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Analysis of Factors Affecting Maintenance Strategy Selection in NNPC Lokoja Pump Station in Kogi State

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Abstract
This research was undertaken to carry-out analysis of factors affecting Maintenance Strategy Selection in NNPC Lokoja Pump Station in Kogi State. A list of factors which in no small measure affect the Maintenance Strategy selection of an organization was expressed in a five-point Likert questionnaire. The questionnaire was administered to technical experts across the oil and gas companies and other allied industries. 52 questionnaires were distributed in 25 companies and other allied industries and 50 questionnaires were returned. More also, the Kaiser-Mayer-Olkin (KMO) value of 0.66 recorded in analysis showed that the data are adequate to carryout principal component analysis and is above 0.50 recommended value and Bartlett's reached statistical significance. In addition, the descriptive statistics, the mean is above 3.0 which implies that the identified factors are being accepted by industry experts that there is no doubt that these factors have effect on maintenance strategy selection. Principal component analysis was employed for the analysis of data. The clustered multiple variables, were labeled into six identified most significance factors which affect maintenance strategy selection in NNPC Lokoja Pump Station. The factors include; Installation of safety control, Installation of new plant equipment, Installation of highly sensitive equipment components/parts, Availability of high level of heat around installed equipment, Uncoordinated equipment installation, Effects of environmental factors/constraints.

Keywords: *Factors, Maintenance strategy selection, NNPC, Pump station, Kaiser-Mayer-Olkin*

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I. INTRODUCTION

Much has happened in engineering since the industrial revolution a couple of hundred years ago but perhaps the most dramatic changes have occurred in the last fifty years. These changes have of course affected how industry's plant has been maintained.

Prior to the Second World War (1939-1945) machinery was generally quite rugged and relatively slow running, instrumentation and control systems were very basic. The demands of production were not overly severe so that downtime was not usually a critical issue and it was adequate to maintain on a breakdown basis. This machinery was inherently reliable. Even today we can see examples of machines made in that period which have work very hard and are still essentially as good as the day they were made.

From the 1950's with the rebuilding of industry after the war, particularly those of Japan and Germany developed a much more competitive market place and there was increasing intolerance of downtime. The cost of labour became increasing significant leading to more and more mechanization and automation. Machinery was of higher construction and ran at higher speeds. They wore out more rapidly and were seen as less reliable.

Production/manufacturing demand better maintenance strategy which is cost effective, reduce downtime and improve high production efficiency. In the recent years, there has been an increasing concentration in maintenance within the business sector. This is as a result of escalating pressure upon manufacturing organisations to meet customer and cooperate demands, as well as improving equipment availability and performance (Baglee and Knowles, 2010). Therefore, maintenance with its various activities, resources, measurement and management, has become critical to manufacturing organisations (Simoes et al., 2011).

In this respect maintenance have come to play an important role in helping organisation to reach their goals of productivity, profitability, and competiveness and making sure that their equipment operate effectively and efficiently (Baglee and Knowles, 2010). The scope of maintenance has moved from a narrow-defined operational view, to an organisation strategic view, with the increasing awareness that maintenance creates added value to the business process (Liyange and Kumar, 2003).

1.2 Problem Statement and Research Motivation

The maintenance of any equipment or facility in an organization is tied to the maintenance strategy adopted by the organization. Different organizations choose and adopt maintenance strategy that is most suitable to them. Poor maintenance strategies can result in poor services to the entire operation, expose the operators and maintenance personnel to accidents and frequent breakdown of plant equipment which tends to reduce equipment's lifespan.

The key issue relating to any maintenance strategy is to select all the possible maintenance strategies that will be the maintenance policy of the organization in order to have hundred percent (100%) availability of all the equipment, so as to meet all operational demand and future demand on the equipment for efficient productivity.

The aim of this study is to carry out analysis of factors affecting maintenance strategy selection in NNPC Lokoja Pump Station. The following objectives are required to achieve the aim of the project:

- To prepare a likert questionnaire
- To administer the questionnaire to respondents who are industry expert
- To analyzed the data obtain from the questionnaires using factor analysis
- To recommend from the analysis, the most viable maintenance strategy for effective sustenance of the organization equipment.

