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Influence of Economic Indicators over the Lifetime of Agricultural Machinery

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Abstract – **Determining lifetime is a key point in the technical operation of agricultural machinery. A variety of technical and economic indicators may be used about that. The paper offers an approach for determining the lifetime of agricultural machinery on the basis of funds spent for purchasing (capital losses) and financial resources for the maintenance and repair of the equipment.**

An analysis has been made of the influence of individual economic indicators over the lifetime of machinery. It was found that the increase in inflation and the volume of production lead to a reduction of the lifetime, while increasing the initial value of the machine has no influence over the lifetime of the agricultural machinery.

Keywords – **Agricultural Equipment, Capital Losses, Economic Indicators, Inflation, Lifetime, Losses for Technical Maintenance and Repair.**

I. Introduction

Determining the lifetime of agricultural machinery is a key point in its technical operation and maintenance. Pursuant to the standard [1], developed by the American Society of agricultural engineers, equipment used in production is replaced due to: occasional break-down after which the recovery of operability is unprofitable; productivity of agricultural machinery does not comply with the requirements of production; obsolete equipment, such being the equipment this is no longer manufactured by industry and spare parts of its repair are missing; reliability of the equipment is very low (unpredictably long outage is observed to the occasional failures of various components); losses from implementing a planned repair result in an increase in the relative financial losses per unit of performance.

According to the same standard, the term lifetime of agricultural machinery measured in years, is a time interval after which the relative financial losses per unit performance calculated for the entire lifetime, reach the minimum level and begin to rise. Moreover, the part of the relative financial losses, comprising the sum total of capital losses and losses for maintenance and repair throughout the entire lifetime of the agricultural machinery.

Agricultural machines as the other machines (cars, airplanes, etc.) are technical systems and the same laws are applied to them [2], [3]. The maintenance of technical systems, the timely delivery of spare parts and repairs reflects positively on the lifetime of the technique [4]. On the other side higher cost of repair could make it unprofitable and, therefore, the machine can be removed from use. For these reasons, technical and economic aspects of the problem are usually considered together [5], [6], [7].

Is known a model for determining the optimum time for the operation of the agricultural machinery formed with the help of the theory of systems [8]. In this article offers a different method for determining the lifetime of agricultural machinery.

II. Objective

The objective of this work is to propose an approach for determining the lifetime of agricultural machinery based on relative financial losses per unit of performance and to analyze the impact of various economic indicators on the duration of the lifetime.

III. Material and Method

For working out the approach for determining the lifetime of agricultural machinery the US standards [1], [9] have been used, as well as the works [10], [11], [12] for determining same of the parameters.

Analysis has been made of the influence of various economic indicators over the lifetime of the technique. The impact of inflation, the initial value of the machines and their volume of production has been determined. For this purpose, the criteria defining the lifetime have been calculated on change of only one of the indicators and permanent values of others.

IV. Results and Discussion

As a result of the study carried out for determining the lifetime of agricultural machinery we offer the following approach:

1. Determine of the residual value of machines as of the end of the i^{th} year.

In accordance with the standard [9] the residual value of the machines is determined by the expression:

$$S_i = S_0 . A . B^i / 100 , \qquad (1)$$

where S_0 is the initial value of the machines; A, B – coefficients governed by [9] and having the value shown in Table I.

Table I: Values of the coefficients A and B for various types of agricultural machinery according to [9].

Type of agricultural machinery	A	B
Tractors	68	0.92
All kinds of harvesters	64	0.885
Self-propelled sprayers	56	0.885
Other field machines	60	0.885

Taking into account inflation α [%], formula (1) shall be the following:

$$S_i = \frac{C_0.A.B^i}{100} \cdot \left(1 + \frac{\alpha}{100}\right)^i . \qquad (2)$$

Inflation may not be taken into account if it is assumed that C_0 is the value of similar new agricultural equipment at the time of evaluation of the old available agricultural machinery of the same type.

2. Determine the decrease of value of the agricultural equipment upon revaluation at the end of the i^{th} year.

$$D_i = S_{i-1} - S_i \qquad (3)$$

3. Determine of the total decrease of the value of agricultural equipment to the end of the i^{th} year.

$$D = \sum_{i=1}^{n} D_i \, , \qquad (4)$$

4. Determine the income from use of the machinery.

At the i^{th} year of operation of agricultural machinery, the magnitude of income from the use of machinery I_i is equal to b simple percentage of the average annual capital (or of the average residual value of machinery between two successive revaluations):

$$I_i = \frac{b}{100} \cdot \frac{S_i + S_{i-1}}{2} , \qquad (5)$$

where S_i is the residual value of the machinery after revaluation at the end of the i^{th} year;

S_{i-1} – the residual value of the machinery before revaluation at the i^{th} year.

