Engineering and Technology Journal e-ISSN: 2456-3358

Volume 08 Issue 10 October -2023, Page No.- 2826-2831

DOI: 10.47191/etj/v8i10.03, I.F. – 7.136

Maintenance Brigade Strategic Planning and Organizational Change

W.A. Akpan[1], E.O.Usungurua[2], A.I.Ukut[3], A.E.Hanson[4]

[1,4]Department of Mechanical and Aerospace Engineering, University of Uyo, Nigeria

[2,3]Department of Mechanical Engineering, Akwa Ibom Polytechnic, Ikot Osurua, Ikot Ekpene, Nigeria

ABSTRACT: This research paper addresses the problem of maintenance planning and scheduling in hospital maintenance. It discusses the effective utilization of mechanics in strategic maintenance planning advocates the use of relay-type of maintenance brigade system (MBS), a system-based mechanic assignment techniques based on self-balancing bucket system created by Bartholdi and Eisenstein was thus adopted and tested. The MBS was compared to traditional assignment techniques via mechanic availability and mechanic utilization each at different levels according to maintenance performance assessment values. The results obtained with MBS showed some improvements compared to the traditional method of maintenance. The MBS had performance, utilization and productivity scores of: 91.7%, 92.3%,93.2% respectively compared to 71.4%, 69.2%, 69.2% respectively. The replacement time to service power generating set1 using MBS was approximately eleven hours lesser than the actual time compared to the traditional method.

KEYWORDS: Maintenance brigade system, strategic planning, performance, productivity utilization, scheduling.

1. INTRODUCTION

There has been an increasing need to balance the demands on plants and equipment in the healthcare delivery system. There should therefore be leadership maintenance philosophy driven by following a chain reaction: improved quality, better utilization of machines and maintenance personnel, especially the mechanics which will result in decreased costs of maintenance. These will enhance better and efficient medical care delivery. The contemporary business environment has raised the important function of maintenance organization, which have significant impact on physical assts. Four strategic dimensions of maintenance management are identified, namely service delivery options, organization and work structuring, maintenance methodology and support systems [1] These dimensions if put into practice will certainly improve the quality of maintenance and product or service quality. The two factors that permeate in the strategic dimensions are human factors and information flow, the latter can be made more efficient by embracing the e-maintenance models, e- maintenance, an emerging concept that exploit the potentials of digital technologies which offers new options to deal with these problems[1].

[2] models maintenance as a transformation process encapsulated in an enterprise system. In the input-output model, the resources deployed to maintenance include labour, materials, spares, tools information and money The way maintenance is performed will affect the availability of production facilities, the volume, quality and cost of production, as well as safety of the operation. This in turn will affect the profitability of the enterprise.

The type of maintenance work to be performed is an important factor affecting the design of the maintenance organizations. Maintenance work can be classified by its planning and scheduling characteristics [3].

First line work: This type of work is performed on daily basis. It consist of emergency corrective work, job that have to be carried out immediately due to safety and economic reasons.

Second line work: This consists of deferred corrective work involving work that usually take less than two days to complete and require restively few tradesmen. Also included are minor services and preventive work. This type of work can be prioritized, planned and schedule in the long term.

Third- line work- It consists major shutdown plant overhaul, capital project and modifications. It creates workloads at medium to long-term intervals.

Employee scheduling is a complicated multiple –objective problem involving such diverse considerations as varying manning requirements, costs, availabilities, skills and personal preferences. The efficient scheduling of the workforce can greatly reduce the labour cost, which is a significant proportion of the total cost for most organizations. Efficient utilization of mechanics is a problem that arises in establishments in hospitals equipment and plant maintenance. The problem is to satisfy the continuous work requirements with the mechanics with varying skills and experiences. Therefore effective utilization of mechanics must be determined in order to satisfy all daily labour demands with minimum cost.

