Research Paper

Introduction of New Method for Servicing and Maintenance of Automobile Engines in Nigeria Government Agencies

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ABSTRACT

This research investigates preventive maintenance management of Automobile Engines in Nigeria Government agencies, the case study of Maritime Academy of Nigeria, Oron. A budget based optimization methodology was used by putting into consideration the age of the equipment (Automobile Engines obtained from the institution maintenance data). This is necessary to provide cost effective maintenance management and replacement programme for critical components of Automobile Engines and reduce the cost of maintenance and quick damaging of the automobile engines. The data were analyzed using budget based optimization methodology. The findings showed that Maritime Academy of Nigeria has been spending a lot of money on the maintenance of their automobile engines; a lot of vehicle of less than three years of purchase has been scrapped due to poor maintenance and till date, Maritime Academy of Nigeria does not have a standard workshop. The results provide effective cost and reliability template which can be used to perform a budget based maintenance planning programme in the Institution and in all Nigeria Government agencies.

Key words: Preventive maintenance, reliability, automobile engines, periodic maintenance, maritime academy.

INTRODUCTION

The need for continuous professional development is a part of career and the importance of upgrading the mechanical workshop and training of technicians and drivers in the Nigerian government agencies need not to be over emphasized. Furthermore, regular maintenance is vital to keep government vehicles moving on the road. The time and effort we put into keeping up with the aforementioned schedule maintenance can save the Academy from spending excessive money. There are procedures and checks that government vehicles need at varying intervals. The achieving of success in an ending war against breakdown of any government vehicle was fully realized.

In addition, the management board is commended for the selection and nomination of Transport Board Committee (TBC) members in Maritime Academy of Nigeria, Oron. “If you have an idea it is better for you to stay in the corridor of power because no one implements your idea rather than you”. I must solicit the concerted effort of the stakeholder (Chief Executive Officer and the Board Management) because vibrant stakeholders can be compelling drivers of social development and changes.

From the different discussion with people in the works department of institutions like Maritime Academy of Nigeria, Oron, University of Uyo, Michael Okpara University of Agriculture, Umudike to mention but a few, I observed that in all Government agencies, both Ministry and Parastatals, lack this preventive maintenance methods and nearly all of these Ministries process the latest automobile vehicles but most of these vehicles are affected by breaking down always and with incompetent technician handling them with no up to date equipment. After the inauguration of the committee on the 16th of June, 2013 in the first meeting the chairman briefed us on the method of maintenance which the management decided to use for the committee, which is Periodic Maintenance, but
to the best of my knowledge I discovered that this method cannot give us a good result because this method can only be introduced in an organization that does not make use of their vehicles at all time; this is applicable to all Nigeria Government agencies. In engineering field, we have different types of maintenance.

Breakdown maintenance (BM)

This refers to the maintenance strategy where repair is done after the equipment failure, stoppage or upon occurrence of severe performance decline.

Preventive maintenance (PM)

This concept was introduced in 1951, which is a kind of physical check up of the equipment to prevent equipment breakdown and prolong equipment service life. PM comprises of maintenance activities undertaken after a specified period of time or amount of machine use (Herbaty, 1990). During this phase, the maintenance function is established and Time Based Maintenance (TBM) activities are generally accepted (Pai, 1997). This type of maintenance relies on the estimated probability that the equipment will breakdown or experience deterioration in performance in the specified interval. The preventive work undertaken may include equipment lubrication, cleaning, parts replacement, tightening and adjustment. The production equipment may also be inspected for signs of deterioration during preventive maintenance work.

Predictive maintenance (PdM)

Predictive maintenance is often referred to as Condition Based Maintenance (CBM). In this strategy, maintenance is initiated in response to specific equipment condition or performance deterioration (Vanzile and Otis, 1992).

Corrective maintenance (CM)

This is a system introduced in 1957, in which the concept to prevent equipment failure is further expanded to be applied to the improvement of equipment so that equipment failure can be eliminated (improving the reliability) and the equipment can be easily maintained (improving equipment maintainability) (Steinbacher and Steinbacher, 1993).