5. Determine of the total income from the use of machinery to the end of the i^{th} year.

$$I = \sum_{i=1}^{n} I_i \, . \qquad (6)$$

6. Determine capital losses resulting from the operation of agricultural machinery.

Capital losses not depend on the performance of agricultural machinery and the intensity of its use [10] and in this case they comprise losses in value of machinery in their annual revaluation due to depreciation D and losses of income with investments I:

$$C_{CL} = D + I \, . \qquad (7)$$

7. Determine the technical resource of agricultural equipment to the end of operation (measured in amount of cultivated area for a certain number of years)

$$T_R = q.i \qquad (8)$$

where q is the annual volume of production, measured in cultivated area;

i – the number of the year.

The statistical formula for the technical resource T_R to the end of operation of the agricultural machinery (in hours) followed by [10], [11]:

$$T_R = \int_0^{T_{RR_i}} P_{FO}(\Delta t).dt, \quad h , \qquad (9)$$

where $P_{FO}(\Delta t)$ is the probability of flawless operation of the relevant agricultural machine for specific observed times Δt for which statistical information has been collected;

T_{RRi} – the time interval for i^{th} major and routine repairs of agricultural machinery.

The probability of flawless work $P_{FO}(\Delta t)$ of the relevant agricultural machine is determined by the formula [10], [11]:

$$P_{FO}(\Delta t) = \exp\left[-\int_0^{T_R} \omega(t).dt \right] , \qquad (10)$$

where $\omega(t)$ is the intensity of the flow of failures of the agricultural equipment measured in *fault/h*.

8. Determine the losses from route maintenance and repair.

According to [1], the dependence of accumulated financial losses for technical maintenance and repair C_{MR} from the time of use of the machinery for the entire technical resource to the end of operation has the form:

$$C_{MR} = S_0.m(T_R / 10^3)^l , \qquad (11)$$

where S_0 is the initial value of machinery;

m, l – parameters of the regression equation.

Equation (11) is an estimate and it is obtained as a result of the use of regression analysis in the processing of data about intensity of the flow of faults and the value of their removal for various types of agricultural machinery. Experimental values of the parameters m and l of the regression equation are shown in Table II [9].

Table II: Values of the parameters m and l for determining the losses from technical maintenance and repair.

Type of agricultural machinery	***m***	***l***
Tractors		
with two leading wheels	0.007	2.0
with four leading wheels and chains	0.003	2.0
Soil-cultivation machines		
ploughs	0.290	1.8
disc ploughs	0.180	1.7
cultivators	0.270	1.4
Grain drill	0.320	2.1
Combines harvesters		
grain harvesters	0.120	2.3
beet harvesters	0.590	1.3
Other machinery		
Fertilizer spreader	0.630	1.3
land sprayers	0.410	1.3
Air-carrier sprayer	0.200	1.6

9. Determine the lifetime of agricultural machinery.

$$C = (C_{CL} + C_{MR}) / q.i \qquad (12)$$

Lifetime of the agricultural machinery is the number of years i corresponding to the minimum value of C.

The application of the presented approach for determining the lifetime of agricultural machinery may be demonstrated by specific calculation for ploughing. The calculation for determining the lifetime is shown in Table III for b = 8 % and plough Vogel & Noot MS 950 with an initial value of 13000 € with annual cultivation of 200 hectares per year, i.e. q = 200 *ha/year*.

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Table III. Results of sample calculation of the lifetime

i	S_i	D_i	D	I_i	I	C_{CL}	$i.q$	C_{MR}	C
1	6903	6097	6097	796.1	796.1	6893.1	200	208.06	35.5
2	6109.2	793.8	6890.8	520.5	1316.6	8207.4	400	724.52	22.33
3	5406.6	702.6	7593.4	460.6	1777.2	9370.6	600	1503.19	18.12
4	4784.8	621.8	8215.2	407.7	2184.9	10400.1	800	2522.92	16.15
5	4234.6	550.2	8765.4	360.8	2545.7	11311.1	1000	3770	15.08
6	3747.6	487	9252.4	319.3	2865	12117.4	1200	5234.41	14.46
7	3316.6	431	9683.4	282.6	3147.6	12831	1400	6908.31	14.1
8	2935.2	381.4	10064.8	250.1	3397.7	13462.5	1600	8785.31	13.9
9	2597.7	337.5	10402.3	221.3	3619	14021.3	1800	10860.05	13.823
10	2298.9	298.8	10701.1	195.9	3814.9	14516	2000	13127.9	13.822
11	2034.6	264.9	10966	173.3	3988.2	14954.2	2200	15584.83	13.88

Table III shows that the lifetime of the plough is 10 years, because $i = 10$ corresponds to the minimum financial losses made for ploughing 1 hectare of land. The results of Table III are presented graphically in Fig. 1. The column with different color shows the duration of the lifetime – 10 years.

The impact of inflation is determined by calculation of the indicator C with average annual inflation of 2 % and keeping the value of the remaining indicators. The result is shown in Fig. 2. It appears that the lifetime of the technique is less – 9 years. This is due to the increase of the capital losses C_{CL} in using of the technique as a result of the increase in inflation.

The impact of the annual volume of production is determined by the adoption of a higher value of the annual production of the machine – 250 ha/year and keeping the other parameters. The result is shown in Fig. 3. The greater load on the machine leads to a reduction of the lifetime of seven years. The reason for this is the rapid rise in the cost of maintenance and repair C_{MR}.

