Improving Management Systems for Oil and Gas Producing Company using Overall Equipment Effectiveness

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ABSTRACT

Consideration of difficulties inherent in maintenance management system in Nigerian oil and gas industries, and to eliminate the tedium associated in the system and improve equipment performance. In this work an attempt was made to assess the equipment maintenance practice in Kwale gas recycling plant of Nigeria Agip Oil Company Limited. Overall equipment effectiveness (OEE) indicator was used to determine the performance of various types of pumps and Turbine power generators installed in the plant, Maintenance records of the pumps and gas Turbine generators provided data for the computation and analysis. The availability, performance and quality rate of the pumps and gas Turbine generators were used to assess the overall effectiveness of the equipment used in the system. Detailed analysis of the failure rate and downtime revealed that a Plan Do Check Act (PDCA) system which is a proactive (predictive) maintenance technique was not adopted in the plant. The highest OEE value of 8.9% obtained confirmed that the current maintenance strategy and policy of the company is very much below standard and unacceptable. Hence this work affirms that the use of PDCA will avert unexpected system failure through early detection of faults, improve safety operation, reliability and durability of equipment. Thereby far less (i) human effort is wasted and (ii) energy expended, both of which led to increase in availability and profitability.

Keywords: *Availability, Performance, Quality Rate and OEE,*

1. INTRODUCTION

Efficiency and effectiveness are buzzwords in today's competitive market. The greater the efficiency and effectiveness, the more productive is the organization. Efficiency and effectiveness of equipment play a dominant role in the oil and gas production industry to determine the performance of the organizational productivity function as well as the level of success achieved. Poor performance and inefficient equipment in oil and gas production industries pose economic problems and losses especially in terms of cost (Ron and Rooda, 2006). However, this is directly attributable to obsolete equipment, scarcity of spare parts to cope with breakdowns, non-availability of trained technical manpower and poor inventory management of production equipment. Effective utilization of Man, Machines, Material and Methods will result into higher productivity (Ahmad *et al.* 2018; Ali & Ali-nejat 2014).

Markus and Eberhard (2015) studied enhancement of the overall equipment effectiveness measure: a contribution for handling uncertainty in shop floor optimization and production planning while Muthiah and Huang (2006) presented a review of literature on manufacturing systems productivity measurement and improvement. Bulent *et al.* (2000) investigated overall equipment effectiveness as a measure of operational improvement a practical analysis. Raffaele and Maria (2013) studied managing OEE to optimize factory performance while Huang *et al.* (2003) assessed manufacturing productivity improvement using effectiveness metrics and simulation analysis and Ylipaa *et al.* (2017) studied identification of maintenance improvement potential using OEE assessment. These studies, however, addressed the problem of improving management systems for oil and gas producing company using overall equipment effectiveness, but in a restricted manner.

Philip (2002) conducted a study to review and analyze the evolution of OEE, present modifications made over the original model and identify future development areas. This paper presents a systematic literature review; a structured and transparent study is performed by establishing procedures and criteria that must be followed for selecting relevant evidences and addressing research questions effectively. Overall equipment effectiveness (OEE) is a key performance indicator used to measure equipment productivity.

2. MATERIALS AND METHODS

2.1 Materials

The materials that were used for this study are failure data collected from the NAOC Kwale Gas Recycling Plant. The information contained in the data collected which was taken from the maintenance record books include

; number of failure, system failure cause, running hour, time before failure and downtime of the plant equipment covering the period from 2014 to 2018. Data was also obtained by direct observation in the environment of the research case study plant. The data for the five-year period was chosen in order to examine the trend in failure intervention call in the process plant.

The collected data in this study was quantitative in nature and was analyzed using the SPSS statistical software which also constitutes part of the materials used for this research work.

