine. The efficiency of the machine shows that as the cassava lump inserted into the machine increases, the efficiency increases from 80% and 83% to 86% and 85% for the TMS 82/00058 and TMS 82/00661 varieties respectively.*

Keywords *-Pedal Driven, Pulverizer, Cassava, Siever, Dewatered Grated Cassava*

I. INTRODUCTION

Cassava (Manibotesculenta) is a major source of carbohydrates and the cheapest source of calorie in human diet especially regions of Africa, Latin America and Asia. Though Cassava originated from Latin America, Africa is the largest producer of Cassava, with 62% of the total world production. Nigeria is leading the world with 19 % of global market share [1]. The total world cassava utilization is projected to reach 275 million tons by 2020 [2]. Cassava can be used in various ways and each component of cassava plant, from leave to roots can be utilized in one way or another. In some communities, the leaves are consumed as a vegetable, or cooked as a soup ingredient or dried and fed to livestock as a protein feed supplement. The stem is used for cassava propagation and grafting. The roots are the main product of the plant and are typically processed for human consumption and industrial utilization [3].

Garri is the dominant product of Cassava and is widely consumed in both rural and urban areas. It can be consumed without any additives, or with variety of additives such as sugar, groundnut, fish, *kuli-kuli* and meat. When prepared in boiled water, it is consumed with soup or stew. It is estimated that more than 65% of the cassava consumed in Nigeria is in the form of *garri* [4]. *Fufu* and *Akpu*, a fermented wet paste from cassava is also widely consumed throughout the country especially in the southern zones [3]. In 2001, it was estimated that 16% of cassava root production was utilized as an industrial raw material in Nigeria. 10% was used as chips in animal feed, 5% was processed into a syrup concentrate for soft drinks and less than 1% was processed into high quality cassava flour used in biscuits and confectionary, dextrin pre-gelled starch for adhesives, starch and hydrolysates for pharmaceuticals and seasonings [5].

To obtain *garri*, Cassava undergoes different stages. These include peeling, washing, grating (mashing), dewatering/fermentation, pulverizing/sieving and frying. The interest of this paper is pulverizing and sieving. Pulverization is the process of breaking the lumps formed during the process of dewatering into smaller pieces before the commencement of sieving operation. Traditionally, pulverizing and sieving are done manually. Sieving is achieved by placing the pulverized lumps on a local mesh, made of raffia or metal and then rubs with hands. The aim of sieving is to eliminate fibrous contaminants and achieve fine granules for easy frying and better *garri* quality. The traditional method of pulverizing and sieving of *garri* production is very tedious, time consuming and have very low output produced.

The need for mechanization led to the fabrication of a cassava lump breaker by Sulaimon and Adigun [6]. Though the performance evaluation of the machine was not performed, they recommended the use of stainless steel instead of mild steel to prevent corrosion and allow hygienic operation. Oyeleke [7] designed, fabricated and carried out performance evaluation of a manually operated cassava sieving machine with locally sourced materials and achieved an overall machine efficiency of 89.6%. Similarly, Orojinmi [8] developed a cassava siever and achieved a machine efficiency and output capacity of 76% and 69.12kg/hr respectively. The above machines performed very well but did not achieve the much desired mechanization of pulverization and sieving as these were done separately, either manually or mechanically, thereby creating a backlogged of work in the manually operated side. To incorporate pulverization and sieving, Odigboh and Ahmed [9] designed and fabricated a prototype machine for pulverizing and sifting *garri* mash. The machine uses an electric motor and can produce up to 125kg/hr. Uthman [10] also designed and fabricated a motorized lump breaking and sieving machine. The machine optimal performance was at a speed of 265rpm. The lumps breaking and sieving gave efficiency of 97% with a throughout capacity of 1.91kg/hr. Another motorized cassava lump breaker and sifting machine was developed by Alabi [11]. He recommends that an outlet provision should be made for unsifted materials. Based on the recommendation by Alabi [11], Kudabo et al. [12] modified the design of Alabi [11] by making provision for the outlet of the unsifted materials and providing cover for the hopper to reduce the amount of spilled cassava lump. They achieved an overall efficiency and output capacity of 93.3% and 136.2 kg/hr respectively. Ikejiofor and Oti [13] carried out the development of a motorised combined cassava mash pulverizer and sifter machine. They obtained overall average machine efficiency for both varieties of cassava to be 86.7%.

