Influence of using time of selected agricultural machines and tractors on residual market price, repair costs, and annual utilisation

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Abstract: For each new machine designed operational parameters exist and the realisation of these parameters determines the ability to perform the operations which it is designed for. It was proved both technically and practically that there is an impact of the using time of machines on the level of realisation of the operational parameters. Based on a selective the statistic survey, the impact is analysed in the article of the using time of selected agricultural machines and tractors on the residual market price, repair costs, and the trend of annual utilisation. The outcome is a functional dependency of decreased residual market price, the growth of repair costs, and the trend of annual utilisation. The changes are presented by means of the proportions to the designed parameters and the outcomes can be used for the calculation of operational costs of the machines.

Keywords: using time; market price; annual utilisation; repair costs; changes of parameters; agricultural machines

For each new machine operational parameters are planned and the level of their realisation determines the attributes for the performance designed (Abrhám *et al.* 2002). It was proved that both technically (Legát *et al.* 1996; Edwards 2001) and practically (Jehlička 1997) an impact exists of the using time of the machines on the level of the realisation of the operational parameters. The impact is analysed in the article of the using time of selected agricultural machines and tractors on the residual market price, repairs costs, and annual use based on a selective statistic survey.

METHODOLOGY

The methodology is based on the selective statistical survey focused on finding relevant operational parameters of agricultural machines and tractors in 17 agricultural companies. In accordance with the types of agricultural machines and tractors, the following operational parameters were surveyed:

– Year of purchase
– Operational age (year)
– Purchasing price (CZK)
– Residual market price (CZK)
– Cumulative repair costs (CZK)
– Cumulative utilisation (ha,Mth)

The machines were encoded in KDSXTT structure where:

K	– specification of the category
KD	– specification of the kind
KDS	– specification of the group
KDSX	– specification of the class
KDSXTT	– specification of the type (complete code of the machine)

Operational parameters were identified with 258 machines and tractors. In total 51 machines and tractors were excluded from this figure due to their using time of eight years. The remaining 207 machines and tractors were divided in 42 classes, 7 types, and 3 categories. Each machine code for the plant production (see also PP) was furthermore completed with the parameter „specification of the type", which allowed the classification by the so called complexity.

The graphs were created from the identified values of the operational parameters using the application

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of the method of statistical analysis (Cyhelský *et al.* 1996; Hair *et al.* 2005), i.e.:

(1) The source data in the graph of the development of the residual market price as the function of the using time expressed in % of purchasing price were interlaid with the line of trend at which the value was set of parameters of approximate function using the method of the smallest squares. The method of the smallest squares consists in minimisation of the residual function, respectively in minimisation of the summed $2n$ power of all residuals (vertical variances of the measured values and the values of approximate function). For the evaluation of approximate quality (interlay) the infallibility coefficient R^2 can be used whose value varies in the interval of $\in < 0;1 >$ (approximation is the best at values approaching $R^2 = 1$). From the presented equation of regressive line is it possible to predict with certain accuracy the development of the residual market price based on the knowledge of age of the machine and the purchasing price.

(2) The source data in the graph of the development of cumulative repair costs were, as in the step above, interlaid with the line of trend at which value was set of parameters of approximate function using the method of the smallest squares, and for the evaluation of approximate quality the infallibility coefficient R^2 was represented. In the case that the infallibility coefficient showed a higher statistical significance, for each year of using the machines the theoretical values was additionally calculated of the development of cumulative repair costs in each year in compliance with the equation of the regressive line of cumulative repair costs. These calculated values were used for setting the annual repair costs.

(3) The graph of the development of annual repair costs as the function of using time was created based on the calculated values of the developed cumulative costs. The annual repair costs consist of the difference of the cumulative repair costs in the year monitored and the cumulative repair cost from the previous year. The graph was created from the calculated values of annual costs whose axis x is the using time. The data line was interlaid with the line of trend and the value of the parameters of the approximate function was determined. The infallibility coefficient R^2 was represented as in the evaluation of approximation quality.