2.1.2 TPM and QMS Improving Management System in Oil and Gas Company

Total productive maintenance (TPM) was first coined in Japan in 1971 as a way for increasing machine availability by better utilizing maintenance and production resources. With typical manufacturing environments, the operator is not considered a member of the maintenance team; but, in TPM, the operator is. Many of the day-to-day activities of simple maintenance and fault-finding are performed by the machine operator. A technical specialist (typically an engineer or maintenance worker) and an operator are formed into a team.

Figure. 2.1: Eight Pillars of TPM (Fotopoulos *et al*., 2010)

2.2 Mathematical Models for System Productivity

The relationship illustrated in the overall performance of a productive system may be expressed mathematically in this general way:

$P_r \quad = \quad f(A\ P\ C) \quad (3.1)$

$A \quad = \quad f\ (R\ \ M\ /\ P\ \ C)\ (3.2)$

Where Pr= Productivity, A=Availability, P = Performance, C = Cost, R= Reliability, M = Maintainability;

2.2.1 Availability Rate Model (A)

The operating availability of an existing power plant or plant equipment is the percent of calendar hours that the equipment is available for production. It measures the percent of time that the equipment can be used. It can be obtained from historical data as follows:

$$Availability\ (A) = \frac{uptime}{uptime + downtime} \quad (3.3a)$$

$$\text{Availability} = \frac{Operatingtime}{PlannedProductiontime} = (3.3b)$$

The "availability" of a system is, mathematically, MTBF / (MTBF + MTTR) for scheduled working time. It is given by:

$$A = \frac{MTBF}{(MTBF + MTTR)} \quad (3.3c)$$

$$\text{Or} \quad A = \frac{T_O}{T_O + T_1} \quad (3.3d)$$

Where: T_0 = Time that plant system works.
T_1 = Time that plant system do not work, include repair and maintenance time.

The first task in setting up an availability goal is the construction of a simple model to provide insight into the significance of the goal. These are series models since the failure of one system will result in shutdown, the unavailability is given by:

$$Unavailablity = \quad 1 - A \quad (3.4)$$

2.2.2 Performance Efficiency Rate Model (P)

The overall performance of a productive system is determined by the qualitative and quantitative properties of the system. These properties are found in all the different components of the systems; and also, in the organization or structure of the systems.

$$\left[Performance = \frac{Actual\ output\ of\ Equipment}{Ideal\ out\ of\ Equipment}\right] \quad (3.5)$$

2.2.3 Quality Rate (Q)

The quality rate of plant equipment refers to the percentage of good electrical output measured in watts at Hertz produced out of total production of output energy per time frame. Mathematically, the quality rate of the equipment is given by:

$$\text{System quality rate} = \frac{\text{Annual output}}{\text{Total installed output}} \quad (3.6)$$

2.2.4 Overall Equipment Effectiveness (OEE)

Equipment performance and reliability have become major concerns as business reorganize, down size and aggressively pursue "lean" principles. Measuring and improving equipment performance is presently a typical issue in production plants. The basic measure associated with PDCA is overall equipment effectiveness (OEE).

According to Dal *et al.* (2000), based on the six major losses, OEE can be measured by obtaining the product of performance efficiency of the process, the availability of equipment, and rate of quality products.

Overall equipment effectiveness (OEE) = Availability (A) x Performance (P) x Quality Rate (Q) (3.7)

3. RESULTS AND DISCUSSION

3.1 Results

This chapter presents results of the research that are achieved through tackling the research problems. It introduces the collected empirical data and their analysis according to the proposed implementation of PDCA in the gas recycling plant. The relevant characteristics of maintenance and other basic maintenance parameters have also been broadly outlined. Process improvement Managers, Engineers, Operators and Technicians will compete with each other using the OEE model by trying to raise advantages that will enable availability to other rivals.

3.1.1 Data Presentation

Data collected from investigative case study plants (NAOC-Kwale Gas Recycling Plant) on conditions of generating and production units for the years from (2014-2018) have been tabulated as shown in the following tables and the failure analysis of all the units for calculation of the overall equipment effectiveness (OEE) is also shown.

