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MAINTENANCE COST MODEL FOR U683DT TRACTOR

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Abstract

On of the main component of TCO (Total cost of ownership) for farm machinery is the maintenance cost. Therefor a good model for maintenance evolution is important to decide for replacement time and to decrease TCO. In this study maintenance costs for U683dt tractor were investigated to present an appropriate mathematical model in order to predict these costs. The mean accumulated maintenance costs were analyzed on the five models, linear, logarithmic, polynomial, power and exponential. Finally, it was found that power model gave better cost prediction with higher confidence and less variation than other models.

Key words : maintenance, farm machinery, tractor, life-cycle, TCO

INTRODUCTION

Today, tractor is one of the most important power sources in agriculture. Effect of tractor power on agriculture is considerable (Singh, G., 2006). The use of modern technology during latter decades resulted in rapid growth of farm production. Tractors and farm machinery are important samples of this modern technology (Singh, G., 2000), (Xinan, D., L. Yuzhou, D. Suocheng and Y. Xiusheng, 2005). The quality of inputs of mechanization and consequently land and labor productivity in both situations, may differ considerably (Singh, G. and H. Chandra, 2002).

Costs of owning and operating of farm machinery represent 35 to 50% of the costs of agricultural production when excluding the land (Khoub Bakht G. M., H. Ahmadi, A. Akram and M. Karimi, 2009). The maintenance cost is an important item in costs of owning and operation. In general, the costs other than those for repair and maintenance cost usually decrease with increasing usage, but the reverse is true with respect to maintenance costs. The cost of maintenance is usually between 10% and 20% of the total cost. As the machine age increases the cost increases until it becomes the largest cost item of owning and operating of farm machines (Rotz, C.A. and W. Bowers, 1991). Agricultural engineers have done many studies regarding maintenance of farm machines. Several studies were conducted in both developed and undeveloped countries either to develop models to determine the cost during a certain period or to get absolute numbers to represent owning and operating certain equipment (Khoub Bakht G. M., H. Ahmadi, A. Akram and M. Karimi, 2009).

Bowers and Hunt (Khoub Bakht G. M., H. Ahmadi, A. Akram and

M. Karimi, 2009) collected information from several farms in Illinois and Indiana in the United States as part of their study. Fairbanks (Khoub Bakht G. M., H. Ahmadi, A. Akram and M. Karimi, 2009) made an extensive survey on 114 farms in Kansas and two models were derived. One model to calculate the cost of repairing diesel tractors and the other model calculated the cost of repair for combines. These models had the same format as given by ASAE (ASAE, 1993), but differed in their parameters. The accumulated cost of maintenance was estimated to be 30% of the list price by the end of the economic age. Farrow (Khoub Bakht G. M., H. Ahmadi, A. Akram and M. Karimi, 2009) tested the performance of prediction equations and estimated the required changes needed for seven farm machines including trucks. The study concluded with emphasis to improve the existing models for obtaining better accuracy. Ward (Khoub Bakht G. M., H. Ahmadi, A. Akram and M. Karimi, 2009) made an extensive study of 10 years of government records for repair costs of 4 wheel and 2 wheel drive tractors and derived a cost model for each type of tractor. This study agreed with other studies regarding the difference existing between the two types of tractors. Rotz (Rotz, C.A. and W. Bowers, 1991) derived a model based on equipment price and operating hours. The testing of the model showed that the costs were more realistic when the area worked was considered instead of the operating hours. Rotz and Bowers (Rotz, C.A. and W. Bowers, 1991) made an attempt to collect information from companies and experts, but limited response was received. They revised the models published by ASAE regarding maintenance costs. They noticed that the maintenance costs varied with operating conditions.

Some studies conducted in undeveloped countries regarding maintenance of farm machines were reported in the literature (Abdelmotaleb, I.A., 1993). The operating costs of the farm machines in undeveloped countries were estimated using the models of developed countries (Khoub Bakht G. M., H. Ahmadi, A. Akram and M. Karimi, 2009). Henderson and Fanash (Khoub Bakht G. M., H. Ahmadi, A. Akram and M. Karimi, 2009) conducted a study in Jordan on the cost of tractor use. This study showed that there was a proportional increase of maintenance costs with tractor use. They proposed a model to estimate the maintenance cost of the tractor/hour/acre based on the Jordanian currency.

