Modelling and Analysis of Overhauling of Crankshaft in Locoshed

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Abstract

The paper details the modelling and analysis for improving the productivity of maintenance carried out for maintaining crankshaft of loco engine in loco shed. An essential ingredient in the successful running of railway is a well maintained system. Railways are made up of complex mechanical and electrical system and there are hundreds of thousands of moving part. If a railway service is to be reliable, the equipment must be kept in good working order and regular maintenance is the essential ingredient to achieve this. A railway will not survive for long as a viable operation if it is allowed to deteriorate because of lack of maintenance. Although maintenance is expensive, it will become more expensive to replace the failing equipment early in its life because maintenance has been neglected. Crankshaft is the most maintenance intensive part of the Engine system and is the most vulnerable if maintenance is neglected. A stalled engine will block a railway immediately and will be cost effective. So reliability is the key to successful railway operation and maintenance should be the priority work to ensure the reliability.

1. Introduction

The performance of maintenance approach can increase human output required for maintenance of crankshaft and reduces required time by the mathematical model. Mathematical model certainly predict the performance of crankshaft overhauling activity. Some of these variables used to formulate this model are given as follows (1) workstation of workplace and Environment of working area, which includes the ergonomic aspect i.e. humidity, temperature, Noise, illumination, etc of the work station(2) various posture of the worker, anthropometric data of the worker, maintenance techniques used by the worker, number of job performed by worker, psychological aspect, physical aspects of the worker, family background etc. (3) overhauling process which includes the number of crankshaft overhauled, Specification of crankshaft and related parts etc(4)Tools used by worker which includes geometric dimension of tool, material of tool, grip of tool based on the data collected of these variables mathematical model is formulated. (5) Other variables like solvents used for cleaning etc.

2. Maintenance Strategy of Locoshed

To satisfy the demand of the industry, production industries depends on the complex industrial equipment which are capable of high speed and production capacity. The maintenance activities for these complex industrial equipments or systems not only ensure the timely delivery for profits in business, preventing environmental hazards and safety hazards. These repairable systems are defined as a system which after failing to perform one or more of its function satisfactorily, can be restored to fully satisfactorily performance by any method other than replacement of the entire system.

Present Traditional maintenance approaches mostly consists of a pre-defined activities carried out at regular intervals or by periodic or continuous condition monitoring. However, such a maintenance policy may be quite inefficient. In present method the human productivity is very less and loss of human energy is substantial. Therefore, present approach should be replaced their maintenance routines using fixed schedules with more flexible programs based on field data based modelling of needs and priorities in which performance parameter of an activity can be compared and improve present method can be selected.

3. Problems in Maintenance of Loco Engine Crank Shaft

In loco shed, maintenance of 3 types of engine (loco) model carried out. These models are ZDM4A, ZDM3A and ZDM3B. The maintenance loco engine is divided into four section (1) Bogie section (2) Transmission unit (3) Gear section (4) Engine block. The engine block of locomotive is one of the most important parts of locomotive which is used to generate power and transmit it to the locomotive through transmission unit. So it is necessary to maintain it properly. The maintenance of crankshaft carried out in heavy schedule . by doing same repetitive work that involved awkward posture and can be physically demanding on the neck, shoulder, back and forearms of the workers and the maintenance required more time and awkward human posture consuming more human energy as compared to other maintenance activities. Improper maintenance will result lubrication problem in engine, heat generation, vibration and other several problem causing reducing in engine efficiency. So it requires overhauling of complete engine and its complete overhauling of engine involves fitting the required parts of engine which can affect engine alignment. So due to present maintenance method the human productivity is very less and loss of human energy and time is substantial. So it is required to identify the factors which are most influencing on the crankshaft maintenance activity. Thus it is necessary to formulate the model for overhauling of crankshaft. With the help of this model, we get the control on performance parameters and variable which helps to increase the productivity and to reduce the required time and human energy.

4. Formulation of Mathematical Model for the Predicting Performance

Mathematical model can predicted and reduces the efficiency and productivity of worker. Hence, this aspect in general instigates to investigate a mathematical model, which can predict the maintenance activity performance which involves man and machine system. Indeed the model will be useful for both workers well as for maintenance engineer to work on prominent variables by which they can improve the performance of worker by deciding the strength and weakness of present method. Once weaknesses are known corrective action can be planned.

5. Formulation Mathematical Model

The mathematical model can be established by an approach of field data based model. The approach is as
(1) Identification of variables or parameter resulting the phenomenon.
(2) Establishment of pie terms
(3) Data collection of crankshaft from workstation
(4) Rejection of absurd data
(5)Formulating the model

5.1. Procedure for rankshaft Overhauling Activity

Various maintenance operations for overhauling of crank shaft is workout.