Table 3.1: NAOC-Kwale Gas Recycling Plant Raw Technical Data (2014-2018)

S/N	PLANT UNITS LOCATION	INSTALLED CAPACITY (MW)/m3h	WORKING CAPACITY (MW)/m3h	NUMBER OF FAILURE 2014-2018	OBSERVATION PERIOD (2014 - 2018) HRS	REMARKS
1	GT 1	21MW	10.5MW	9	43800	Running ok
2	GT 2	21MW	10.5MW	7	43800	Running ok
3	Delivery Pump Unit 4100	175.6m^3/h	88m^3/h	50	43800	Running ok
4	Diesel Pump Unit 5600	15m^3/h	2.5m^3/h	50	43800	No spare part
5	Booster Pump Unit 6100	185m^3/h	93m^3/h	20	43800	Running ok
6	Condensate Pump Unit 7100	5m^3/h	3.0m^3/h	23	43800	No spare part
7	Fire Pump Unit 7100	200m^3/h	18.0m^3/h	12	43800	Available, Running ok
8	Auto-clave Pump Unit 7100	30m^3/h	18.0m^3/h	12	43800	Running ok
9	Water Treatment Pump R/A	3.5m^3/h	2m^3/h	13	43800	Available, Running ok
10	TOTAL	42/614.1	21/316.5			

The Table 3.1 shows detail of the data obtained from different plant units location, the parameters include installed capacity, working capacity, number of failure and the observation period between 2014 to 2018 of Nigerian Agip Oil Company Ltd - Kwale Gas Recycling Plant

3.1.2 Determination of System Overall Equipment Effectiveness (OEE).

From the Pumps at Kwale Gas Plant Location data in Table 3.1, the System availability which is the product of individual pumps availability was determined using equation (3.3b) and the system performance efficiency which is the average sum of individual pumps Performance was determined using equation (3.5). The overall equipment effectiveness (OEE) for the year was computed and presented in the Table 3.2 as shown.

Months	Availability %	Performance Efficiency %	Rate of Quality %	OEE %
Jan	52	50	28	7.3
Feb	59	43	24	8.2
Mar	59	52	27	8.3
Apr	51	52	28	7.4
May	52	40	37	7.8
Jun	54	55	15	4.5
July	58	59	15	4.8
Aug	58	45	19	4.9
Sept	58	69	19	7.6
Oct	58	52	19	5.7
Nov	58	53	29	8.9
Dec	58	44	29	7.4

The results for values of availability, performance efficiency and quality rates of the plant equipment for the year 2018 are presented in Figure 3.1 to 3.3.