(4) The processing of the values of the cumulative use was followed by the determination of the development of annual utilisation of machines. Based on these values, a graph was created whose data line was interlaid with the line of trend and as in the above mentioned case the values were determined of the parameters of approximation function and infallibility coefficient R^2. In the case that the infallibility coefficient showed a higher statistical significance, a theoretical development of annual utilisation was calculated for each year of using the machines according to the time of use based on the equation of regressive line of cumulative utilisation.

The statistical analysis of the identified values of the operational parameters was in compliance with the principals of statistical significance determination (Cyhelský *et al.* 1996). Due to the insufficient volume of the source data, the evaluation according to types could not be realised while in the case of classes only the statistically significant set of tractors with a power over 120 kW could be evaluated (see Figure 1 to 4 and Table 1). The changes of the residual market price and repair costs caused by the using time are set by the proportion of the purchasing price, and the changes of annual utilisation are set by the proportion against the maximum of the average value which allows the definition of conclusions also for non-homogeneous groups of machines (by kinds and complexity).

RESULTS AND DISCUSSION

The results of the selective statistical survey are the functional dependencies of the decrease of the residual market price of the machines monitored, the increase of the repair costs, and the changes of annual utilisation. The resulting dependencies are stated in the following order:

(1) By classes:
   – Wheel tractors (4 × 4) over 120 kW

(2) By kinds:
   – Wheel tractors
   – Harvest machines
   – Soil treatment and cultivation machines

(3) By complexity:
   – Machines for the plant production with own power source (self-moving harvesters, cutters, and sprinklers)
   – Machines for the plant production complex (seeders, spreaders, reapers, appended sprinklers and cutters, presses, semi trailers, roll up presses, harvesting machines for potatoes)
   – Machines for the plant production simple (tools with passive work bodies)

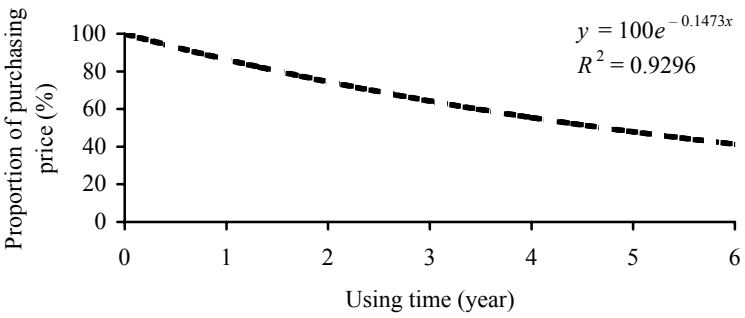

Figure 1. Development of market price as the function of using time of wheel tractors (4 × 4) over 120 kW

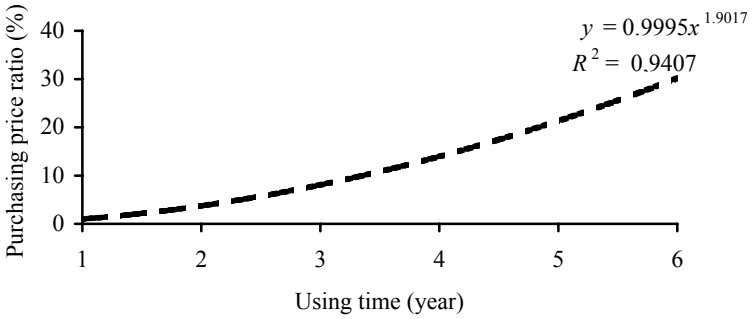

Figure 2. Development of cumulative repair costs in a function of using time of wheel tractors (4 × 4) over 120 kW

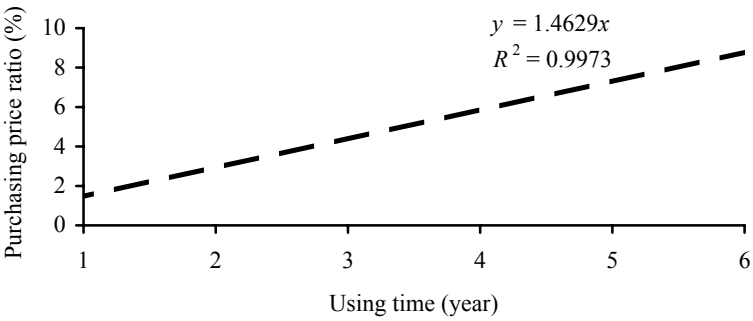

Figure 3. Development of annual repair costs as the function of using time of wheel tractors (4 × 4) over 120 kW

