Replacement age of agricultural tractor (MF285) in Varamin region (case study)

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Abstract: One of the main aims in the management of farm equipment and tractors is deciding about their replacement, based on technical and economic conditions. The objective of this research was to determine the economic life time for common used tractor in Varamin region, Iran, namely Massey- Fergusen 285. First the annual depreciation and interest were calculated considering the initial purchase price of tractor, and then the economic life was calculated based on repair and maintenance costs. The results showed that the most suitable replacement age is nine years for Massey- Fergusen 285.

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1. Introduction

Agricultural tractors are the most common sources of power generating in the present mechanized agricultural operations. One of the aims in agricultural machinery management is decision making about the replacement of tractors considering the technical and economical conditions of the region which are used. Proper application and appropriate decisions about timely replacement of tractors and equipment causes to do agricultural operations in time with good quality and consequently results lower costs and higher revenue. In Iran, tractors are even used for some more years after their economic life by farmers and they don't have attention to the replacement issues, because the repair and maintenance costs are not calculated properly and the timeliness costs are not considered in the agricultural sections. It is clear that the breakdown cases will be increased after the economic life of the tractors while many of them may not be predicted, so the delay rate will be very high. On the other hand, the fuel consumption will be increased after economic life because of parts aging so the importance of the replacement is more clear due to the importance and high value of the fossil fuels. Making decision about the replacement of aged machines is based on the economic life. Economic life, which is also known as useful life, is usually shorter than the machine's life and it depends on the repair costs of the machine. In general, the total costs of a machine are divided into fixed and variable costs. With increasing of the operating hours of the machine, the fixed costs including depreciation and interest have a declining trend per operation unit (area or time), while the variable costs including repair and maintenance will be increased. Economically the optimum time for replacing the aged machine is when the total cost is minimum per operation unit and after that will be increased again (ASAE Standards . 2000b).

The main aim of this research is to evaluate the operational conditions of more used tractor in this region namely Massey- Fergusen 285, in order to find the best replacement age for this tractors in Varamin region.

2. Materials and methods

The data and information for twenty MF285 (75hp) tractor in Varamin (40 km southeast of Tehran) was collected and examined over 10 years. The collected data includes of repair and maintenance costs, annual operating time, as well as purchase price. The price of MF 285 is taken as 12000 $ based on the official documents of The Agricultural Machinery Development Agency, and the inflation rates posted by the central bank in 2008. Repair and maintenance costs were roughly calculated by referring to the owners and considering the costs of spare parts, used materials, and repair fee and then a questionnaire was completed for tractor. The annual operating hours were determined based on the tractor's working hour counter.

2.1 Depreciation

The declining balance method (reduction with fixed percent) was used for calculation of depreciation based on equations 1 and 2 (ASAE Standards, 2000a).

$V_n = P\,(1-x/l)^n$	(1)
$D_n = V-V_{n+1}$	(2)

In which D_n is depreciation rate in the year of calculation, n is machine's age in the year of calculation, V_n is remaining value of the machine at the end of the n^{th} year ($), x is depreciation ratio (1<x<2), l is total machine life (year) and P is purchase price ($).

In the computations, x is designated a mean value of 1.5 and L equals to 10 years (ASAE Standards, 2000b).

2.2 Interest

Equation 3 was used for calculation of interest (ASAE Standards, 2000b).

$I_n=V_n \,.\, i$	(3)

In which I_n is interest in the n^{th} year ($), i is interest rate in Iran based on central bank rate in 2008 (i=15%)

2.3. Replacement determination method

Following the calculation of repair and maintenance costs and operating hours over 10 years as well as depreciation and interest over the same period, the economic life of the tractor was calculated as follows. First, depreciation and interest costs, known as capital costs, were calculated. Total accumulated cost was calculated through adding accumulated repair and maintenance and accumulated capital costs. Total accumulated cost per operating unit was obtained by dividing the total accumulated cost by the accumulated operating hours. In this study, operation time is assumed as the operating unit. Economically, the optimum time for replacement of the machine is when the minimum total accumulated cost per operating unit occur (Cross, 1998).

3. Results

3.1. Depreciation and interest

The depreciation rate, interest rate, annual interest, and annual interest added depreciation as well as accumulated capital costs is shown in Table 1 for MF285 tractor in the first 10 years of the tractor's life. It is obvious that annual capital costs are reduce with time.

3.2. Repair and maintenance, capital and total accumulated costs

Tables 2 shows the rate and the percentage of costs of spare parts, repairs, oil and filter costs, total repair and maintenance costs in each year as well as the annual and total accumulated costs of repair and maintenance for MF285 tractor .

