Available online at www.elixirpublishers.com (Elixir International Journal)

Control Engineering

Elixir Control Engg. 47 (2012) 8684-8688

ISSN: 2229-712X

Determination of appropriate time for farm tractors replacement based on economic analysis

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ARTICLE INFO

Article history:

Received: 12 April 2012;

Received in revised form:

18 May 2012;

Accepted: 29 May 2012;

Keywords

Economic life,

Iran,

Farm management.

ABSTRACT

Nowadays, tractor is one of the most important power sources in agriculture. Replacement of tractor is one of the most important decisions that should be made by farmer. Proper performance in this case can lead to timely, high quality farm operations which in turns results in considerable decrease in product expenditures and also more income. The current study was performed in order to determine economically optimum life of MF285 tractors in Debal Khazaei Agro-Industry Co. in Khuzestan province of Iran. Moreover, listed price of tractor, annual depreciation and Internal Rate of Return in the study period were calculated. Then, these items accompanied by their repair and maintenance cost were used to determine their economic life. Finally, replacement time for the study tractors was obtained equal as 6981 hours. These hours of operation are performed in about 14 years and thus the tractor should be replaced.

Introduction

The quality of mechanization inputs and consequently land and labor productivity in both situations may differ considerably (Gifford, Rijk 1980; Singh 1997; Singh, Chandra 2002). 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 (Xinan et al. 2005; Singh 2000a; Singh 2000b). Today, tractor is one of the most important power sources in agriculture and effect of its power on agriculture economy is considerable (Singh 2006).

Management of farm machinery is one of the important branches of farm management. Determination of replacement time of farm machinery is related to conditions of their economical and technological is one of the considered aims in management of farm machinery. A complete line of machinery is one of the largest investments that a farm business can make. Yet, unlike land or buildings, machinery must be constantly monitored, maintained and eventually replaced. How and when equipment is replaced can make a difference of thousands of dollars in annual production costs.

Deciding for replacing old machinery by a new similar one is usually performed based on its economic life. Economic life, named as optimum life, has a direct relation with repair and maintenance costs. Costs of owning and operating of farm machinery represent about 35 to 50% of the costs of agricultural production when excluding the land (Anderson 1988). The R&M (repair and maintenance cost) is an important item in costs of owning and operation. 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 of farm machines (Rotz and Bowers, 1991). Agricultural engineers have done many studies regarding to R&M 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 of certain equipment (Bowers, Hunt 1970; Fairbanks et al. 1971; Farrow et al. 1980; Ward et al. 1985; Rotz 1987; Gliem et al. 1986; Gliem et al. 1989). Based on ASAE, replacement age for a machine that is placed on economic life arrives typically before fundamental breakdowns resulted worn out and technological disabling (ASAE Standards S495, 2006). Economic or optimum life for a machine presents a time period based on constant and variable costs that using the machine is economical (ASAE Standards EP496, 2006; Hunt 2001). Each machine has a determined economical life that thereafter using the machine is not economical. It is known that repair and maintenance cost has a large share from machine ownership costs.

As it is shown in Figure 1, while machine age is raised, fixed cost is reduced, but repair and maintenance (variable) costs is raised. As it is seen, indication of total annual machine costs is obtained by adding fixed and variable costs. Minimum point of this curve, that is intersection point of constant and variable cost curves, presents the most appropriate time for replacing machine (Ward et al. 1985).

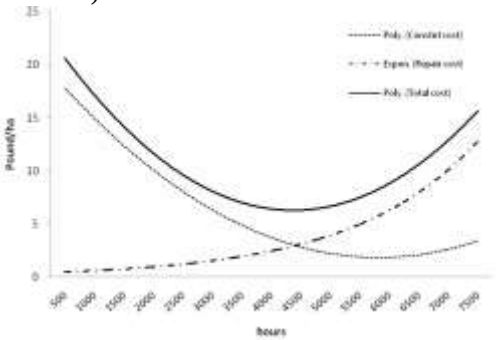

Fig. 1: Curves of total annual machine, constant and variable costs for two wheel drive tractor

