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Full Length Paper

Maintenance Effectiveness and its General Impact in the Oil and Gas Industry

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Abstract

In other to know the performance of a personnel in optimizing maintenance resources and plant availability for utilization, evaluation of maintenance performance needs to be done on regular basis for proper planning and control of maintenance activities in an organization. This study is based on maintenance effectiveness and its general impact in the oil and gas sector. The multiplicative multi-attribute model was used to assess the performance of maintenance resources. Six performance ratios were identified using Nominal group Technique and integrated by utility concept. The trend of the performance ratios indicate frequent production stoppage due to machine breakdown resulting in poor performance of overall maintenance measure. In conclusion, the company require improvement on proper planning and control as well as proper preventive maintenance scheduling. Finally, some recommendations are made for optimal capacity production in terms of plant utilization and maintenance management.

Keywords: *Maintenance effectiveness, planning and control. Performance measure*

1. BACKGROUND

To obtain the best utilization of resources through good decision making and communication processes, productivity and creativity is required. Equally, maintenance of system is of great importance to ensure optimal performance at high level of efficiency. The relationship between maintenance and production operation is identified and emphasis is placed on the need to adopt a systems approach to solving problems of maintenance in manufacturing and service industries. The major objective of every organization is to make profit. A business will automatically close down when it is not meeting up in terms of profit. In the oil and gas sector, it is recommended that performance evaluation must be done regularly. A good maintenance organization should tend to reduce the number of maintenance management problem, minimize effort involved to reduce organizational friction, promote effective teamwork, and keep operating cost to a minimum. The overall objective of maintenance organization is to develop team work that function as a single instrument for low cost maintenance activities. The purpose of this study is to recommend effective maintenance strategy in the oil and gas industry. Maintenance is necessary on a daily basis as it ensures that the machines, services, equipment and other facilities are operating at the required level of productive efficiency.

1.1 Maintenance Activities

Predictive Maintenance (PdM) is a kind of maintenance strategy which is considered necessary and right-on-time. It is a function of failure limit strategy where maintenance is done at the time reliability indices or failure rate attains a determined level (Tsang 2002). According to Jardine et al. (2006), predictive maintenance can be classified into condition-based maintenance (CBM). And reliability-centered maintenance (RCM). However, most maintenance approach has been implemented as CBM considering good number of production systems where certain performance indices are attained periodically (Barajas and Srinivasa 2008) or continuously monitored (Cao et al. 2012). CBM is considered as a technique or a process required for monitoring the functioning or operational physiognomies of machines (or components). Fluctuations and inclinations in the observed characteristics can be used for prediction of the possible maintenance before serious breakdown or deterioration occurs in such machines. Thus, CBM endeavors to circumvent unnecessary maintenance tasks by taking maintenance actions only when there is evidence of abnormal behavior in a piece of equipment or process (Aliustaoglu et al. 2009). By reducing the number of unnecessary scheduled preventive maintenance operations, a properly established and effectively implemented CBM program can significantly reduce maintenance costs (Liao and Pavel, 2012). For example, based on a high-level analysis of the automotive industry (Sztendel et al. 2012; Demetgul, 2013) stated that the best return on investment (ROI) is achieved through predictive maintenance as opposed to reactive or preventive maintenance (Jin et al., 2016; Fadeyi et al. 2016).

1.2 Forms of Maintenance

Some forms of maintenance are listed thus: *Preventive maintenance* **–** This has to do with the maintenance activities conducted at scheduled intervals or to prescribed criteria before the need arises and aims at avoiding interruption or major breakdowns. It consist of proper design and installation of equipment, periodic inspection of plant and equipment to prevent breakdown before it occurs, repetitive servicing, up keep and overhaul of equipment and adequate lubrication, cleaning and painting of buildings and equipment; *Corrective maintenance* is the maintenance carried out to restore (including adjustment and repair) an item, equipment or facility that has ceased to meet acceptable performance conditions; *Emergency maintenance* is the maintenance carried out, as is necessary to put back in working order immediately an item or equipment so that serious consequences are avoided (such as loss of production, extensive damage to assets or even loss of life); *Planned maintenance* is the scheduled maintenance programmed or action carried out with forethought control and record by management in order to prevent failure or sudden breakdown of equipment. It may cover some period of weeks, months or year; *Breakdown maintenance* is usually planned after corrective maintenance. It is the work carried out after a failure but for which advance provision has been made, in the form of spares, materials, labour and equipment; *running maintenance* that is planned preventive maintenance is carried out while the facility is still in operation mode; *Shutdown maintenance* may be planned preventive or corrective shutdown maintenance and is the maintenance work, which can only be carried out when the facility has been taken out of serviced. Inspection is the process by which a facility is assessed base on a specific standard performance and that the level is maintained. Overhauling which is also Recondition, Refit, Rebuild is the comprehensive examination and restoration of a facility, or a major past thereof, to an acceptable condition.