5.2. Identification of Varibles or Quantities

The first step in this process is identification of variables .The parameters of the phenomenon is called variables. Identification of dependent and independent variable of the phenomenon is to be done based on known qualitative physics of the phenomenon. These variables are of three types
(1) Independent variables,
(2) Dependent variable, and
(3) Extraneous variable.
If the system involves a large number of independent variable, the experimentation becomes tedious, time consuming and costly. By deducing dimensional equation for the phenomenon, we can reduce the number of independent variable. The exact mathematical form of this equation will be targeted model. Upon getting the experimental results, adopting the appropriate method for test data checking and rejection, the erroneous data be identified and removed from the gathered data. Based on the purified data as mentioned above one has to formulate quantitative relationship between the dependant and independent Pi terms of the dimensional equation. The crankshaft overhauling phenomenon is influenced by following variables.

5.3. Establishment of Pi terms

These Independent variables have been reduced into a group of pi terms. The Equation (1) shows the dimension less pie terms for the phenomenon.
List of Independent and dependent Pi term of crankshaft overhauling activity.

Table 1. Pi Terms

Description of Pi terms	Equation of Pi term
Pi term relating anthropometric data of worker	Π1=[Nw*Exw*Pow*Hw*Ad)/(Aw*Skw*Ew*Hlw)]
Pi term relating specification of crankshaft and workstation	Π2=[(Dsp*Nsn*Lsn*Dsb*Nsmab*Lsmab*Dsiab*Nsc*Lsc*Dmj*Ncpj*Lcpj*Tmjb*Dcpjb*Tcpjb)/(Lsp*Dsn*Nsb*Dsmab*Nsisb*Lsiab*Dsc*Nmj*Lmj*Dcpj*Dmjb*Lmjb*Lcpjb)
Pi term relating specification of	Π3=[(Dbr*Dsms*Dsis*dbrd)/(Lbr*Lsms*Lsis*Lbrd)]

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tools	
Pi term relating specification of solvent ,lube oil and compressed air	Π 4=[(Ke*Ca/Eb)]
Pi term relating specification of Axial clearance of crank pin and Saddle bolt elongation	Π 5=[(Axmj*Elsb/Axcp)]
Pi term relating specification of temp. noise, light, humidity	Π 6=[(Tws*Nws/Hws*Ilws)]
Pi term relating specification of workstation	Π 7=[(Lf*hf)/(Wf)]

Formulation of dimensional equation for response variable

$$(Y)=K\{[(Nw*Exw*Pow*Hw*Ad)/(Aw*Skw*Ew*Hlw)]^{a}, [(Dsp*Nsn*Lsn*Dsb*Nsmab*Lsmab*Dsiab*Nsc*Lsc*Dmj*Ncpj*Lcpj*Tmjb*Dcpjb*Tcpjb)/(Lsp*Dsn*Nsb*Dsmab*Nsisb*Lsiab*Dsc*Nmj*Lmj*Dcpj*Dmjb*Lmjb*Lcpjb)]^{b}, [(Dbr*Dsms*Dsis*dbrd)/(Lbr*Lsms*Lsis*Lbrd)]^{c}, [(Ke*Ca/Eb)]^{d}, [(Axmj*Elsb/Axcp)]^{e}, [(Tws*Nws/Hws*Ilws)]^{f}, [(Lf*hf)/(Wf)]^{g}\} \quad (1)$$

5.4. Model Formulation by Identifying the Constant and Various Indices of Pi Terms

The multiple regression analysis helps to identify the indices of the different pi terms in the model aimed at, by considering seven independent pi terms and one dependent pi term. Let model aimed at be of the form,

$$(Y1)=K*[(\pi1)^{a}*(\pi2)^{b}*(\pi3)^{c}*((\pi4)^{d}*(\pi5)^{e}*(\pi6)^{f}*(\pi7)^{g}] \quad (2)$$

$$(Y2)=K*[(\pi1)^{a}*(\pi2)^{b}*(\pi3)^{c}*((\pi4)^{d}*(\pi5)^{e}*(\pi6)^{f}*(\pi7)^{g}] \quad (3)$$

$$(Y3)=K*[(\pi1)^{a}*(\pi2)^{b}*(\pi3)^{c}*((\pi4)^{d}*(\pi5)^{e}*(\pi6)^{f}*(\pi7)^{g}] \quad (4)$$

In the above equations (2),(3) and (4) variable, π1 represent anthropometric data of worker, π2 represents crankshafts variable, π3 represents specification of tools, π4 represents solvent ,lube oil and compressed air, π5 represents axial clearance ,π6 represent environmental and physical variable and π7 represents workstation details.

