American Journal of Engineering Research (AJER)
E-ISSN: 2320-0847 p-ISSN: 2320-0936
Volume-7, Issue-12, pp-166-178
www.ajer.org
Research Paper Open Access

Statistical Model To Evaluate Turn-Around-Maintenance Of Port Harcourt Refinery In Nigeria

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ABSTRACT: *This research work brings to bear application of Statistical model to evaluate the effectiveness of Turn-Around Maintenance in Port Harcourt Refinery, located at AlesaEleme Port Harcourt, Rivers State - Nigeria. Primary source data were obtained from the system of research. A total of 67 closed-ended Questionnaires were served to the senior cadre staff of the TAM Planning and execution Team of the operations department of the PHRC. A holistic assessment of the response data PHRC had its TAM in 1991, 1995, 2000, 2015. The data were analyzed quantitatively using the software SPSS ie statistical package for social sciences which contains the statistical models. The results of the analysis of data stood high as follows: mean of 3.10 as against the decision rule of 2.50, failure to adequately use money meant for turnaround maintenance due to corruption (3.30), disruption of distribution network as a result of militancy attacks on oil facilities (3.15). The results showed the following areas of weakness of the TAM process; Contractor Selection and Management having a Grand Percentage of 59.68% (NO response) as against the benchmark of above 50%, Cost Estimation and Profile (55.68%), Quality Plan (62.7%) and Documentation (57.32%). The challenges in carrying out TAM in the refinery include failure to approve and start the TAM at the appropriate time having a mean of 3.10 as against the decision rule of 2.50, failure to treat TAM as a project (3.33), failure to release fund for TAM (3.12), failure to use money meant for maintenance due to corruption (3.27), lack of experience contractors to carry out TAM due to political interference (3.06), lack of comprehensive planning (3.45). It is observed that execution of proper TAM from 1990 to 2000 which is a decade of plant operations showed there was effective finished products and allied products supply to the public which prohibited scarcity to the society. And, the research reveals why there is scarcity and Government leaning solely on importation of products from 2000 till date. This inference drawn from the work is corroborated with values of the SPSS results which show high values above.*

Keywords: *Turn-around-maintenance, statistical models, Refinery, Primary data*

Date of Submission: 01-12-2018 Date of Acceptance: 31-12-2018

I. INTRODUCTION

Turnaround maintenance process is a series of actions and/or procedures carried out by Nigerians in order to reactivate the effectiveness and reliability of process plantsof Refinery, and Petrochemical [Jacobs, 1984] in quote *–That, the Port Harcourt Refinery company PHRC maintenance has been turn-around during Nigeria period of austere economy, the foreign exchange process was made difficult to bring in vendors of the refinerymaintenance reminisced by [Wordu,2018] to give the word TAM proper place in research works.*

Oil refinery is an industrial process plant where crude oil is transformed and refined into more useful products such as gasoline, diesel fuel, asphalt base, kerosene, liquefied petroleum gas and jet fuel [James, 2006]. Today, the refining business is growing globally with new technology, new markets, new feed stocks, new policies and regulations. In order to satisfy requirement of demand, the oil processing industry must aim to ensure that the productive capacity of its plant is not reduced. This is very important when demand is very high or the supply of petroleum products is low. A reduction in the productive capacity of the plants, even if small[1-10%], has a negative effect on fulfillment corporate objectives. This decline can be due to unforeseen equipment failure which can force the cease of operations and the emergency procedure of an unplanned shutdown of plant. For this reason, in order to ensure continuity of the operation of the plant, turnaround maintenance is required

(Bobby, 2000)**,** which proffer specific allocated time for carrying out maintenance and replacement of working equipment, which cannot be carried out during the normal production period [Makarand, 1999].

Turnaround maintenance [TAM] is a strategic management tool used to ensure plant reliability. TAM is periodic and plants are shutdown to allow for inspections, repairs, replacements and overhauls that can't be carried out when the plant facilities are in operation [Benaya, 2007]. Because of the complexity and size of TAM project in most process plants, the successful accomplishment of this event in terms of quality and cost is vital to the profitability of the company and to its competitive advantage.

[Halib, Ghazali, &Nordin, 2010], identified fifteen [15] petrochemical companies, refineries and natural gas plants that carried out their TAM activities once every three years, and 8 companies executed their TAM activities once every five years. [Lawrence, 2012] reported that all the processing plants such as refinery and petrochemical plants that operate continuously under extreme conditions must be shut down every few years to achieve TAM functions.

In an opinion poll carried out by [Adenikinju&Falobi, 2006] to show the cause of fuel scarcity by respondents, it was seen that most respondents believed that good working conditions of Nigerian refineries are a necessary preface to continuous problem free supply of petroleum products. It was recommended in a research study by [Uhunmwuan, 2012] that as a first step in overcoming the shortages of petroleum products supply, all domestic refineries must be put in full productive capacity.

There are fifty five [55] oil refineries in Africa; the total distillation capacity for the continent is approximately 3,450,000 b/d as at May, 2015. Africa refining capacity is short of regional demand which requires a net of 0.95 billion bbl/d of main products to be imported [Stratas Advisor, 2014]. There are four refineries owned by Nigerian Government with a name-plate refining capacity of 445,000 barrels per day. According to the [Nigerian National Petroleum Corporation [2016]Annual Statistics Bulletin, the refineries operated at an average of 12.85% of full production capacity that is, 57,182.50 barrels per day at 2016.