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Some studies were performed to determine the economic life of MF285 tractors in different regions of Iran. The Mechanization Extension Center (MEC) of Iran obtained 13 years with 13000 hours operation for these tractors. Sharifi (1994), Taheri (1998), Ashtiani (2005) and Khoubakht (2008) determined the economic life for mentioned tractors in Tehran province, Parsabad Agro-industry Co., Dashte-Naz Agro-industry Co. and Isfahan province of Iran. As it is seen in Table 1, all economic lifes have been obtained in the range of 13000 hours reported by MEC. The life time reported by Khouakht is highly greater than the others. He explained that its reason was due to the wide increase of list price of Mf285 tractors in recent years in Iran.

Table 1. The economic life of MF285 tractors in varies regions of Iran

Useful life of MF285 tractor		Study region	researcher
year	hours		
13	13000	Whole of Iran	MEC
-	14800	Tehran province	Sharifi (1994)
-	13296	Parsabad Agro-industry Co.	Taheri (1998)
8	11554	Dashte-Naz Agro-industry Co.	Ashtiani (2005)
20	18000	Isfahan Province	Khoubakht (2008)

The aim of this study is to provide a statically analysis on constant and variable costs for MF285 tractor in order to present the best time for replacing tractor. Determining economical life for farm machinery provides planners and policy makers and also farmers an opportunity to evaluate the performance of machinery economic.

Material and methods

Study area

Debal Khazaei Agro-Industry Co. is located in 25 kilometers south of Ahvaz in Iran. Arable lands of this company are located in 31° to 31°10′S latitude and 45° to 48°36′E longitude. This region has dry and warm climate. Soil of this region is heavy and semi-heavy and each farm size is 25 ha in regular forms. Totally, 65 tractors model MF285, 20 tractors model MF399 and 15 tractors model MF8160 are used in this company. These tractors are operated in implementing of sugar cane harvesting and transportation of slip. Reports of service and maintenance of tractors have been recorded since 10 years ago. These reports were available and ready to be studied.

Machinery costs

Machinery costs are divided into two categories, fixed costs and variable costs. Variable costs increase proportionally with the amount of operational use given to the machine, while fixed costs are independent of use. It is not always clear as to which category some of the specific costs belong. The costs of interest on the machinery investment, taxes, housing and insurance are dependent on calendar-year time and are clearly independent of use. The costs of fuel, lubrication, daily service and maintenance, power and labor are clearly cost associated with use. The two remaining cost items, depreciation and the cost of repairing, seem to be functions of both use and time. There are no personal property taxes and insurance in Iran. Also, insurance of farm machinery is not popular and the farmers accept the risk of sudden costs. Housing for the mentioned tractors is the campus of maintenance unit of Agro-industry Co. and has not any considerable cost. Therefore, only depreciation and interest on investment were investigated in this research.

Estimation of yearly costs is adequate for determining crop production costs and for deciding if machine ownership is profitable; but the time of replacement depends on the accumulated costs over a period of years. Figure 2 compares yearly costs and accumulated costs during the life of a machine. The costs in Fig. 2 need to include only depreciation, interest on investment and R&M, as all other costs are assumed to be independent of the time of replacement.

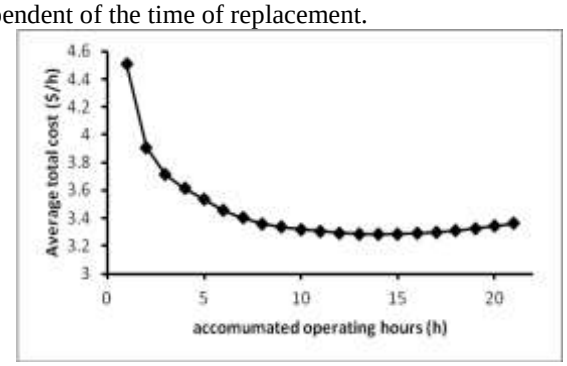

Fig. 2 Average total costs for MF285 tractor

Depreciation

Depreciation is a cost resulting from wear, obsolescence, and age of a machine. The degree of mechanical wear may cause the value of a particular machine to be somewhat above or below the average value for similar machines when it is traded or sold. Introduction of new technology or a major design change may make an older machine suddenly obsolete, causing a sharp decline in its remaining value. But age and accumulated hours of use usually are the most important factors in determining the remaining value (V) of a machine at any time.