Maintenance prevention (MP)

This was introduced in the 1960s. This is an activity wherein the equipment is designed such that they are maintenance free and an ultimate ideal condition of “what the equipment and the line must be” is achieved (Steinbacher and Steinbacher, 1993).

Reliability centered maintenance (RCM)

Reliability Centered Maintenance (RCM) was also founded in the 1960s but initially oriented towards maintaining airplanes and used by aircraft manufacturers, airlines and the government (Dekker, 1996). RCM can be defined as a structured, logical process for developing or optimizing the maintenance requirements of a physical resource in its operating context to realize its “inherent reliability”. Inherent reliability is the level of reliability which can be achieved with an effective maintenance program.

Productive maintenance (PrM)

Productive maintenance means the most economic maintenance that raises equipment productivity. The purpose of productive maintenance is to increase the productivity of an enterprise by reducing the total cost of the equipment over the entire life from design, fabrication, operation and maintenance and the losses caused by equipment degradation.

Computerized maintenance management system (CMMS)

This system assists in managing a wide range of information on maintenance workforce, spare-parts inventories, repair schedules and equipment histories. It may be used to plan and schedule work orders, expedite dispatch of breakdown calls and also manage the overall maintenance workload.

Total productive maintenance (TPM)

TPM is a unique Japanese philosophy developed based on the productive maintenance concepts and methodologies. With all the explanation earlier mentioned one can discover that the best method to adopt in the institution (MAN, Oron) is preventive method such that the entire vehicle and equipment will have a long life span and also prevent vehicles from breakdown.

METHODOLOGY

Data for this research were collected from both primary and secondary sources. The primary information was
obtained from maintainers, supervisors, engineers and managers. This information include: wear and tear, engine failure on the road or at a particular position and what it can cause if there is continuous failure. The main data were obtained from the log book for a period of one month. This data include the movement covered, mileage before, mileage after, mileage covered and ten critical parts selected for the study.

This data formed input into a maintenance and replacement model developed by Kamran (2008). The information was used to predict future maintenance plan for the automobile engines (Vehicles) in the next one with a given budget and the objective of reducing maintenance cost and increasing the reliability of the automobile engines used by the institution. The methods used in solving the problem were generalized reduced gradient (GRG) and simulating annealing (SA).

**Optimization model**

The model by Kamran (2008) provides a general framework that was applied on the study. In the total cost minimization equation, the constraints for the solution of the equation are:

- Constraints that address the initial age of each component at the beginning of planning horizon. Thus:

\[ X_{i0} = 0; \ i = 1... N \]

(1)

Where \( i = \) component; \( j = \) period and \( N=\)Number of components.

- Effective age of the components based on preventive maintenance activities recursively.

\[ X_{i,j} = (1-m_{i,j-1})(1-r_{i,j-1})X_{i,j+1} + m_{j+1}(\alpha X_{i,j+1}) \]

(2)

\( i = 1... N \) and \( j = 2... T \)

\[ X'_{i,j} = X_{i,j} + \frac{T}{J} \]

\( i = 1, N \) and \( j = 1... T \)

(3)

\[ m_{i,j} + r_{i,j} \leq 1; \ i = 1... N \) and \( j = 1... T \)

Where:

\( X_{i,j} \) = Effective age of component \( i \) at the start of period \( j \);

\( X'_{i,j} \) = Effective age of component \( i \) at the end of period \( j \);

\( T = \) Number of periods;

\( J = \) Number of intervals;

\[ m_{i,j} = \begin{cases} 1 & \text{if component } i \text{ at period } j \text{ is maintained,} \\ 0 & \text{otherwise} \end{cases} \]

(4)

\[ r_{i,j} = \begin{cases} 1 & \text{if component } i \text{ at period } j \text{ is replaced,} \\ 0 & \text{otherwise} \end{cases} \]

\( \alpha = \) Improvement factor of component \( i \).