II. RELATED WORKS

Previous studies have reported that maintenance account between 15% - 70 % of the total production cost (Bevilaqua and Bragila, 2000). In manufacturing organisations, maintenance related costs are estimated to be 25% of the overall operating costs (Komonen, 2002; Simoes et al., 2011). It is further reported that about 30% of maintenance costs are related to unnecessary expenditures, due to bad planning, overtime and unmet preventive maintenance (Salonen and Deleryd, 2011).

Campbell and Reyes- Picknell (2006) and Bergman and Klefsjo (2010) explained strategy as the idea of how to reach the objectives which means to take different steps of performing activities. The overall direction, a plan which describes the activities to be performed.

Alsyouf (2007) viewed the content in the maintenance strategy as a mix of techniques and/or policies which depends on factors such as the nature of the plant, the maintenance goals or the equipment which required to be maintained, the work environment and the work flow patterns (Product focus, Process focus). Alsyouf (2007) itemized a number of maintenance strategies and concepts have been suggested by intellectuals or implemented by practitioners.

Pride (2008) Reactive maintenance is particularly effective for non-critical, low-cost system components and equipment. As such, reactive maintenance should be used whenever the cost of maintaining an asset exceeds the asset's replacement value, unless the risk associated with failure is too severe(Pride,2008)

According to Sullivan et al., (2004) Reactive maintenance also provides benefits for small maintenance operations when the staff is not large or qualified enough to adequately perform routine maintenance activities. Despite these advantages there are numerous disadvantages to reactive maintenance.

Sullivan et al., (2004) the primary disadvantage of reactive maintenance is the high risk of unscheduled failures. Unscheduled failures often require more money to correct, especially if overtime labour is required to correct the problem. In addition, the opportunity cost of lost productivity from unplanned equipment downtime must also be included. A further risk of reactive maintenance is the potential for secondary system damages that may result from equipment failure. While reactive maintenance may seem to save maintenance and capital costs, it is an inefficient use of staff resources and has been shown to have higher long-term costs than other maintenance approaches (Sullivan et al., 2004)

According to Turner (2002), as with deferred maintenance, the compounding effects of reactive maintenance can have negative effects on the overall maintenance operation; this situation is known as the reactive maintenance strategy the premise of the reactive maintenance strategy is that successive preventable failures consume resources to the extent that the maintenance operation can only afford less- expensive, temporary repairs.

According to Sullivan et al., (2004) Predictive maintenance is defined as a process of determining maintenance action requirements according to regular inspections of an equipment or asset's physical parameters, degradation mechanisms, and stressors in order to correct problems before failure occur. Also known as conditions-based maintenance, this strategy differs from preventive maintenance in the fact that maintenance actions are performed according to the physical condition of the equipment, rather than an established frequency (Kwak, Takakusagi, Sohn, Fujii& Park, 2004; Lin et al., 2002). Predictive maintenance works particularly well for systems that are easy to monitor and have easily identifiable characteristics that can be statistically analyzed to determine remaining system life (Lin et al., 2002).

Brown, (1999) viewed Predictive maintenance relies on assessments of equipment or infrastructure condition; it can be applied to nearly any equipment problem where a physical parameter can be measured.

Nowland and Heap reached the conclusion that, "a maintenance policy based exclusively on some maximum operating age would, no matter what the age limit, have little or no effect on the failure rate". In separate independent studies, it was noted that a difference existed between the perceived and the intrinsic design life for the majority of equipment and components.

According to Massinio Bertolin et al. (2005) presents a lexicographic goal programming (LGP) approach to define the best strategies for the maintenance of critical centrifugal pumps in an oil refinery for each pump failure mode, the model allows to take into account the maintenance policy burden in terms of inspection or repair and in terms of the manpower involved, linking them to efficiency risk aspects quantified as in FMECA, Failure Mode, Effects and Criticality Analysis through the use of classic parameters such as occurrence, severity and detectability, evaluated through an adequate application of AHP, Analytic Hierarchy Process technique.