In this study, declining-balance method was used to calculate depreciation for the mentioned tractors. A uniform rate is applied each year to the remaining value (includes salvage value) of the machine at the beginning of the year. The depreciation amount is different for each year of the machine´s life. Equations 1, 2 and 3 express the relationships by formulas.

$$D = V_n - V_{n+1} \quad (1)$$

$$V_n = P\left(1 - \frac{x}{L}\right)^n \quad (2)$$

$$V_{n+1} = P\left(1 - \frac{x}{L}\right)^{n+1} \quad (3)$$

Where: D (Depreciation), is amount of depreciation charged for year n+1, n, is a number representing age of the machine in years at beginning of year in question, V, is remaining value at any time and x, is ratio of depreciation rate used to that of straight-line method (x may has any value between 1 and 2). If x = 2, the method is called a double-declining-balance method and is the maximum rate method permitted by the IRS[1]. For tractors model MF285, the rate value was x = 1.5.

Interest on Investment

The interest on investment in a farm machine is included in operational cost estimates. Even if the investment money is not actually borrowed, a charge is made since that money cannot be used for some other interest-paying enterprise. Nominal interest

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rates include expected inflation. In times of substantial monetary inflation, a machinery manager must include the effects of inflation on machinery planning. Inflation causes increased prices for goods and services in future years.

The real interest rate, I_r , is a function of the nominal interest rate, I_p and the rate of inflation, I_g, as shown in Eq. 4.

$$I_r = \frac{I_p + I_g}{1 + I_g} \quad (4)$$

Therefore the interest on investment was calculated by using Eq. 5

$$In = V_n . I_r \quad (5)$$

Where, *In* is the interest on investment in n-th year ($) and I_r is the real interest rate.

Repair

This study was carried out in Debal Khazaei Agro-Industry Co. in south region of Iran. Data were collected from 60 MF285 tractors operated in the company by using reports of service and maintenance form. The service and maintenance reports had different information such as tractors entree and exit from shooting gallery, type of tractor failure, replaced and repaired parts.

The mean working hours per year were obtained, separately, for each year, after stratifying service reports. Also, for each year, the mean annual repair and maintenance costs were separately calculated. Repair costs are the expenditures for parts and labor for, 1: installing replacement parts after a part failure and 2: reconditioning renewable parts as a result of wear. The anticipated annual cost of repair for any machine is highly uncertain.

To determine time of replacement for the study tractors, accumulated depreciation, interest on investment and repair costs were calculated and then, regression analysis was performed on the data by using computer software SPSS 16.0 (version 2009).

Results and Discussion

Accumulated depreciation, interest on investment, repair and total costs for the tractors operated in Debal Khazaei Agro-Industry Co. are presented in Table 2.

One of the difficulties in analyzing machinery costs is that they change over time. Depreciation, often the largest cost of farm machinery, measures the amount by which the values of a machine decrease with the passage of time whether used or not. As it is seen in Table 2, depreciation tends to be great at first, especially for a new machine, but declines over time.

Likewise, interest expends is high initially but gradually diminishes. This is true whether the interest cost is cash interest paid on a loam, or an opportunity cost based on revenue foregone by continuing to own a machine year after year.

On the other hand, repair costs may amount to little or nothing when a machine is still under warranty, maintenance requirement rise. Accumulated operating hours, total accumulated costs and also average total costs are presented in Table 3. As it is seen in the table, average total costs in 14th year (9985 hours usage) drop to their lowest value.