Nigeria is said to be one of Africa's leading crude oil exporter and the third largest leader in installed crude oil refining capacity but remains the continent's largest importer of refined petroleum products. The country's four crude oil refineries with a combined installed capacity of 445,000 barrels of oil per day; according to [US Energy Information Administration [EIA], should easily be able to meet the current domestic demand in refined products excluding export. EIA estimate this about 270,000 barrels of oil per day. The four refineries continue to operate at an average of 22.98% of installed refining capacity in 2012 and 12.85% of installed refining capacity in 2016 [Nigerian National Petroleum Corporation [NNPC], 2018]. Also, fuel scarcity that occurs in the country increases the price of petrol at a given time. The fuel scarcity is as a result of over dependence on import of petroleum products and the inefficiency of refineries in Nigeria to produce at full capacity. This study has become very imperative because the refineries in Nigeria are not functioning effectively to produce at required capacity. Maintenance when done properly enhance plant reliability which enable plant to produce at required capacity. If crude oil is refined in the country to meet domestic needs, then export charges, import charges could be redirected to other pressing projects. This can also bring the price of petrol at fuel station less expensive compared to the current fixed price.

The research Objectives is to find out the number of times Turnaround Maintenance had been carried out in Port Harcourt Refinery; determine the factors responsible for the under-utilization of the refinery in Nigeria; assessment of the turnaround maintenance process of the refinery on the strengths and weaknesses of the process;and identify the challenges in carrying out turnaround maintenance of the refinery in Nigeria.

Phases of Turnaround Maintenance

Project Management Institute Method was injected by [Lenahan, 1999] in initiating, preparing, and executing and terminating turnaround maintenance. The methodology was developed by the Project Management Institute and documented into Project Management Body of Knowledge [PMBOK] which states that projects are split into five process groups. The five groups include initiating, planning, executing, controlling and closing. [Lenahan, 1999] injected this methodology into turnaround maintenance because it is considered a project and involved large number of workforce and resources. This brought about the four 4 phases of turnaround maintenance, which are initiation, preparation, execution and termination.

Initiation

Turnaround maintenance is initiated from the time some top managers' flags up the necessity to start considering the requirement for a forth coming turnaround maintenance (this could be two years before the event). It is therefore necessary to define, in detail, the strategic issues to be addressed and the activities required to move the process to the point where it can actually be planned and prepared. The phase is characterized by defining objectives, setting policy and appointing the necessary personnel to set up the preparation team and gather basic data.

Steering group and turnaround manager are appointed by top management; they define objectives and strategies regarding manpower, planning and procurement for the maintenance. A rough list of the activities to be performed during the turnaround is defined along with a list of personnel required for specific functions along with authority delegation for the preparation work. The initiation phase also contains reviews of previous turnarounds maintenance carried out based on experience and lessons learnt [Lenahan, 1999].

Detailed planning of all aspects of the turnaround maintenance [TAM] should be carried out during the initiation phase [Duffuaa& Ben-Daya, 2004]. This includes defining work scope, identifying pre shutdown works, procuring material and item, contractors' selection, creating TAM plan, defining TAM Organization, site logistic plan, TAM cost profile, defining safety and quality program.

A. Preparation

The preparation team appointed by the steering group work over a period of time to review the initial rough work list, specify, schedule and cost the large volume of tasks required to perform the event. During the approximately one and a half year long preparation phase, all activities are planned for execution. At this point the turnaround manager freezes the work list. The planning needs some lag-time for unforeseen events, not all maintenance work during a turnaround are known prior to the execution. The final act of preparation is to communicate the requirements of the turnaround maintenance to every single person who will be involved in any level. This is accomplished by a series of briefings [Lenahan, 1999].

B. Execution

Execution phase is characterized by a large volume of tasks performed by several skilled people in a specified time. The effective control and co-ordination of work is of high importance. The plant might need steaming, or decontaminating, to get rid of hazardous hydrocarbons, which then is handled by the plant production team prior to permit releases for each section. After the plant is decontaminated and cooled as well as isolated for safety reasons the execution team can start their work.

The execution team, mainly consisting of contractors, performs all activities according to the work list: installation of new plant equipment, overhaul of old and removal of redundant once. Most activities are governed by the completion of prior ones. The activities are planned at the preparation phase and the contractors hired to perform the specific activity construct a further detailed plan, governed by the time limits set in the activity plan.

Work activities are checked with respect to quality systems. When all scheduled and unforeseen activities are performed and checked-out, the plant start-up will be executed following a predefined start-up plan. During start up pressure, leak and instrumentation testing takes place along with trip and alarm tests to ensure the safety and performance of the plant. The execution phase generally takes between a couple of weeks to a few months depending on plant size and magnitude of the turnaround [Lenahan, 1999].

C. Termination

The termination phase continues one to two weeks during which the entire turnaround work is closed and performance is to be reviewed against the plan. There are three separate elements involved in terminating the event. The first is ensuring that the plant is handed back in a fit condition and second is the final removal of equipment, redundant plant parts and obsolete materials, as well as cleaning the site and third is the debriefing of every member of the Turnaround organization. Manager hands out questionnaires and organize debriefing meetings with all contractors and teams to evaluate the work performed. From these meetings, the performance is analyzed and evaluated to form a final report of the turnaround. De-briefing is done to capture the lessons learned from the event so that subsequent turnaround maintenance may be performed more effectively [Lenahan, 1999].

Turnaround Maintenance Process Evaluation Framework

Figure 1 is a framework developed to evaluate the processes in carrying out turnaround maintenance of the plant.