According to Ling Wang et al. (2007) analysis that deal with uncertain judgement of decision makers, a fuzzy modification of the AHP method is applied as an evaluation tool where uncertain and imprecise judgements of decision makers are translated into fuzzy numbers. In order to avoid fuzzy priority calculation and fuzzy ranking procedures in the traditional fuzzy AHP methods, a new fuzzy prioritization method is proposed. This fuzzy prioritization method can derive crisp priorities from a consistent or inconsistent fuzzy judgement matrix by solving an optimization problem with non-linear constraints.

According to Ming- Feng Yang et al., (2008) in his paper on AHP approach is used evaluating food quality management of bakery sector. In this approach triangular numbers were introduced into the convectional AHP in order to improve the degree of judgements of decision maker(s).

According to Mansoore Momatic et al., (2011) studied the selection of maintenance strategies in Electro Fan Company. It was studied that the evaluation of maintenance strategies for each piece of equipment is a Multiple Criteria Decision Making (MCDM) Problem. To deal with the uncertain judgement of decision makers are translated into fuzzy numbers. A specific example of selection of maintenance strategies in this company with the application of proposed Fuzzy TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution). Method is given, showing that the preventive maintenance strategy is the most suitable for equipment.

Jureen Thor et al., (2013) reviewed and compared analytic hierarchy process, elimination and compared analytic hierarchy process, simple additive weighting and technique for order preference by similarity to ideal solution. The comparisons were based on the aspects of consistency problem structure, concept, core process and accuracy of final results.

It is therefore, regarded as agents of national development for improving the quality of infrastructure in our society, needed maintenance culture at government level and private sectors as well as individual levels. It is on this note that the paper addresses causes and effects of poor maintenance and way out of the menace in order for our country to realize her lofty dreams.

2.1 Theoretical Framework

2.1.1 Reliability

According to Kumar (2000) ever since the very beginning of the industrial era, customers have demanded better and faster deliveries of products and services, all these at lower costs. In other words, they want to get value for their money spent. This problem is due to the fact that one produces, what someone else-consumes, this is important due to the competitive market, "Operators want infinite performance of assets, at Zero life- cycle costs, with 100% availability from the day they take delivery to the day they dispose it.

This of course the ideal request, but of course impossible to achieve. The operators demand is to get as close as possible to this extreme, or at least closer than their competitors. One step is to reach a high level of availability is to increase the reliability of the products, although this is on its own, one can't fulfill all those demands, but it is a link in the chain consisting of reliability, maintenance and logistic support, where maintenance comes as a natural part of reliability

2.1.2 Probability Theory

Probability theory is applicable in various situations where the outcome is uncertain, such as in experiments, trials and repeated processes etc. Where predictions have to be made. This is a topic that plays a leading role in modern science, in fact it was previously developed as a tool to guess the outcome of some game chance; however this thesis does not intend to describe the topic in detail with theorems and proofs, but just to give some brief overview of the concept.

2.1.3 The Reliability Function

The most frequently used function in life data analysis and reliability engineering is the reliability function. This function gives the probability of an item operating for a certain amount of time without failure. As such, the reliability function is a function of time, in that every reliability value has an associated time value. In other words, one must specify a time value with the desired reliability value i.e 95% reliability at 100 hours. This degree of flexibility makes the reliability function a much better specification than the MTTF, which represents only one point along the entire reliability function.

2.1.4 Lifetime Distributions

A statistical distribution is fully described by its PDF (or Probability Density Function). The functions most commonly used in reliability engineering and life data analysis, namely the reliability function, failure rate function, mean time function and median life function, can be determined directly from the pdf definition, or f(t). Different distributions exist, such as the normal, exponential etc., and each one of them has a predefined f(t). These distributions were formulated by statisticians, mathematicians and/or engineers to mathematically model or represent certain behaviour. For example, the 'Weibull distribution was formulated by Weibull and thus it bears his name. Some distributions tend to better represent life data and are most commonly referred to as lifetime distributions. The pdf of the well-known normal, or Gaussian, distribution is given by:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2} \qquad (1)$$

In this definition, note that t is our random variable which represents time and the Greek letters (mu) and (sigma) represent which are commonly referred to as the parameters of the distribution. Depending on the values of f(t) will take on at different shapes. The normal distribution is a two-parameter distribution, with two parameters μ and σ.

