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DETERMINATION OF REPAIR AND MAINTENANCE COST FOR MF375 TRACTOR: A CASE STUDY IN KANO METROPOLIS, NIGERIA

Abubakar M. S*., Zakari M. D., Shittu S. K. and Attanda M. L.

(Department of Agricultural Engineering, Bayero University, Kano, Nigeria)

*Corresponding author's e-mail address: abubakarms@gmail.com

Abstract

The agricultural tractor is at the center point of agricultural mechanization. Tractor costs have great influence on farm business profit. Knowledge of tractor costs for farm operations has a prime importance in making management plans and decisions especially in comparing different tractor types and models thereby assisting in the selection of a more appropriate farm tractor. This study reports the repair and maintenance cost for MF375 tractors with a view to providing such decision making aids as machine's replacement and overall farm budgeting for machinery managers. Information on 75 MF375 tractors was obtained through a structured questionnaire. Data collected was sought on tractor characteristics and economic costs such as use of tractor each year, fuel consumption cost, lubrication oil cost, oil and fuel filters replacement cost and workmanship cost. Result showed that the cost of tractor spare parts replacement had the highest percentage share (54.2%) from the total percentage cost followed by cost of fuel (20.4%), workmanship cost (13.0%), and then cost of lubrication oil (10.3%) while cost of oil and fuel filter replacement had the least (2.1%) percentage share.

Keywords: Repair, maintenance, cost, tractor, MF375, Nigeria

1. Introduction

Agricultural tractor is one of the most important energy and power sources in agricultural mechanization(Gifford and Rijk, 1980). It requires high initial capital investment. Effect of tractor power on agriculture is very huge (Singh, 2006). The introduction of modern technology during the last century resulted in rapid growth of farm production. Tractors and farm machinery are important samples of this modern technology (Singh, 2000a; Singh, 2000b; Xinan *et al.*, 2005).Tractor costs have great influence on farm business profit. Knowledge of tractor costs for farm operations has a prime importance in making management plans and decisions especially in comparing different tractor types and models thereby assisting in the selection of a more appropriate farm tractor. Costs of owning and operating farm machinery represent 35 to 50% of the costs of agricultural production when the land is excluded (Anderson, 1988). The repair and maintenance (R&M) cost is an important item in the costs of ownership and operation. R&M cost is a function of machine age and use (Hunt, 2001). In general, the costs other than those for R&M usually decrease with increasing usage, but the reverse is true with respect to R&M costs. The cost of R&M is usually about 10% of the total cost; as the machine age increases the cost increases until it becomes the largest cost item of owning and operating the farm machines (Rotz and Bowers, 1991). Agricultural engineers have carried many studies regarding R&M of farm machines. Several studies were conducted in both developed and developing 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 (Abimbola, 1989; Bowers and Hunt, 1970; Fairbanks *et al.*, 1971; Farrow *et al.*, 1980; Gliem *et al.*, 1989; Gliem *et al.*, 1986; Rotz, 1987; Ward *et al.*, 1985). Some studies conducted in developed countries regarding R&M of farm machines have been reported in the literature. Bowers and Hunt (1970) collected information from several farms in Illinois and Indiana in the United States. Also Fairbanks *et al.*, (1971) made an extensive survey on 114 farms in Kansas and they developed two models from their study. One model was to calculate the cost of repair for diesel tractors and the other one was to calculate the cost of repair for combine harvesters. The operating costs of the farm machines in developing countries were estimated using the models of developed countries (Inns, 1978). Henderson and Fanasb (1984) conducted a study in Jordan on the cost of tractor use. This study showed that there was a proportional increase of repair costs with tractor use. Farrow *et al.*,(1980) tested the performance of prediction equations and estimated the required changes needed for seven farm machines including trucks. A standard model was established for the prediction of repair and maintenance costs of medium-size, two-wheel drive, diesel engine tractor in Sudan. The model was derived based on data collected over a 10 year period, from several locations in Sudan, and it predicts repair and maintenance costs as a power function of tractor cumulative use in hours. The model showed that the tractor cumulative use in hours was the major determinant factor of the tractor repair and maintenance costs. The study concluded with emphasis to improve the existing models for obtaining better accuracy. Ward *et al.*,(1985) made an extensive study of 10 years of government records for repair costs of 4-wheel and 2-wheel drive tractors and developed 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 (1987) developed a model based on equipment price and operating hours. Testing the model showed that the costs were more realistic when the area worked was considered instead of the operating hours.

