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Development of Mathematical Model for Repair and Maintenance of Farm Tractors

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Abstract

A study was conducted to modelling of accumulated R&M 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.

For the prediction of cumulative repair and maintenance costs, the power model proved better than the models that is linear, polynomial, logarithmic and exponential, among the various alternatives power model was found ($Y= ax^b$) most suitable in order to predict accumulated R&M costs of tractor. The service life of the tractor near 10000 hours, the power model $Y=1.910X^{1.64}$ (where x in1000) with R^2 = 0.989 to predict accumulated R&M costs of JNKVV tractors can be strongly recommended.

The R&M cost consist of spare parts, wages and lubricant recored were 43.24, 15.5 and 13.36%, respectively in case of Hindustan –HWD50.

Key words: *Exponential, logarithmic, linear and polynomial model.*

Introduction

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 restorethe 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 (R&M) costs of farm machinery which is necessary to restore or maintain technical soundness and reliability of the machine. The accurate prediction of R&M 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[1].

The R&M cost of tractors is essential for both owner and manager to achieve information on overall cost to control financial and production economy[2,3]. It is small but relatively important portion of owning and operating farm machinery, repair cost are generally 10 to 15% of the total cost. Since it tends to increase with machine usage, repair costs becomes 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 R&M costs

Thereafter, the model is used to predict the expected repair and maintenance cost[4].

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

Materials and Methods

This study was 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 bad 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.

All the selected farms are situated at JNKVV campus around the college of agricultural engineering Jabalpur (M.P.) which is lies between 22^0 49' N and 24^0 8' N latitude and 78^0 21' E and 80^0 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 5310Dname 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. Some variations were apparent between individual tractors for the service hours. As hours of annual usage for each tractor were needed for the purpose of data analysis study. To determine tractors at any point of service life, accumulated hours of use for e ach year were added up to previous usage hours are independent variable (X) of the model (s). Then, R&M costs as percentage of initial purchase price which was considered to be dependent variable (Y) obtained through dividing the total accumulated R&M 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 other 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 R&M 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 considered to be independent variable x (where X in 1000) of the model(s). Then, R&M costs as percentage of initial purchase price which was considered to be dependent variable (Y) obtained through dividing the total accumulated R&M costs by initial purchase price of the tractor. To acquire information (i.e. R&M costs, hours of service and also 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 R&M costs trends.

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

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

Result 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 inchrage .The repair and maintenancedata for the tractors of the farms under this study were collected from the records. The data and the analysed result are below.

Determination of appropriate mathematical model to predict R&M 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/puin percentage, x = cumulative working hours. Whereas 1, 2, 3…….10 shows the age of the tractor represent cumulative hours [Table 1, Fig. 1, Fig. 2).