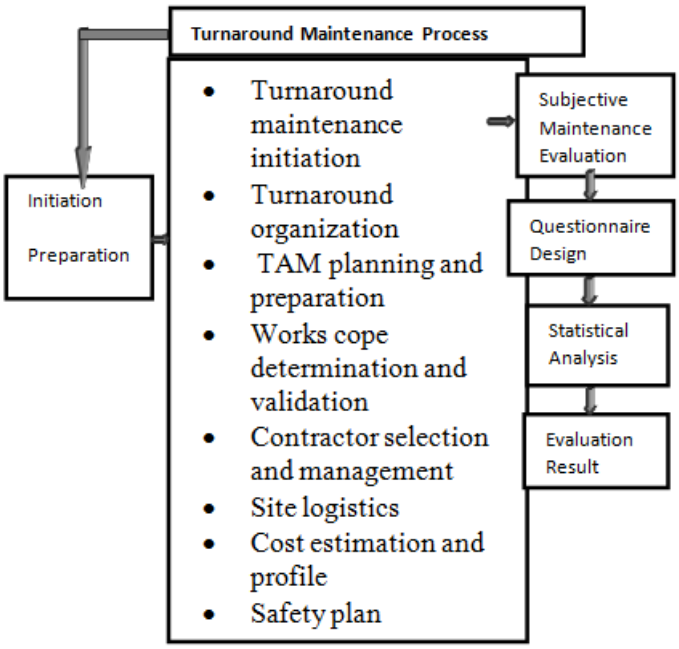

Figure 1 Turnaround Maintenance Process Evaluation Framework

II. MATERIALS AND METHOD

2.1 MATERIALS - Research Design

Survey research design was used for the study. Justification for using a survey research design was that questionnaire was used to collect primary data from senior cadre staff of Port Harcourt Refining Company and Warri Refining and Petrochemical Company that is involved in TAM.

2.1.1 Method of Sampling

Purposive sampling was used to select Port Harcourt Refining Company out of the other two refineries in Nigeria. The purpose of selecting Port Harcourt Refining Company is for proximity. Furthermore, accidental sampling was used when administering the research instrument. A total of 67 closed ended questionnaires were filled and returned by senior staff involved in TAM planning and execution in the Operations Directorate of Port Harcourt Refining Company.

2.1.2 Data collection Instrumentation

Data for this study was obtained through primary source. The primary data used in this study was collected using a structured questionnaire specifically developed by the researcher for the purpose of this study. To ensure uniformity, the questions were closed ended and formulated to obtain responses which portray the characteristics of the variables investigated in the study.

2.1.3 Questionnaire Design

The content of the questionnaire was developed by the researcher after reviewing literatures and other empirical studies related to the research topic. The design of the questionnaire is in two parts. Part one give bio data of respondents as well as instructions on how to respond to the questions, while part two is divided into three sections. Section 1 contains closed ended questions on determining the factors responsible for the under-utilization of the refinery in Nigeria.

The section of the questionnaire was designed using 4-point Likert Scale in the following format:

SA = Strongly Agree [4 points]
A = Agree [3 points]
D = Disagree [2 points]
SD = Strongly Disagree [1point]

Section 2 is divided into thirteen [13] elements where questions are set to assess the process carrying out turnaround maintenance in the refinery using dichotomous [Yes/No] questions. The thirteen [13] elements are made up of the following maintenance functions which are gotten from the four phases of turnaround maintenance (initiation, preparation, execution and termination);

- Turnaround maintenance initiation
- Turnaround organization
- TAM planning and preparation
- Works cope determination and validation
- Contractor selection and management
- Site logistics
- Cost estimation and profile
- Safety plan
- Quality plan
- Communication and reporting
- Execution
- Termination
- Documentation

Section 3 contains closed ended questions which are aimed to determine the challenges in carrying turnaround maintenance in the refinery using 4 point Likert Scale. The 4 point scale is chosen over 5 point scale because a neutral option in the sample was undesirable.

Respondents were asked to tick from one of the response options provided for each questions (item). In carrying out this research, consent letters were addressed to various respondents to seek their consent, to assure them of the confidentiality of information to be collected and assurance of their anonymity.

2.2 METHOD - Method of Data Analysis [SPSS Models applied]

To Determine the Factors Responsible for the Under-Utilization of the Case Study Refinery: Data gotten from section one of the questionnaire was analyzed using descriptive statistical approach, that is, mean and standard deviation.

The mean; $\bar{x} = \frac{\sum x}{n}$ **(1)**

Where $\bar{x}$ = mean; $\sum$x = sum of all responses from respondents; n = number of respondents

Standard deviation is gotten from; $S = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}$ **(2)**

Where S is the sample standard deviation, **x** is the sample mean, x = responses from respondents and n are the number of respondents in the sample.

Assessment of the Turnaround Maintenance Process of the Case Study Refinery: The data gotten from section two (2) of the questionnaire was analyzed using frequency and percentage to determine the strength and weaknesses of the turnaround maintenance process of the refinery.

Percentage (%) = $\frac{\text{Part value}}{\text{Wholevalue}}$ x 100 **(3)**

To Identify the Challenges in Carrying out Turnaround Maintenance in the Examined Refinery: The data gotten from section 3 of the questionnaire was analyzed using mean and standard deviation.

To obtain an accurate analysis and a comprehensive result the data was analyzed using Statistical Package for SocialSciences [SPSS] computer software version 21.

