American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-7, Issue-5, pp-60-68
www.ajer.org
Research Paper Open Access

Design ofaLow Cost Concrete Mixer Machine

UkwuabaSamual Ifeanyi

Department of Mechanical Engineering, Petroleum Training Institute (PTI), Effurun, Nigeria

ABSTRACT :*The construction and building industries are expanding on a daily basis as a results of increase in human population and continually demand for shelter. Concrete which comprises mainly of sand, cement and gravel is an important component required for construction of houses and roads. However, most operation of mixing concrete in Nigeria is done manually as a result of lack of insufficient machinery and high importation cost. In this research, I carried out the design of a low cost concrete mixing machine. The materials used in this research work are as follow; sand, gravel, water, mild steel, hopper, electric motor, shaft, bearing, V-belt, angle bar, mild steel plate, bolts and nuts, etc. In other to achieve a good design, feasibility studies, and preliminary tests were carried out. The materials selected for this design were justified. Detailed designed to determine the torque, power, force, mixing chamber, etc., were carried out. The results obtained show that a power of 2hp, mixing force of 450N, torque of 135Nm, belt tension of 692.56N, mixing volume of 0.0085m3, were required.*

Keywords-*Design,concrete mixer, power, torque, belt tension, mixing volume*

Date of Submission: 18-04-2018 Date of acceptance: 03-05-2018

I. INTRODUCTION

Concrete is a structural material widely used in the construction industry. It consists essentially of cement, fine aggregate (sand) and coarse aggregate (natural gravels or chippings). These constituent materials proportioned are properlymixed together with water to form the concrete. The cement serves as the binder to the aggregates while the aggregates serve as the filler materials that give strength to concrete. Concrete has the unique distinction of being the only construction material manufactured on the site, whereas other materials are merely shaped to use at the work site [1]. A concrete mixer machine is a device that homogeneously combines cement, aggregate such as sand or gravel, and water to form concrete [2]. A typical concrete machine mixer uses a revolving drum to mix the components.

The compressive strength of concrete depends on the aggregate grading, aggregate/cement ratio as well as the water/cement ratio. The freshly mixed concrete should be workable to be properly placed and the hardened concrete needs to be durable and attain a specific compressive strength [3]. The aim of concrete mixer machine design is to achieve concrete that meets a specified strength. Concrete can be produced by employing either mechanical or manual mixing methods. In Nigeria like every other developing countries, hand mixing which involves turning over the mixture of the concrete materials from one end of the mixing tray or platform to the other is a popular methodof producing concrete. However, the end product obtained from manual mixing method possesses weak compressive strength. The compressive strength of concrete depends so much on the consistency achieved through mixing [4].

Continuous increase in human population brings about the need for development increases to provide homes, jobs, and roads for everyday needs. Shelter is one of the basic human necessities. Nevertheless, irrespective of the significance of shelter, most people do not have access to good shelter especially in developing, and underdeveloped countries. There is an estimated deficit of between 17 and 18 million housing units in Nigeria in 2012 [5]. The poor are most adversely affected by this housing shortage. The most important building materials is low-cost housing concrete [6], but conventional quality concrete mix manually possesses weak compressive as a result of non-uniform mixing.

Building and construction is one of the major industries around the world. The construction industry is labour-intensive and equally conducted in dangerous manners; thus, the importance of carrying out construction works with machines being realized and is grown rapidly. The construction revolution of today has made the contractors to equip their construction so as to perform the highest output with minimum construction cost. In order to have highest output, parameters like accuracy, precision, quality, and cycle time have to be optimized. This is possible either by having skilled manpower or by mechanizing the system [7]. With constant increase in the construction industries, contractors are forced to increase their construction bearing in mindthe quality of the construction work in the competitive market. The construction industry in most countries amounts to 10–20% of the GNP [8], making it the largest economic employing sector. It is still labour dependent and most of the work involved is repetitive. The growth of any country is dependent on the construction industry; hence, it is of prime economic significance to many industrial sectors. Intense competition, quality raw materials, skilled labour, and technological advances are forcing rapid changes in the construction industry, thus encouraging its mechanization. The construction of buildings, apartments, complex, shops, roads, and homes are basic requirements of human being. In this construction area, concretes are required. However, manual concrete mixing method is still largely used to produce a mixture of components for construction work by average Nigerians. Manual mixing method takes a lot of time to produce a mixture and also requires large human effort to mix it. There are many concrete mixers machines which are in existence. However, numbers of these machines are too expensive and because of this small scale construction workers are carried out using tradition method of mixing concrete. In this research work, a low cost concrete mixer machine was designed. This project work brought advantages over manual mixing and expensive mechanized concrete mixer machine that are usually imported to Nigeria.