Fig.1 Cumulative repair and maintenance trends for tractor T1

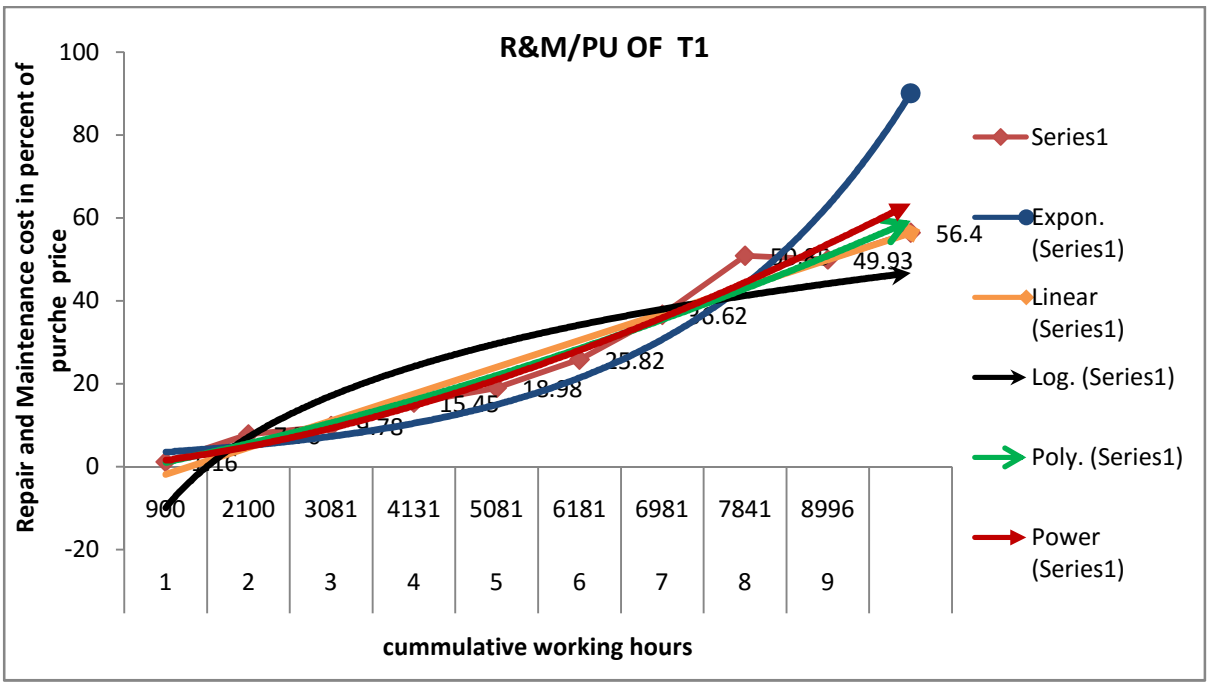


Table No. 2 The coefficient and coefficient of determination (R^2) of the five regression model obtained for tractor T1

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	
Lolynomial	$Y=a+bx+cx^2$	0.991	0.942	-1.991	5.727
Power	$Y=ax^b$	0.997	1.701	1.614	

Fig. 2 Cumulative repair and maintenance trends for tractor T2

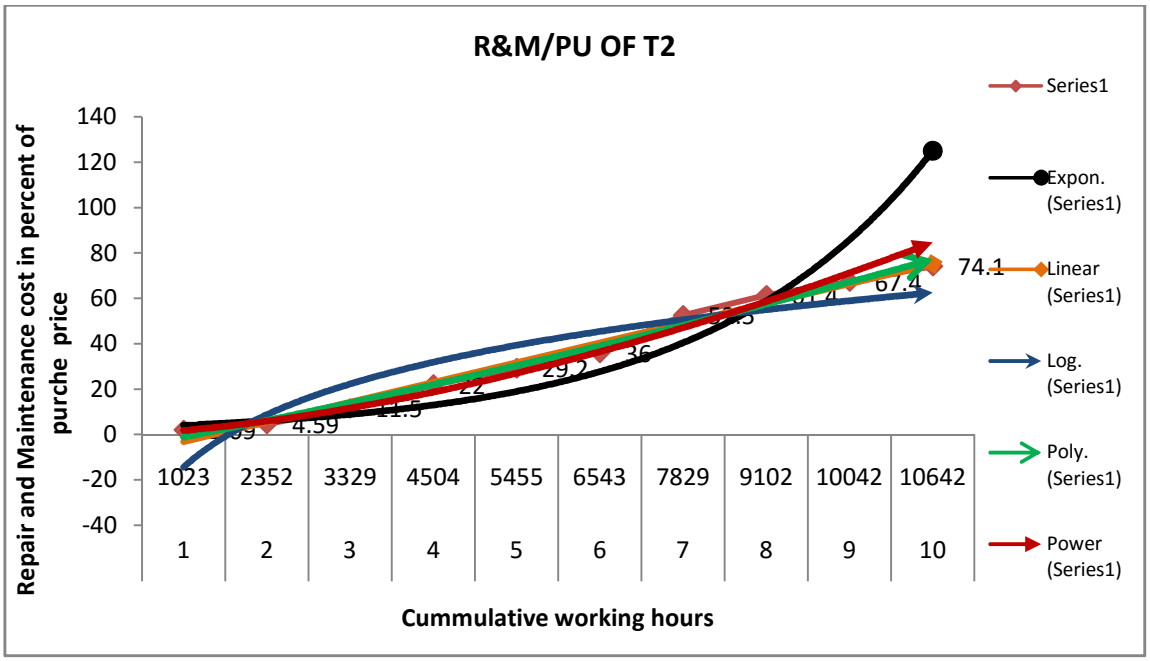


Table No. 3 the coefficient and coefficient of determination (R^2) of the five regression model obtained for tractor T2

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	.

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[Table 2, Table 3].