Decision rule for interpreting results gotten from section 1and 3of the questionnaire was based on the values of the calculated mean. Responses on each of the research questions will be considered high and agreed when the mean is 2.50 and above and will be disagreed when less than 2.50. It is calculated from the average of the weight of the response options,

That is,

$$\frac{SA+A+D+SD}{n} = \frac{4+3+2+1}{4} = 2.50$$

Where SA = 4; A = 3; D = 2; SD = 1 and n = number of response option; SA, A, D, SD are the weight of the response options.

Decision rule for interpreting results gotten from section 2was based on the percentage of Yes and No. Responses on each of the research questions will be considered strength when the percentage of the YES response is higher than 50% and is considered weakness when the percentage of the YES response is lower than 50%.

2.1 Validation and reliability of the instrument

Content validation was used to validate the questionnaire. This was done by maintenance expert. Their comments, corrections and constructive criticism guided the authors towards reframing and reconstructing some items in the questionnaire.

To ascertain the reliability of the questionnaire, twenty copies were administered to staff of Warri Refining and Petrochemical Company Limited. The refinery shared similar characteristics with the Port Harcourt Refining Company Limited but is located in a different state. Both refineries are owned by the Federal Government of Nigeria. The reliability of the instrument was ascertained using Cronbach's Alpha in SPSS developed by Lee Cronbach in 1951 to check for internal consistency. Reliability coefficients of 0.79, 0.85 and 0.81 were ascertained for section 1, 2 and 3 respectively while the overall reliability coefficient was 0.82. This indicates that the questionnaire was considered suitable for the study.

$$\alpha = \frac{N\,\bar{C}}{\bar{V}+(N-1)\,\bar{C}} \qquad [4]$$

Where: α = cronbach alpha N = the number of items; $\bar{C}$ = average covariance among items; $\bar{V}$ = average variance of each item.

III. RESULTS AND DISCUSSIONS

3.1 Demographic Characteristics of the Respondent

Table 1 shows the demographic characteristics of the respondents involved in the study at the examined plant.

Demographic Characteristics		No. of Respondents	Percentage
Gender	Male	59	88.1
	Female	8	11.9
Age group	30- 39yrs	12	17.9
	Above 40 yrs.	55	82.1
Educational Level	Degree/HND	39	58.2
	Post Graduate Degree	28	41.8
Job Level	Senior Management	15	22.4
	Middle Management	44	65.7
	Other	8	11.9
Department	Maintenance	30	44.8
	Engineering & Technical Service	24	35.8
	Production	13	19.4
Length of Service (Yrs.)	5 – 9	14	20.9
	10-15	37	55.2
	15 and above	16	23.9

Table 1 Demographic Characteristic Of Respondents

3.2 Number of times Turnaround Maintenance had been carried out in Port Harcourt Refinery

Information sourcing through interview and relevant TAM records available in the refinery shows that the Port Harcourt refinery had its TAM in 1991, 1995, 2000 and 2015. The number of TAM that had been carried out is not effective enough to bring the refinery to its required production capacity. At the visit to Port Harcourt Refining Company, it was seen that the plant had been shut down for about 4 months due to turnaround maintenance that is ongoing. Failure to hold regular comprehensive maintenance is a major contributor to equipment failure and plant shutdowns.

Despite the number of times TAM had been carried out, the Port Harcourt Refinery had not been reliable; it functioned at 17.28% of its refining capacity in 2016. However Nigerian National Petroleum Corporation had planned to contact the Original Refinery Builders for total Turnaround Maintenance for total rehabilitation
of the refinery by 2019.

3.3 Factors responsible for the under-utilization of the Port Harcourt Refinery

Table 2 presented the results of data analyses on the factors responsible for the under-utilization of the examined plant.

Table 2 Factors responsible for the under-utilization of Port Harcourt Refinery

S/N	ITEM	SA (4)	A (3)	D (2)	SD (1)	x	SD	DECISION
1.	Lack of turnaround maintenance.	29	21	12	5	3.10	0.96	AGREE
2.	Inability to make necessary improvements or innovations to improve refinery activities.	13	16	19	19	2.34	1.09	DISAGREE
3.	Failure to adequately use money meant for	38	16	8	5	3.30	0.95	AGREE

	Turnaround Maintenance due to corruption							
4.	Fire incidence at various areas of the plant.	14	16	18	19	2.37	1.11	DISAGREE
5.	Disruption of distribution network as a result of militancy attacks on oil facilities.	34	16	10	7	3.15	1.03	AGREE
6.	Long decision making processes that delay important investments.	3	9	14	41	1.61	0.89	DISAGREE
7.	Aging plant due to depreciation.	31	22	7	7	3.15	0.99	AGREE
Grand Mean and Standard Deviation						2.72	1.00	AGREE

[Source: Survey Data, 2018]

The findings of the research showed that the factors responsible for the under-utilization of the examined refinery includes lack of comprehensive turnaround maintenance, failure to adequately use money meant for turnaround maintenance due to corruption, disruption of distribution network as a result of militancy attacks on oil facilities and aging plant due to depreciation.

Table 3 Analysis of variance on the factors responsible for the under-utilization

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	0.110	2	0.055	0.379	0.686
Within Groups	9.326	64	0.146		
Total	9.437	66			

Table 3 presents the result of Analysis of Variance [ANOVA] on the relationship between the responses and the categories of respondents. The significance value of 0.686 which was higher than 0.05 indicates that there is no significant difference between the mean responses of staff in the various departments.