II. MATERIAL AND METHOD

The materials used in this research work are as follow; sand, gravel, and water. Other materials used include; mild steel, hopper, electric motor, shaft, bearing, V-belt, angle bar, mild steel plate, bolts and nuts, etc. The durability, safety and most importantly the performance of a machine depends on the material used. For a better design to be achieved, good materials at possible lowest cost must be used.

2.1 Feasibility Study

A feasibility study aims to objectively and rationally uncover the strengths and weaknesses of an existing machine or proposed machine to design, opportunities and threats present in the environment, the resources required to carry through, and ultimately the prospects for success [9]. Feasibility study was carried out using existing method of producing concrete interlocking tiles machine. Different existing designs were look at, modification made, optimization for profit done, environment, ease of use and minimization for loss consider.

2.2 Preliminary Design

The preliminary design bridges the gap between the design concept and the detail design phase. In this task, the overall system configuration is defined and schematics, diagrams and layout of the project will provide early project configuration. During detailed design and optimization, the parameters of the parts being created will change but the preliminary design focus on creating the general framework to build the project on. Preliminary tests were carried-out using manual method of producing concrete. Here the cement is mixed with water and fine granite by able body men using shovel. The same method and procedure were followed to design the machine.

2.3 Design Requirement

Establishing design requirements is one of the most important elements in the design process and this task is normally performed at the same time as the feasibility analysis. The design requirements control the design of the project throughout the design process. The following design requirements were drawn:

i. Estimation of power required by the concrete mixer machine
ii. Determination of approximate length of the belt (m)
iii. Determination of load on shaft pulley and belt tensions (N)
iv. Determination of speed of driver and driven pulley
v. Determination of torque transmitted by electric motor
vi. Determination of force require to compress the interlocking tiles block
vii. Selection of bearing for shaft
viii.

2.4 Design Consideration

Since zero slump concrete is used in construction work, the quality of end product of concrete produced will

depend upon various parameters;
i. Vibration of machine
ii. Grade of cement used
iii. Water content
iv. Quality of aggregates used
v. Gradation and mix design adopted
vi. Additives used
vii. Handling equipment employed
viii. Level of supervision
ix. Workmanship and
x. Quality control achieved

Other facets were considered in the design process are as follow:
i. Functionality
ii. Reliability
iii. Durability
iv. Materials and labour use
v. Mixing
vi. Simplicity
vii. Portability and space
viii. Operational procedure
ix. Power supplier
x. Usability
xi. Maintenance
xii. Cost
xiii. Safety

2.5 Functionality

The concrete mixer machine will be able to produce tiles that are relatively strong and tough. The machine should be able to produced interlocking tiles at a possible short time.

2.6 Reliability

The concrete interlocking tiles block machine will be design to ensure that the reliability is above average (60%). It must be reliable in the sense that it must discharge its duty very well and it does not easily get spoiled.

2.8 Durability

The concrete mixer machine should have long active life (10 years). In other words, it must be able to last long.

2.9 Labour Use

The durability of the machine is another important physical design consideration. The operating environment in Nigeria has the potential to be harsh, with extreme heat and humidity. These conditions necessitate choosing materials that are corrosion resistant. Additionally, the machine will be design so that it can be used by many different operators, so the materials of machine must withstand prolonged heavy use. The weight of the final product was another factor consider in choosing materials for the design. The labour is limited to the ones available in an integral mechanical engineering. Some jobs are done on rolling machine, drilling machine and welding machine.