1.1 Farm machinery cost

Farm machinery costs are divided into two categories, namely owning or fixed costs and operating or variable costs (Morris, 1988). Owning or fixed cost includes annual depreciation, interest, taxes and shelter charges. The operating costs were defined as fuel, lubrication, maintenance, repairs and labour costs. Variable costs increase proportionally with the amount of operational use of the machine, while fixed costs are independent of use (Hunt, 2001). It is not always clear as to which category some of the specific costs belong. Estimations of yearly costs are adequate for determining crop production costs and for deciding if machine ownership is profitable; but the time of replacement decision depends on the accumulated costs over a period of years. Repair and maintenance (R&M) costs of farm machinery are difficult to estimate because of variability among machines and operating conditions from one farm to another and also due to unavailability of good records keeping (Lazarus and Selley, 2005). Therefore, the aim of this study is to provide a mathematical model for the repair and maintenance costs for MF375 tractor for Kano State of Nigeria. The results of the study could serve as benchmark information to tractor owners in the study area regarding optimum use of tractors for minimizing repair and maintenance cost per operating hour and for making replacement policy. Thus it could be used by policy makers, farm managers and other agencies for future planning in the provision of tractor services to the farmers at relatively lower repair and maintenance cost.

2. Materials and methods

2.1 Data collection

The study was conducted in Kano metropolis of Kano State, Nigeria. Data were collected from 75 MF375 tractor operators using structured questionnaire. Tractor operators were selected randomly from the study area. Information was sought on tractor characteristics and economic costs such as use of tractor each year, fuel consumption cost, lubrication oil cost, oil and fuel filters replacement cost and workmanship cost. The tractors were then classified according to their age (years) into 25 groups (ie 1 to 25). The mean operating hours per year was obtained separately then the mean annual repair and maintenance costs were also calculated separately for each group. The accumulated operating hours per group was calculated using equation 1 as reported by Khoubbakht (2008):

$$X_n = \sum_{i=1}^{n} x_i \qquad (1)$$

where X is the accumulated operating hours for the 'n' group in hour (h), n is the tractor age group in year (y), x is the mean annual operating hours per group in hour per year (h/y) for the group i. Also accumulated repair and maintenance cost was calculated using equation 2 below as reported by Ward *et al.*,(1985):

$$Y_n = \sum_{i=1}^{n} y_i \qquad (2)$$

where Y is the accumulated repair and maintenance cost based on percentage of list price for the 'n' group and y is the mean annual repair and maintenance cost based on percentage of list price for the group i. Based on the above relationships, the ratio of the cumulative repair and maintenance costs per group based on the list price was estimated as the dependent variable and the cumulative operating hours were computed as independent variable. In order to determine mathematical model for the study, regression analysis was performed on the data using the Statistical Analysis Software (SAS, 2009). Five models were used to perform regression analysis, which included the following;

$Y = a + b\mathrm{x}$ Linear model (3)

$Y = a + b\mathrm{x} + c\mathrm{x}^2$ Polynomial model (4)

$Y = ae^{b\mathrm{x}}$ Exponential model (5)

$Y = a + b\ln x$ Logarithmic model (6)

$Y = ax^{b}$ Power model (7)

Both the dependent and independent variables were used to obtain the best equations to estimate repair and maintenance costs from the five models above.

3. Result and discussions

3.1 Determination of repair and maintenance costs of the MF375 tractor

Repair and maintenance costs of the MF375 tractor were sought from the following: fuel consumption cost, lubrication oil cost, oil and filter replacement cost, spare parts cost and workmanship cost. Table 1 presents the result of the calculated mean annual repair and maintenance costs of the MF375 tractor with the cost of each parameter and percentage share of the total. It was observed that the cost of tractor spare parts replacement (54.2%) had the highest percentage share compared to other parameters' cost. This could be due to the fact that majority of the spare parts used were substandard which led to continuous replacement of spare parts.