Table 2. Accumulated costs for Mf285 tractor

Age	Accumulated repair cost	Accumulated depreciation cost	Accumulated interest on investment cost	Total accumulated cost
(year)	($)	($)	($)	($)
1	103	1357	703	2163
2	224	2299	1354	3877
3	418	3170	1955	5543
4	678	3976	2512	7165
5	1014	4721	3027	8762
6	1442	5411	3503	10356
7	1940	6049	3943	11932
8	2521	6639	4351	13510
9	3148	7184	4728	15060
10	3834	7689	5076	16599
11	4615	8156	5399	18169
12	5470	8588	5697	19754
13	6398	8987	5973	21358
14	7400	9357	6228	22984
15	8475	9699	6464	24637
16	9624	10015	6682	26321
17	10846	10307	6884	28037
18	12141	10578	7071	29790
19	13510	10828	7244	31582
20	14952	11059	7404	33416
21	16468	11273	7552	35293

The average total costs was obtained through an equation of quadratic ($y = 4.415 + 3.834E\text{-}8\ x^2$) with a correlation coefficient $R^2 = 0.89$ for MF285 tractors. As it is shown in the Figure 2, the first year´s costs are high due to the very real marketplace depreciation obtained from the estimate value method. The yearly costs drop to their lowest value (14th year) and then begin to rise if the annual repair costs increase with age. The accumulate cost curve drops more gradually and levels out at the point where it crosses the yearly cost curve.

Regarding to other studies in Iran, the appropriate time for replacement of the MF285 tractors was less than the others based on hours of use (6981 hours) and was approximately similar to other studies based on years of tractor life (14 years) and the minimum average total cost was 3.284 dollars per hectare. Annual operating hours for the mentioned tractors in this study were less than the others. As shown in Table 3, the annual hours of tractor usage were about 500 hours in each year. This means that, the R&M costs for each year was little in this study but the amount of depreciation and interest costs were equal to the other studies. These costs (depreciation and interest costs) are affected by list price of tractors (P in the Eq. 2 and 3) and aren't depended on the hours of tractor operation in each year. Therefore, the effective factor affecting the appropriate year of tractor replacement, are the depreciation and interest costs and the other factor which affects the appropriate hours of tractor usage is R&M cost. It is concluded that the useful life of farm tractors depends on intensity of R&M cost and the amount of depreciation and interest costs. Whatever the intensity of R&M cost is greater, the useful life will be sooner and whatever

the depreciation and interest costs is more, the useful life of tractors will be forced to later. In other words, the amount of R&M costs doesn't effect on the tractor replacement point however, intensity of increase in R&M costs in the recent years greatly affects on determination of the useful time.

Table 3.

Operating hours and cost for MF285 tractor

Average total cost	Total accumulated cost	Accumulate operating hours	Annual operating hours	Age
($/h)	($)	(h)	(h)	(year)
4.507	2789	480	480	1
3.908	5235	992	512	2
3.713	7328	1493	501	3
3.615	9200	1982	489	4
3.534	10903	2479	497	5
3.454	12491	2998	519	6
3.401	13972	3508	510	7
3.358	15385	4023	515	8
3.336	16719	4515	492	9
3.321	18002	4998	483	10
3.305	19260	5479	481	11
3.293	20543	5981	502	12
3.287	21846	6489	508	13
3.284	23136	6981	492	14
3.286	24462	7479	498	15
3.291	25816	7975	496	16
3.299	27179	8459	484	17
3.311	28639	8965	506	18
3.325	30177	9481	516	19
3.342	31738	9985	504	20
3.362	33331	10481	496	21

The standard rule for minimizing the long-run cost of equipment is to make a change when the annualized total cost of owning and operating the machine begins to increase. In the study, this happens in about the 14th year of ownership. At this point repair costs begin to increase faster than depreciation and interest costs decrease. However, the rate at which total costs rise is often very gradual. Thus, while the rule of increasing total cost can give a general picture of period to replace a particular machine, it cannot give a precise answer.

Conclusions

The appropriate time for replacement of MF285 tractors operated in Debal Khazaei Agro-Industry Co. in Khuzestan province of Iran based on economic analysis is about 14 years with 6981 hours operation.

The interest and depreciation costs affect on the year of tractor replacement and R&M costs determine the amount of tractor economical usage.

References

Anderson AW. Factors affecting machinery costs in grain production, ASAE Paper. 1988. No. 88-1057.