Assessment of the Turnaround Maintenance Process of the Refinery to show the Strengths and Weaknesses

Results of data analysis in Table 4 show the frequency and percentage of responses on the respondents' ratings of strengths and weaknesses of the various aspects of turnaround maintenance in the examined refinery.

Table 4 Strengths and Weaknesses of the turnaround maintenance process

S/N	ITEMS	YES		NO		DECISION
		N	%	n	%	
i.	**Turnaround Maintenance Initiation**					
8.	Does the initiation phase of the turnaround maintenance begin two years before the event?	18	26.9	49	73.1	WEAKNESS
9.	Is TAM carried out every 3 – 5 years?	16	23.9	51	76.1	WEAKNESS
10.	Is there a detailed turnaround maintenance objective at every start of the initiation phase?	48	71.6	19	28.4	STRENGTH
11.	Does the objective align with the refinery corporate goals?	56	83.6	11	16.4	STRENGTH
12.	Is Steering group appointed at the initiation of the turnaround maintenance?	42	62.7	25	37.3	STRENGTH
13.	The steering group is formed by senior management and consist of plant, operations, project, safety, maintenance, turnaround, process and financial managers	35	52.2	32	47.8	STRENGTH
14.	Does the steering group appoint preparation and planning team?	44	65.7	23	34.3	STRENGTH
15.	Does the TAM manager mobilizes and lead preparation team for the collection and collation of data?	42	62.7	25	37.3	STRENGTH
16.	Review of past TAM events and data are done?	25	37.3	42	62.7	WEAKNESS
17.	Are the necessary documents needed for the planning of the TAM event provided?	43	64.2	24	35.8	STRENGTH
18.	Plant maintenance team issues the initial work list.	42	62.7	25	37.3	STRENGTH
19.	Are TAM policies formulated?	44	65.7	23	34.3	STRENGTH
20.	Is there a well-structured agenda formulated by the steering group.	21	31.3	46	68.7	WEAKNESS
GRAND FREQUENCY AND PERCENTAGE		**36.6**	**54.7**	**30.4**	**45.3**	**STRENGTH**
CHI-SQUARE VALUE		**0.584**				**NOT SIGNIFICANT**
ii.	**Turnaround Organization**					
21.	Is there an organizational chart for TAM that clearly defines job functions, duties and responsibilities?	38	56.7	29	43.3	STRENGTH
22.	Is the planning team made up of plant and preparation team, inspectors, engineering personnel, contractor's representative, project managers and engineers?	41	61.2	26	38.8	STRENGTH
GRAND FREQUENCY AND PERCENTAGE		**39.5**	**59**	**27.5**	**41**	**STRENGT**

						H
CHI-SQUARE VALUE		**0.233**				**NOT SIGNIFICANT**
iii.	**Work scope Determination**					
23.	Does planning team brake down work scope into various kinds of tasks to be performed by different contractors?	38	56.7	29	43.3	STRENGTH
24.	Is work scope broken down to suit various contractors?	47	70.1	20	29.9	STRENGTH
25.	Are preventive maintenance task included in the turnaround maintenance?	63	94.0	4	6.0	STRENGTH
26.	Is there a work package specifying all information necessary to execute all jobs?	38	56.7	29	43.3	STRENGTH
GRAND FREQUENCY AND PERCENTAGE		**46.5**	**69.4**	**20.5**	**30.6**	**STRENGTH**
CHI-SQUARE VALUE		**0.50**				**NOT SIGNIFICANT**
iv.	**Turnaround Maintenance Planning and Preparation**					
S/N	**ITEMS**	**YES**		**NO**		**DECISION**
		N	**%**	**n**	**%**	
27.	Is there a preparation network in the TAM process of your refinery?	21	31.3	46	68.7	WEAKNESS
28.	Is computer maintenance management system software used for planning and scheduling TAM in your refinery?	25	37.3	42	62.7	WEAKNESS
29.	Are work scope reviewed and activities for carrying out TAM prepared?	51	76.1	16	23.9	STRENGTH
30.	Does the turnaround manager freeze the work list?	58	86.6	9	13.4	STRENGTH
31.	Preparation team and plant team challenge and validate the work list.	48	71.6	19	28.4	STRENGTH
32.	Are job specification package prepared?	45	67.2	22	32.8	STRENGTH
33.	Are contractors involved in TAM planning?	22	32.8	45	67.2	WEAKNESS
34.	Is there a contingency plan in the TAM process including additional work list?	25	37.3	42	62.7	WEAKNESS
35.	Are there site rules and briefing documents in the TAM process?	45	67.2	22	32.8	STRENGTH
36.	The preparation team defines who handles control, communication, supervision, management and oversight completion.	47	70.1	20	29.9	STRENGTH
37.	Is there environmental plan for waste disposal?	58	86.6	9	13.4	STRENGTH
38.	Is there shutdown and start up network in the TAM process?	29	43.3	38	56.7	WEAKNESS
39.	Contract for procurement of materials, equipment and machines are initiated on time	24	35.8	43	64.2	WEAKNESS
40.	Are long delivery items and other necessary materials, equipment and machines delivered on time before execution?	24	35.8	43	64.2	WEAKNESS
41.	Is TAM duration minimized through effective planning?	21	31.3	46	68.7	WEAKNESS
42.	Does steering group analyze and gives approval for TAM plan before execution.	37	55.2	30	44.8	STRENGTH
43.	Is there detailed audit plan for each phase?	15	22.4	52	77.6	WEAKNESS
44.	Is the audit plan implemented in monitoring the performance of each phase?	10	14.9	57	85.1	WEAKNESS
GRAND FREQUENCY AND PERCENTAGE		**33.61**	**50.16**	**33.39**	**49.84**	**STRENGTH**
CHI-SQUARE VALUE		**0.60**				**NOT SIGNIFICANT**
v.	**Contractor Selection and Management**					
45.	Is there a good criterion (cost, safety, quality, work experience, tools, skills and expertise) for contractor selection?	5	7.5	62	92.5	WEAKNESS
46.	Are work contracted to original refinery builders?	6	9.0	61	91.0	WEAKNESS
47.	Is there permit to work system in the TAM process?	57	85.1	10	14.9	STRENGTH
48.	There is day to day oversight and supervision of contractors in the TAM process?	40	59.7	27	40.3	STRENGTH
GRAND FREQUENCY AND PERCENTAGE		**27**	**40.33**	**40**	**59.68**	**WEAKNESS**
CHI-SQUARE VALUE		**0.005**				**NOT SIGNIFICANT**
vi.	**Responses on Site Logistic**					