2.1.5 Failure Rate

Failure rate is the frequency with which an engineered system or component fails and is expressed for example as failure per hour. It is often denoted by the Greek letter; λ (lambda) and is important in reliability engineering. The failure rate of a system usually depends on time, with the rate varying over the life cycle of the system.

In practice, the mean time between failures (MTBF) is often used instead of the failure rate. This is valid if the failure rate is constant (general agreement in some reliability standards (Military and Aerospace) - part of the flat region of the Reliability bathtub curve, also called the "useful life period". The MTBF is an important system parameter in systems where failure rate needs to be managed, in particular for safety systems. The MTBF appears frequently in the engineering design requirements, and governs frequency of required system maintenance and inspections. In special processes called renewal processes, where the time to recover from failure can be neglected and the likelihood of failure remains constant with respect to time, the failure rate is simply the multiplicative inverse of the MTBF (1/λ).

2.1.6 The Bathtub curve

Davies (1998) stated that normal mechanical failure modes degrade at a speed directly proportional to their severity. Thus, the problem is detected early, major repairs can be prevented in most instances.

According to Davies one needs to find the right time for the failure to prevent major repairs, but before trying to find the time for a failure, one needs to examine and learn more about the lifetime of the component. The failure rate of a component is often high in the initial phase of its lifetime. This can be explained by the fact that there may be undiscovered defects in the components, when the component has survived the initial period; the failure rate stabilizes at a level where it remains for a certain time until it starts to increase again as the component begin to wear out. The shape of the curve depicting the failure rate of the component, is similar to that of a bathtub, hence the expression bathtub-curve. Figure 1 and 2 shows the bathtub curve with the three typical phases. The initial phase is called burn in period, the stable phase is called useful life period and the end phase is called wear out period. Other example of names for these three periods are break in, operations and breakdown.

Describing the bathtub curve, NIST (National Institute of Standards and Technology, USA) states that the initial region that begins at time zero when a customer first begins to use the product is characterized by, a high but rapidly decreasing failure rate. This region is known as the Early Failure Period (also' referred to as Infant Mortality Period, from the actuarial origins of the first bathtub curve plots). This decreasing failure rate typically lasts several weeks to a few months. Next, the failure rate levels goes off and remain roughly constant for (hopefully) the majority of the useful life of the product. Figures 1 and 2 shows the reliability "bathtub curve" which models the cradle to grave failure rates vs. time.