2.10Simplicity

The concrete mixer machine should be of the following;
i. Low in price
ii. High and small in size
iii. Easy to operate
iv. Easy to maintain
v. Have readily available spare part
vi. Marketable

2.11Portability and Space

The concrete mixer machine is design in such a way that it can easily be carried from one place to the other. It should not occupy large space. The machine must be something one can carry and it should not have much space to occupy.

2.12Operational Procedure
No specialization skill of experience is required for its operation. Switch on the power source so that that it drives the pulley to rotate the shaft that carried the mixer (i.e., for concrete mixer).

2.13Power Supplier
The concrete mixer machine requires power. AS soon as you plug in electricity, the power firstly goes to the electric motor that transmits the motion to the pulley that makes the whole system to work. The rotation of the shaft causes the concrete mixer blades to rotate thus carrying out mixing process.

2.14 Material Selection
The material selection for this research work is based on [10];
i. Service Requirement
ii. Fabrication Requirement, and
iii. Economic Requirement

2.14.1 Service Requirement
Service requirement in material selection involves the properties a material should have, to serve the purpose for which it is designed for. Some of these properties include: corrosion resistance, conductivity, strength, toughness, resistance to heat, maintainability, safety, etc. [10].

2.14.2Fabrication Requirement
Fabrication requirement entails workable properties a material should have, and they include machinability, forgability, malleability, ductility, weldability, castability, etc. [10]

2.14.3 Economic Requirement
Economic requirement in material selection entails the affordability of the material for fabrication and commercialization. It would not be profitable to manufacture at a high cost and sell below the manufactured cost [10].

2.15Choice of Material
The following materials listed in Table 1 were chosen for the various component parts of the plant.

Table 1. Material Selection and Justification

S/N	Component Description	Material	Justification
1	Metal sheet	Mild Steel	At high temperatures it prevents scale, toughness and maintains strength.
2	Angle bar	Medium carbon steel	Ability to withstand shear force and compressive force
3	Pulley	Cast iron	Tough, hard, low cost and has high strength
4	Shaft and lever	Medium carbon steel	Ability to withstand shear force and compressive force.
5	V- Belt	Reinforced rubber	*It is strong, flexible and durable, *It has a high coefficient of friction
6	Ball bearing	High Carbon Steel	Resistance to wear and corrosion, hard, tough and has high strength.

2.16 Detailed Design

2.16.1 Determination of Mixing Force of the Concrete
The mixing force of the concrete was calculated as follow:

$$W = M_T \times g \quad (1)$$

where,
M_T = Total Mass = Mass of concrete + Mass of mixing drum
g = Acceleration due to gravity = 10m/sec^2
But,
Maximum mass of concrete the mixing drum can take = 40kg (Measured)

Mass of drum = 5kg (Measured)
Therefore,
Total Mass $M_T = 40kg + 5kg = 45kg$
Therefore,
Weight required by the grating machine $W = M_T \times g = F$
$W = 45 \times 10 = 450N$
Thus, the force required for proper mixing of concrete = 450N

2.16.2 Determination of Volume of Mixing
The volume of the mixing chamber is calculated as follows:
$V_{mC} = \pi r^2 h$ (2)
where,
V_{mc}= Volume of mixing chamber
r = Radius of cylinder = 300mm = 0.3m
h = Height of cylinder = 300mm = 0.3m
Therefore,
$V_{mC} = \pi \times 0.3^2 \times 0.3 = 0.0085m^3$

2.16.3 Determination of Belt Length
The belt length can be obtained as follow:
$L = 2C + \frac{\pi}{2}(D_1 + D_2) + \frac{D_1+D_2}{4C}$ [14] (3)
$= 2 \times 0.55 + \frac{\pi}{2}(0.15 + 0.25) + \frac{(0.15 + 0.25)}{4 \times 0.55} = 1.91m$