Most of the recent development in mechanizing the process of pulverization and sieving requires an electric motor powered by electricity. This source of power is becoming increasingly scarce and expensive in most developing countries. There is therefore the need to have a human driven machine that can be used for pulverization and sieving operation. To achieve this, Okegbile et al. [14] designed a pedal driven pulverizing and sieving machine for dewatered grated cassava. This paper presents the fabrication and performance evaluation of the pedal driven pulverizing and sieving machine for dewatered grated cassava.

II. METHODS

2.1 Materials Selection

The materials used for the design and fabrication of the pedal driven pulverizing and sieving machine were based on availability of materials, ease of fabrication, serviceability, strength, and cost. The key materials used are mild steel and galvanized iron sheet. Due to its ability to resist corrosion, galvanized iron sheet was used to fabricate component such as feed hopper, sieve shaker, discharge outlet and the conveyor. These parts are always in contact with water and cyanide acid. The bicycle body frame and pulveriser are the non-hygroscopic parts of the machine and are fabricated using mild steel. To minimise the effect of corrosion, the mild steel was painted. Mild steel has found application in various other locally fabricated machines in Nigeria such as refrigeration [15-17], water heater [18], hydraulic accumulator [19, 20], groundnut shelling, roasting and oil expelling machines [21-23].

2.2 Fabrication

Hopper

A galvanized iron sheet was shaped to form a pyramidal frustum with dimension 670 mm x 200 mm. The unit was then fitted above the pulveriser and firmly place-tighten on the frame of 500 x 200 mm of the mild steel angle box. The discharge hopper is a larger sieving channel and smaller rectangular size of dimension 550 x 160 mm and 300 x 120mm respectively.

Chute, Mainframe, Connecting Rod and Bearing Support

The mainframe was made of angle iron. The connecting rod and bearing support are made of mild steel materials, while the chute is made of galvanized steel. The chute is 470 x 280 mm and is projected at an angle of 40° to the horizontal to give away for easy sliding of the sieved cassava lump pulverized. The mainframe was rigidly welded together with a dimension of 775 x 550 x 685 mm. The connecting rod which carries the slider cranks metal to give momentarily movement to and fro by transforming a circular motion to reciprocating motion. The bearing support measures 165 x 240 mm and used to give base to the arrangement of pulley and bearing.

Bicycle

Is a hollow shaft and made of mild steel to resist tension fragility, sagging and shearing respectively.

Angular Bar

A pair of angular bar measuring 840 x 50 mm was used to give support to the bicycle to resist physical factors damages.

Sprocket, Spikes, Chains and Pedals

The sprockets are of 4-types with a pair supporting and transmitting torque in two directions and are arranged systematically to give kinematic movement in one plane. The Spikes has a length of 54mm welded firmly to the cylinder such that both make up the pulveriser to allow for sprockets attachment. The Pedals provides an inductive energy for motion. It employs a heavy bused semi-conductor to reduce heat energy and pressure inherent in the process of operating. The Chain is connected via the sprockets and transmits power from input to output sources. For the purpose of this design, roller chain was used.

Machining of Shaft

The shaft made of structural mild steel is about 800mm long with diameter of 35mm. The shaft was hold by high-speed chuck on the lathe machine for both the turning and facing operations.

Pulveriser

The pulverizing cylinder comprises of the rotating drum and spikes. This arrangement was selected based on the impact force required to break the pods without causing any structural failure on pulverizing cylinder. It is made up of mild steel of diameter 50mm hollow throughout to allow for a shaft of 25mm diameter to be force fitted which bring a length of 700mm for the main frame on the bearing. For this machine, a galvanized pipe was used for drum and baffles were welder at the ends of the pipe which the main shaft passes through.

The Spikes were made of 10mm diameter plate mild steel and 54mm long. The spikes were then welded on to the drum at 90^0 with a distance of 20mm apart. The Galvanizer pipe is 700mm long, 2mm thick and a diameter of 25mm. It was attached to the bored plate at 20mm and welded. The End plates were circular and of 3mm thick with a hollow centre to allow passage of main shaft and welded on to the pipe both ends.