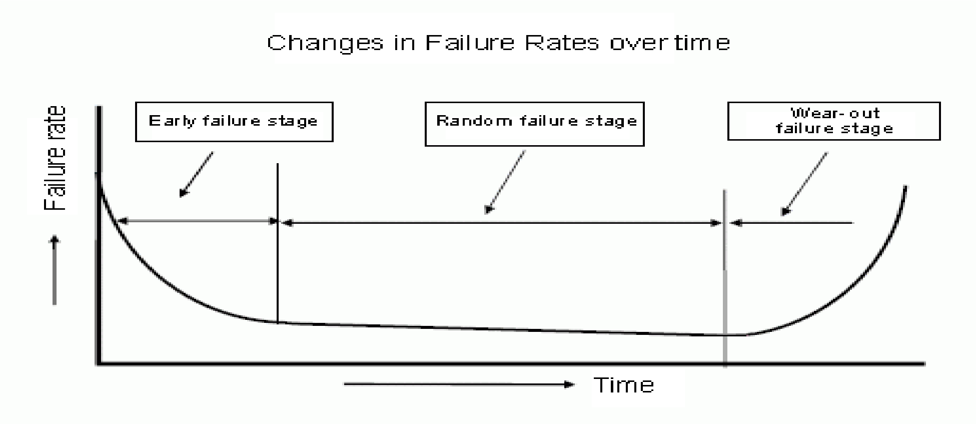

Figure 1: Bathtub Curve

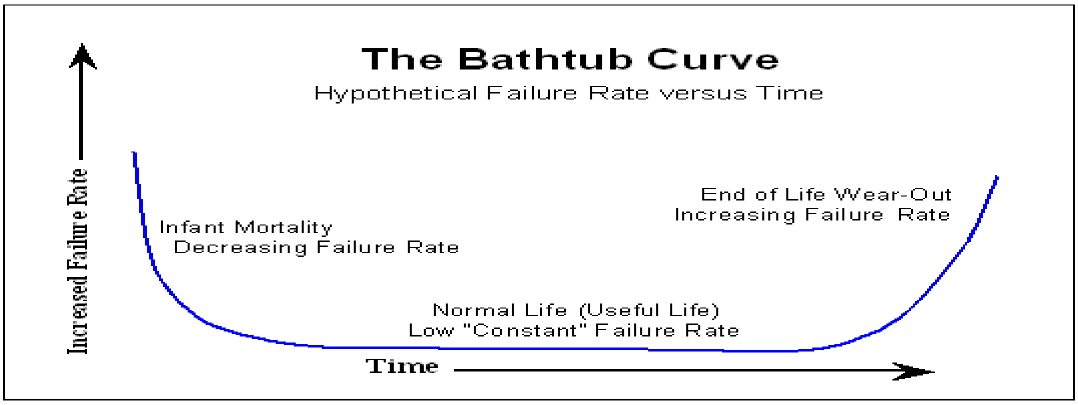

Figure 2.: Reliability Bathtub Curve

III. MATERIALS AND METHOD

3.1 Introduction

This section outlines the method used to acquire and analyze the data required to determine the factorial study of the analysis of factors affecting maintenance strategy selection in NNPC Lokoja Pump Station which tend to X-Ray all factors which required proper examination taking into consideration the cost implication and the need to avoid operation downtime. Therefore the research is centered on NNPC Lokoja Pump Station in particular and Nigeria in general.

3.2 Population of Study

The population is drawn from selected group of experience maintenance staff from various technical organizations, so as to have a board and encompassing views on all types of maintenance being practice in those organizations. The various maintenance pool visited are:

i. Oil and gas maintenance staff.
ii. Heavy duty generator overhauling Maintenance staff.
iii. Electrical/Instrument/Mechanical workshop.
iv. Servicing maintenance staff.

All within age group of 18-60years.
Since the population were made up of these categories of persons, it became necessary to carry-out sampling in order to ascertain data from all class of individual listed above.

3.3 Method of Data Collection

After considering the (52) fifty two factors and other factors which will likely affect the maintenance strategy selection and for the sake of the research, fifty two factors were considered. I designed a questionnaire (Likert scale questionnaire) that state broadly "performance of a machine depends on the type of maintenance strategies employed on it". Industry experts are free to comment based on their experience by ticking.

- Primary data collected using a cross-sectional survey method where questionnaires are administered to experience maintenance skill-pool in various technical establishments.
- The experience maintenance staff respondents on the questionnaire in those organizations were interviews to have their view on kind of maintenance being carry-out in their organization (field research).
- Secondary sources of information is a collection from certified literature search of relevant reputable publications from books, journals, research reports, newspapers and technical skills magazines.

3.4 Likert Scale

This is a psychometric scale commonly involved in research that employs questionnaires. It is most widely used approach to scale responses in survey research.

An important distinction must be made between a Likert scale and Likert item. The Likert scale is the sum of responses in several Likert items. Likert items are often accompanied by a visual analog scale (e.g. a horizontal line, on which a subject indicates his or her response by circling or ticking marks). A Likert item is simply a statement which the respondent is asked to evaluate according to any kind of subjective or objective criteria, generally based on the level of agreement or disagreement is measured. It is considered symmetric or balanced because there are equal amount of positive and negative positions, often five ordered response levels are used.

For this research, a five point response level was used ranging from "Strongly Agree" to strongly disagree".

Conclusively, Likert scaling is a bipolar scaling method measuring either positive or negative response to statement.