Table 3.2: OEE Value for year 2019

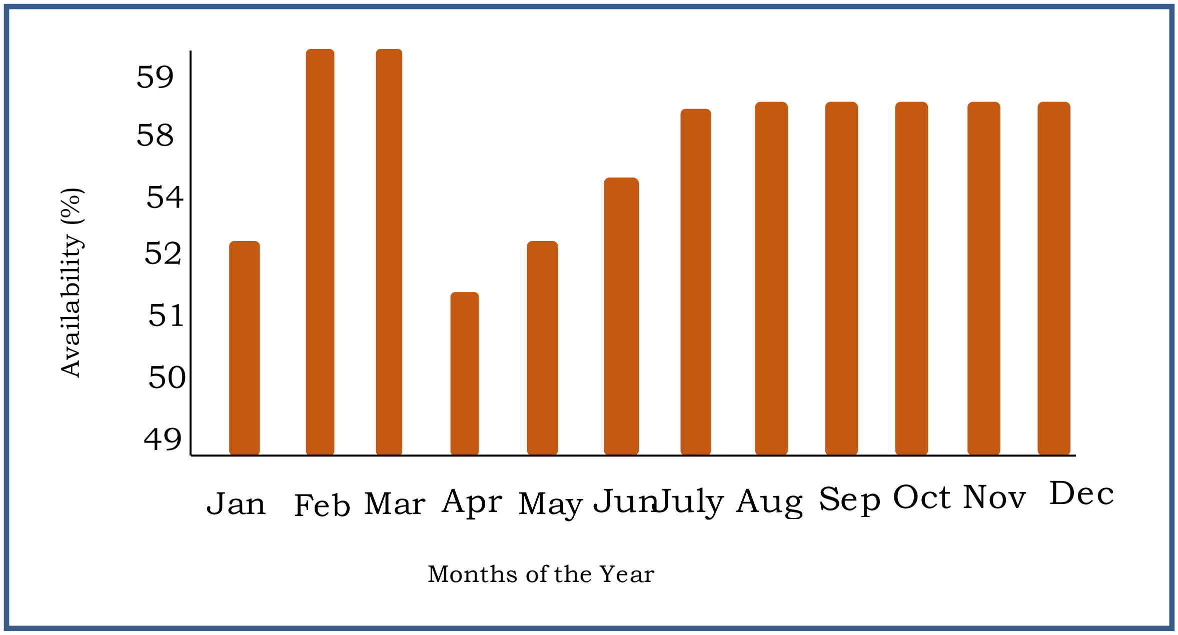

Figure 3.1: Availability Rates of the Plant

The availability rates of the plant equipment were analyzed and presented in Figure 3.1. The results showed that the availability of the plant equipment has its highest value of increase of 59%, a value less than world's standardized value of 90%.

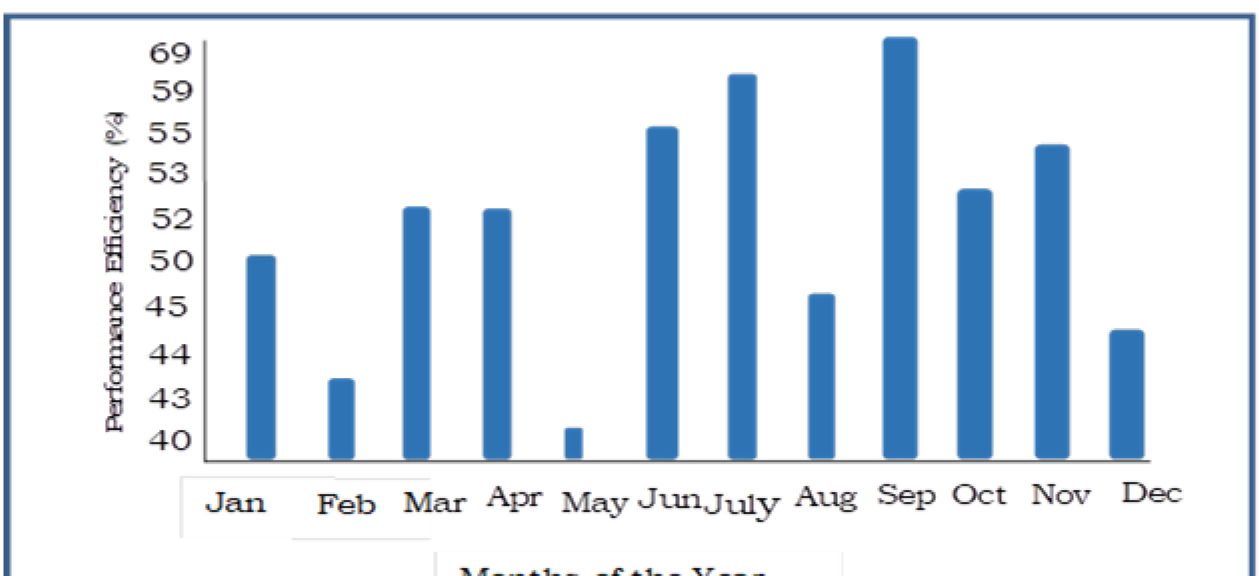

Figure 3.2: Performance Efficiency Rates of the Plant

The performance efficiency rates of the plant equipment were analyzed and presented in Figure 3.2. The results showed that the performance efficiency of the plant equipment has highest rate of 69%, which is less than expected rate of 95%.