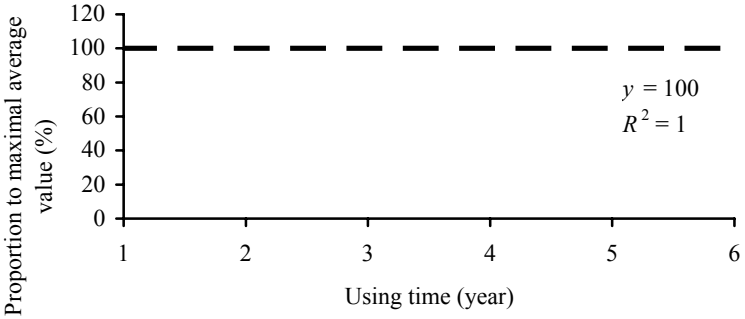

Figure 4. Development of annual utilisation as the function of using time of wheel tractors (4 × 4) over 120 kW

Wheel tractors (4 × 4) over 120 kW

The residual market price has a decreasing tendency (Figure 1 and Table 1) which complies best with the exponential type of regressive trend. The exponential type of the curve of regressive trend has in this case the value $R^2 = 0.9296$, which represents a significantly high value to allow the prediction that the trend line has a significant dependency on the calculated values. From Table 1 is it obvious that in 1st year of use the machines lost as much as 14% of the purchasing price. Further decrease of the residual market price has a digressive character and based on the calculated values, the after 6 years of using the wheel tractors (4 × 4) over 120 kW have about 40% residual price of the purchasing price.

Cumulative repair costs have a growing tendency (Figure 2 and Table 1). The power type of the regressive trend curve has in this case the infallibility value $R^2 = 0.9407$. It can be said from this indicator that

Table 1. Development of surveyed parameters of wheel tractors (4 × 4) over 120 kW (in %)

Operational time	Year					
	1	2	3	4	5	6
Residual market price of the purchasing price	86	74	64	55	48	41
Development of cumulative repair costs	1	4	8	14	21	30
Development of annual repair costs	1	3	4	6	7	9

Table 2. Development of surveyed parameters of machines by kinds (in %)

Operational time	Year					
	1	2	3	4	5	6
Residual market price of purchasing price						
Wheel tractors	86	74	64	55	48	41
Machines for soil treatment and growth cultivation	88	78	69	61	54	47
Harvest machines	85	72	61	52	44	37
Development of cumulative repair costs						
Wheel tractors	1	4	8	14	22	30
Machines for soil treatment and growth cultivation	0	2	6	12	20	30
Harvest machines	1	4	8	14	22	31
Development of annual repair costs						
Wheel tractors	1	3	4	6	7	9
Machines for soil treatment and growth cultivation	0	2	4	6	8	11
Harvest machines	1	3	4	6	8	9

the trend line has a significant dependency on the calculated quantities.

Annual repair costs (Figure 3 and Table 1) have a linearly growing trend, namely from 1% of the purchasing price in the first year of using up to 9% in the sixth year of use. The format of the trend line of the graph of annual repair cost development as the function of the using time is of linear type with the infallibility value R^2 = 0.9973, which represents a statistically significant dependency between the source data and the trend line chosen.

The annual utilisation has an invariable linear tendency (Figure 4).