The influence of the initial value of the machine on the lifetime is determined by a higher initial value of the machine – 20000 € and keeping the values of other parameters. The results in Fig. 4 show that the lifetime of the machinery is 10 years, same as with an initial value of 13000 € (Fig. 1). Therefore, the initial value of the machine does not affect the lifetime. The value of the indicator C is changing – growing with the increase of the initial value, but trend in his amendment is retained.

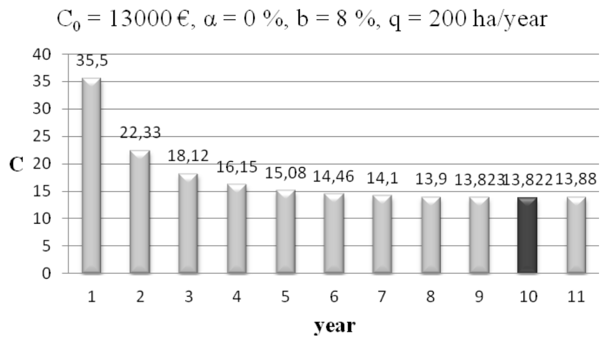

Fig.1. Determine of the lifetime of agricultural machinery with certain economic parameters.

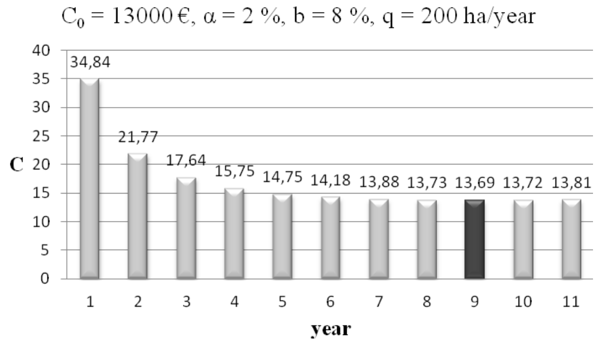

Fig.2. Influence of the inflation on the lifetime of agricultural machinery.

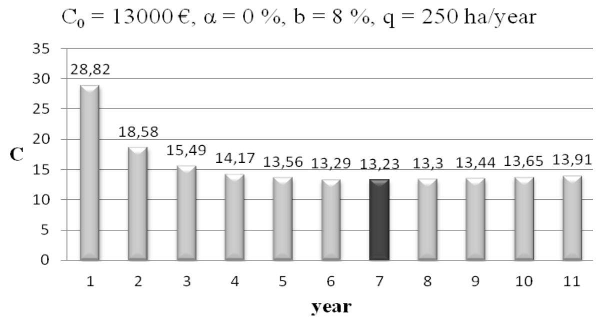

Fig.3. Influence of the annual volume of production on the lifetime of agricultural machinery.

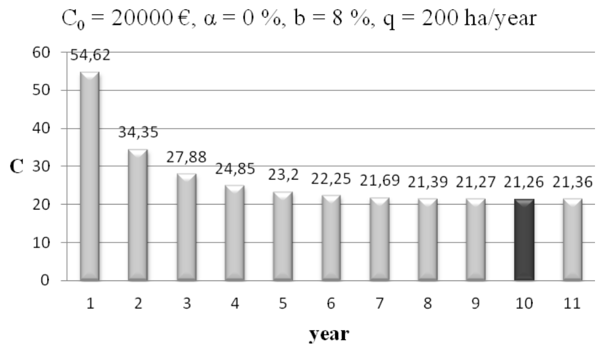

Fig.4. Influence of the initial value of the machine on the lifetime of agricultural machinery.

The indicator C which determines the lifetime of machinery includes capital costs C_{CL}, the cost of maintenance and repair C_{MR} and the technical resource of agricultural equipment ($i.q$). For its part the cost of maintenance and repair also depends on the technical resource (11) which includes the annual volume of production (annual load) q. From Fig. 1, 2, 3 and 4 may be noted that the determining factor for the current value of the lifetime of an agricultural machine is the annual load of the machine as a technical system by its users.

V. Conclusion

It was found that the increase of inflation decreases the duration of lifetime of the technique, due to increasing capital losses in its use. The increase of the annual volume of production of agricultural machine leads to a reduction of lifetime, due to the rapid increase of the cost of maintenance and repair. The initial value of the machine does not affect the lifetime.

With this work, the authors consider that the described approach for determining the lifetime of machinery by the economic indicators is realizable and applicable to the conditions of the industry "Agriculture" in the country.

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Author's Profile

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In 2007 he was awarded Professor of the Trakia University on specialty „Atomized Systems for Treatment of Information and Control". He has more than 400 scientific works, publications and developments, 100 of which – abroad. He has published 35 scientific books and textbooks, 15 of which – monographs.
On 29 September 2009 he is chosen as Professor at Technical University, Sofia. On 29.07.2011 he was awarded a diploma for specialization "Philosophy of natural science problems" in the University "Prof. D-r Asen Zlatarov", Burgas. In 2012, during his participation in the Contest for academician correspondent of Academic corresponding member of the Bulgarian Academy of Sciences he was ranked sixth place.
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