2.16.4 Distance between driver and driven pulley
The centre to centre distance between driving and driven pulley is given as:
$C = 2D_1 + D_2$ (4)
where;
D_1 = Diameter of the driver = 100mm = 0.10m
D_2 = Diameter of the driving = 200mm = 0.20m
C= Centre to centre distance between driving pulley and driven pulley
Therefore;

$$C = 2 \times 100 + 200 = 400mm = 0.40m$$

2.16.5 Design for Speed Ratio for Belt Drive
The velocity ratio for belt drive is the ratio between the velocity of the driver and the follower (driven). It may be expressed mathematically as:
$\frac{N_2}{N_1} = \frac{D_1}{D_2}$ (5)
where;
D_1 = diameter of the driver = 100mm
D_2 = diameter of the driven = 200mm
N_1 = speed of the driver = 1440rpm
N_2 = speed of the follower =?
Therefore;

$$N_2 = \frac{(1440 \times 100)}{200} = 720rpm$$

2.16.6 Determination of Lap Angle
The equation is expressed as follow:
$\alpha = 180 \pm 2\sin^{-1}\left(\frac{D_2-D_1}{2C}\right)$ [11] (6)
where;
α_1 = Angle of lap for driving pulley (rad)
α_2 = Angle of lap for driven pulley
C = Centre to centre distance between driving pulley and driven pulley
However, for open belt angle of lap is given as

$$\alpha = 180 - 2\sin^{-1}\left(\frac{D_2 - D_1}{2C}\right)$$

Therefore;

$\alpha = 180 - 2\sin^{-1}\left(\frac{0.20-0.10}{2\times0.40}\right) = 165.75^0$

Converting the angle from degree to radian;

$165.7° \times \frac{\pi}{180°} = 2.89\text{rad}$

2.16.7 Determination of Torque

The torque is obtained from the equation as follow:

$T = Fl$ (7)

where;

T = Torque

F = Force

L = Length of the paddle

Therefore;

$T = 450 \times 0.3 = 135Nm$

2.16.7 Determination of Power

The power requires mixed the concrete is the power that turns the shaft and is calculated as follow:

$P = FV$ (8)

But;

$V = \frac{\pi DN}{60}$ (9)

Equation 3.19 becomes:

$P = F\frac{\pi DN}{60}$ (10)

where;

P = Power to turn the shaft

V = Speed

F= Force

D= Diameter

N= Speed in revolution per minute

Therefore;

$$V = \frac{3.142 \times 0.10 \times 1440}{60} = 7.54m/sec$$

Also;

$P = \frac{135 \times 3.142 \times 0.10 \times 1440}{60} = 1018.008watts$

But;

750watts = 1hp

This implies that:

1018.008 watts = 1.36hp

Considering safety factor of 1.4

Therefore, required power = 2hp

2.16.8 Determination of Belt Tension

The belt tension can be calculated as follow:

$2.3log\left(\frac{T_1}{T_2}\right) = \mu\alpha$ [11]

where,

α = angle of wrap of an open belt

μ= coefficient of friction = 0.47

T_1= Tension in the tight side of the belt

T_2= tension in the slack side of the belt

Also;

$P = (T_1 - T_2)V$ (11)

where,

P = Belt power (watts)
V = Belt speed (m/sec)
T_1 and T_2 are tension on the tight and slack sides respectively (N)
Therefore;

$$1500 = (T_1 - T_2)7.54$$

$T_1 - T_2 = \frac{1500}{7.54} = 198.94$

$T_1 - T_2 = 198.94$ (12)

Also;

$2.3 log\frac{T_1}{T_2} = 0.47 \times 2.89$

$$log\frac{T_1}{T_2} = \frac{0.47 \times 2.89}{2.3} = 0.591$$

$\frac{T_1}{T_2} = e^{0.591} = 1.806$

$T_1 = 1.806T_2$ (13)

From equation (12),

$T_1 = 198.94 + T_2$ (14)

Equating both equation (13) and (14),

$1.806T_2 = 198.94 + T_2$

$1.806T_2 - T_2 = 198.94$

$0.806T_2 = 198.94$

Therefore;

$T_2 = \frac{198.94}{0.806} = 246.82N$

Hence;

$T_1 = 198.94 + 246.82 = 445.76N$

But;

$$T = T_1 + T_2 = 445.76 + 246.82 = 692.58N$$

2.16.9Design of Shaft

$T_d = \frac{60PK_L}{2\pi N}$ (15)