Machines by kinds

The data for total 7 kinds of machines were gained by a statistical survey: (1) Wheel tractors, (2) Soil treatment and plant cultivation machines, (3) Sowing and planting machines, (4) Fertilisation, protection, and watering machines, (5) Harvesting machines, (6) Tractor semi trailers and container carriers, (7) Loaders and unloaders. The evaluation was done with three kinds of machines. From the group of seven kinds, the following were excluded due to an insufficient number in each year of using: tractor semi trailers and container carriers, loaders and unloaders, and sowing and planting machines. Due to a low infallibility value R^2, which did not express enough values to estimate if the trend line had a significant dependency on the calculated values, the results are not presented for the fertilisation, protection, and watering machines.

The residual market price has with all three kinds a decreasing tendency (Figure 5 and Table 2) on the basis of the exponential type of regressive trend. The infallibility values of the chosen trends were with Wheel tractors R^2 = 0.9405, with the kinds Soil treatment and plant cultivation machines and Harvesting machines R^2 = 0.9. From Table 2 it is obvious that already in 1st year of use the machines lost 12–15% of purchasing price. The course of the decrease of the residual market price had a digressive character and after 6 years of use the residual price ranges between 37–47% of the purchasing price. The lowest price decrease after 6 years is shown with Soil treatment and plant cultivation machines.

Cumulative repair costs (Figure 6 and Table 2) have a growing tendency. As the most appropriate type of regressive trend, the power type was chosen for

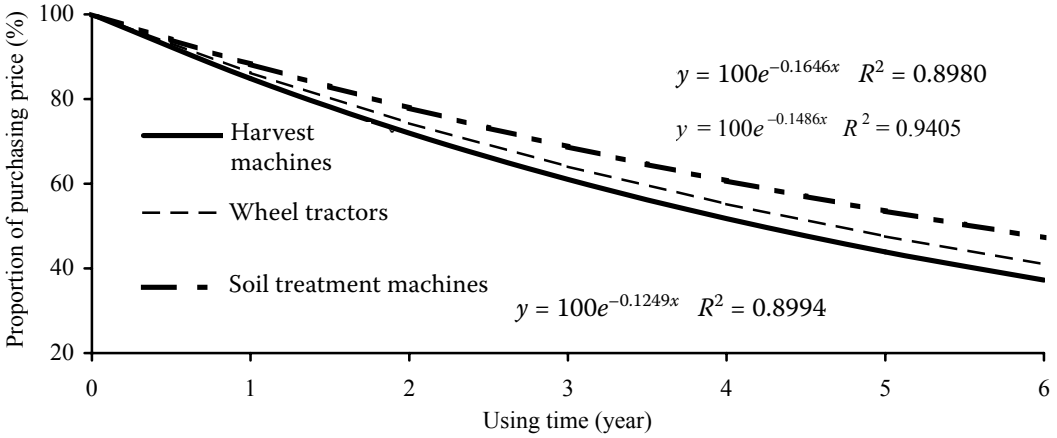

Figure 5. Development of market price as the function of using time of machines by kinds

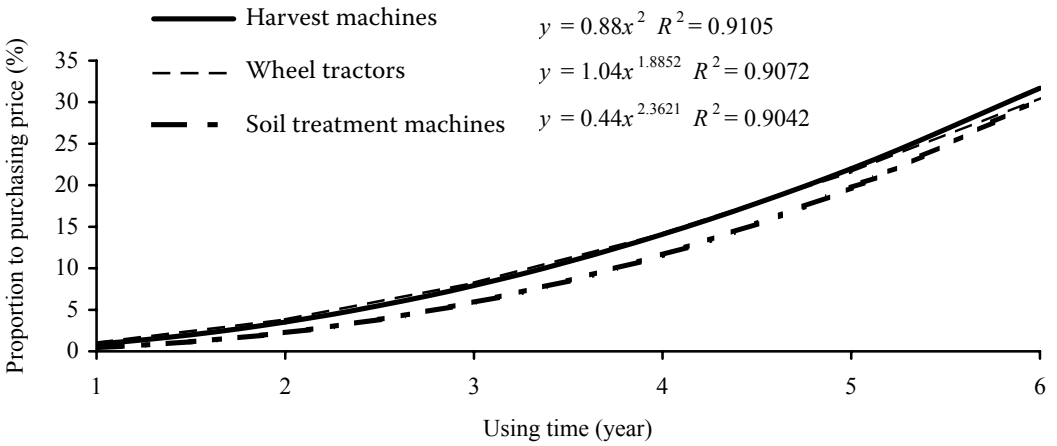

Figure 6. Development of cumulative repair costs as the function of using time of machines by kinds