ASAE Standards S495. Uniform Terminology for Agricultural Machinery Management. 2006.

ASAE Standards EP496. Agricultural Machinery Management Engineering Practice. 2006.

Ashtiani AR, Ranjbar I, Toorchi M. Determining the economic life for three agricultural tractor models in Iran (Case Study: Mazandaran Dasht-e-Naz Farm Company), Journal of Agricultural Sciences, Islamic Azad University.2005. 12(1): 221-230.

Bowers W, Hunt DR. Application of mathematical formulas to repair cost data. Transactions of the ASAE. 1970. 13(6): 806-9.

Fairbanks GE, Larson GH, Chung DS. Cost of using farm machinery. Transactions of the ASAE. 1971. 14(1): 98-101.

Farrow S, Shepherd JF, Waelti H. A regional test of machinery repair cost equations.

ASAE Paper. 1980. No. 80-1017.

Gliem JA, Stinson DM, Carpenter TG, Holmes RG, Ozcan HE. Updated variable costs of farm machinery operation in Ohaio, ASAE paper. 1986. No. 86-1024.

Gliem JA, Persinger KM, Carpenter TG, Holmes RG. A comparison of ASAE estimated tractor and combine repair and maintenance costs to actual repair and maintenance costs of selected farms. ASAE paper. 1989. No. 89-1024.

Hunt DR. Farm Power and Machinery Management, Tenth Edition, Iowa State University Press, Ames. USA. 2001.

Lazarus W. Machinery cost estimates, Extension published by Department of Applied Economics, University of Minnesota. 2008.

Khoubakht GM. Determination of optimum life (economic life) for MF285 tractor, A case study in west region of Isfahan province), M.Sc. Thesis, Faculty of Agricultural Engineering and Technology, Department of Agricultural Machinery Engineering, University of Tehran, Iran.(2008).

Rotz CA. A standard model for repair costs of agricultural machinery. Appl. Engineering in Agric. 1987. 3(1): 3-9.

Rotz CA, Bowers W. Repair and maintenance cost data for agricultural equipment. ASAE Paper. 1991. No. 91-1531.

Singh G. Estimation of a mechanization index and its impact on production and economic factors, A case study in India, Biosystems Engineering. 2006. 93(1): 99-106.

Singh G. Modernization of agriculture in India (part I)—farm mechanisation. Agricultural Situation in India. 2006.

Gifford RC, Rijk AG. Guidelines for Ministry of Agriculture, New Delhi. agricultural mechanisation strategy in development. Economic and Social Commission for Asia and the Pacific (ESCAP), Regional Network for Agril. Machinery. 1980.

Sharifi A. Determination of a mathematical model to predict the repair and maintenance cost of three models of farm tractors in Iran, M.Sc. Thesis, Faculty of Agricultural Engineering and Technology, Department of Agricultural Machinery Engineering, University of Tehran, Iran. (1994).

Singh G. Data book on mechanization and agro processing in India after independence. Technical Bulletin CIAE/97/71, Central Institute of Agricultural Engineering, Nabi Bagh, Berasia Road, Bhopal, India. 1997.

Singh G, Chandra H. Production and economic factors growth in Indian agriculture, Technical Bulletin No. CIAE/ 2002/91, Central Institute of Agricultural Engineering, Nabi Bagh, Berasia Road, Bhopal, India. 2002.

Singh RB. Environmental consequences of agricultural development: a case study from the Green Revolution state of Haryana, India. Agriculture, Ecosystems and Environ. 2000. 82: 97-103.

Taheri MR. Determination of a mathematical model to predict the repair and maintenance cost of three models of farm tractors in Parsabad Agro-industry Co., M.Sc. Thesis, Department of

Agricultural Machinery Engineering, University of Tabriz, Iran. (1998).
Ward SM, Mcnulty PB, Cunney MB. Repair costs of 2 and 4 WD tractors. Transactions of the ASAE. 1985. 28(4): 1074-6.
Xinan D, Yuzhou L, Suocheng D, Xiusheng Y. Impact of resources and technology on farm production in northwestern China. Agril. Systems. 2005. 84: 155-169.