- Condition/constraint preventing occurrence of simultaneous maintenance and replacement actions on the components.

\[ \prod_{i=1}^{N} \prod_{j} e^{-(\lambda_{i}(X'_{i,j})\beta_{i}(X_{i,j}))} \gg RR_{\text{series}} \]

(5)

\[ X_{i,j} \geq 0; \ i = 1, N \) and \( j = 1... T \)

(6)

Where:

\( \lambda = \) Characteristic life (scale) parameter of component \( i \);

\( \beta = \) Shape parameter of component \( i \), \( RR_{\text{series}} = \) Required reliability of the series system of components.

Consider the case where component \( i \) is maintained in period \( j \). For simplicity, it is assumed that the maintenance activity occurs at the end of the period. The maintenance action effectively reduces the age of component \( i \) at the beginning of the next period (Akpan, 2015):

\[ X_{i,j+1} = \alpha iX'_{i,j} \text{ for } i = 1,..., N; j=1,...,T \text{ and } (0 \leq \alpha \leq 1) \]

(7)

The term \( \alpha \) is an “improvement factor” similar to that proposed by Malik (1979) and Jayabalan (1992). This factor allows for a variable effect of maintenance on the aging of a system. When \( \alpha = 0 \), the effect of maintenance is to return the system to a state of “good-as new”. When \( \alpha = 1 \), maintenance has no good effect and the system remains in a state of “bad-as-old”.

The maintenance action at the end of period \( j \) results in an instantaneous drop in the ROCOF of component \( i \). Thus, at the end of period \( j \), the ROCOF for component \( i \) is \( v_{j}(X'_{i,j}) \), at the start of period \( j + 1 \) ROCOF drops to \( v_{j}(0) \). If component \( i \) is replaced at the end of period \( j \), the following applies:

\[ X_{i,j+1}=0 \text{ for } i = 1,...,N; j=1,...,T \]

(8)
That is, the system is returned to a state of "good-as-new". The ROCOF of component \( i \) instantaneously drop from \( v_i(X'_{i,j}) \) to \( v_i(X_{i,j}) \) and if no action is performed in period \( j \), there is no effect on the ROCOF of component \( i \) and thus:

\[
X'_{i,j} = X_{i,j} + \frac{T}{j} \text{ for } i = 1, ..., N; j = 1, ..., T
\]  

(9)

\[
X'_{i,j+1} = X_{i,j} \text{ for } i = 1, ..., N; j = 1, ..., T
\]  

(10)

\[
v_i(X_{i,j}) = v_i(X'_{i,j}) \text{ for } i = 1, ..., N; j = 1, ..., T
\]  

(11)

Where:

\( T = \) Number of periods;
\( j = \) Number of intervals;
ROCOF = Rate of occurrence of failure.

For a new system, the cost associated with all component levels of maintenance and replacement actions in period \( j \), remains as a function of all the actions taken during that period. The expected number of failures of component \( i \) in period \( j \) becomes:

\[
E[N_{i,j}] = \left[ \int_{X_{i,j}}^{X'_{i,j}} v_i(t) dt \right] \text{ for } i = 1, ..., N; j = 1, ..., T
\]  

(12)

Under the non-homogenous poison process assumption (NHPP) the expected number of component \( i \) failures in period \( j \) is:

\[
E[N_{i,j}] = \frac{1}{\alpha} \left( X'_{i,j} \right)^\alpha - \frac{1}{\beta} \left( X_{i,j} \right)^\beta \text{ for } i = 1, ..., N; j = 1, ..., T
\]  

(13)

If the cost of each failure is \( F_i \) (in units of \#/failure event), which in turn allows the computation of \( F_{ij} \) as the cost of failures attributable to component \( i \) in period \( j \) become:

\[
F_{ij} = F_i E[N_{i,j}] \text{ for } i = 1, ..., N; j = 1, ..., T
\]  

(14)

Hence, regardless of any maintenance or replacement actions (which are assumed to occur at the end of the period) in period \( j \), there is still a cost associated with the possible failures that can occur during the period.

If maintenance is performed on component \( i \) in period \( j \), a maintenance cost constant \( M_i \) is incurred at the end of the period. Similarly, if component \( i \) is replaced in period \( j \), the replacement cost is the initial purchase price of the component \( i \), denoted by \( R_i \).