Maintenance optimization can both be qualitative and quantitative. The former includes techniques like total productive maintenance (TPM), reliability centered maintenance (RCM). Etc.; while the latter incorporates various deterministic and stochastic models. The latter is further classified as stochastic models under risk or under warranty. [4] also presented another classification of these models as age and block replacement model. They have further identified applications tools like decision support system or expert system. A fully Bayesian, that is subjective approach of presenting uncertainty related to future events to decision makers, in context of an inspection maintenance decision problems has been presented by [5]..[6] used the most informative maintenance approach, fuzzy multi criteria decision method (MCDM) evaluation methodology and approaches.[7] used fuzzy linguistic approach to achieve subjective assessment of maintenance strategies and practices in an objective manner.[8] has applied Galbraiths information processing model to study how the maintenance function applies different strategies to cope with the environmental complexity

Under preventive maintenance (PM), [9] presented a mathematical model for a randomly failing production unit operating in an environment where repair and PM durations are random. [10] presented an approach to generate an adaptive PM schedule, which maximizes the savings from PM subject to workforce constraints. [11] evolved joint optimal periodic and conditional maintenance strategy. [12] proposed a maturity grid to support the CMMS implementation.

When bucket brigades were implemented at the national distribution centre of Revco drugs, Inc; which supports over 2,000 retail outlets, the results were impressive. The implementation required less than an hour, with no special equipment and no changes to the warehouse management system or related operations.. The most important benefit of bucket brigade was the increase in pick rates, which reached sustained levels of 34% gretaet than the previous historical averages under zone picking, while simultaneously reducing management inventory. This was achieved at essentially no cost, and in particular with no change to the product, equipment and control system.. The bucket brigade system applied to the assignment and scheduling of mechanics can produce similar results in maintenance department to those obtained at the distribution centres for order picking.In a typical corrective maintenance assignment technique, mechanics are assigned to specific machines in the same way that the order pickers are assigned to zones. The number of own machines waiting for a mechanic to become available should be reuced, as the rate of picking orders increased with the self-balancing, team –based nature of the bucket brigade, in which a group of individuals were systematically assigned to various zones. Further, the reduction of machines waiting service increase their availability..

The MBS developed is thus hypothesize to outperform the traditional assignment techniques because, other than assigning mechanics to a specific number of machines, the MBS si a self-organizing system where all the mechanics share the workload as a teem, rather than on an individual basis. The expected outcome is the collective utilization of the mechanics at a reduced cost and more availability of equipment and of course it built high morale and team work and internal learning at no cost, which is clearly demonstrated by the application of MBS.

This concept is quite new. The concept was originally being used in warehouses but this is being able to or applied in hospital maintenance function or management because normal industrial maintenance strategies have not proven effective in hospital maintenance function. The Maintenance brigade system was used in BMSH maintenance management strategy.

In a traditional maintenance assignment technique of machines and mechanics, the driving indicator has been machine coverage, consequently, utilization of mechanics has been neglected and thus having idle mechanics is typical. In traditional assignment systems, mechanics are assigned exclusively to a number of specific number of machines according to their level of training and machines' maintenance complexity [3]. Under this type of scenario, it is not rare to find machine not waiting to be serviced, while part of the workforce is idle.. Thus having plenty of waiting mechanics does not guarantee high levels of machine availability as a result of the inherent inefficiency of the mechanic- assignment system [3]. Hence this research sort a practical application for the development of the maintenance brigade system(MBS) for assigning mechanics for corrective action that will increase mechanic utilization and machine availability. The MBS is modeled after the bucket system of [4] that does not require significant capital investment or extensive training programme. The Braithwaite Memorial Specialist Hospital (BMSH) is responsible for all work relating to economic and technical preservation of facilities, equipment and systems in order to perform their designated functions. There has been the techniques of assigning mechanics to machines which composed of management strategies, optimization techniques and heuristics methodologies. These techniques have often neglected the effective utilization of mechanics and in some cases delay maintenance of machines and equipment. The objective of this research is to investigate the feasibility of corrective maintenance planning and control system that achieves targeted machine availability, while also maximizing the utilization of mechanics.