The aim of this study is to provide a statistical analysis for the maintenance costs of Universal 683dt tractor in order to present an appropriate mathematical model. Display of appropriate models for the maintenance costs of farm machineries provide planners and policy makers and also farmers an opportunity to evaluate the performance of machinery economic.

MATERIAL AND METHODS

This study was carried out in Bihor and Arad county, in northwestern region of Romania. Data were collected from Universal 683dt tractor in the study region by using a questionnaire in the late of 2010. Information was sought on tractor characteristics and economic costs such as use of tractor, fuel consumption, lubrication cost, filter cost, repairman wage cost, etc.

The tractors were classified according to their fuel consumption in steps of 5000 liters. The mean maintenance cost per fuel consumption, which are separately calculated for each step. Accumulated maintenance cost for each step were calculated using equation 1.

$$Y = \frac{\sum_{i=1}^{n} y_i}{n} \tag{1}$$

Where Y is the accumulated mean maintenance cost based on percent of list price for n tractors and y_i is the total maintenance on percent of list price for tractor number i. Based on that, ratio of the cumulative costs to the list price was estimated as the dependent variable and the cumulative fuel consumption were obtained as independent variable. In order to determine mathematical model for the study tractor, regression analysis was performed on the data by using the computer software IBM SPSS 19. Five models were used to perform regression analysis, which included the following:

Y = a + bx	linear
$Y = a + bx + cx^2$	polynomial
$Y = ae^{bx}$	exponential
Y = a + b lnx	logarithmic
$Y = ax^b$	power.

Dependent and independent variables were used to obtain the best equations to estimate maintenance costs. Other models in the reported studies were used to predict repair and maintenance costs of the study tractor and compared with obtained model in this study.

RESULTS AND DISCUSSION

The results of obtained data from tractors were used to calculate the accumulated maintenance cost and fuel consumption are listed in table 1. The presented data in this table were used to analysis and determine five maintenance cost model as result in table 2.

This models was compared with models made by others researchers.

Table 1

The accumulated maintenance cost and total fuel consumption

Step	Total fuel consumption (liters)	Accumulated maintenance cost (percent of list price)
1.	10000	3.92
2.	20000	6.85
3.	30000	11.05
4.	40000	15.79
5.	50000	20.34
6.	60000	26.28
7.	70000	31.26
8.	80000	39.43

Table 2

The models an	d parameter	estimates
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Model	Parameter estimates			
Iviouei	R Square	Α	b	С
linear	0.9854	- 3.1811	0.0005	
logarithmic	0.8482	- 151.19	16.188	
polynomial	0.9987	1.1868	0.0002	3.10-9
power	0.9902	0.0001	1.12	
exponential	0.9601	3.6921	3.10-5	

The chart of maintenance cost based on accepted power model is presented in figure 1. Different others models made by researchers were presented in figure 2 (Khoub Bakht G. M., H. Ahmadi, A. Akram and M. Karimi, 2009).



Fig. 1. Resulted maintenance cost model

The highest value of correlation coefficient among presented models is related to polynomial model with $R^2=0.9987$ and after that power model with $R^2=0.9902$ has the most value of correlation coefficient. In the most



published studies in this field and also the present study, power model gave better cost prediction with higher confidence and less variation.

Others formulas made by researches (Khoub Bakht G. M., H. Ahmadi, A. Akram and M. Karimi, 2009) are : $Y = 0.042 \left(\frac{x}{120}\right)^{1.895}$, $Y = 1.2 \left(\frac{x}{1000}\right)^2$, Y = 0.00865x, $Y = 0.076 \left(\frac{x}{120}\right)^{1.6}$, $Y = 0.042 \left(\frac{x}{120}\right)^{1.895}$, $Y = 0.0000996 \cdot x^{1.4775}$, $Y = 0.002 \cdot x^{1.162}$.

CONCLUSIONS

The large percent of maintenance cost can be due to numerous factors such as making use of substandard tractor spare parts, unsuitable use of tractor, novice driver, undesirable repairs and making use of tractor more than its optimum life.

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