For a multi-component system, the cost structure is defined as earlier stated; the problem can be reduced to a simple problem of finding the optimal sequence of maintenance, replacement or do-nothing for each component independent of all other components. That is, one could simply find the best sequence of actions for component one regardless of the actions taken on component two. This would result in \( N \) independent optimization problems. Such a model seems unrealistic as there should be some overall system cost penalty when an action is taken on any component in the system. It would seem that there should be some logical advantage to combine maintenance and replacement actions for example, while the system is shutdown to replace one component, it may make sense to go ahead and perform maintenance or replacement of some other components, even if it is not at its individual optimum point where maintenance or replacement would ordinarily be performed. Under this scenario, the optimal time to perform maintenance or replacement actions on individual components is dependent upon the decision made for other components. As such, a fixed cost of "downtime" \( Z \) is charged in period \( j \) if any component (one or more) is maintained or replaced in that period. Consideration of this fixed cost makes the problem much more interesting and more difficult to solve as the optimal sequence of actions must be determined simultaneously for all components.

From the vantage point, at the start of period \( j = 0 \), it is right to determine the set of activities that is maintenance, replacement or do nothing for each component in each period such that total cost is minimized. In order to have \( X_{ij} \) age of component \( i \) at the end of period \( j \) using Equation 2. First, define \( m_{ij} \) and \( r_{ij} \) as binary variables of maintenance and replacement actions for component \( i \) in period \( j \) as:

\[
m_{ij} \begin{cases} 1 & \text{If component } i \text{ at period } j \text{ is maintained,} \\ 0 & \text{otherwise} \end{cases}
\]  

(15)

\[
r_{ij} \begin{cases} 1 & \text{If component } i \text{ at period } j \text{ is replaced,} \\ 0 & \text{otherwise.} \end{cases}
\]  

(16)

The following recursive function of \( X_{ij}, X'_{ij}, m_{ij}, r_{ij} \) \( \alpha \), with a constraint are constructed:

\[
\begin{cases}
X'_{i,j} = (1-m_{i,j-1})(1-r_{i,j-1})X_{i,j-1} + m_{i,j-1} + (\alpha X_{i,j-1}) \\
X_{i,j} = X'_{i,j} + \frac{T}{j}
\end{cases}
\]  

(17)

(18)
\[ m_{i,j} + r_{i,j} \leq 1 \]
\[ i=1, N, \quad j=1, T \] \hspace{1cm} (19)

In addition, the initial age for each component is equal to zero:

\[ X_{i,j} = 0 \text{ for } i = 1, \ldots, N \] \hspace{1cm} (20)

If component replacement occurs in the previous period then:

\[ r_{i,j-1} = m_{i,j-1} = 0, \] \hspace{1cm} (21)

\[ X_{i,j} = \alpha X_{i,j-1} \] \hspace{1cm} (22)

And finally if nothing is done:

\[ r_{i,j-1} = 0, m_{i,j-1} = 0 \text{ and } X_{i,j} = X_{i,j-1} \] \hspace{1cm} (23)

Which correspond to our basic assumption given in Equation 1. From the definitions of each type of cost, the total cost function (Akpan, 2015) is:

\[ \text{Total}_{\text{min}} \text{Cost} = \sum_{i=1}^{N} \sum_{j=1}^{T} \left[ (F_{i,j} X_{i,j}^\beta - (X_{i,j})^\beta) + M_{i,j} m_{i,j} + R_{i,j} r_{i,j} \right] + \sum_{j=1}^{T} \left[ Z \left( \sum_{i=1}^{N} \| r_{i,j} \| \right) \right] \]
\[ i=1, N, \quad j=1, \ldots, T \] \hspace{1cm} (25)