2. METHODOLOGY

The maintenance brigade system will be used in this research. In the MBS the mechanics are ranked according to several factors, such as education level, days of formal training, years of experience, years with the company and certification level for a particular category of machine, among others. There are some mechanics that are capable of servicing more than one machine type based on ability and experience, and the similarity among the different machine categories. The machines are also grouped in categories according to the similarity of maintenance service requirements. For instance, there are machines that require service of electrical and mechanical parts, while others require mechanical service only. The mechanic categories are aligned from the lowest to the highest as shown in Figure 1. The lowest category is represented by triangle 4, and the highest by triangle 1. In each category there may be several mechanics, and these are graphically depicted by the shades behind each triangle.

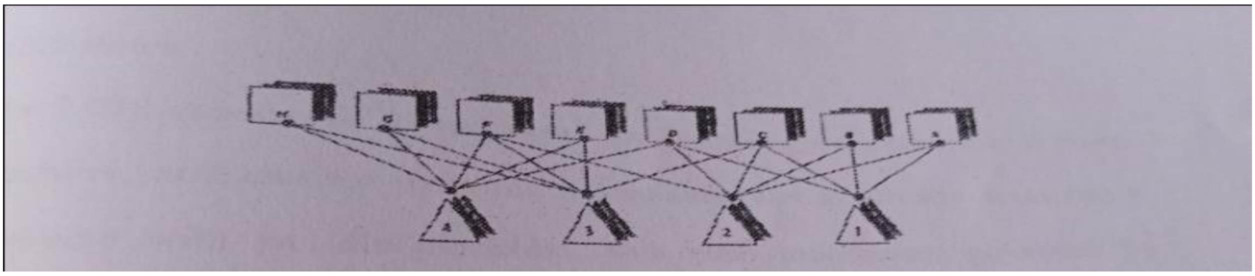

Figure 1: Organization of MBS

The different machine categories are represented by the squares and similar to the mechanic categories, the shades behind each square represent that there can be several machines within the machines within that machine category. The lines and nodes in Figure 1 represent the relationship between the machine and the mechanic categories. These lines, starting from the mechanic categories' node, indicate the different machine categories that each mechanic category is capable of servicing. Conversely, starting at the machine categories' node the lines show the different mechanic categories that are capable of servicing each machine category. When a mechanic that is servicing a machine becomes free, he has to service to service a specific machine, or replace a specific mechanic, in order to increase the manpower utilization and at the same time, maximize the probability of machine availability. The rules of MBS are discussed as follows:

The MBS consists of a mechanism for assigning a mechanic to a down machine, and for replacing a mechanic that is already servicing a machine with an idel mechanic, with each mechanism governed by distinct rules. The mechanics are assigned to the machines only when the equipment is down and unattended if another mechanic is already servicing the machine, then the replacement scenario takes place, which is described later, The rules for assigning a mechanic are described as follows:

Rule 1

When a machine goes down, assign the lowest mechanic category capable of servicing that machine, and the best available mechanic within that category. Assigning the lowest mechanic category to service a machine may aloow the system to increase the probability of machine coverage by sparing the higher (and more capable) mechanic categories to service the machines that may fail next. This increment in machine coverage allows maximizing the availability of machines by having a mechanic available to service a machine. In addition, the best available mechanic in that category should be assigned to the down machine to increase the utilization of the mechanics by keeping the best mechanics busy within a mechanic category. This will allow determining the utilization of lower ranked mechanics in a mechanic category, and if such utilization is low, then this can be an indicator that the system may not need that many mechanics in that category, and thus a reduction in the manpower levels may be feasible.

Rule 2

In the case that there are no available mechanics in the lowest feasible category for the scenario described in rule 1, then assign the best available mechanic of the next available mechanic category. Assigning the next higher available mechanic category may maximize, as in rule 1, the availability of the machines by assigning the lowest mechanic categories available, which results in sparing the mechanics with higher capabilities to service the maxchines that may subsequently fail. Rule 2 may also help determine whether or not a particular mechanic category is necessary.