S/N	ITEMS	YES		NO		DECISION
		n	%	n	%	
49.	Is there a site plan?	55	82.1	12	17.9	STRENGTH
50.	Is there plot plan in your TAM process?	50	74.6	17	25.4	STRENGTH
51.	Does the plot plan has the following elements; Plot plan showing plant perimeter and boundaries	11	16.4	56	83.6	WEAKNESS
52.	All major items of plant equipment and pipe work	50	74.6	17	25.4	STRENGTH
53.	All roads (site and prohibited roads) including access to site	44	65.7	23	34.3	STRENGTH
54.	All location for fire assembly points	52	77.6	15	22.4	STRENGTH
55.	Layout areas for contaminated material and hazard substances	49	73.1	18	26.9	STRENGTH
56.	Layout design for TAM storage	53	79.1	14	20.9	STRENGTH
57.	Approved vehicle routes with direction of traffic	48	71.6	19	28.4	STRENGTH
58.	Areas for various technical works such as welding.	57	85.1	10	14.9	STRENGTH
59.	Site for TAM induction, meetings and debriefing	53	79.1	14	20.9	STRENGTH
60.	Various contractors area	58	86.6	9	13.4	STRENGTH
61.	Are the various workforce monitored for strict compliance to the laid down plot plan?	59	88.1	8	11.9	STRENGTH
GRAND FREQUENCY AND PERCENTAGE		**49.15**	**73.36**	**17.85**	**26.64**	**STRENGTH**
CHI-SQUARE		**0.369**				**NOT SIGNIFICANT**
vii. Cost Estimation and Profile						
62.	Is scope of work determined based on work request given by plant maintenance team?	49	73.1	18	26.9	STRENGTH
63.	Is cost estimated for in house labor, contracted labor, materials and equipment?	51	76.1	16	23.9	STRENGTH
64.	Is there budget for contingency planning or cost in the TAM process?	13	19.4	54	80.6	WEAKNESS
65.	Is there cost tracking in the TAM process?	10	14.9	57	85.1	WEAKNESS
66.	There is proper cost estimate and expenditure control system in the Tam process.	7	10.4	60	89.6	WEAKNESS
67.	Cost and expenditure is analyzed by control team	23	34.3	44	65.7	WEAKNESS
68.	Control team define and cost emergent work	45	67.2	22	32.8	STRENGTH
69.	Are some tasks eliminated if the estimated cost is higher than the allotted budget?	40	59.7	27	40.3	STRENGTH
70.	Is there cost minimization program in the TAM process?	17	25.4	50	74.6	WEAKNESS
71.	Is the TAM estimated cost given to steering group for approval?	42	62.7	25	37.3	STRENGTH
GRAND FREQUENCY AND PERCENTAGE		**29.7**	**44.32**	**37.3**	**55.68**	**WEAKNESS**
CHI-SQUARE		**0.472**				**NOT SIGNIFICANT**

viii. Safety Plan

S/N	ITEMS	YES	NO			DECISION
		n	%	n	%	
72.	Is there a safety manager available to formulate safety plan?	44	65.7	23	34.3	STRENGTH
73.	Does the TAM safety plan include safety policy, safety communication network and safety working routine?	51	76.1	16	23.9	STRENGTH
74.	Are there proactive measures for safety in TAM process?	59	88.1	8	11.9	STRENGTH
75.	Are there supervisors available to supervise and implement safety?	48	71.6	19	28.4	STRENGTH
76.	Is there a safety induction before executing TAM?	35	52.2	32	47.8	STRENGTH