The Sieve and Sieve Shaker

The sieve shaker is a mild steel welded rectangular unit measuring 560 x 445 x 50 mm and assembled together with 2 pairs of 10mm diameter rod. An attachment of the sides to provide guides is done to prevent the sieve shake unit. It is made of mild steel material. The sieve is a rectangular frame of 550 x 390 x 150 mm welded together and incorporated with gauge wires of micro millimetre to allow the desired refine particle of sieve cassava to be obtain.

III. OPERATION OF THE MACHINE

3.1 Description

The machine consists of three units: the pulverizing unit, the sieving mechanism and the bicycle unit. The pulverizing unit includes the feed hopper, discharge hopper and a pulverizer (a cylindrical shaft) where the cassava pulp into smaller particles and discharge it through the discharge hopper onto the sieve. The sieving mechanism is mounted on the main frame and with the chute beneath it for accepting the finer grain of *garri* after sieving. The sieving mechanism consists of a disc which is connected to the rectangular sieve housing for its reciprocating motion. A flywheel is mounted on the other side of the disc to enhance its efficiency. The bicycle unit consists of the power transmitting parts, which when peddled, transmits power through the help of sprocket and chain drive into the system.

3.2 Operational Principle

The cassava pulps are feed into the machine through the feed hopper and are reduced to smaller particles with the aid of the pulveriser. Motion is transmitted from the peddling of the bicycle via the chain drive arrangement. The rotating motion of the driven sprocket is changed to reciprocating motion via the connecting rod at the casing of the sieve. The reciprocating motion produces to and fro motion on the sieve box. This enables the grated cassava to vibrate. The vibrational motion forces the fine particles of grated product through the sieve and the finer particles are collected from the chute.

3.3 Maintenance Procedure

An important form of preventive maintenance activities is inspection at regular intervals. This has been adapted for this machine to achieve optimum performance. For the effective performance of the reciprocating sieve, the following activities are recommended:

- The chaff of the cassava should be removed after each operation and the sieves properly cleaned.
- Regular lubrication of the crankshaft bearing.
- Regular lubrication of the rollers, the connecting rod bearing.
- Apply protective coats of paints to the frame periodically to prevent corrosion.
- Machine should be properly covered from moist and dust with protective guard during operation and when not in use.
- Regular checking of bolts and nuts for likely loosening before on and after operation.
- Check for chain tension and adjuster regularly.

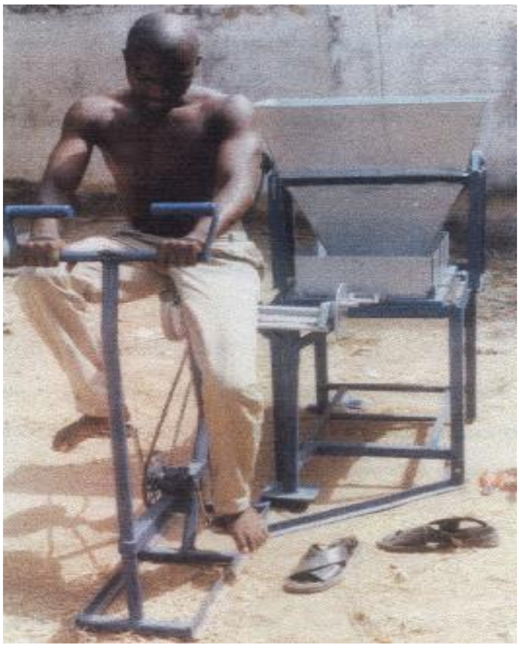

Figure 1. The Pulverizing and Sieving Machine being operated by an operator

IV. Performance Evaluation

4.1 Performance

The performance of the machine was evaluated based on the sieving efficiency of the machine and is defined as:

$$\eta_m = \frac{W_{ps}}{W_l} X100 \qquad (1)$$

Where, η_m is the efficiency of the machine; $W_{ps}$is the weight of pulverized and sieved lump of cassava (Kg); $W_{fl}$is the weight of the fed lump (Kg).

4.2 Test Procedure

Two varieties of Cassava tubers (TMS 82/00058 and TMS 82/00661) were bought from local farmers in Minna, Niger State. The tubers were peeled, washed, grated, fermented and dewatered. 1.5 kg of the dewatered cassava pulps was weighed and poured into the hopper of the machine. As pressure was applied to the pedal by the operator, the pulveriser turns and breaks the cassava lumps into smaller particles. The smaller particles cassava lumps drops into the sieve box. The reciprocating motion produces to and fro motion on the sieve box. This enables the grated cassava to vibrate. The vibrational motion forces the fine particles of grated product through the sieve and the finer particles are collected from the chute. The weight of the finer particles was recorded. Similar procedure was carried out for both varieties of Cassava. The test was repeated for 3.5 kg and 5.5 kg for the two varieties of cassava recorded. The efficiency was calculated using equation (1).

