INTERACTION OF PLANNING, MANUFACTURING AND MACHINE MAINTENANCE

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Introduction

We want to present in present article as a case study based on our data measured at some agricultural companies chosen representatively, that by analyzing the costs arisen during the operation cycle of high cost machines drawn into the experimental work the company management what technical-economical conclusions should consider for the sake of maximizing the profit.

We have worked out a machine operation professional user-friend system [3., 4] aided by computer in order to manage the task on company level, which doesn't need special theoretic knowledges, because after entering datum into the computer the informational parameters needed to the decision preparation are generated automatically.

The computer system is based on the theoretical work [1., 2] elaborated already earlier and is formed by the following more important mathematical connections.

1. The material flow – in general turnover energy – flow – balance equation of the company (as a system):

$$X(t_N) = X(t_0) + U(t_{0,}t_N) - Y(t_{0,}t_N) \pm K(t_{0,}t_N)$$

where:
- $X(t_N)$ = the condition characteristic of the system at a given tN time,
- $X(t_0)$ = the condition characteristic of the system in the starting time, in the starting time of the operation of the system,
- $U(t_{0,}\, t_N)$ = the totality of inputs flow into the system in the examined time interval,
- $Y(t_{0,}\, t_N)$ = the totality of outputs flow out from the system in the examined time interval,
- $+ K(t_{0,}\, t_N)$ = the totality of finished products ready to transportation produced in the system in the examined time interval, meaning the products and can be marked as source,
- $- K(t_{0,}\, t_N)$ = the total costs needed to operate the system respectively needed to produce products in the examined time interval which can be interpretated as swallower according to system-theory.

2. The regulating balance – equation that can show the process efficiency at same time:

$$\Delta V(t_{0,}t_N) = V_{Kf}(t_{0,}t_N) - V_{Kr}(t_{0,}t_N)$$

where
- $\Delta V(t_{0,}\, t_N)$ = the regulating variable characterizing the given process which can have got financial and natural characteristics, it can also be the target function expediently of the company as company profit,
- $V_{Kf}(t_{0,}\, t_N)$ = is the result of the given process (for example: motor-cycle, tractor, washing machine, etc.) in general as sources, and the elements can have got natural or financial characteristics.
- $V_{Kr}(t_{0,}\, t_N)$ = is the needed costs to maintain the given process (for example: sheets with different materials, steel and plastic rods, castings, semi-finished and finished product available in the commerce, various energy sources, etc.)

3. The specific parameter representing first of all the determination of the optimum service-life and is the basis of the appreciability according to the given technical-economical process. Where the specific cost reaches the minimum there is the maximum of the attainable profit.

$$k = \frac{V_K(t_{0,}t_N)}{T} \rightarrow \quad \min imum$$

where:
- k = is the specific parameter of the given process,
- $V_K(t_{0,}\, t_N)$ = can be any member on the right side of the equation in the No.2 point, as it can be equally important specific value of both the result (source) and of the smallower (cost), but the change of them in particular,
- T = the value of such element characterizing the given process which can be determined objectively and so the specific parameter can be used correctly to evaluate to qualify respectively the company activity. So the T can be for example number of pieces, time, km, etc.
- t_0 = is the moment meaning the beginning (the operation of the system) of the given process,
- t_N = is the moment meaning the end of the system operation.

4. The transformation operator of the given process by using it the work done with a chosen so called basic machine is carried out in the computer simulation process with another machine, what can be called virtual machine practically.

$$\bar{\Delta} = \begin{bmatrix} \Delta(t_1) \\ \Delta(t_2) \\ \Delta(t_3) \\ \dots \\ \Delta(t_N) \end{bmatrix}$$

where
- $\bar{\Delta}$= is the transformation operator of the process,
- $\Delta(t_i)$-k = are the multiplication parameters belonging to the given year.

Practical experiences and results applying the model at the company

To verify the practical applicability of the model such large companies were looked for already having several year's data and were ready to take part in the experimental work, so 4 agricultural companies were chosen.

We choose with mutual agreement those machines to be drawn into the examination. These were tractors with various power, combines, ensilage harvesters, in number 60 pieces.

We put down in Table all those data composing the datum of determining the characteristic parameters according to the balance-equations and identifying the machines belonging to one-one company. It is noteworthy that the non-public data (for example the names of the companies, the names of machine manufacturing companies and types of machines manufactured by them) can occur in coded form as naming them can allude to legal questions. Taking this into account we don't make known such data neither here.