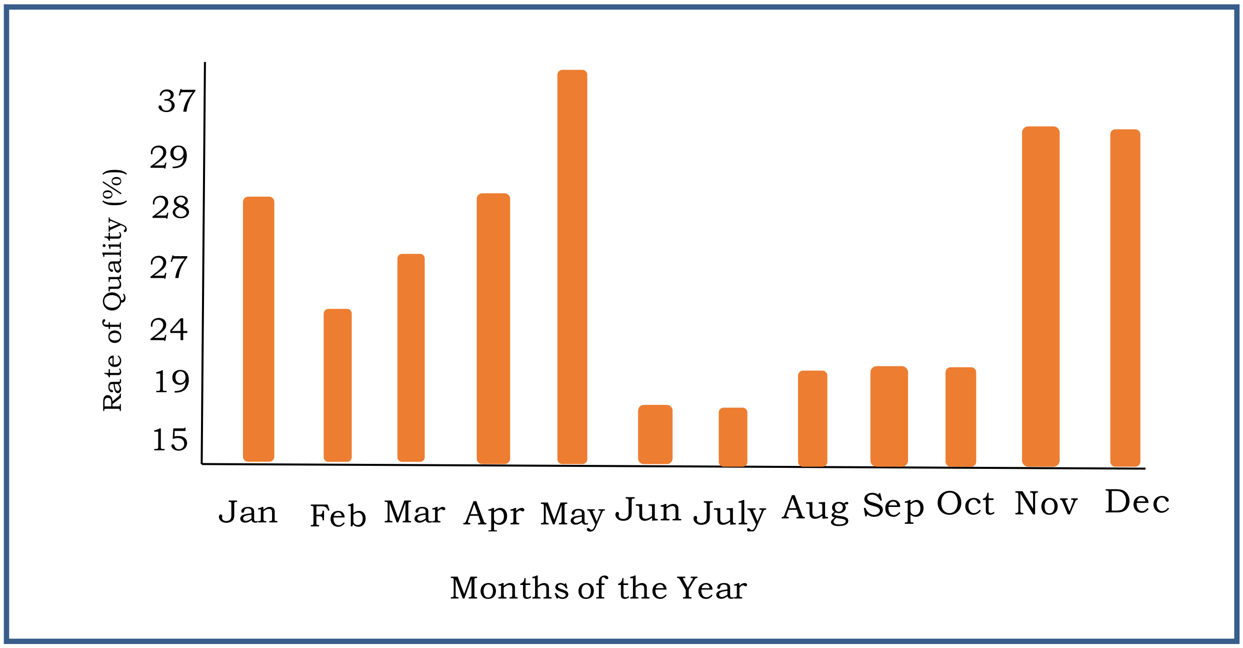

Figure 3.3: Quality Rates of the Plant

The quality rates of the plant equipment were analyzed and presented in Figure 3.4. The results showed that the quality rate of the plant equipment has highest rate of increase of 37%, which is less than required rate of 99%.