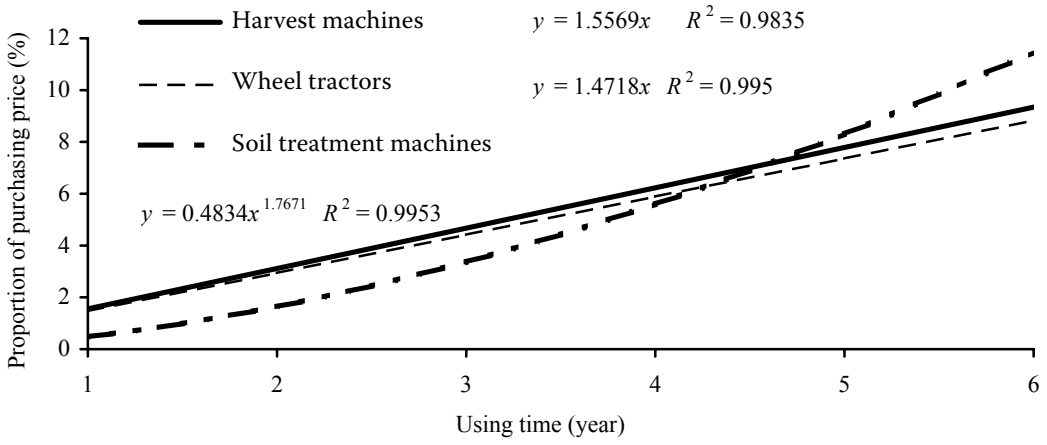

Figure 7. Development of annual repair costs as the function of using time of machines by kinds

all three kinds. The infallibility value R^2 was in all groups around 0.9.

Annual repair costs (Figure 7 and Table 2) have a growing tendency. For Wheel tractors and harvesting machines it revealed the linear trend, for Soil treatment and plant cultivation machines the power trend. Infallibility value R^2 was in all kinds close to 1.

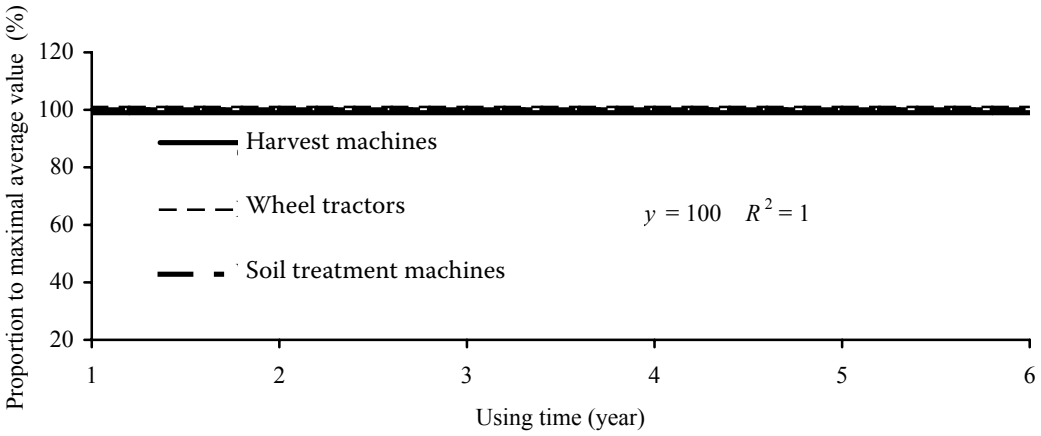

Figure 8. Development of annual utilisation as the function of using time of machines by kinds

The annual utilisation has an invariable linear tendency (Figure 8).

