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Development of Mathematical Model for Repair and Maintenance of Some of the Farm Tractors of JNKVV, Jabalpur, India

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Abstract

An experiment was conducted to studies on Development of mathematical model for repair and maintenance of some of the farm tractors JNKVV Jabalpur, the repair and maintenance data of the farm tractor were taking from the breeder soybean production farm, biotechnology, groundnut farm and horticulture farm. The data collect yearly working hours; yearly repair and maintenance costs included spare part and repairable part, lubricant, wages and others. A study was conducted to modelling of accumulated repair and maintenance costs of JNKVV farm tractors as percentage of initial purchase price (Y) based on accumulated usage hours (x). Recorded data were used to determine regression model(s). Exponential, logarithmic, linear, polynomial. The Prediction of cumulative repair and maintenance costs the power model is better than the models that is linear, polynomial, logarithmic and exponential, among the various alternatives power model was found ($Y=ax^b$) most suitable to predict accumulated repair and maintenance costs of tractor. The service life of the tractor near 1000 hours the power model $Y=1.910x^{1.64}$ (where x in 1000) with $R^2=0.989$ to predict accumulated repair and maintenance costs of JNKVV tractors can be strongly recommended. The repair and maintenance cost consist of spare parts, lubricant, wages and other. The average spare parts, wages and others and lubricants costs is 49.32, 17.24 and 12.15%.

Keywords: Exponential; Logarithmic; Linear and polynomial model

Introduction

Worldwide Tractor is the main source of power on the farm, and represents a major component of farm fixed costs. With due field maintenance tractors can operate for long period and do great deal of work before major repairs are required [1]. Tractor break down can be of a high cost not only from expenditure point of view, but also because of the disastrous effect on crop productivity, and the fact that idle staff must still be paid. The extent of the problem of tractor failure in developing countries is more serious as compared to developed countries. This is due to acute shortage of genuine spare parts, preventive maintenance, absence of future planning for integrated maintenance management and programs that strive to identify incipient faults before they become critical to enable more accurate planning of preventive actions. As such system performance can be improved by developing optimal maintenance prediction models that minimize overall maintenance cost or maximize system performance measures [2].

A repairable mechanical system (as agricultural tractor) is subjected to deterioration or repeated failure. The system is subjected to periodic inspection that identifies the condition of deterioration. Based on the degree of deterioration (system condition), preventive maintenance is performed or no action is taken. At each inspection of failure, the system status is classified into partial, combined and complete. According to this Condition-Based Maintenance classification the level of maintenance is determined and performed to restore the system to "as good as new" state.

Machinery ownership (fixed) and operational (variable) cost represent substantial portion of total production experiences. Machinery ownership costs usually include charge for depreciation, interest on investment, taxes, insurance and housing facilities. Operational costs include repair and maintenance costs of farm machinery which is necessary to restore or maintain technical soundness and reliability of the machine. The accurate prediction of repair and maintenance costs trends is critical for determination of optimum economical life of machine and to make appropriate decision for machinery replacement. The prediction of these costs at an acceptable level can be made by fitting of linear, logarithmic, polynomial, and exponential and power equation.

The repair and maintenance cost of tractors is essential for both owner and manager to achieve information on overall cost to control financial and production economy. It is small but relatively important portion of owning and operating farm machinery, repair cost is generally 10 to 15% of the total cost. Since it tends to increase with machine usage, repair costs become important for replacement policy. Hence, five performance measures of the model process are used to find the optimal algorithm parameters that maximize the system availability. The model decision variables are working hours, and repair and maintenance costs. Thereafter, the model is used to predict the expected repair and maintenance cost [3].

Appropriate mathematical model for the maintenance costs of farm tractors provide planners and policy makers and farmers an opportunity to evaluate the machine economics.

Materials and Methods

This study is carried out at JNKVV Jabalpur Madhya Pradesh. The repair and maintenance data of farm tractors were collected from breeder soybean production unit, biotechnology and groundnut unit, and horticulture farm, the Major activities are Tillage, seed bed preparation, sowing, spraying, harvesting, threshing, and transportation. Major crop in that farms are Paddy, maize, soybean, wheat, gram, berseem, pea and tuar, potato, ground nut, cauliflower, chilli, bottle guard, cucumber, etc.

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All the selected farms are situated at JNKVV campus around the college of agricultural engineering Jabalpur, India, which lies in between 22° 49' N and 24° 8' N latitude; 78° 21' E and 80° 85' E longitude. The data sample was taken four tractors; the study data available from the first-year life of the tractors and tractor horse power 55 hp. The selected two tractors name are Hindustan HWD50, John-deer 5310D name like T1, T2 and these tractors data available up to 10 year or more.