2. Maintenance Measurement scheme

Measurement scheme may be defined as strategies and plan of activities designed to measure the performance of an organization. The steps required include:

Step l: Creating awareness within an organization
Step 2: Study existing information within the system
Step 3: Productivity measurement indices must be ensured
Step 4: Report and Data collection forms must be well designed and updated
Step 5: Conducting maintenance performance evaluation
Step 6: Reporting implementation
Step 7: Review of details

The basic model of flow chart indicating the Step-by-Step process involved in executing Maintenance measurement scheme is presented as shown in Figure. 1.

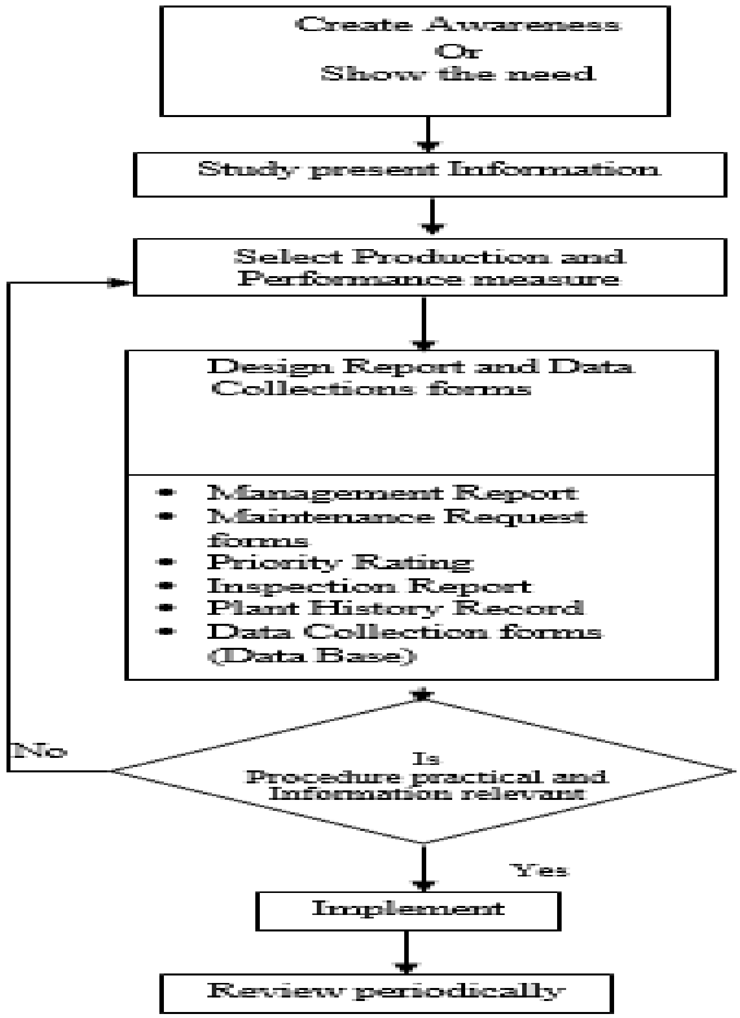


Figure 1: Basic Model in setting The Maintenance Productivity Measurement System

3. MODEL DESCRIPTION AND METHOD OF STUDY

The model under study and the method adopted in carrying out the research are presented.

3.1 Concept of Utility Approach

Utility is a measure of desirable outcome. Utility can also be expressed as an ordinal preference. Utility theory provides a theoretical framework for the construction of indices that combine multiple indicators in different units. The concept of utility can be used to quantify the goodness of states and actions hi a system. System states can be compared using utility measures.

The combined values (composite utility) represent the net effect of all the surrogate measures on the perceived performance towards the organizations objectives. This composite utility thus reflects overall productivity within the definition of total organizational productivity. Utility theory can provide a firm theoretical foundation from which to include subjective elements.

3.2 Determination of Utility Values

A step-by-step procedure for determination of utility values is presented shown as follows:

Step 1: Assume X_1, X_2..................... X_n be are events of a criterion. Rank X_i in order of preference

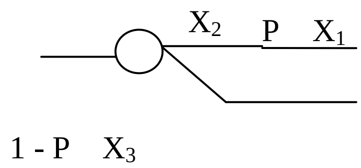
such that $Xi > X_2$....................................... X_n-i>X_n

Where X_i is the most preferred Event and X_n is the least preferred.