$T_d = \frac{60 \times 1875 \times 1.75}{2 \times \pi \times 1440} = 135Nm$

T_D= Design torque
K_L= Load factor=1.75 for line shaft
Thus, for diameter of shaft

$d^3 = \frac{16}{\pi S_S}\sqrt{(K_b M)^2 + (K_t T_d)^2}$ (16)

$d^3 = \frac{16}{\pi \times 2,103.61}\sqrt{(3 \times 1,262.17)^2 + (3 \times 135)^2}$

$\approx 40mm$

where,
M=Bending moment
For suddenly applied load (heavy shock), the following values are recommended for K_b and K_t
K_b= 2 to 3
K_t= 1.5 to 3
Selecting material of shaft SAE 1030
S_{ut}= 527MPa
S_{yt}=296MPa
$\tau_{max} \leq 0.30S_{yt}$
$\tau_{max} \leq 0.18S_{ut}$
where,
S_{ut}= Ultimate yield strength

III. RESULTS AND DISCUSSION

Table 2 shows the bill of engineering materials used and evaluation.

Table 2. Bill of Engineering Materials and Evaluation

S/N	COMPONENT	MATERIAL	DIMENSIONS (mm)	QTY	UNIT COST (₦)	TOTAL COST (₦)
1	Electric motor	Cast iron	2hp	1	16,500	16,500
2	Ball Bearing	Stainless Steel	Dia: 40mm	4	1,250	5000
3	V-Belt	Rubber	A35	2	300	600
4	Pulley	Cast iron	Dia. ; 250	2	2000	4000
5	Solid Shaft	Stainless Steel (ASTM A36)	Length: 3feet Dia: 40mm	2	1500	3000
6	Angle bar	Mild Steel (ASTM A36)	Length: 5500 50x50x20	2	1200	2400
7	Flat Plate	Galvanized metal	Thickness: 1.5mm	2	2500	5000
9	Bolt & Nut	Mild Steel (ASTM A36)	11	12	100	1200
10	Electrode	N/A	N/A	2	1000	2000
TOTAL						**39,700**

At the time of this research work, a Nigeria naira which is her unit of money was exchange to three hundred and sixty three dollars. This simply shows that the machine is cheap because the unit cost in dollar is $109.37. Moreover, imported concrete mixer machine can be obtained at ₦175,000 (i.e. $482.09). Figure 1 shows the isometric view of the concrete mixer machine.