Data base and processing

The datum base consists the following main – measurable – data:
- type of the machine, its power, its naming,
- the purchase cost of the machine,
- the purchase year of the machine,
- the material cost used to repair the machine,
- the material cost used to the maintenance of the machine,
- the working hours and wage spent on maintenances and repairs,
- the different works done by the machine,
- amount of fuel, lubricant used and their costs,
- the social security contribution on wages,
- overheads,
- etc.

As a result of arranging and processing the datum [4] such parameters, indicators can be determined giving objective possibility to characterize technically and economically the given machine. During the experimental work we drew conclusions based by analyzing the machine maintenance – and machine operation characteristic curves from among parameters determined by means of measuring, grouping of more than 25.000 data. Figure 1 shows process of the data collecting and processing.

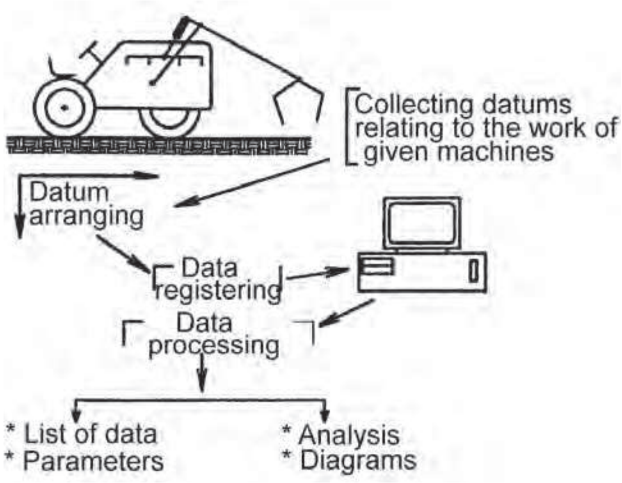

Figure 1.

Results

We indicated partly the specific machine operation costs and partly the specific machine maintenance costs in the function of the work done by them in Figure 2 and 3. We indicated the work done in nha (normal hectare) on the horizontal axis. The normal hectare is the unit indicator of different agricultural works (1 nha =25,315 KWh). We indicated the specific machine operation cost (c_{smv}) in Figure 2, and Figure 3.a, and the specific machine maintenance cost (c_{smm}) in Figure 3.b on the vertical axis.

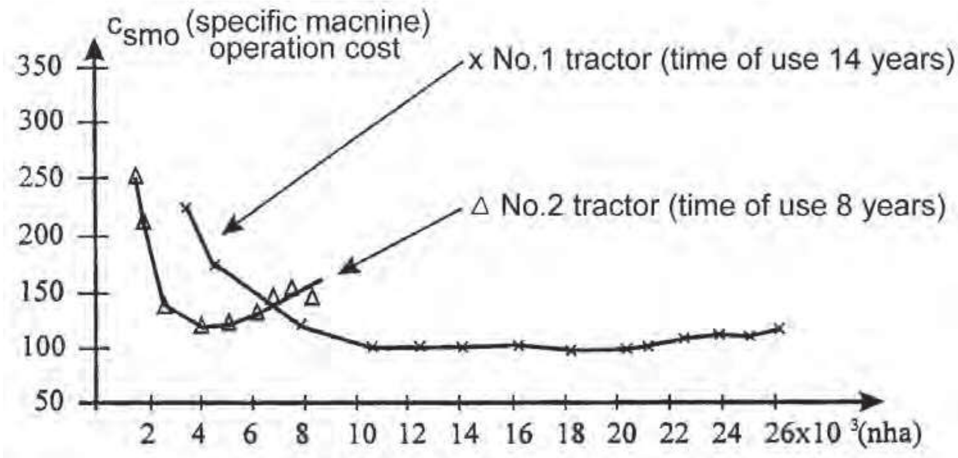

Figure 2.

The machine operation characteristics of two kinds of caterpillars made to carry out quasi-similar tasks can be seen in Figure 2, and the following conclusions can be made:
- the No.2 tractor operates with very favourable cost as reaching the surroundings of the minimum has got constant value during long time with small fluctuations (between 12 000 and 22 000 nha), and the cost is smaller than No.1 tractor,
- further advantage is for the operator that the machine with horizontal characteristic operates on optimal level for a long time and so the time of machine change is shifted to a longer period as against the No. 2 machine which reaches the minimum already at the surroundings of carrying out 4000 nha work and its further operation results profit reduction for the company,
- the No.1 characteristic machine is also very favourable for the manufacturing company because its market demand has got indisputable advantage as against the No.2 machine,
- the No.2 machine has got disadvantage to both to the operator and to the manufacturing company actually. It has got disadvantage for the operator because after starting up the specific cost reaches the minimum rapidly then increases rapidly. The operation during longer period of such machine is partly very expensive partly the incline of the curve requires quick capital mobility to change such machines.
  However it has got disadvantage for the manufacturing company because the customer will give preference to the No.1 machine.