\> indicates the order of preference meaning "preferred to"

Step 2: Assign utility value $U(X_1) = 1.0$ and $U(X_n) = 0$ to the most and the least preferred events --respectively.

Step 3: Determine $U(X_2)$ such that indifference is obtained between the following sweepstakes.



$$X_V = P^*(1.0) + (1\text{-}P)^*(0.0)$$

The two extreme event X_1 and X_2 are taken as the reference points for the sweepstakes which is expressed as $U(X_2) = PU(X_1) + (I\text{-}P)\ U\ (X_n)$

Step 4: Repeat step 3 (n-3) times with X_2 being replaced each time by X_3, X_n-1 respectively.

Step 5: Having determined utility $U(X_1)$, $U(X_2)$.......................... values, repeat Step 3 using $U(X_1)$ and $U(X_{n-1})$ as the set of new reference points to obtain new set of utility values $U(X_2)\ U\ (X_{n-2})$ which must be consistent with utility values earlier

Obtained, when compared step3 is restarted.

Step6: Repeat step 5 (n-4) times with X_2 replaced each time by X_3..

Inconsistencies are found, the procedure is repeated until all the utilities values agree

Satisfactorily.

The above steps provide a basis for the determination of utility values by using single decision maker and is rather tedious and laborious when a large number of events are considered and also difficult to apply to multi-attribute criteria

3.3 Determination of Scaling Factors

The overall utility is represented by the multiplicative form of the utility function rather Than a simple weighted average. The multiplicative form is given by:

$$\left\{ U(x) = 1/k\ \pi\ (KKiUi\ (Xi) + 1)\text{-}1\ \pi_{i=1}^{n} \right.$$

Where

$U(x)$ = the total utility

X_i = the performance level of attribute

$U_i(X_i)$ = the single attribute utility for attribute i

i = 1, 2, 3, ...n attributes

K_i = Scaling factor.

It is of paramount that the attribute scaling factor must be evaluated before determining the overall utility of the system. A weight of 100 points is usually assigned to the highest ranked criterion. Weights can be assigned to other performance measures in order of their ranking. The sum of these weights is used as a denominator of each weight to get a scaling factor for each of the measures.

4. OPERATIONAL PROCESS

In pursuing the stated objectives of this study, the following steps were taken. An oil and gas facility in Delta State was visited. The maintenance and production records were examined. Data on maintenance and production was obtained. Interview was also conducted with the top maintenance personnel. Relevant performance measures were identified during the interview. Graphs and utility curves were plotted for each relevant performance measure. The overall maintenance performance was computed using composite surrogate performance indices. Data was collected in a section of maintenance department of the oil and gas company which is responsible for assisting in maintaining equipment and machinery in the plant.

4.1 Data Classification

Direct investigation was performed for the period between January 2019 and April 2021. Production, Maintenance and Accounting departments of the Company were responsible for the supply of these Data. The cost related data was obtained from the Accounting department while data related to equipment was obtained from job history cards of the equipment the data collected was on monthly basis and classified into the columns. It is also important to note the following during implementation process:

1. Cost of Spares and Supplies: This is the amount spent on the supplies of spare parts.
2. Direct maintenance Labour Cost: This is the total amount spent on the technicians doing the maintenance jobs.
3. Total maintenance cost: This is the overall amount spent on the maintenance activities.
4. Down Time: This is the unproductive Time Due to machine breakdown.
5. Down Time from Shutdown: This is the unproductive time as a result of deliberate or undeliberate shutdown of the plant.
6. Operating Time (UPTIME): This is the hours of operation of the machines.
7. Active Time: This is the actual production time of the production plant.

4.2 Analysis of Performance Measure

From the interview and data available, the following performance measures were identified;

Equipment Availability, Cost of Spares and supplies, Equipment Shutdown Intensity, Maintenance Cost Components, Emergency Failure Intensity and Direct Maintenance Labour cost. The performance measures were ranked in the following order by using concept of Nominal Group Technique (NGT).