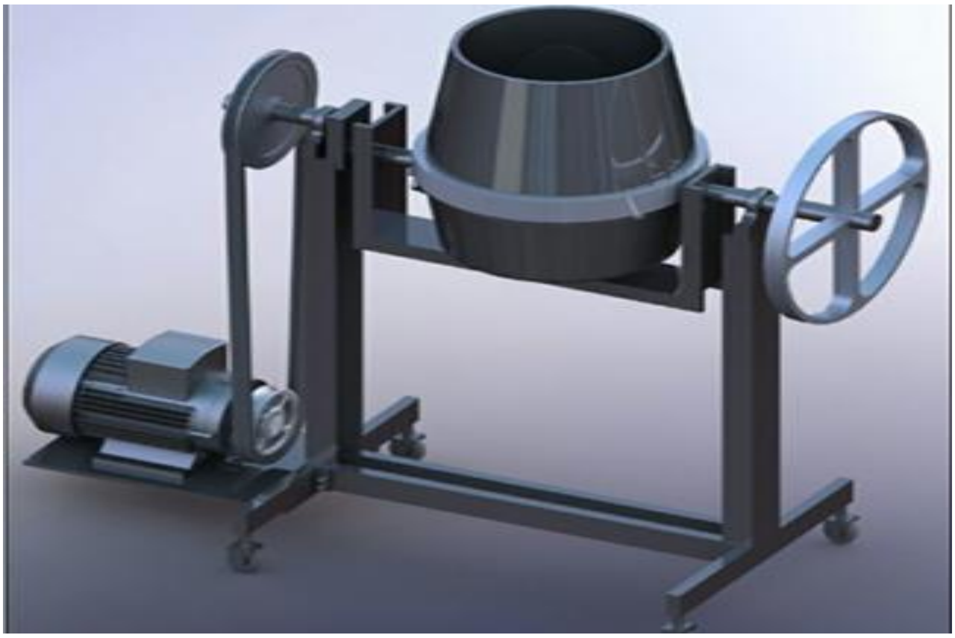

Figure 1. Isometric Modeled View of Concrete Mixer Machine

The results of the detailed design show that for a proper mixing of the concrete, a minimum force of 450N is required is required. This force was used to evaluate the power and torque required by the concrete mixer machine. a torque of 135Nm and a power of 2hp were designed for. This power was small enough for the machine to be powered by a petrol or diesel fueled generated. The mixing volume of the concrete mixer machine was obtained as 0.0085m3. Thus the machine is portable enough to be moved around especially in area of frequent usage that distance is a factor. The length of the belt, belt tension, distance between the driver and driven pulley, and shaft diameter were obtain as 1.91m, 692.58N, 0.4m, and 40mm respectively. However, considering cost, maintenance and ease of use, a ball bearing was selected based on the abovementioned calculated shaft diameter.

IV. CONCLUSION

Concrete is used extensively for construction purpose. Considering the usage of concrete, mechanization of the process is required to increase production output. This research work is focused on the design of a low cost concrete mixer machine. The machine was successfully designed.The efficiency of a mixer is determined by the uniformity of the concrete produced. It could also be considered as being determined by the power used in producing a given quantity of concrete of the required uniformity. In this case a minimum power of 2hp power was obtained. Others parameters such as force, and torque was reasonable enough that the outcome produced a low cost machine.

Furthermore, mixing is a complicated process that is affected by the type of mixer, the mixing cycle as defined by the duration, the loading method, the energy of mixing, and most importantly the material for the blade. In this design, a stainless steel material was selected as the blade material. Thus, the problem of failure as a result of strength, corrosion was overcome in this new design. Finally, with this designed the problem of the manual method of mixing concrete in Nigeria and high cost of importing one can be overcome.

REFERENCES

[1] S.O. Yakubu, and M.B. Umar, Design, Construction and Testing Of a Multipurpose Brick/Block Moulding Machine". American Journal of Engineering Research (AJER), 04(02), 2015, pp-27-32

[2] C.F. Ferraris, Concrete Mixing Methods and Concrete Mixers: State of the Art", Journal of Research of the National Institute of Standards and Technology, 106(2), 2001, pp.391-399

[3] G.H. Ristow,Mixing and segregation in rotating drums, Proc. Symposium on Segregation in Granular Flows, The Netherlands: Kluwer Academic publishers, 2000, pp.311–320

[4] J.I. Aguwa ‚Effect of Critical Variable-Time on Concrete Production". Journal of Science, Technology and Mathematics Education, 8(2), 2006, pp. 23-39

[5] L. Chuku, Addressing Housing Deficit in Nigeria, Available at http://www.pmnews nigeria.com/2014/01/16/addressing-housing-deficit, Accessed 7th November, 2017

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

[7] P.K. Mahesha, and R. Sree, Design and Fabrication of Automatic Wall Plastering Machine Prototype, IOSR Journal of Mechanical and Civil Engineering, 11(4), 2014, pp.1-6

[8] S.M.S. Elattar, Automation and robotics in construction: opportunities and challenges, Emirates Journal for Engineering Research, 13 (2), 2008, pp.21-26

[9] P.O. Osunde, E.K. Orhorhoro, P.O.B. Ebunilo, Design of Three Stages Continuous Anaerobic Digestion (AD) Plant, American Journal of Engineering Research (AJER),6(11), 2017, pp-311-321

[10] E.K. Orhorhoro, P.O.B. Ebunilo, and E.G. Sadjere, Design of Bio-Waste Grinding Machine for Anaerobic Digestion (AD) System. European Journal of Advances in Engineering and Technology, 4 (7), 2017, 560-568

[11] R.J. Khurmi and J.K. Gupta, Machine Design, Eurasia Publishing House (pvt) Ltd, New Delhi, 731-739, 2013

Ukwuaba Samual Ifeanyi. "Design of a Low Cost Concrete Mixer Machine"American Journal of Engineering Research (AJER), vol. 7, no. 5, 2018, pp.60-68.