Subject to:

\[ X_{i,j} = 0 \quad i=1, \ldots, N \]
\[ X_{i,j} = (1 - m_{i,j-1})(1 - r_{i,j-1}) X_{i,j-1} + (r_{i,j-1} + \alpha X_{i,j-1}) \quad i=1, \ldots, N, \quad j=2, \ldots, T \] \hspace{1cm} (27)
\[ X_{i,j} = X_{i,j-1} + \frac{T}{J} \quad i=1, \ldots, N, \quad j=1, \ldots, T \] \hspace{1cm} (28)

\[ m_{i,j} + r_{i,j} \leq 1 \]
\[ i=1, \ldots, N, \quad j=1, \ldots, T \] \hspace{1cm} (29)

\[ \prod_{j=1}^{T} e^{-(\lambda_{i,j}/\beta) - (X_{i,j})/\beta} \gg RR_{\text{series}} \]

\[ m_{i,j}, r_{i,j} = 0 \text{ or } 1; \quad i=1, \ldots, N \text{ and } j=1, \ldots, T \] \hspace{1cm} (30)

\[ X_{i,j} \geq 0 \quad i=1, \ldots, N \text{ and } j=1, \ldots, T \] \hspace{1cm} (31)

Table 1 shows this objective function computes the total minimum cost subject to the aforementioned stated constraints with input parameter.

**RESULTS AND DISCUSSION**

Here is an example based on the research made before the invitation to join the Transport Board Committee. With the help of Mr. Victor Smart and Mr. Uwem (drivers), an Haice bus of plate number 19D02FG was used as a case study on the 11th June, 2013 and the vehicle serviced with the mileage number 52907KM. Table 1 showed that the detailed movement of the vehicle and the mileage covered are also applicable to all vehicles in the academy.

With the aforementioned information vehicles in academy cannot undergo periodic maintenance. The Haice bus 19D02FG was overdue for servicing with the total mileage covered between 12th June to 1st July, 2013. Compared to the last servicing date 11th of June 2013, it was observed that not up to a month and at the time this report was compiled the current mileage number was 57785 to 52907 equal to 4878 which can cause wear and tear of the vehicle thereby leading to breakdown at any time, considering periodic servicing with the data at hand the vehicle is in unsafe condition. Due to the aforementioned reasons I hereby suggest to the chief executive and the management boards that the best method to adopt in Maritime Academy is the Preventive method.

The method earlier stated (Preventive method) at the beginning will give all the vehicles in Maritime Academy long life and reduce the cost of maintenance; this will be of fortune to the Academy, all Agencies and Parasatal in Nigeria, if they can follow the right procedure.

Before preventive maintenance can be achieved in the institution, other Agencies and Parasatal the following should be put in place:

- Log book: There will be a log book for all vehicle users (Drivers) and they will be taught how to use the log book so that when the car is reaching the maximum mileage to service and to replace any other spare part in the vehicle,
### Table 1: The Toyota Hiace Bus in Maritime Academy of Nigeria according to the driver.