3.5 Sampling Techniques

The stratified random sampling method was used in the study of the population. This approach is based on the theory that a homogenous population is more likely to produce error than heterogenous one (Agbonifoh and Yomere 1999). This ensures adequate or proportional representation of the different categories that make up the population in the selected sample, this is likely to generate results which are more representative of the whole population, and it is also helpful in making correlations and comparisons.

3.5 Method of Data Analysis

The data obtained from the population were analyzed through Statistical Procedure for Social Sciences (SPSS) (Pallant, 2001), under which reduction tool will be used (i.e. factor analysis), and primarily Principal Component Analysis (PCA). Factor analysis is used to find factors among observed variables. That is to say, if your data contains many variables, factor analysis expressed group variables with similar characteristics together.

Large set of variables are being "reduced" or summarized using a smaller set of factors or components. This, it does by looking for "clumps" or group among the inter-correlation of a set of variables. This is almost impossible to do with the eye. Factor analysis has many uses. It is used extensively by researchers in development and evaluation of tests and scales. Scale development starts with a large number of individual scale items and questions by using factor analytic techniques, they can refine and reduce these items to form a smaller number of coherent subscales. Factor analysis establishes underlying dimension between measure variable and latent constructs thereby allowing the information and refinement of theory. (William et al, 2010) factor analysis is also used to reduce a large related variable to a more manageable number, before using them in other analysis.

The term factor is different in the case of factor analysis as compare to statistical analyses or procedures; in that the factor analysis is refers to the group, while in analysis of variance (ANOVA) technique is refers to the independent variable.

There are two main approaches to factor analysis exploratory and confirmatory. Exploratory factor analysis is often used in the early stages of research to gather information about (explore) the interrelationships among set of variables.

Confirmatory factor analysis is a more complex and sophisticated set of techniques used later in the research process to test (confirm) specific hypothesis or theories concerning the structures underlying a set of variables, for the project under consideration, exploratory factor analysis (EFA) was the approach used.

The survey was designed to explore analysis of factor that affect maintenance strategy selection in NNPC Lokoja Pump Station.

Questionnaires used are fifty- two Likert items which elicit responses from the appropriate persons (or those who have experiences in maintenance of their organization facilities). As such, it is a repeated measures design. The scale employed in the survey was a Likert scale. The five point Likert scale, which deals with the sum of responses on several likert items. With the items being in this case the variable factor are five- points showing that it range from strongly agree to strongly disagree. Strongly agree was assigned the value 5 and strongly disagree 1. The scale was been labelled as follows:

- Strongly Agree _ 5
- Agree _ 4
- Neutral _ 3
- Disagree _ 2
- Strongly Disagree _ 1

IV. RESULTS AND DISCUSSION

Table 1 shows the obtained responses from the respondents to the administered questionnaires are in matrix form. The factor loading for the data matrix, as generated by the software, is shown in table 1

Table 1: Quartimax Rotated Factor Loading

	Component					
	1	2	3	4	5	6
Availability of equipment safety controls	.877					
Scarcity necessary lubricants	.829					
Availability of substandard parts	.811					
Availability of modern working tools	.809					-.455
Fast change/fading of equipment technology	.714					
Constant rainfall	.702					
Poor plant utilization	.608					
Availability of roofing shelters overheads the equipment	.584					
Availability of highly inflammable products on these equipments	.572			-.453		
Availability of sensitive components on the equipment		.851				
Faults developed by these equipments		.842				
Volatile nature of the area where the equipment is sited			.817			
Availability of new equipment			.728			
Misalignment problem				.752		
Accessibility of installed equipment				-.624		
Level of heat present in the equipment while running					.761	
Availability of untrained equipment operators	.470				.667	
Non-availability of spare parts						.782

The factor loading for the variables were ranked and the highest, irrespective of sign, were selected
The communalities for the eighteen variables are shown in table 2.