4.3 Result and Discussions

The results of the performance evaluation of the locally fabricated pulverizing and sieving machine for dewatered grated Cassava are shown in Figures 2 to 4. Figures 2 and 3 show the weight of Pulverized and Sieved cassava for TMS 82/00058 and TMS 82/00661 varieties respectively. The results show that when 1.5 kg of cassava lump was inserted into the machine, 1.2 and 1.25 kg of pulverized cassava was received for the TMS 82/00058 and TMS 82/00661 varieties respectively. When 5.5 kg of cassava lump was inserted into the machine, 4.75 and 4.65 kg of pulverized cassava was received for the TMS 82/00058 and TMS 82/00661 varieties respectively. The performance of the machine increases with increase in the amount of cassava lump input. Figure 4 shows the comparative efficiency of the machines when using the two varieties of cassava. The efficiencies reveal that as the cassava lump inserted into the machine increases, the efficiency increases from 80% and 83% to 86% and 85% for the TMS 82/00058 and TMS 82/00661 varieties respectively as shown in Figure 4.

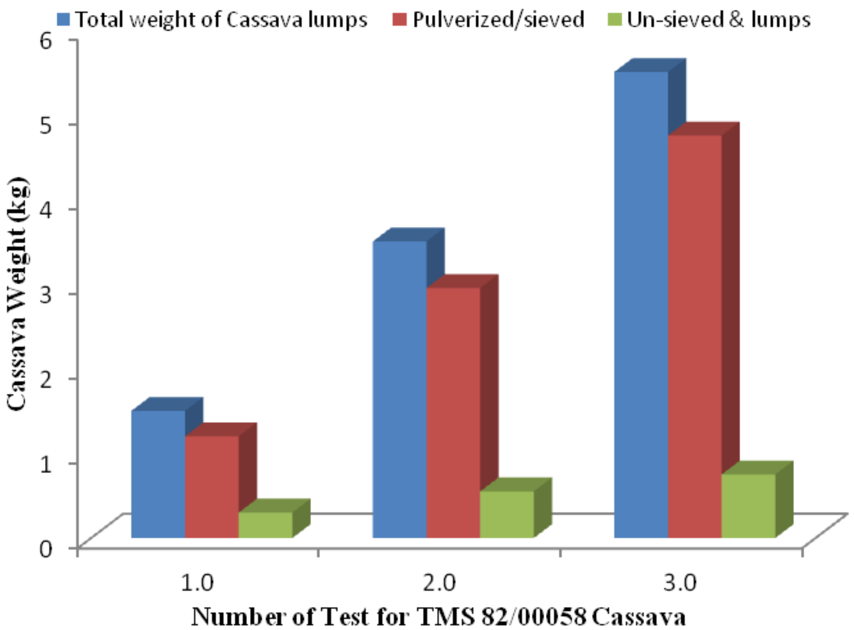

Figure 2. Performance of pulverizing and sieving machine for TMS 82/00 058 Cassava

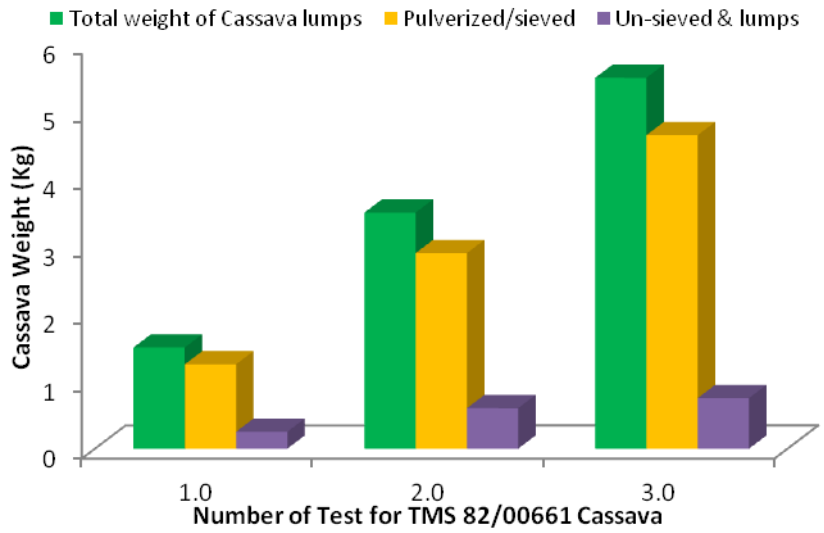

Figure 3. Performance of pulverizing and sieving machine for TMS 82/00661 Cassava