Machines by complexity

The residual market price (Figure 9 and Table 3) has in all groups a decreasing tendency and the exponential type of regressive trend. The infallibility values of the chosen trends are in the group Machines for plant production with own power source R^2 = 0.949, in the group Machines for plant production complex R^2 = 0.9256, and in the group Machines for plant production simple R^2 = 0.8994. The course of the decrease of the residual market price has a digressive character and after 6 years of use the residual price in each group is in the range of 39–47% of the purchasing price. The highest price decrease after 6 years of use is shown in the group of Machines for plant production with own power source.

Cumulative repair costs (Figure 10 and Table 3) have a growing tendency. As the most appropriate type of regressive trend, for all groups power type was chosen. In the group Machines for plant production with own power source, the infallibility value is equal to R^2 = 0.9779, in the groups Machines for plant production complex and Machines for plant production simple the infallibility values of the chosen regressive trend are R^2 = 0.8486 a R^2 = 0.9042, respectively. In all three evaluated groups the infallibility values testify a significant dependency between the regressive trend chosen and the input data.

Annual repair costs (Figure 11 and Table 3) have a growing tendency. The most appropriate trend for the group Machines for plant production complex was the logarithmic type of the trend line, and in

Table 3. Development of surveyed parameters of machines by complexity (PP – plant production) (in %)

Operational time	Year					
	1	2	3	4	5	6
Residual market price of purchasing price						
Machines for PP with own power source	85	73	62	53	45	39
Machines for PP complex	86	74	63	54	46	40
Machines for PP simple	88	78	69	61	54	47
Development of cumulative repair costs						
Machines for PP with own power source	1	5	11	19	30	44
Machines for PP complex	4	9	14	19	25	31
Machines for PP simple	0	2	6	12	20	30
Development of annual repair costs						
Machines for PP with own power source	1	4	6	8	11	14
Machines for PP complex	4	5	5	5	6	6
Machines for PP simple	0	2	4	6	8	11

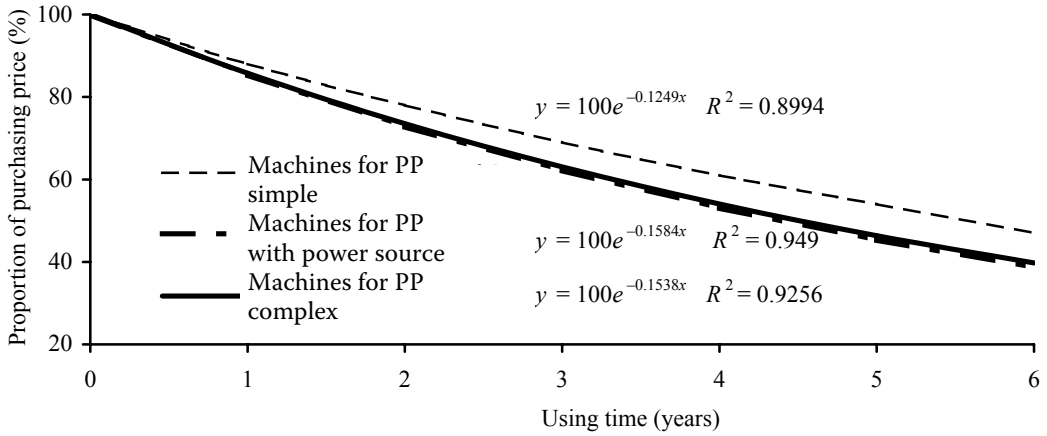

Figure 9. Development of market price as the function of using time of machines by complexity (PP – plant production)