Table1. Depreciation, interest, and capital costs for MF285 tractor

year	Annual depreciation costs(1000$)	Annual interest of investment (1000$)	Annual capital costs (1000$)	Accumulated capital costs (1000$)
1	18	15.3	33.3	33.3
2	15.3	13	28.3	61.6
3	13	11.05	24.05	85.65
4	11.06	9.39	20.45	106.1
5	9.4	7.98	17.38	123.48
6	7.99	6.78	14.77	138.25
7	6.78	5.77	12.55	150.8
8	5.77	4.9	10.67	161.47
9	4.9	4.17	9.07	170.54
10	4.18	3.54	7.72	178.26

Table 2. Repair and maintenance costs for MF285 tractors over 10 years

Year	Spare parts		Repairs		Oil and filter		Total repair and maintenance costs in year	Total accumulated repair and maintenance costs
	Rate (1000$)	Percent	Rate (1000$)	Percent	Rate (1000$)	Percent		
1	1.85	43.52	1.5	35.29	0.9	21.17	4.25	4.25
2	2.5	41.66	2.05	34.16	1.45	24.16	6	10.25
3	3.74	46.38	2.68	33.30	1.66	20.30	8.06	18.31
4	4.97	44.33	3.89	34.74	2.34	20.91	11.21	29.52
5	8.11	41.85	6.72	34.63	4.56	23.50	19.4	48.92
6	10.60	40.33	8.70	33.13	6.7	26.52	26.25	75.17
7	14.76	42.03	11.72	33.36	8.64	24.59	35.12	110.29

8	16.91	41.90		13.90	34.44		9.55	23.65	40.36	150.65
9	18.47	42.81		14.43	33.43		10.24	23.74	43.15	193.8
10	39.53	44.86		32.03	36.35		16.54	18.77	88.11	281.91
Mean		**42.96**			**34.28**			**22.73**		

Accumulated repair and maintenance, accumulated capital and total accumulated costs per year for tractor is shown in table 3. In this tables, the total accumulated costs in each year was obtained by sum of the total accumulated repair and maintenance costs and accumulated capital costs of that year.

Table 3. Repair and maintenance, capital, and total accumulated costs for MF285 tractors (1000$)

Year	Accumulated repair and maintenance costs	Accumulated capital costs	Total of accumulated costs
1	4.25	33.3	37.55
2	10.27	61.6	71.87
3	18.31	85.65	103.96
4	29.52	106.1	135.62
5	48.92	123.48	172.4
6	75.17	138.25	213.42
7	110.29	150.8	261.09
8	150.65	161.47	312.12
9	193.8	170.54	364.34
10	281.91	178.26	460.11

4. Discussions

Based on the results shown in table 1, the annual capital costs including depreciation costs and annual investment interest decrease year by year. These costs have no direct relationship with the usage rate during machine life but somehow they are affected by them. Usage of machines causes less depreciation costs and investment interest, because a certain portion of annual costs will be divided to more operating hours (Ward *et al.*, 1985). Table 2 shows the repair and maintenance costs for MF285. These costs are depended on the operation time of the machine. Higher usage of the machine results higher repair and maintenance costs. The table also shows an increase in repair and maintenance, spare part and oil costs. The percentage of each item is different in different years and it may be higher or lower than the past or next year but in calculation the sum of repair and maintenance costs is important which increase in time. For example, considering table 2, the percent of spare parts costs in the eighth year is lower than those in the seventh and ninth years. Higher costs of spare parts may be caused by low quality of the parts, overuse or early replacement of the spare parts, improper usage of tractor caused by insufficiently trained

drivers, non-standard parts, improper repair and more importantly, excessive use after the economic life of the tractor .

Table 4. Accumulated, accumulated operating and total costs per operating hour for MF 285 tractors (1000$)

Year	Total accumulated costs	annual operating costs	accumulated operating costs	Total accumulated costs per operating
1	37.55	1021	1021	36.77
2	71.87	1029	2050	35.05
3	103.96	1100	3150	33
4	135.62	1200	4350	31.17
5	172.4	1350	5700	30.24
6	213.42	1450	7150	29.84
7	261.09	1710	8860	29.46
8	312.12	1750	10610	29.41
9	**364.34**	**1840**	**12450**	**29.26**
10	460.17	1270	13720	33.54

Based on the data in table 4, the total accumulated costs per operating hour, calculated by dividing the total accumulated costs accumulated operating hours. According to table 4, the total accumulated costs per operating hour decrease first and then increase after the ninth year for MF285. Hence the best time for replacement is when the total accumulated costs per operating hour are minimum after which costs rise again (Hunt, 2001; Ward *et al.*, 1985).It maybe concluded that the best age of replacement for MF285 is at the end of the ninth year. According to the available information in mechanization development center of Iran in 2002, the actual mean useful life for tractors in Iran is considered to be about 13 years while unofficial reports show higher levels. Obviously, there is a significant difference between economic life of tractors and their true and operational function. When the repair and maintenance costs of these tractors are not calculated properly, the true level of costs is not clear to use for replacement decisions and in most cases continued use of old tractors is not economic. The time of agricultural proactive and timeliness costs are still overlooked in Iran especially in small farms. It is known that when the economic life of a tractor is exceeded, breakdown cases increase and down time delay will be high, whereas timely replacement can prevent these losses. The important aspects for increasing the economic life of tractors are timely servicing, repairs and maintenance, using good quality spare parts and materials and proper training of drivers. It is suggested to perform similar studies in different regions having different operational, climatic, economical and management conditions to determine the best time for replacement of tractor in that region. This process requires a system for collecting and recording data on operating hours, repair and maintenance costs, and calculating depreciation, interest and timeliness costs.

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