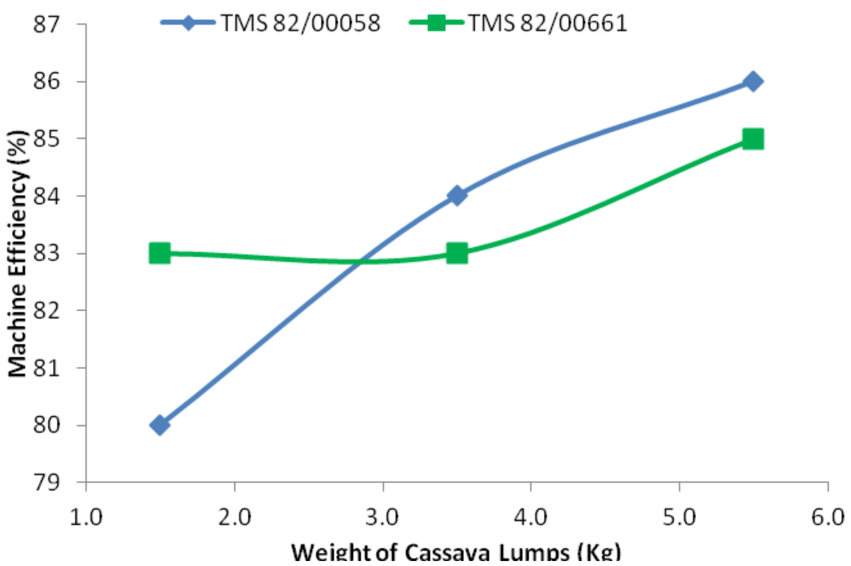

Figure 4. Machine efficiency of two varieties of Cassava

V. CONCLUSION

The fabrication and performance evaluation of a pedal driven pulverizing and sieving machine for dewatered grated cassava has been presented. The performance of the machine increases with increase in the amount of cassava lump inserted into the machine. The efficiencies show that as the cassava lump inserted into the machine increases, the efficiency increases from 80% and 83% to 86% and 85% for the TMS 82/00058 and TMS 82/00661 varieties respectively. The success of the design and performance evaluation has proved that proper development of farm machinery using local resources is very important and economical. The workability is satisfactory and the efficiency is favourable when compared to the existing locally made designs. The uniqueness of this machine is its ability to be used in rural areas characterised by epileptic power supply. The design can be improved upon and adopted for commercial production nationwide to enhance processing of cassava in rural areas.

REFERENCES

[1]. Hillocks, R. (2002). Cassava in Africa. In R. Hillocks, J. Thresh, & A. C. Bellotti, eds., Cassava Biology, Production and Utilization. CABI Publishing.

[2]. Westby, A. (2008). Cassava Utilization, Storage and Small-scale Processing. In R. Hillock, J. Thresh, & A. C. Bellotti, eds., Cassava Biology, Production and Utilization. CABI Publishing.

[3]. Ajao K. R and Adegun I. K. (2009). "Performance Evaluation of a Locally Fabricated Mini Cassava Flash Dryer", Journal of Science PublicationVol 1(3), 54-60. Retrieved from www.sciencepub.net. Accessed on 15th January, 2011.

[4]. Adamu, S.O. (1989). Trends and Prospects of Cassava in Nigeria. International Food Policy Research Institute, USA, Pg 174-176.

[5]. Phillips, T.P., Taylor, D.S., Sanni, L., and Akoroda, M.O. (2004). A cassava industrial revolution in Nigeria: The potential for a new industrial crop. The Global Cassava Development Strategy. FAO. Accessed on 01/06/2014, retrieved from: ftp://ftp.fao.org/docrep/fao/007/y5548e/y5548e00.pdf .