Table 2: Communalities

	Initial	Extraction
Scarcity necessary lubricants	1.000	.860
Availability of new equipment	1.000	.692
Misalignment problem	1.000	.757
Accessibility of installed equipment	1.000	.590
Availability of equipment safety controls	1.000	.827
Availability of sensitive components on the equipment	1.000	.896
Faults developed by these equipments	1.000	.869
Level of heat present in the equipment while running	1.000	.652
Availability of roofing shelters overheads the equipment	1.000	.722

Availability of untrained equipment operators	1.000	.875
Availability of substandard parts	1.000	.796
Poor plant utilization	1.000	.733
Non-availability of spare parts	1.000	.814
Volatile nature of the area where the equipment is sited	1.000	.773
Constant rainfall	1.000	.815
Fast change/fading of equipment technology	1.000	.808
Availability of highly inflammable products on these equipments	1.000	.721
Availability of modern working tools	1.000	.888

Extraction Method: Principal Component Analysis.

The Kaiser-Meyer-Olkins measure of sample adequacy indicated almost 50% adequacy as shown in table 3

Table 3: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.669
Bartlett's Test of Sphericity	Approx. Chi-Square	529.856
	Df	153
	Sig.	.000

4.1 Clustering Of Variables, Labeling Factors and Analysis

The variables were clustered into six factors based on quatrimax rotation. The variables under each factors shown in tabular form and labeled accordingly. The factors are scale/group into six factors, starting from one to six in order of precedence. of 52 identified and analyzed cluster factors is to be labeled installation of equipment safety control. 5 out of 52 identified and analyzed clustered factors to be labeled installation of new plant equipment. 3 out of 52 identified and analyzed clustered factors is been labeled installation of highly sensitive equipment component parts. 4 out of 52 identified and analyzed clustered factors is been labeled uncoordinated equipment installation. 2 out of 52 identified and analyzed clustered factors is been labeled effect of environmental factors/constraints

Table 4: Factor 1

Description of Variables	Loading
Availability of equipment safety controls	.874
Scarcity necessary lubricants	.818
Availability of modern working tools	.794
Availability of substandard parts	.777
Constant rainfall	.741
Fast change/fading of equipment technology	.686
Availability of roofing shelters overheads the equipment	.677
Availability of untrained equipment operators	.658
Poor plant utilization	.555
Availability of sensitive components on the equipment	.440
Availability of highly inflammable products on these equipments	.430
Misalignment problem	.431

Table 5: Factor 2

Description of Variables	Loading
Availability of new equipment	.752
Non-availability of spare parts	.708
Accessibility of installed equipment	.538
Faults developed by these equipment	.531
Volatile nature of the area where the equipment is sited	.447

Table 6: Factor 3

Description of Variables	Loading
Availability of untrained equipment operators	.452
Availability of sensitive components on the equipment	.690
Faults developed by these equipment	.677

Table 7: Factor 4

Description of Variables	Loading
Availability of untrained equipment operators	.428
Level of heat present in the equipment while running	.640
Availability of highly inflammable products on these equipment	-.597
Volatile nature of the area where the equipment is sited	.562

Table 8: Factor 5

Description of Variables	Loading
Poor plant utilization	.541
Non-availability of spare parts	.420
Level of heat present in the equipment while running	-.409
Misalignment problem	.635

Table 9: Factor 6

Description of Variables	Loading
Availability of modern working tools	-.445
Constant rainfall	.510

The Principal Component Analysis (PCA) model adopted when the 52 factors were reduced to six labeled factors for fast management decision. The scree plot of the factor shown in fig. 3