Table 1: Parameters for Performance Measure

Performance Measure	**Ranking**
Equipment Availability	1
Cost of Spares and supplies	2
Equipment Shutdown Intensity	3
Maintenance Cost Components	4
Emergency Failure Intensity	5
Direct Maintenance Labour Cost	6

The deduced target for the above performance measures are:

Table 2: Performance Measure and Ranking

Performance Measure	Ranking
Equipment Availability	0.9
Cost of Spares and supplies	0.22
Equipment Shutdown Intensity	0.08
Maintenance Cost Components	0.25
Emergency Failure Intensity	0.10
Direct Maintenance Labour Cost	0.40

The data obtained from the facility was ranked as shown in Table 2.

4. 3 Development of Utility Curves for each selected measures

The following procedures were used to develop utility curves for each selected measures.
Step 1*: The* best and the worst value for each measure were identified.
Step 2: The Best value was assigned with utility value of 1.0 and the worst value was assigned with 0.0
Step3: Utility value was assigned to intermediate value of each measure based on the experience of maintenance personnel.
Step4: These intermediate values are the used to draw utility curves for each measure.
Step5: From the Utility Curve, the utility values for various maintenance performance measures can be found.
The best and worst values of each measure are obtained

4.4 Determination of Scaling Factors

A weight of 100 point was assigned to equipment availability which is the highest ranked performance measure. Other measures were assigned weight in order of their rank. The sum of these weights was then used as a denominator of each weight to get a scaling factor for each measure.

4.5 Computation of overall maintenance performance measure

In order to compute overall maintenance performance measure, the utility values obtained from the corresponding utility curves developed for the measure are multiplied by their respective scaling factors. These values are then added up to obtain the overall maintenance performance for each month under study. The utility values and overall maintenance performance in the review period must be investigated and the variation of overall maintenance performance over time.

4.6 Computation of overall maintenance target

The overall maintenance target is then determined by multiplying utility value of each Target with their respective scaling factor and then summed up to obtain overall maintenance target.

5. DISCUSSION OF RESULTS

5.1 Result Based on Selected Measures Equipment Availability

From the investigation, it shows that the measure perform fairly well as the average overshoots the target. The measure performed unsatisfactorily in the following months: March, November, December, 2019, September, November, 2020. This bad performance in the above stated months suggested frequent machine breakdown in those months. Other Months show a very good performance due to proper maintenance management.

5.2 Equipment Shutdown Intensity

From the exposition made at the facility, equipment Intensity is the measure performed satisfactorily as the average undershoots the target value. Poor performance was however recorded in following few Months: December 2019, January and December, 2020. The satisfactory performance suggested that the company did not incorporate the habit of shutdown anyhow. It implies that there is proper maintenance, no shortage of materials and the logistics was being planned accordingly.

5.3. Emergency Failure Intensity

With the target of 10%, , shows that emergency failure intensity did not perform well in the following Months: November, 2018, September and November 2019, January, February-, April, May, July, and November2020. This implies that there was frequent machine breakdown during those months due to lack of proper maintenance schedule.

5.4. Maintenance Cost Components

The investigation shows the poor performance of the measure in the following Months: January, and April2018, December 2019. Also January, February. March, 2021 as their values were above target value of 25%. This suggested that more costs were incurred in maintaining production machine suggested that Mean Time to Repair was very high during those Months of poor performance.

5.5 Direct Maintenance Labour Cost

Considering the company's direct maintenance labour cost few Months performed satisfactorily, they are: January, September, October, November, and December 2019, March and July2020, February 2021. Other period which witnessed poor performance of the measure for all other Months suggested that there was poor -utilization of maintenance man power as well as lack of maintenance effort.

5.6 Overall Maintenance Measure

From the investigation, the maintenance measure revealed overall target of 70%. On average, the measure undershoots the average which gives an indication for poor performance for the overall maintenance measure. This suggested that there was poor utilization of maintenance resources, increased equipment failure, lack of effective preventive maintenance and old age of equipment.

CONCLUSION

This project work evaluates the overall maintenance performance in an oil and gas company. The maintenance department studied is responsible for maintenance of the plant. Six performance ratios were identified and combined using a utility concept to produce a singular value. The poor performance is an indication of poor planning and control of maintenance resources. The overall Maintenance Performance performed fairly well. The poor performance could also be as a result of lack of basic evaluation, planning, control and maintenance scheduling. All the selected performance measure contributed both positively and negatively to the overall maintenance measure but the best among them is the Equipment Shutdown Intensity. It is recommended that: The performance of the maintenance department of the company should always be evaluated on regular basis; proper preventive maintenance scheduling is necessary; maintenance and production personnel should always work as a subsystem within the system; maintenance personnel should be trained constantly; complete and adequate records of maintenance activities is recommended.

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