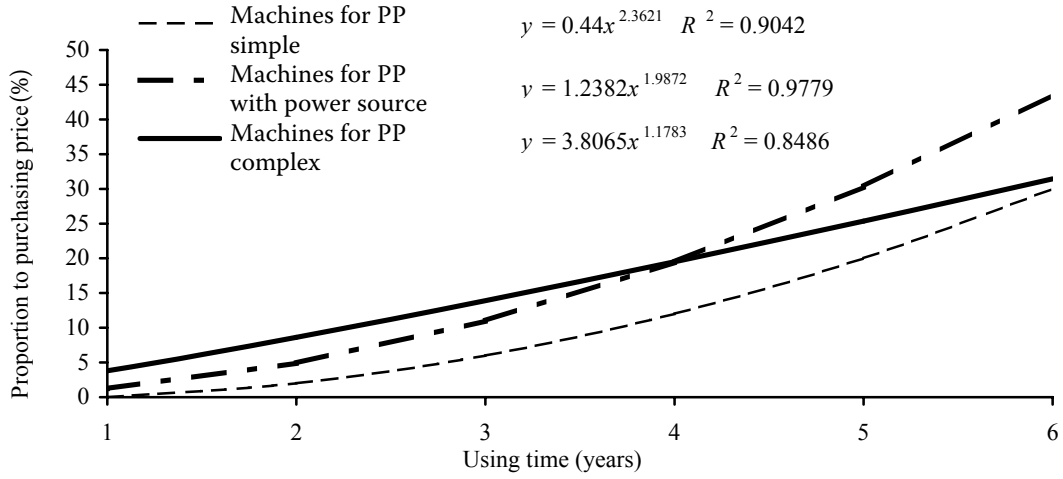

Figure 10. Development of cumulative repair costs as the function of using time of machines by complexity (PP – plant production)

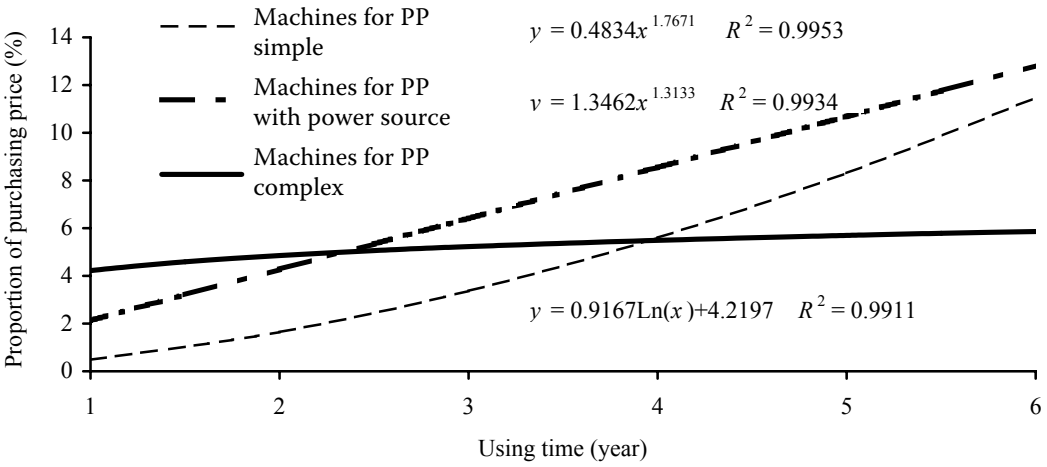

Figure 11. Development of annual repair costs as the function of using time of machines by complexity (PP – plant production)