<table>
<thead>
<tr>
<th>Date</th>
<th>Movement Covered</th>
<th>Mileage Before</th>
<th>Mileage After</th>
<th>Mileage covered (km/h)</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>12/06/13</td>
<td>MAN – Area Command&lt;br&gt;MAN – Airport)2x&lt;br&gt;Airport – MAN) 2x</td>
<td>52907</td>
<td>53156</td>
<td>249</td>
<td></td>
</tr>
<tr>
<td>13/06/13</td>
<td>MAN – Airport&lt;br&gt;Airport – MAN&lt;br&gt;MAN – Calabar&lt;br&gt;Calabar – MAN</td>
<td>53156</td>
<td>53572</td>
<td>416</td>
<td></td>
</tr>
<tr>
<td>14/06/13</td>
<td>MAN – Airport&lt;br&gt;Airport – Uyo&lt;br&gt;Uyo – Le - meridian&lt;br&gt;Le- meridian – Uyo</td>
<td>53572</td>
<td>53816</td>
<td>244</td>
<td></td>
</tr>
<tr>
<td>15/06/13</td>
<td>MAN – Ikotepene&lt;br&gt;Ikotepene – Calabar&lt;br&gt;Within Calabar town to Tinapa</td>
<td>53816</td>
<td>54244</td>
<td>428</td>
<td></td>
</tr>
<tr>
<td>16/06/13</td>
<td>Tinapa – Town&lt;br&gt;Tinapa to MAN</td>
<td>54244</td>
<td>54521</td>
<td>277</td>
<td></td>
</tr>
<tr>
<td>18/06/13</td>
<td>MAN - Le- meridian)2x&lt;br&gt;Le- meridian – MAN)2x</td>
<td>54521</td>
<td>54930</td>
<td>409</td>
<td></td>
</tr>
<tr>
<td>19/06/13</td>
<td>Facilities Tour</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20/06/13</td>
<td>MAN – Sky point, Shuttle&lt;br&gt;MAN- Uyo&lt;br&gt;Uyo - MAN</td>
<td>54930</td>
<td>55169</td>
<td>239</td>
<td></td>
</tr>
<tr>
<td>21/06/13</td>
<td>Within MAN- Sky point</td>
<td>55169</td>
<td>55245</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td>22/06/13</td>
<td>MAN – Biase L.G.A Cross rivers State</td>
<td>55245</td>
<td>55738</td>
<td>493</td>
<td></td>
</tr>
<tr>
<td>24/06/13</td>
<td>MAN – Calabar&lt;br&gt;Calabar – MAN</td>
<td>55738</td>
<td>56218</td>
<td>480</td>
<td></td>
</tr>
<tr>
<td>25/06/13</td>
<td>MAN- Uyo&lt;br&gt;Uyo – MAN</td>
<td>56218</td>
<td>56618</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>28/06/13</td>
<td>MAN – Calabar</td>
<td>56618</td>
<td>57785</td>
<td>1167</td>
<td></td>
</tr>
<tr>
<td>29/06/13</td>
<td>Calabar – Biase L.G.A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30/06/13</td>
<td>Biase – Calabar</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>01/07/13</td>
<td>Dropping of guest in Hotel – Oron Beach&lt;br&gt;Hotel – Airport – Calabar&lt;br&gt;Calabar – MAN</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
the driver can inform the supervisor.

- Workshop/Seminar: There should be workshop for all drivers by inviting the VIO, Road safety and any other body that are experts in the field so that they will be able to know road wordiness and how to drive safety within and outside Academy and even outside the state, to note the sound of a vehicle when it changes, when friction takes place and when any indication is shown on the dash board.

- Reorganized and Remodernized: The auto mechanic workshop in Maritime Academy of Nigeria, Oron need to be remodernized with the equipments well fixed and the maintenance of all Maritime vehicles put in place so as to reduce cost of maintenance.

- Training: Technicians and craftsmen (Mechanics) should be trained in any standard Toyota company so that they will be able to bring out up to standard repairs and all academy vehicles will be in good condition for a long period of time.

- Materials and spare parts: With the availability of materials in the store, experts should be sent to bring those materials to the academy so that bad materials or spare parts will not be supplied and also to get the required mechanical tools. Spare part materials like engine oil, oil filter, fuel filter and top cylinder gaskets should be made available in order for the vehicles to have a long life span.

Conclusion

The following conclusions were made: Preventive maintenance can be used to determine the life span of academy vehicle. This can assist management in taking decisions on future academy vehicle purchase, operation and maintenance, the management fleet, in addition, pool and other vehicles will be maintained within the Academy in good condition and the Academy vehicles will have higher operation and availability.

RECOMMENDATIONS

Due to the new method of maintenance (Preventive method) brought to the Nigeria Government Agencies, the following recommendations were made:

1) There is need for the institution (Maritime Academy of Nigeria, Oron) to keep good maintenance record of vehicle which will serve as a database for information.

2) Good maintenance schedule and practice should be developed for equipments to reduce avoidable failure and increase vehicle availability.

3) Feedback between the driver and the maintenance department should be encouraged to track vehicle performance.

There is need for the management of the institution (Maritime Academy of Nigeria, Oron) to adopt a structured maintenance information system presented in this research project.

REFERENCES


Pai (1997). Preventive maintenance is a kind of physical check up on Econ. 116546 and Breakdown maintenance. This refers to the maintenance HR MGT 101.

Stanbacher [1993]. Evaluation of maintenance policies and reliability center for maintenance.


Table 1: Cont.

| Total mileage covered between 12th June, to 1st July, 2013 | 4,878 |

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