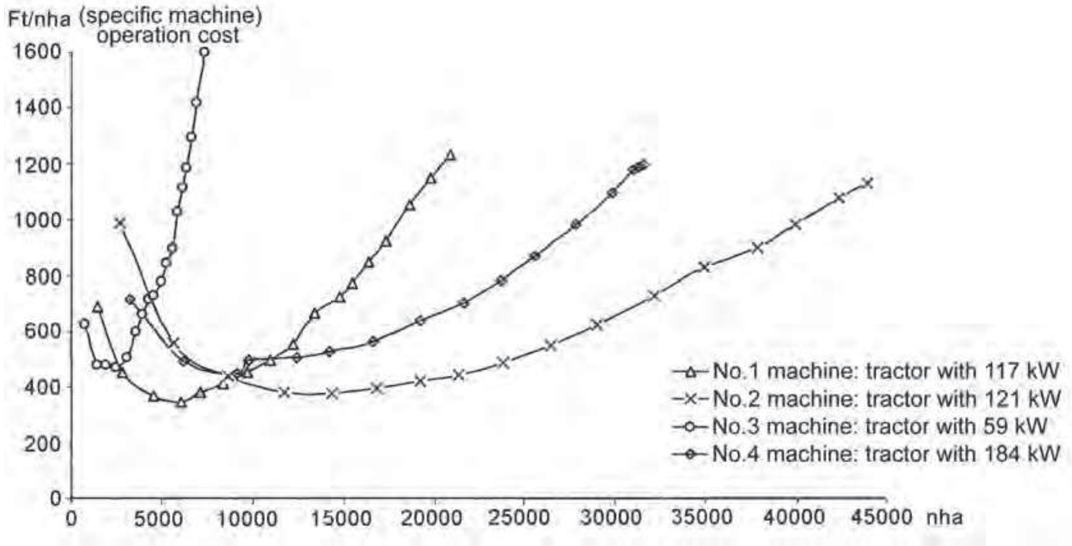

Figure 3.a.

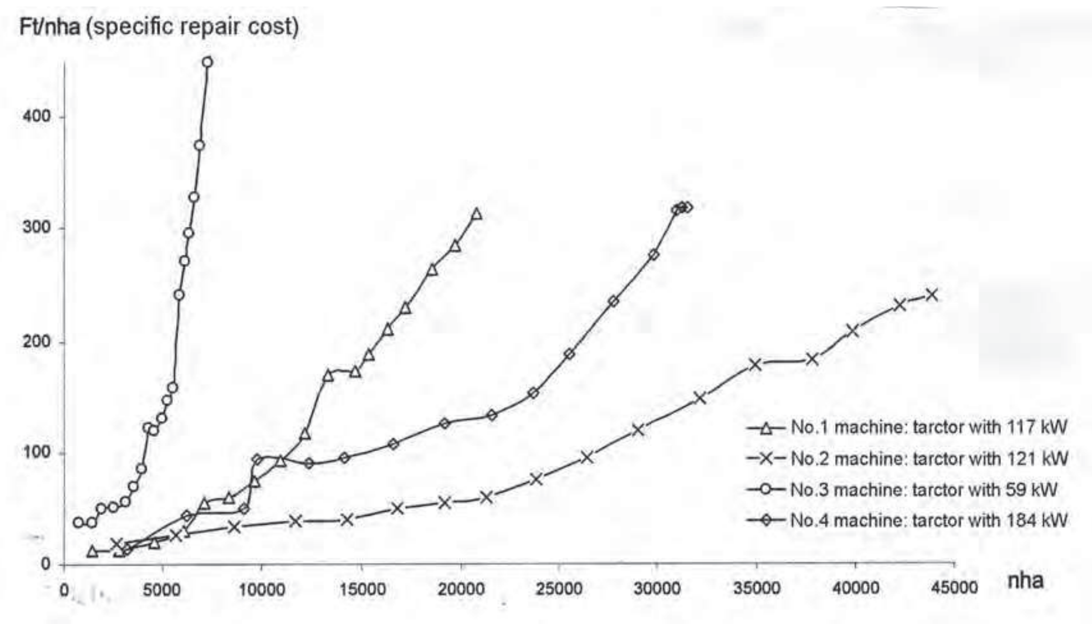

Figure 3.b.

Specific machine operation – and repair costs' characteristics of 4 pcs. wheeled tractors with various products and powers can be seen in Figure 3.

Based on taking into account the parameters the No.2 machine can be qualified as the most favourable in long period. The a figure and also the b figure support this. However the No. 1 machine can be qualified the best in short period surely that machine has got the most favourable optimal specific cost. The transformation operator ensures the more objective help how to take into account the time horizon at the investment strategy of machines performing nearly the same tasks.