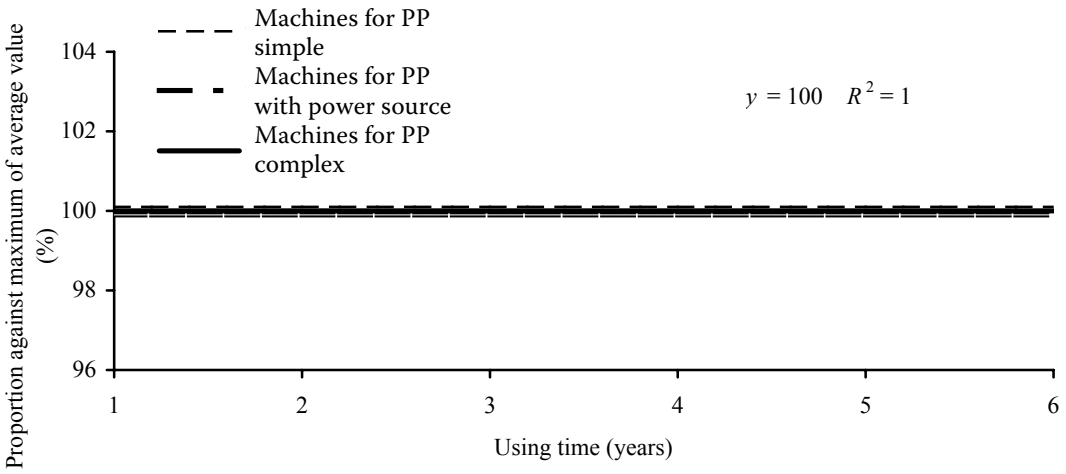

Figure 12. Development of annual utilisation as the function of using time of machines by complexity (PP – plant production)

the groups Machines for PP with own power source and Machines for plant production simple it was the power type of the trend line. The infallibility values were with all three groups nearly $R^2 = 1$.

The annual utilisation has an invariable linear tendency (Figure 12).

CONCLUSIONS

The results presented in Tables 1 to 3 could be used in the calculations of the operational costs of the machines compared. They can be especially used for the calculation of the amortisation costs, own capital increase, and repair costs. The following conclusions can be also expressed:

Market residual price as the function of using time

The development of the market residual prices in all groups of machines identified has a regressive character as it was assumed. The residual market price was in all identified groups in the fourth year of use in the range of 50–60% of the purchasing price.

Cumulative repair costs as the function of using time

Cumulative repair costs as the function of using time increase by gradual additions of repair costs during the using time of the machine. The rate of the cost increase and the initial and final values are dependent on the quality of the identified machines. In the sixth year of use, the cumulative repair costs in the groups classified by classes, types, and complexity achieve values in the range of 30–44% of the purchasing price of the respective machines which, considering the purchasing price means a significant financial amount.

Annual repair costs as the function of using time

Annual repair costs as the function of the using time have a growing tendency. The rate of the growth and the initial and final costs values are dependent only on the character of the groups divided by classes, types, machines categories, and complexity. For some groups of machines, for example, this growth is gradual after certain time and the differences in the annual costs of three-year-old machine and six-year-old machine do not exceed 1% of the purchasing price (machines classified by complexity Machines for plant production complex). The reason for the almost constant development of annual repair costs after this time of using is most probably the invariable workload of the same machine parts at constant annual utilisation. After-seasonal repairs equalise the costs differences invested into the repairs of newer and older machines. Further reason can reside in a drop of the prices of spare parts that can be obtained from older non-working machines, in a longer time interval. This possibility is most probably used, with obsolete machines that are being replaced by new ones.

Annual utilisation as the function of using time

The estimated course of annual utilisation as the function of the using time should have a gradual

decreasing tendency. However, the results show a linear type of the trend line with an unchangeable course. This is given by the fact that the time of use of up to 6 years was considered. Hypothetically, it can be assumed that after this time the annual utilisation will drop, which was identified in a work by Jehlička (1997).

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Abstrakt

Sailer J., Kavka M., Kavka P., Kavka P. (2008): **Vliv doby používání na zbytkovou tržní cenu, na náklady na opravy a na roční využití u vybraných skupin zemědělských strojů a traktorů**. Res. Agr. Eng., **54**: 199–207.

Každý nově vyrobený stroj má projektované provozní parametry a stupeň realizace těchto parametrů určuje jeho využitelné vlastnosti k činnostem, ke kterým je určen. Vědecky i prakticky bylo dokázáno, že existuje vliv doby používání strojů na stupeň realizace provozních parametrů. V článku je na základě výběrového statistického šetření analyzován vliv doby používání vybraných skupin zemědělských strojů a traktorů na zbytkovou tržní cenu, na náklady na opravy a na roční využití. Výsledkem jsou funkční závislosti úbytku zbytkové tržní ceny sledovaných strojů, růstu nákladů na opravy a vývoje ročního využití strojů. Změny jsou uvedeny poměrem k projektovaným parametrům výsledků je možné využít při kalkulacích nákladů na provoz sledovaných strojů.

Klíčová slova: doba používání; tržní cena; roční využití; náklady na opravy; změny parametrů; zemědělské stroje

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