The Information on yearly repair and maintenance cost data of the tractors such as use of tractor each year, repair and maintenance costs of major part, lubricants, wages etc. was collected [4]. Some variations were apparent between individual tractors for the service hours. As hours of annual usage for each tractor were needed for data analysis study. To determine tractors at any point of service life, accumulated hours of use for each year were added up to previous usage hours are independent variable (x) of the model (s). Then, repair and maintenance costs as percentage of initial purchase price which was dependent variable (Y) obtained through dividing the total accumulated repair and maintenance costs by initial purchase price of the tractors.

Regression analysis

In any kind of mathematical relationship, one value of the variable is known and the value of another variable can be determined exactly. But it is possible case of statistical relationship the value of one variable from that of the other variable cannot be determined exactly. In this case, the estimation of the other variable is made with the help of known by using regression analysis. It is an important statistical technique used in science, business and economics.

To determine regression model(s) for predicting repair and maintenance costs of these tractors at any point of service life, accumulated hours of use for each year were added up to previous usage hours and the sum was independent variable x (where x in 1000) of the model(s). Then, repair and maintenance costs as percentage of initial purchase price which was dependent variable (Y) obtained through dividing the total accumulated repair and maintenance costs by initial purchase price of the tractor. To acquire information (i.e., repair and maintenance costs, hours of service and initial purchase price) for all tractors, cumulative of data was employed for analysis. Regression analysis of data for all tractors was done. The regression model Exponential, Linear, Logarithmic, Polynomial and Power equation were tried. The regression model(s) having the highest coefficient of determination (R^2) was selected as the best model(s) for predicting actual repair and maintenance costs trends (Table 1).

Results and Discussion

Tractor is used for tractive as well as stationary work in the farm. To perform the work timely. For better performance of a tractor, repair and maintenance is done by the farm in charge. The repair and maintenance data for the tractors of the farms under this study were collected from the records. The data and the analysed result are below.

S. No.	Model	Equations
1	Exponential	$Y=ae^{bx}$
2	Linear	$Y=a+bx$
3	Logarithmic	$Y=a+\ln bx$
4	Polynomial	$Y=a+bx+cx^2$
5	Power	$Y=ax^b$

Table 1: Five models are used to perform regression analysis.

Determination of appropriate mathematical model to predict repair and maintenance cost for JNKVV tractors

Determination of appropriate mathematical model for cumulative repair and maintenance for JNKVV farm tractor. Five regression models namely polynomial, linear, logarithmic, polynomial and power are applied. For the determination of equation Y=crm/pu in percentage, x=cumulative working hours. Whereas 1, 2, 3…….10 shows the age of the tractor represent cumulative hours [5,6] (Figures 1 and 2) (Tables 2 and 3).

Considering R^2 values, there is a significant correlation between x and Y variables in all five models. However, R^2 values indicate that the power and polynomial models have higher conformity with actual data trend in comparison with the linear, exponential and logarithmic models, for prediction of accumulated repair and maintenance cost.

It was found that the power model is best for prediction of cumulative repair and maintenance costs and the polynomial model of second order also predict good cumulative repair and maintenance but power model is used to calculate the cumulative repair and maintenance because of the value of R^2 is 0.99 as well as simple structure and ease in calculation.

Repair and maintenance costs fractions

The average spare parts, wages and others and lubricants costs is 49.32, 17.24 and 12.15%. Among the cost of spare parts, wages, lubricant and other; spare parts cost is more than the other costs which varies from 41.37 to 50.23% of the total repair and maintenance costs [7] (Figures 3 and 4).

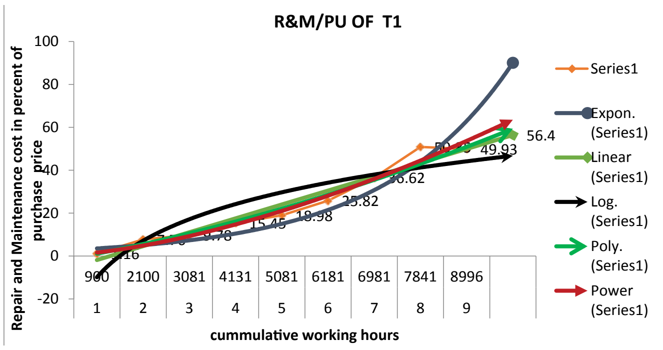

Figure 1: Cumulative repair and maintenance trends for tractor T1.