The regression equations become as under.

$$\Sigma Y1 = nK1 + a1*\Sigma A + b1*\Sigma B + c1*\Sigma C + d1*\Sigma D + e1*\Sigma E + f1*\Sigma F + g1*\Sigma G$$

$$\Sigma Y1*A = K1*\Sigma A + a1*\Sigma A*A + b1*\Sigma B*A + c1*\Sigma C*A + d1*\Sigma D*A + e1*\Sigma E*A + f1*\Sigma F*A + g1*\Sigma G*A$$

$$\Sigma Y1*B = K1*\Sigma B + a1*\Sigma A*B + b1*\Sigma B*B + c1*\Sigma C*B + d1*\Sigma D*B + e1*\Sigma E*B + f1*\Sigma F*B + g1*\Sigma G*B$$

$$\Sigma Y1*C = K1*\Sigma C + a1*\Sigma A*C + b1*\Sigma B*C + c1*\Sigma C*C + d1*\Sigma D*C + e1*\Sigma E*C + f1*\Sigma F*C + g1*\Sigma G*C$$

$$\Sigma Y1*D = K1*\Sigma D + a1*\Sigma A*D + b1*\Sigma B*D + c1*\Sigma C*D + d1*\Sigma D*D + e1*\Sigma E*D + f1*\Sigma F*D + g1*\Sigma G*D$$

$$\Sigma Y1*E = K1*\Sigma E + a1*\Sigma A*E + b1*\Sigma B*E + c1*\Sigma C*E + d1*\Sigma D*E + e1*\Sigma E*E + f1*\Sigma F*E + g1*\Sigma G*E$$

$$\Sigma Y1*F = K1*\Sigma F + a1*\Sigma A*F + b1*\Sigma B*F + c1*\Sigma C*F + d1*\Sigma D*F + e1*\Sigma E*F + f1*\Sigma F*F + g1*\Sigma G*F$$

$$\Sigma Y1*G = K1*\Sigma G + a1*\Sigma A*G + b1*\Sigma B*G + c1*\Sigma C*G + d1*\Sigma D*G + e1*\Sigma E*G + f1*\Sigma F*G + g1*\Sigma G*G \quad (5)$$

The above equations n is the number of sets of readings, A,B,C,D,E,F and G represent the independent pi terms π1, π2, π3, π4, π5, π6, and π7 while, Y represents, dependent pi term. Next, calculate the values of Independent Pi term for corresponding dependent Pi term, which helps to form the equation in matrix form. It is recommended to use MATLAB software for this purpose for making this process of model formulation quickest and least cumbersome.

Sensitivity of Inputs

The exact form of model is obtained as

$$(Y1) = 6.91256*(\pi1)^{0.05}*(\pi2)^{-1.0607}*(\pi3)^{0.0219}*(\pi4)^{-1.312}*(\pi5)^{0.068}*(\pi6)^{0.52}*(\pi7)^{0.318}$$

$$(Y2)=56.231*(\pi1)^{4.5}*(\pi2)^{02.3}*(\pi3)^{1.987}*(\pi4)^{22.1}*(\pi5)^{-5.6}*(\pi6)^{0.0019}*(\pi7)^{0.0019}$$

$$(Y3)=3.34*(\pi1)^{0.1120}*(\pi2)^{0.2070}*(\pi3)^{0.205}*(\pi4)^{2.06}*(\pi5)^{-4.0327}*(\pi6)^{3.0459}*(\pi7)^{2.0219}$$

In the above equations (y1) is relating response variable time of crankshaft maintenance activity,(y2) is relating response variable productivity of crankshaft maintenance activity and (y3) is relating response variable human energy of crankshaft maintenance activity.

5.5. Interpretation of curve fitting constant

The value of curve fitting constant in this model for (Y1) is 6.91256. This collectively represents the combined effect of all extraneous variables. Further, as it is positive, this indicates that, there are good numbers of causes, which have influence on increasing effect of the Models

The activity of maintenance of crankshaft is concerned any one will wish to maximize Y2 (i.e. productivity) whereas he would like to minimize Y1 Now it is the time to apply the subject optimization technique for arriving at, at which values the inputs that Y2 can be maximized and Y1 & Y3 can be minimized. This has to be the sole objective of deciding. Thus this approach of formulation of mathematical model for such a workstation system should be looked upon as a new technique of method study. This was not possible in the absence of establishing such models. These models will help to predict the relationship between input and output of crankshaft maintenance activity.

5.6. Reliability of Models

The validity of the model predicated the performance of the model. It is necessarily to decide the validity of the model. This is so because though we have taken care to purify the observed data there is a chance of some impure data entering in the mathematical processing of the data.

The approach to decide the validity would be to substitute in the model known inputs for every observation & decide the difference in response by model and actually observed response. This will give us pattern of distribution of error & frequency of its occurrence.

6. Conclusion

The mathematical model will helpful for predicating the behaviour of the performance parameters. As performance parameters are influencing the overall productivity such postural discomfort experience of workers which involved in crankshaft overhauling became the cornerstone for this research work .They are not aware as to what extent ergonomic intervention can elevate their drudgery. The responses of various inputs such as anthropometry of workers, specification of crankshaft, specification of tools, surrounding environmental conditions and their responses such as time to complete overhauling, human energy and productivity of crankshaft maintenance activity is not known to them quantitatively

7. References

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