GRAND FREQUENCY AND PERCENTAGE		**47.4**	**70.74**	**19.6**	**29.26**	**STRENGTH**
CHI-SQUARE		**0.755**				**NOT SIGNIFICANT**
ix.	**Quality Plan**					
77	Is there a quality plan?	36	53.7	31	46.3	STRENGTH
78.	Are there proactive measures for quality control in TAM process?	14	20.9	53	79.1	WEAKNESS
GRAND FREQUENCY AND PERCENTAGE		**25**	**37.3**	**42**	**62.7**	**WEAKNESS**
CHI-SQUARE		**0.539**				**NOT SIGNIFICANT**
x.	**Communication and Reporting**					
79.	There is an effective communication package specifying different line of reporting and communication?	51	76.1	16	23.9	STRENGTH
80.	There is a plan for formal meetings in the TAM process	60	89.6	7	10.4	STRENGTH
81.	Formal meetings are frequently carried out in the TAM.	49	73.1	18	26.9	STRENGTH
GRAND FREQUENCY AND PERCENTAGE		**53.33**	**79.60**	**13.67**	**20.40**	**STRENGTH**
CHI-SQUARE		**0.339**				**NOT SIGNIFICANT**
xi.	**Execution**					
S/N	**ITEMS**	**YES**		**NO**		**DECISION**
		n	**%**	**n**	**%**	
82.	There is briefing of all personnel involved in TAM before the start of execution.	49	73.1	18	26.9	STRENGTH
83.	Plant team shuts down plant as planned.	36	53.7	31	46.3	STRENGTH
84.	TAM is executed within 2 to 8 weeks depending on the work scope.	23	34.3	44	65.7	WEAKNESS
85.	Is inspection (visual and instrumental examination and report) of plant part of the process?	47	70.1	20	29.9	STRENGTH
86.	Plant cleaning and final inspection of the turnaround part of the execution of TAM.		53.7	31	46.3	STRENGTH
GRAND FREQUENCY AND %		**38.2**	**56.98**	**28.8**	**43.02**	**STRENGTH**
CHI-SQUARE		**0.368**				**NOT SIGNIFICANT**
xii.	**Termination**					
87.	Is de-briefing of every member of TAM organization by the TAM manager usually carried out?	50	74.6	17	25.4	STRENGTH
88.	Are the performance of turnaround maintenance measured using cost, safety, time and reliability?	43	64.2	24	35.8	STRENGTH
89.	Are lessons learnt compiled in order to do a final successful review?	28	41.8	39	58.2	WEAKNESS
90.	Is final handover carried out?	45	67.2	22	32.8	STRENGTH
91.	Is benchmarking usually done with previously carried out TAM?	8	11.9	59	88.1	WEAKNESS
92.	Does the final report covers TAM policy?	32	47.8	35	52.2	WEAKNESS
93.	Does the final report cover work scope?	63	94.0	4	6.0	STRENGTH
94.	Does the final report cover preparation phase?	36	53.7	31	46.3	STRENGTH
95.	Does the final report cover planning?	45	67.2	22	32.8	STRENGTH
96.	Does the final report cover TAM organization?	63	94.0	4	6.0	STRENGTH
97.	Does the final report cover control of work?	9	13.4	58	86.6	WEAKNESS
98.	Does the final report cover safety and quality?	42	62.7	25	37.3	STRENGTH
99.	Does the final report cover site logistics?	28	41.8	39	58.2	WEAKNESS
100	Does the final report cover communication and recommendations?	26	38.8	41	61.2	WEAKNESS
GRAND FREQUENCY AND PERCENTAGE		**37**	**55.22**	**30**	**44.78**	**STRENGTH**
CHI-SQUARE		**0.957**				**NOT SIGNIFICANT**

xiii. Documentation						
S/N	**ITEMS**	**YES**		**NO**		**DECISION**
		n	**%**	**n**	**%**	
101	Is there detail format and documentation of major TAM process and procedures in the refinery?	30	44.8	37	55.2	WEAKNESS
102	Are there Gantt chart showing roles and responsibilities for all key personnel, key activities and resource requirements?	47	70.1	20	29.9	STRENGTH
103	Are all information documented in computerized maintenance management system (CMMS)?	14	20.9	53	79.1	WEAKNESS
104	Are there documents covering specifications, operation, maintenance and repair for each major item of equipment?	9	13.4	58	86.6	WEAKNESS
105	Is there turnaround maintenance manual in your refinery?	24	35.8	43	64.2	WEAKNESS
GRAND FREQUENCY AND PERCENTAGE		**24.8**	**37**	**42.2**	**63**	**WEAKNESS**
CHI-SQUARE		**0.784**				**NOT SIGNIFICANT**