[6]. Sulaiman M.A. and Adigun R.A, (2008). Fabrication of cassava lump breaker. Unpublished project report submitted to the department of Mechanical Engineering Kwara State Polytechnic Ilorin.

[7]. Oyeleke,O.O.(1997). "Construction of a Manually Operated Cassava Sieving Machine", An unpublished HND Project Report. Submitted to the Department Agricultural Engineering and Water Resources. Kwara State Polytechnic Ilorin, Kwara State.

[8]. Orojinmi M.A. (1997). Development of cassava siever. Unpublished HND project Agricultural Engineering Department Kwara State Polytechnic Ilorin.

[9]. Odigboh E.U and Ahmed S. F. (1984); "A Machine for Pulverizing and sifting gari mesh" Vol. 8 (1):19-23.

[10]. Uthman, F. 2011. Design And Fabrication Of Cassava Lump Breaking And Sieving Machine, Oasis Journal Of Research And Development, Vol 1 No 2):42-50.

[11]. Alabi,O. O. (2009). "Design, Fabrication and Performance Evaluation of a Cassava Lump Breaking and Sieving Machine", An unpublished HND project. Department of Agricultural and Water Resources, Kwara State Polytechnic Ilorin, Kwara State.

[12]. Kudabo, E. A; Onipede, E.A., Adegbenro, O. A. (2012). Design, Fabrication AndPerfomance Evaluation Of An Improved Cassava Mash Sifter, Journal of Agriculture and Veterinary Sciences, Volume 4 (March):53-64.

[13]. Ikejiofor M.C. and Oti E. 2012, performance evaluation of a combined cassava mash pulverizer/sifter. International journal of advanced scientific and technical research, Vol 5 (2):304-308.

[14]. Okegbile O. J., Hassan A. B., Mohammed A., Abdullahi A. A., Jimoh D. S. (2014). The Design of a Pedal Driven Pulverizing and Sieving Machine for Dewatered Grated Cassava, International Journal of Scientific and Research Publications, Vol. 4 (4): 516-520.

[15]. Mohammed A., Elaigu A. E., Adeniyi A. A, Hassan A. B. (2012). Development and Evaluation of a Prototype Refrigerated Cooling Table for Conference Services. International Journal of Engineering and Technology, Vol. 4 (2): 97-108.

[16]. Mohammed A., Elaigu A. E., Hassan A. B., Adeniyi A. A. (2012). The design of a cooling table for conference services. Elixir Mechanical Engineering, 44: 7354-7358.

[17]. Nasir A., Mohammed A., Abdulkarim H. T., Saheed A. A. (2013). Design and Performance Evaluation of an Ice Block Making Machine. ARPN Journal of Science and Technology (ISSN 2225-7217), Vol. 3 (4):332-339.

[18]. Mohammed A., Hassan A. B. (2012). Design and Evaluation of a Motorized and Manually Operated Groundnut Shelling Machine. International Journal of Emerging Trends in Engineering and Development (UK), Vol. 4 (2): 673-682.

[19]. Okegbile O. J., Hassan A. B., Mohammed A., Onekutu E. A. (2014). Design of an Improved Hydraulic Accumulator for a Truck Loading Lift, International Journal of Advanced Scientific and Technical Research, Vol. 2(4): 194-203.

[20]. Okegbile O. J., Mohammed A., Hassan A. B., Onekutu E. A. (2014). Fabrication and Testing of an Improved Hydraulic Accumulator for a Truck Loading Lift, International Journal of Engineering Trends and Technology, Vol. 10 (12): 586-589.

[21]. Nasir A., Mohammed A., Alewo I. G. (2012). Modeling and Experimental Performances of a Thermal Domestic Water Heater in Nigeria. International Journal of Advanced Scientific Research and Technology, Vol.4 (2): 366-374.

[22]. Okegbile O. J., Mohammed A., Hassan A. B., Obajulu O. (2014). Fabrication and Testing of a Combined Groundnut Roaster and Oil Expeller Machine, American Journal of Engineering Research, Vol. 3(4): 230-235.

[23]. Okegbile O. J., Hassan A. B., Mohammed A., Obajulu O. (2014). Design of a combined groundnut roaster and oil expeller machine, International Journal of Science and Engineering Investigations, Vol. 3(26): 26-30.