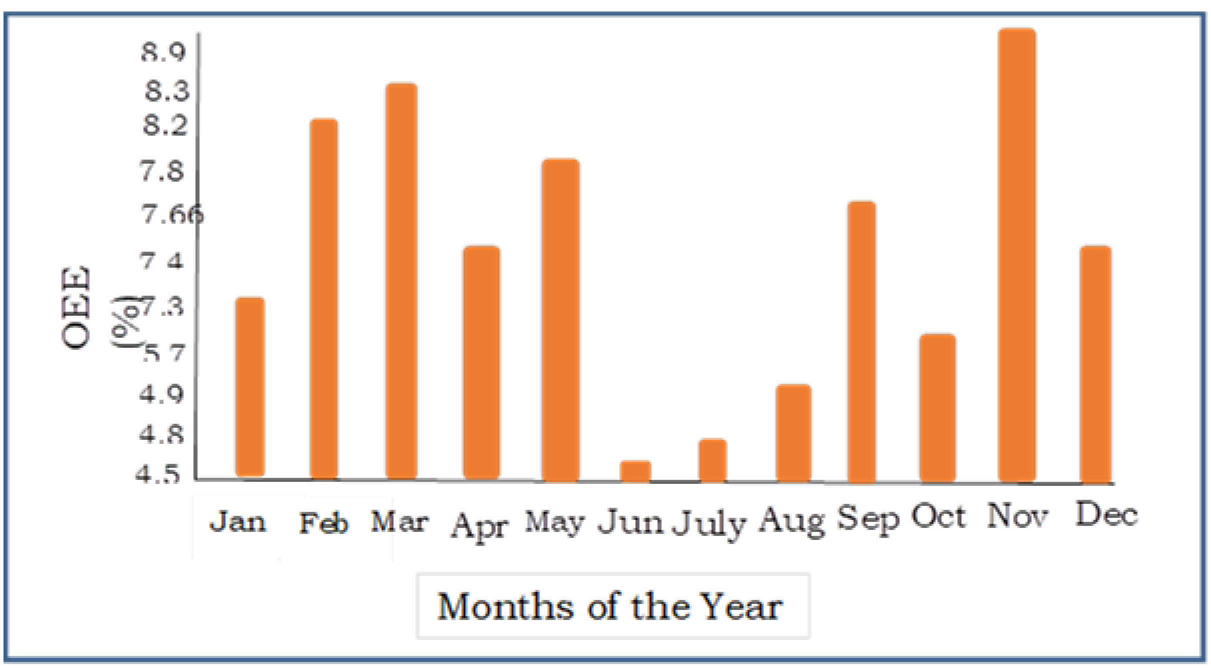

Figure 3.4: Overall Equipment Effectiveness (OEE) Rates of the Plant
The overall equipment effectiveness (OEE) rates of the plant equipment were analyzed and presented in Figure 3.4. The results showed that the overall equipment effectiveness (OEE) of the plant equipment showed poor highest value of 8.9%.
A bottleneck is a phenomenon, where the performance or capacity of an entire system is limited by a single or limited number of components or resources. In engineering, a bottleneck is a phenomenon by which the performance or capacity of an entire system is severely limited by a single component. Formally, a bottleneck lies on a system's critical path and provides the lowest throughput. A bottleneck in project management is one process in a chain of processes, such that its limited capacity reduces the capacity of the whole chain.

The bottle neck machine is due to which productivity is going down most of the time. From the OEE analysis, the pumps in the gas plant poises a huge bottleneck in the productivity of the system as the OEE of the gas plant pump determined is 5.3%. The reason for the poor pump OEE is due to low availability rate of the pump system arising from high failure rate. The availability and ultimately the OEE of the pump system can be improved by reducing the downtime of the gas plant's pump system due to high rate of pump failure and improving the MTBF of the pump system. This can be achieved using the PDCA model.

3.2 Result of the Analysis of Overall Equipment Effectiveness (OEE) of the Gas Plant using PDCA Model.

Using PDCA model as shown in Figure 4.5, the Monte Carlo simulation procedure has been adopted to simulate the data for availability, performance efficiency and quality rates of the plant equipment for the year 2019 were optimized. The model is based on the continuous quality management and improvement concept (i.e. Plan, Do, Check, Act) known as the Deming's PDCA-cycle. A method meant to take care of limitations in maintenance activities, while retaining the core philosophy as model for policy decision making for mutual collaboration in the form of action research.