Table 1 Mean annual repair and maintenance costs of the MF375 tractor

Parameter	Cost ₦ ($)*	Percentage
Fuel consumption	3,774,000 (24,192)	20.4
Lubrication oil	1,905,500 (12,215)	10.3
Oil and fuel filters	388,500 (2,490)	2.1
Spare parts	10,027,000 (64,276)	54.2
Workmanship	2,405,000 (15,417)	13.0
Total	**18,500,000 (118,590)**	**100**

* Exchange rate of ₦156.00 per 1.00$ as at 2012

The next single parameter with high cost of the percentage total was the fuel consumption (20.4%). While the least cost was obtained from oil and fuel filters parameter (2.1%). Also this may be attributed to the age of the tractors which could lead to consumption of more fuel. The result reported in this study was similar to the one obtained by Khoubbakht *et al.*, (2008).

3.2 Determination of mathematical model to predict the repair and maintenance costs of the MF375 tractor

Table 2 presents the result of the calculated accumulated repair and maintenance cost and the operating hours of the MF375 tractor from the seven-five number of tractors. The accumulated repair and maintenance and the operating hours values obtained were used to analysis and determine the mathematical model.

Table 2 Accumulated repair and maintenance cost and operating hours of MF375 tractor

Age (year)	Accumulated operating hours	Accumulated repair and maintenance cost (Percentage of list price)
1	985.19	5.33
2	1843.21	10.86
3	2941.64	16.27
4	3732.10	22.06
5	4892.76	27.47
6	5672.90	33.00
7	6598.32	38.79
8	7520.87	45.22
9	8345.14	52.10
10	9311.45	59.95
11	11250.21	67.33
12	11850.76	73.54
13	12458.54	82.92
14	12980.12	95.21
15	13778.65	101.36
16	14999.24	112.17
17	16425.76	121.37
18	17656.43	132.82
19	18555.97	151.53
20	19583.56	162.49
21	20543.77	171.72
22	21769.25	183.95
23	22650.69	191.53
24	23430.21	201.12
25	24150.13	215.73

The relationship between the accumulated repair and maintenance cost and the accumulated operating hours on the mathematical models is shown in Table 3. It was observed that the highest value of coefficient of correlation (R^2) amongst the models was found on polynomial model (R^2 = 0.999) then followed by the power, linear, exponential and logarithmic models with R^2 of 0.977, 0.955, 0.893 and 0.842 respectively. These findings are in agreement with results of many researchers (Adekoya and Otono, 1990; Beppler and Hummeida, 1985; Khoub bakht *et al.*, 2008; Konda and Larson, 1990).

Table 3 Model summary and parameter estimates

Model	Model summary		Parameter estimate		
	R^2	F value	a	b	c
Linear	0.955	1890.215**	-20.722	0.01	
Logarithmic	0.842	85.060**	-580.950	72.213	
Polynomial	0.999	53020.070**	4.312	0.005	2.15×10^{-8}
Power	0.977	6120.544**	0.00018	1.2145	
Exponential	0.893	190.320**	15.210	0.00015	

Table 4 presents the comparison of models developed by different researchers in predicting the accumulated repair and maintenance costs. It was observed that some of these models developed gave higher accumulated repair and maintenance costs by up to and above 3 times when compared with the model developed in the present study. However, the comparison of Kano standard prediction model with similar models established in some developed and developing nations revealed that the estimates of repair and maintenance costs of the agricultural tractor in Sudan were not significantly higher but with that of industrialized countries, they were significantly higher.

Table 4 Models developed by different researchers and for present study

Models developed by different researchers	Accumulated repair and maintenance costs based on percentage of list price			Source(s)
	5000 hours	8000 hours	10000 hours	
$y = 0.042\left(\frac{x}{120}\right)^{1.895}$	49	120	183	Ward *et al.*,(1985)
$y = 1.2\left(\frac{x}{1000}\right)^{2}$	30	77	120	ASAE (1983)
$y = 0.00865X^{1}$	43	69	86	Culpin(1975)
$y = 0.072\left(\frac{x}{120}\right)^{1.6}$	30	63	89	Bowers and Hunt (1970)
$y = (0.00996X^{1.4775})10^{-3}$	29	57	80	Morris (1987)
$y = 0.005X^{1.2}$	36	62	85	For present study

4. Conclusions

The following conclusions were drawn from this study.

1. It was found that repair and maintenance cost increased with an increased in operating hours of MF375 tractor.
2. The model developed has the tractor accumulated operating hours as the major determining factor of the repair and maintenance costs.

It is recommended that the use of mathematical models developed for tractor repair and maintenance be applied only to those conditions for which they were developed.

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