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 were 43.24, 15.5 and 13.36%. Among the costs spare part costs, wages and other and lubricant, spare parts costs is more than the other costs which varies from 41.37 to 50.23% of the total R&M costs [fig. 3, fig. 4].

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

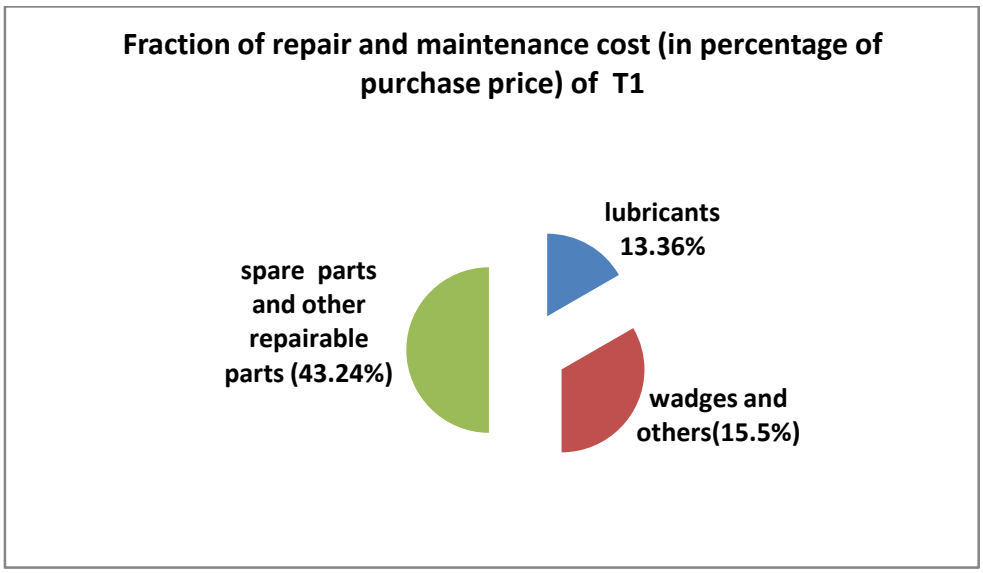
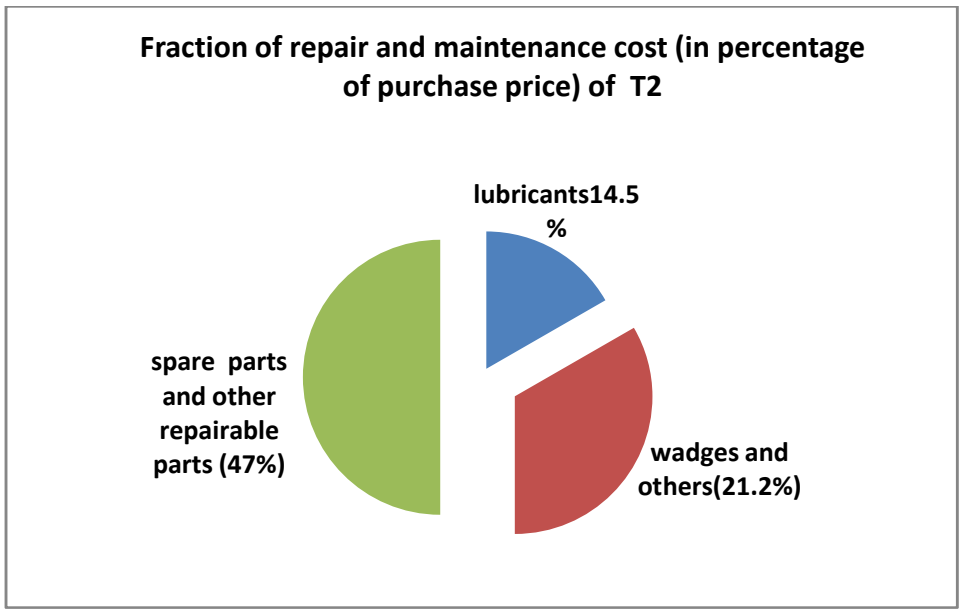


Fig.4 Fraction of repair and maintenance cost (in percentage of purchase price):-



Conclusion

Results of this study indicated that average R and M 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 1.96in 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 no significant correlation between cumulative working hours and cumulative repair and maintenance costs.

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