Rule 3

If a mechanic becomes free and there are at least two down machine among the machine categories that he can service, he should service the one of greater importance to the firm.

The management must decide which machine should be serviced first based on factors such as the profitability and the cost associate with each machine breakdown. If the company finds frequently in a scenario, where there are at least two down unattended machines, then there is a possibility that the maintenance system is undermanned or that the machines do not have the necessary level of reliability in order to meet production demand.

Replacing a busy mechanic with a fre mechanic: The mechanic replacement is performed in order to increase the utilization of the mechanics and the probability of future machine coverage. It allows, the mechanics to be cross-trained, which minimize the impact of labour turnover. This feature is what makes MBS a unique maintenance assignment technique. Under the MBS a mechanic replacement occurs when a mechanic of any given category becomes free an there are no down and unattended machines.

Rule 4

If a mechanic becomes free and therr are no down machines under his machine categories, then he should replace the mechanic with the highest ranking from the category that is servicing a marine that is under the free mechnanic’s machine categories..

The MBS, as most other maintenance manpower management systems, is focused on maximizing machine availability. By replacing the best mechanic of the highest feasible mechanic category with a free mechanic, the probability of future machine coverage will be increased. Since the machine coverage of a mechanic from a higher mechanic category is typically greater, then when another machine breaks down the down the mechanic can service it immediately, thus possibly maximizing the utilization of the highly ranked mechanics.

Rule 5

In the case that there are no mechanics from higher categories as in the scenario described by rule 4, then the free mechanic should replace the lowest ranking mechanic from the lowest feasible mechanic category, as long as the time saved by performing the replacement is greater than zero.

Similar to the rules for assigning a mechanic to a machine, the higher ranked mechanics within a category should have a greater utilization than the lower ranked mechanics, in order to justify their higher cost. The replacement of a mechanic from a lower category, as stated by rule 5, is not always undertaken, but depends on the following condition for replacement:

$$\text{Replacement time} = C.M_{std.time} - F.M_{std.time} - S - L \quad (1)$$

where, Replacement time is the time saved by performing a replacement

$C.M_{std.time}$ is the standard time to service a machine by the current mechanic;

$F.M_{std.time}$ is the standard time to service a machine by the free mechanic.

S is time spent by current mechanic in the machine; and L is loading time for the machine.

Equation 1 yields the amount of time that will be saved if the replacement occurs. Assuming that the idle mechanic needs to start the job again and also requires time L to replace the current worker, and then $C.M_{std.time}$ compared with $F.M_{std.time}$. A deterministic value will be used for the loading time for a machine, represented by L for simplicity. Future research should investigate whether the use of stochastic values of L can have an effect on assignment and ultimately, the performance of the system.

Depending on the amount of time that each mechanic stays idle, his presence in the system is evaluated if a low utilization is yielded by the MBS, then a reduction in manpower levels for such a category can be justified.

Utilization (u) is a measure of how much of the available time is spent working. It is given in Equation 2.

$$u = \left(\frac{TH}{TH + DH}\right) x 0.89 \quad (2)$$

where TH is the total work hours and DH is the delay hours and 0.89 is the adjustment factor. Ths adjustment factor is calculated as follows: over a week period (48.75) working hours, 5.5 hours are lost as ; two ten minutes for break, two 5 minutes for (wash-up), period daily and half an hour lunch break every day except Sundays:

Performance factor (P) is a measure of the speed at which people work. It is determined by the conditions surrounding their work by the level of their inmate and acquire skills, and by the efforts, which they put into the task.

$$P = \frac{SH}{AH} \quad (3)$$

where SH is the standard hours and AH is the actual hours.

Method level (m) is the method used compared to good maintenance practice. The availability and quality of standard practice is determined by the types of tools, equipment and work sequence used. Its value range from 90% for poor to 100%% for good maintenance system, since all tools and procedures are followed.

$$\text{Productivity} = (p)(u)(m) \quad (4)$$

2.1 Collection of Data

Data were collected from log book of Braithwaite memorial specialist hospital on specific equipment and productivity analysis performed using the traditional method (Table 1 and Table 2). Similar data were collected for power generating set 1 (PGS 1) for traditional method and maintenance brigade systems (MBS).