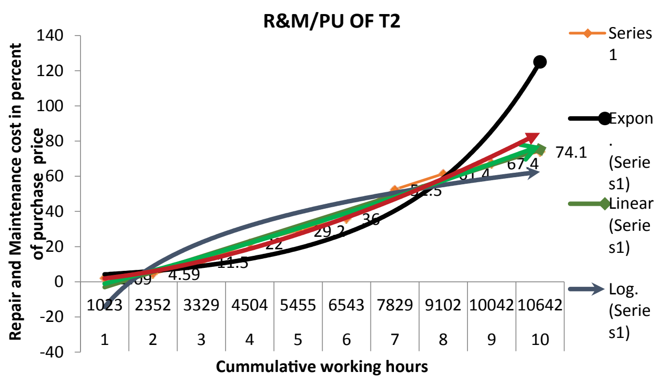

Figure 2: Cumulative repair and maintenance trends for tractor T2.

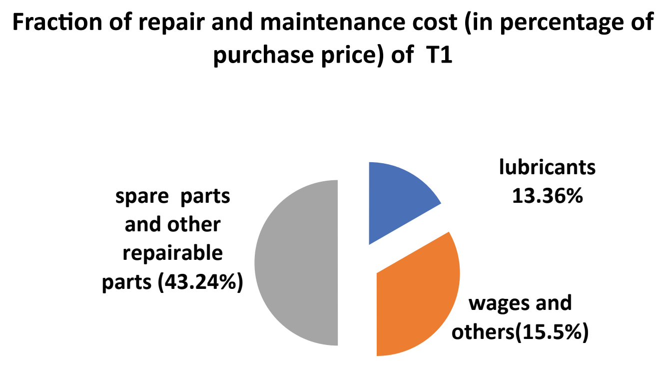

Figure 3: Fraction of repair and maintenance cost (in percentage of purchase price).

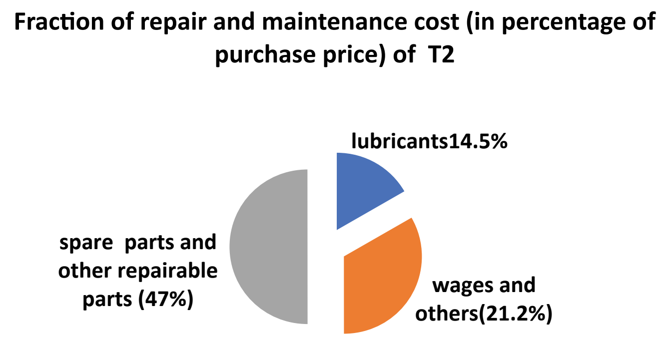

Figure 4: Fraction of repair and maintenance cost (in percentage of purchase price).

T1	Model Summary		Parameter		
Model	Equation	R^2	a	b	c
Exponential	$Y=ae^{bx}$	0.901	2.47	0.375	
Linear	Y=a+bx	0.917	8.378	−15.01	
Logarithmic	Y=a+blnx	0.709	30.43	−14.9	
Polynomial	$Y=a+bx+cx^2$	0.991	0.942	−1.991	5.727
Power	$Y=ax^b$	0.997	1.701	1.614	

Table 2: The coefficient and coefficient of determination (R^2) of the five-regression model obtained for tractor T1.

T2	Model Summary		Parameter		
	Equation	R^2	a	b	c
Exponential	$Y=ae^{bx}$	0.881	2.897	0.376	
Linear	Y=a+bx	0.985	8.704	−11.78	
Logarithmic	Y=a+blnx	0.850	33.39	−14.35	
Polynomial	$Y=a+bx+cx^2$	0.988	0.167	6.866	−8.110
Power	$Y=ax^b$	0.989	1.910	1.647	

Table 3: The coefficient and coefficient of determination (R^2) of the five-regression model obtained for tractor T2.

Conclusion

Results of this study indicated that average repair and maintenance costs per hour increased with tractor age. For Prediction of cumulative repair and maintenance costs the power ($Y=ax^b$) model is better than the models that is linear, polynomial, logarithmic and exponential. The value of "b" varies from 1.61 to 1.96 in power model and the value of R^2 is between 0.997 to 0.993. The values of R^2 indicate that the power, polynomial and linear models have higher conformity with actual data trend in comparison with exponential and logarithmic models. For exponential, logarithmic model there is no significant correlation between cumulative working hours and cumulative repair and maintenance costs.

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