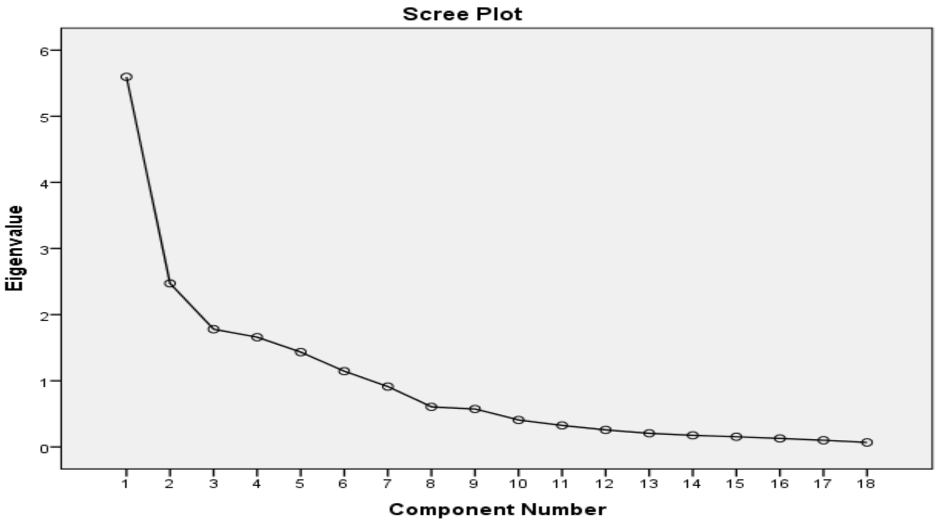

Fig. 3: Scree Plot of Factors Generated from the Respondents' Scores

The scree plot the point of inflexion on the curve which at point 6. This curve is difficult to interpret because the curve begins to tail off after six factor but there is another drop after the seven factors before a stable plateau is reached. Therefore, we could probably justified retaining either 5 or 6 factors.

4.2 Detail Discussion of the Identified Factors Affecting Maintenance Strategy Selection in Lokoja Pump Station

- **Installation of safety control**: Since safety control has been installed on the equipment, the possibility of detecting abnormal/mal-operation of the equipment which will make the equipment to trip or shut down. This will definitely make the management to consider the kind of maintenance strategy to be adopted either a passive maintenance strategy or reactive maintenance strategy.
- **Installation of new plant equipment**: Since the equipment is new, the need to follow manufacturer instruction manual to know the kind of maintenance which is recommended, which will now make the management to know the kind of maintenance strategy to be adopted either a preventive or predictive maintenance strategy.
- **Installation of highly sensitive equipment components/ parts**: Since the equipment has sensitive parts/ components, the need to have extra technical skilled workers in handling the parts becomes an issue for

management consideration of the kind of maintenance strategy to be adopted which might be reliability centered maintenance strategy or predictive maintenance strategy.

- **Availability of high level of heat around installed equipment**: Since heat is involved, there are kind of maintenance activities that cannot be easily carried out within the area where the faulty equipment is located as such as welding cannot be carried out. So a particular maintenance strategy like passive (opportunistic) maintenance strategy might be adopted.
- **Uncoordinated equipment installation**: This means that equipment installation should be handle by competent and experience skilled workers, so as not to have problem with installed plant equipment having misalignment or wrong cable rating. This will now determine the kind of maintenance strategy to be adopted such as reactive maintenance strategy.
- **Effects of environmental factors/constraints**: If the plant location is where rain usually fall frequently it means that serious equipment overhaul cannot be carried outside unless in a workshop.

V. CONCLUSION

The study was taken to analyzed factors that affect the maintenance selection strategy in lokoja pump station and which is applicable in the oil and gas industry maintenance strategy selection. The research was carried out with a detail designed likert questionnaire that encompasses all the factors that actually affects the kind of maintenance strategy selection.

Industry experts carefully ticked the questionnaires, with oral interview conducted which they categorically emphasized the fact that these factors really affect the maintenance strategy selection. The population was made of some selected group of technical maintenance companies across vast field of engineering.

Using SPSS, the data was analyzed with fifty-two item of the likert scale were subjected to principal component analysis (PCA) using SPSS 20.0. Prior to performing PCA, the suitability of the data for analysis was assessed. Inspection of the correlation of matrix revealed the presence of correlation of 0.3 and above.

The Kaiser-Meyer-Olkin values was 0.66 exceeding the recommended value of 0.5 (Kaiser, 1970, 1974) and the Bartlett’s test of sphericity (Bartlett, 1954) reached statistical significance. From the data analyzed, the followings conclusion were drawn. Properly examined maintenance strategy will definitely boast efficiency of the organization output. All the maintenance strategy has their pros and cons which likely play within the already examined factors. Equipment maintenance is a serious business which if taken serious will make or mar an organization.

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