3.0 RESULTS AND DISCUSSION

Results and discussion of this research are presented in this section.

3.1 Results

Table 1 shows equipment, work done and the crew size.

Table 1: Equipment, work done and crew size

S/N	Area	Work done	Crew size
1	Cooler 6	Change of cooler	Welder: 1 Mechanic: 2 Total: 3

2	Cooler 5	Changing of motor fan	Foreman: 1 Fitter: 1 Electrician: 2 Total: 4
3	EP6	E-Plant	Fitter: 1 Welder: 1 Mechanics: 2 Total: 4

Table 2 presents the productivity analysis of the three equipment using traditional method of maintenance.

Table 2: Productivity Analysis for cooler 5, cooler 6 and EP6

S/N and Total	Estimated hours	Actual hours.	Delay hours	Adjustment factor	Performance	Utilization	Productivity
 1 Total	10 20 30	18 34 52	8 14 22	0.89 0.89 0.89	0.577	0.625	0.563
 2 Total	2 3 6 11	5 5 9 19	3 2 3 8	0.89 0.89 0.89 0.89	0.579	0.704	0.626
 3 Total	5 2 8 15	2.5 9 16 27.5	2.5 7 8 17.5	0.89 0.89 0.89 0.89	0.545	0.611	0.543

Data was collected on the power generating set1 (PGS 1) as presented in Table 3.

Table 3: Service Data for PGS 1

S/N	Operations	Traditional in hours	MBS in hours
1	Estimated time	25	22
2	Mean downtime	1879	1253
3	Delay time	10	2
4	Actual time of maintenance	35	24

Table 4 shows the comparison between the traditional method and MBS applied on a power generating set 1 of the hospital.

Table 4: Productivity Analysis for PGS 1

Maintenance method	Adjustment factor	Performance	Utilization	Productivity
Traditional	0.89	0.714	0.692	0.692
MBS	0.89	0.917	0.923	0.923

3.2 Discussion

Based on the results in Table 1, the following weaknesses (opportunity for improvement) were noticed in the BMSH maintenance system: poor productivity score of that the maintenance department is suffering from poor utilization and performance factors of 55% to 70% compared with a good maintenance system which should have a 90-100% percent utilization factor and performance 80-98% .These was the same with the power generating set 1 using traditional method as shown in Table 4. However when MBS was applied to the same power generating set 1, the productivity and utilization was 92.3% respectively with a high performance index of 91.7%,. For the PGS 1, the actual time for maintenance (replacement time) is 24 hours compared to traditional 35 ours, giving a savings of 11 hours. These results were obtained without additional cost to training or additional tools and equipment for maintenance. As observed in the system, there was no standard reporting of the mechanics and tradesmen performance productivity and utilization rates. There was weak manual work-order system which should be corrected. Job resources requirements were not known in advance and the coordination between maintenance and hospital equipment users was absent. Some of the spare parts were not available when required. No standard, only unreliable inconsistent estimate of job measurements of job duration was noticed before the introduction of MBS.No proper arrangement was made with equipment users and mechanics had to wait after arrival at job site and even during the job execution .The foremen rarely checks on the progress of work. They did not make enough visits to job to identify actual potential problems. The jobs were not checked for quality after finish or following completion. There was no written policy and most of the job-descriptions require reviewing. Also, the organizational charts are not current and completed and that appeared in the present mechanic skills assignment.

4.0 CONCLUSION

The results obtained with MBS showed some improvements compared to the traditional method of maintenance. The MBS had performance, utilization and productivity scores of: 91.7%, 92.3%, 93.2% respectively compared to 71.4%, 69.2%, 69.2% respectively for the traditional method. The replacement time to service power generating set1 using MBS was approximately eleven hours lesser than the actual time compared to the traditional method. The MBS is therefore an effective tool in mechanic utilization and productivity increase.

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