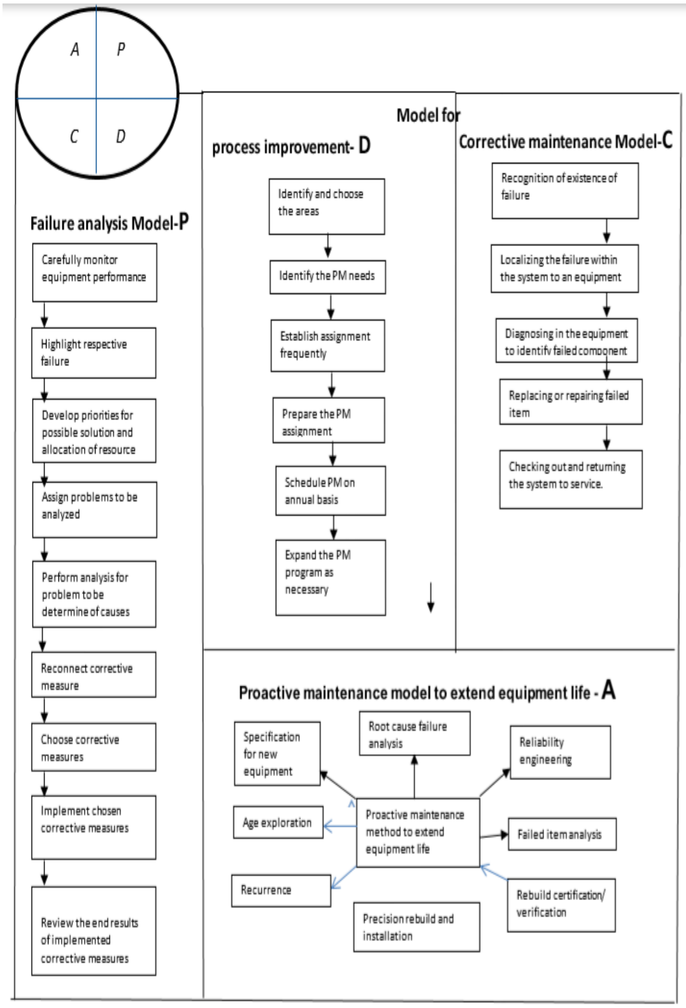

Figure 3.5: Corrective improvement through Deming's PDCA flow diagram

The method largely follows other conventional processes i.e. conditioned based maintenance (CBM) and reliability centered maintenance (RCM) that reduces the downtime of the system and increases the MTBF of the system. Both differ in the methodology of identifying potential failures that causes downtime and unavailability of the system. The improvement process PDCA uses history of past failures for providing the initial round of predictive, preventive and default actions. This allows a quick realization of availability and reliability improvement in comparison with other conventional methods. The PDCA incorporate the use of several quality improvement tools RCM taking care of excessive delay in implementation of the conventional processes with the goal of simplification (Vincent & Maxwell, 2017).

This process in effect provides an amalgamation of various methods that collates the key features of CBM, and RCM in one target, that of failure prevention. However, this may not be without its limitations and the most obvious one is the fact that a sequential process is established that may lead to potential failure that may not be apparent at the initial stage of implementation. An outlined detailed master deployment plan that identifies the resources needed for training, equipment restoration and improvements, maintenance management system and new technologies, to promote and sustain maintenance activities and establish quantifiable goals. The other three steps of this process show the basic objectives of this method to provide for improvement as soon as or even concurrently as the failure modes are identified, taking care of one of the causes of failure in the conventional maintenance methods.

4. CONCLUSION

This study aimed at Improving Management Systems for Oil and Gas Producing Company using Overall Equipment Effectiveness, a case study of Nigerian Agip Oil Company Limited gas recycling plant, necessary for global competition, hence PDCA, which traces the various roles played by the maintenance dimensions by first self-auditing and bench-marking before implementation. The objectives of this dissertation which included; to assess the gas recycling and utilization process so as to identify the salient factors leading to losses in the plant operations was achieved as presented in Figure 2.3, to analyze the availability rate, performance rate and quality rate of the gas plant was achieved using the availability, performance and quality rate models and presented in section 3.1.2 and ultimately, to model, analyze and optimize the overall equipment effectiveness of the gas plant was achieved using PDCA model.

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