Source: Survey data, 2018

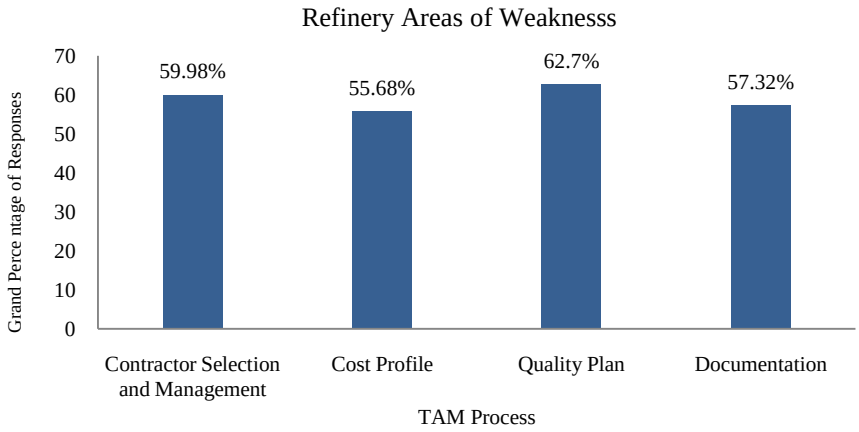

Figure 2 Respondents ratings on weakness on turnaround maintenance process

From the results the refinery's areas of strength are:
Communication and reporting;Safety plan;The refinery is providing a good planning prospect at the initiation phase of TAM, although most of these plans are hindered from actualization due to bureaucracy and corruption; Execution process of TAM; Work scope determination; the refinery has good procedures for site logistics; the examined refinery has good procedures for terminating TAM and also TAM report format.
TAM Organization
The following aspects were considered weak in the Turnaround Maintenance process and therefore needs improvement;
Documentation ofturnaround maintenance process and procedures in the surveyed refinery; Involvement of contractor's representative in planning at the preparation phase of TAM; Cost estimation and profile aspect of TAM process was considered weak and therefore needs improvement in these areas; contingency planning, cost minimization, cost tracking and control; Contractor selection and management; this aspect of TAM has impeded contract award to inappropriate contractors due to political interference; As a result there is no proper measure to quality checkon the TAM; Feedback from previous TAM to improve on past mistakes; TAM planning using maintenance management softwarethis will ease planning of TAM and facilitate effective and comprehensive planning.

Identifying the challenges in carrying out turnaround maintenance of the refinery in Nigeria.

Table 5 presented the results of data analyses on the challenges in carrying out turnaround maintenance in the examined refinery in Nigeria.

Table 5 Challenges In Carrying Out Turnaround Maintenance

S/N	ITEM	(SA) 4	(A) 3	(D) 2	(SD) 1	x	SD	DECISION
106.	Failure to approve the Turnaround Maintenance at the appropriate time.	33	17	8	9	3.10	1.07	AGREE
107.	Failure to treat turnaround maintenance as a project.	40	16	4	7	3.33	0.99	AGREE
108.	Failure to apply maintenance best practice in carrying out turnaround maintenance.	40	12	8	7	3.27	1.04	AGREE
109.	Failure to release fund on time.	34	15	10	8	3.12	1.07	AGREE
110.	Failure to adequately use money meant for Turnaround Maintenance due to corruption.	41	10	9	7	3.27	1.05	AGREE
111.	Lack of experience contractors to carry out TAM due to political interference.	31	19	7	10	3.06	1.09	AGREE
112.	Lack of experience staff due to poor hiring decision and political interference.	5	5	18	39	1.64	0.92	DISAGREE
113.	Lack of experience staff due to poor training.	4	6	12	45	1.54	0.89	DISAGREE
114.	Inability to control work scope.	5	5	22	35	1.70	0.90	DISAGREE
115.	Lack of comprehensive planning.	40	21	2	4	3.45	0.82	AGREE
116.	Late delivery of procured equipment, machines and tools.	32	17	11	7	3.10	1.03	AGREE
GRAND MEAN AND STANDARD DEVIATION						2.78	0.99	AGREE

[*Source: Survey data, 2018]*

The findings of this study show that the challenges in carrying out turnaround

maintenance in the examined refinery include failure to approve and start the turnaround maintenance (TAM) at the appropriate time, failure to treat turnaround maintenance as a project, failure to apply maintenance best practice in carrying out turnaround maintenance, failure to release fund for TAM, failure to adequately use money meant for turnaround maintenance due to corruption, lack of experience contractors to carry out TAM due to political interference, lack of comprehensive planning and late delivery of procured equipment, machines and tools. The study found out that lack of experience staff due to poor hiring decision and political interference, lack of experience staff due to poor training and inability to control work scope have low mean, hence disagreed by the respondents as challenges in carrying out turnaround maintenance in the surveyed refinery.

Table 6 analysis of variance on the challenges in carrying out turnaround maintenance

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	0.397	2	0.199	1.820	0.170
Within Groups	6.981	64	0.109		
Total	7.378	66			

The results of analysis of variance in Table 6 indicate that there is no significant difference between the mean responses of staff in the various departments. This is because the significance value of 0.170 is higher than 0.05 level of significance.

IV. CONCLUSION

The research identified that Federal Government owned refineries were maintained adequately for some years and later abandoned for importation of petroleum products due to scarcity. Port Harcourt refinery had its TAM in 1991, 1995, 2000, at this period there was no product scarcity. The factors responsible for the under-utilization of the Port Harcourt Refinery arelargely due to negligence. The research was able to determine the refinery's areas of weakness as contractor selection and management, cost estimation and profile, quality plan and documentation. Finally, the challenges in carrying out turnaround maintenance (TAM) in the refinery include failure to approve the TAM at the appropriate time, failure to apply maintenance best practice in TAM among others.

NOMENCLATURE
ACRONYMS AND ABBREVIATIONS

Acronym	Meaning
AGO	Automotive Gas Oil
ANOVA	Analysis of Variance
BBL/D	Barrel per Day
BCM	Business Centered Maintenance
CDU	Crude Distillation Unit
CRU	Catalytic Reforming Unit
DPK	Dual Purpose Kerosene
DPR	Department of Petroleum Resources
EIA	Energy Information Administration
FCCU	Fluid Catalytic Cracking Unit
HPFO	High Pour Fuel Oil
KHU	Kero Hydro-Treating Unit
KRPC	Kaduna Refining and Petrochemical Company
LPFO	Low Pour Fuel Oil
NHU	Naphtha Hydro-Treating Unit
NNPC	Nigerian National Petroleum Corporation
ORB	Original Refinery Builders
PHRC	Port Harcourt Refining Company
PMBOK	Project Management Book ofKnowledge
PMS	Premium Motor Spirit
RCM	Reliability Centered Maintenance
TAM	Turnaround Maintenance
TPM	Total Productive Maintenance
TQM	Total Quality Management
WRPC	Warri Refining and Petrochemical Company

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