We present in Figure 4 that the comparison in pairs of the No.1, No.2, No.3 and No.4, No.2 power machines shown in Figure 3 to what conclusions give possibility.

The Figure 4.a shows unambiguously that concerning the final result in case of long range operation there is no difference between the two machines, well the costs are almost the same in case of operation beyond the crosspoint (t_m) of the operation characteristics. It has to indunce thinking the investor that the basic machine requires significantly smaller investment cost than the virtual machine. The suboptimum at t_m thus calls attention sharply to the importance of the long range strategic decisions.

The Figure 4.b shows a typical case. Namely there is a definite difference between the two operation curves before the crosspoint (tm) and also after it. The economic strategy in such case is the following: if the expected operation time is not longer than t_m (it is near to it respectively) the No.3 machine is chosen, surely it can be seen well at the starting costs that the capital investment demand of the No.3 machine is significantly smaller than the No.1 machine. The savings is substantial which can be utilized favourably by the company at other profitable investment. The company decides beside the investment of the No.1 machine however in that case the expected operation time is much longer than t_m.

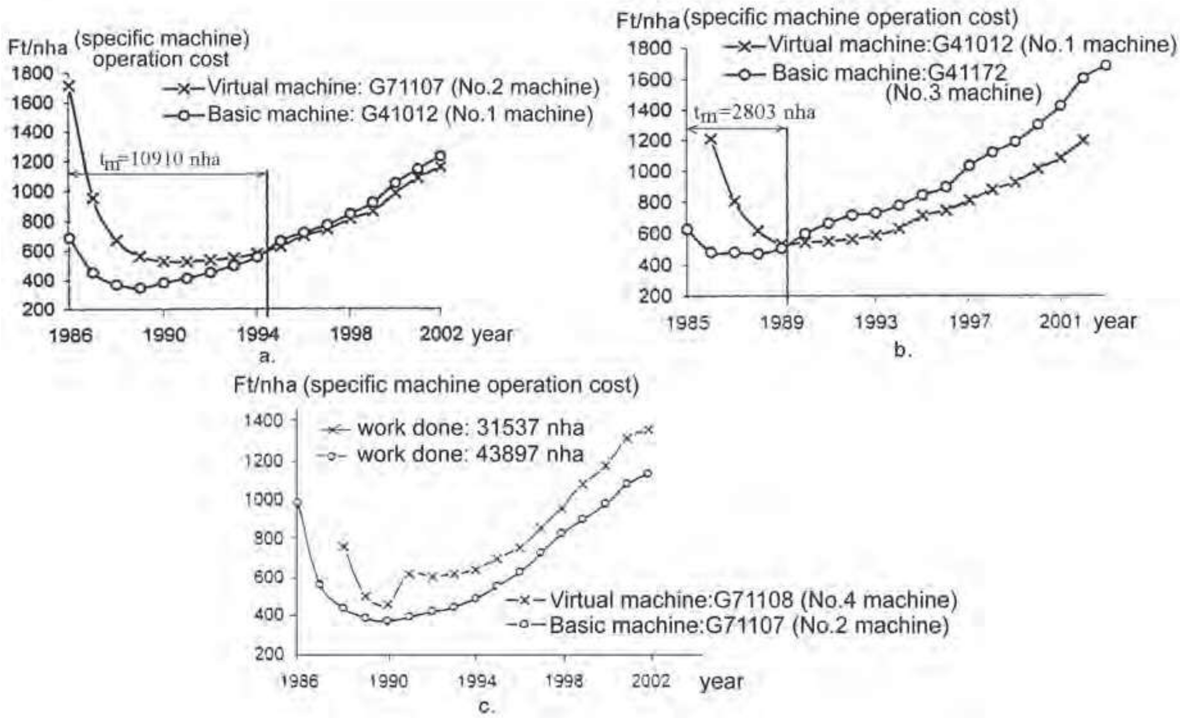

Figure 4.

The Figure 4.c shows that special case when it is evident totally that the No.4 virtual machine can't be the strategic alternative of the No.2 basic machine.

Summary

The technical-economical parameters provided by the model worked out by us prove that the working application of the Zsoldos-Janik computer machine operation professional system is established, provides objective information for the designers, manufacturers, sellers and operators of high cost machines with different types alike.

That is also natural such enormous system can't be acquainted with such detailed level which would make possible also to know the particulars, so we could only aspire to present the theoretical structure and application of the system-theoretic model.

The greatness of the company doesn't limit the application of the model that fact increases its importance , well it can be applied effectively just like in case of one-two machines, too.

Literature

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