

**Olimpia Kunert**  
**Grzegorz Malczewski**  
Lodz University of Technology  
Faculty of Mechanical Engineering  
Institute of Machine Tools and Production Engineering

## **THE METHOD OF MACHINERY AND DEVICE ASSESSMENT BASED ON MAZTE-M UTILIZATION**

### **Abstract**

*Interdisciplinary relations of the issues concerning machinery and device utilization have gained significant importance in technical diagnostics in the aspect of their applications. Technical diagnostics as a discipline of the methods and techniques to examine the technical condition of structures, refers to the assessment of the reliability through monitoring functional performance of production and assisting processes and the features of the end product. The MAZTe-M method enables assessment of the value of the fixed assets within the area of machinery and devices on the basis of the technical environment of their operations (according to their technical condition, reliability, the amount of work performed and order priority) in two aspects: their wear in the specific working place in a company as well as economic profitability of utilization. The MAZTe-M method analyses the utilization of machinery and devices in a particular technical environment. In order to estimate the average value of a machine, one applies functions describing coefficient values against the passing of time. In the case of economic wear of machinery and devices, calculating complementary synergy coefficient is calculated taking into account the process of machinery and devices liquidation under the owner's supervision.*

PN-82/N 04001 norm defines **utilization** as a set of purposeful organizational, technical and economic activities implemented by people in reference to technical objects and the dependencies between subjects and objects from their acceptance to perform the assigned task till their liquidation. Such a definition treats utilization as a technical and economic entity along with the item's production, the sale of an item or a system and is finalized with their withdrawal.

Interdisciplinary relations of the issues concerning machinery and device utilization have gained a significant importance in technical diagnostics in the

aspect of their applications. The science of utilization currently consists of a number of individual scientific trends which have formed the foundations of its dynamic development. They include: machine security, technical diagnostics, exploitation systems, reliability and tribology.

Technical diagnostics as a discipline of the methods and techniques to examine the technical conditions of structures, refers to the assessment of reliability through monitoring functional performance of production and assisting processes and the reliability of the end product. The application of the MAZTe-M method remains one of the forms of raising qualifications and competences as technical and economic skills at the operational level thus the managerial competencies of the first degree.

The classical view presents the tasks of technical diagnostics in the following way:

- to examine and describe symptoms of faults (in all phases; early, advanced and impending danger),
- to work out examination methods,
- to work out protection precautions.

As the utilization of a machinery progresses its exploitation potential runs out as a result of:

- technical wear and tear (mechanical),
- moral depreciation (economic).

The assessment of a machine's wear is based on the utilization assessment though categorized information on the evaluated machine. Due to this fact, the utilization assessment of an item should take into consideration the technical context (the utilization of the exploitation potential, the effects of utilization and implementation expenditure) and the economic climate (the utilization of potential, gained effects and expenditure accepted – by the owner, buyer, middleman)<sup>1</sup>.

The exploitation assessment of a machine comprises activities whose aims are:

- verification estimation – refers to the utilization of a machine from the start to the set date of its assessment; it avails of the factual data, the precision can be enhanced by the usage of data on such items according to their type, age, and conditions of utilization,
- anticipatory estimation – refers to the machine from the received estimation date till the end of its operation, it utilizes hypothetical, estimation computational data; the precision can be enhanced by the usage of simulation and prognostics data of machine utilization.

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<sup>1</sup> J. Napiórkowski, A. Muzalewski, *Metodyka wyceny używanego sprzętu rolniczego refundowanego w ramach Sektorowego Programu Operacyjnego „Restrukturyzacja i modernizacja sektora żywnościowego oraz rozwój obszarów wiejskich 2004-2006”*, Warsaw, 2006.

The quantitative assessment is a transformation of information and views about the item and its operation into an expertise on its technical condition. The essential assessment aims at:

- awareness of technical and utilization features,
- the assessment of device functionality,
- finding a reference pattern – a collection of assessment criteria.

In order for the machine to work properly it is necessary to categorize the features describing a machine according to their importance:

*Critical features* – a group of features when the value exceeds the acceptable level of tolerance range leads to a decrease of its effectiveness and may cause its destruction or put a person or his/her environment at risk.

*Essential features* – the features whose value, when exceeded, leads to decreasing machine operation and effectiveness and poses a danger of its destruction.

*Features of less importance* – the features whose value, when exceeding the set range, cause acceptable lower efficiency.

*Ignorable features* – the features whose changes bear no impact on the effectiveness.

By *technical wear* one understands permanent and undesired physical and chemical changes which occur during operation, as a result of which the operation period to perform required functions becomes gradually exhausted. As a consequence, one can observe changes of properties and shape of material from which the elements of the machine are constructed. Such a fact stems mainly from strain, stress or chemical reactions occurring in the material of a given element as well as between the material and its environment.

*Reversible wear* – refers to those elements or machines which, through repair or modernization, may return to the nominal usage parameters or for which it is possible to adjust their function to the current technical condition.

*Irreversible wear* – refers to those elements or machines of which the process of functional changes has made the repair or modernization unprofitable or impossible.

*Natural aging* – is a gradual process of reducing nominal functional parameters triggered by the physio-chemical phenomena.

*Premature aging* – refers to a too speedy loss (when compared to natural aging) of functionality of machines caused by improper utilization or technological faults.

**MAZTe-M enables us to put an estimate on the assets within the area of machinery and devices based on the analysis of their functional environment according to the set operational strategy (according to their technical condition, reliability, work performed, order priority). The analysis of the value of machines and devices is conducted on two levels:**

1. technical wear in the local working environment,
2. economic aspect according to the profitability.

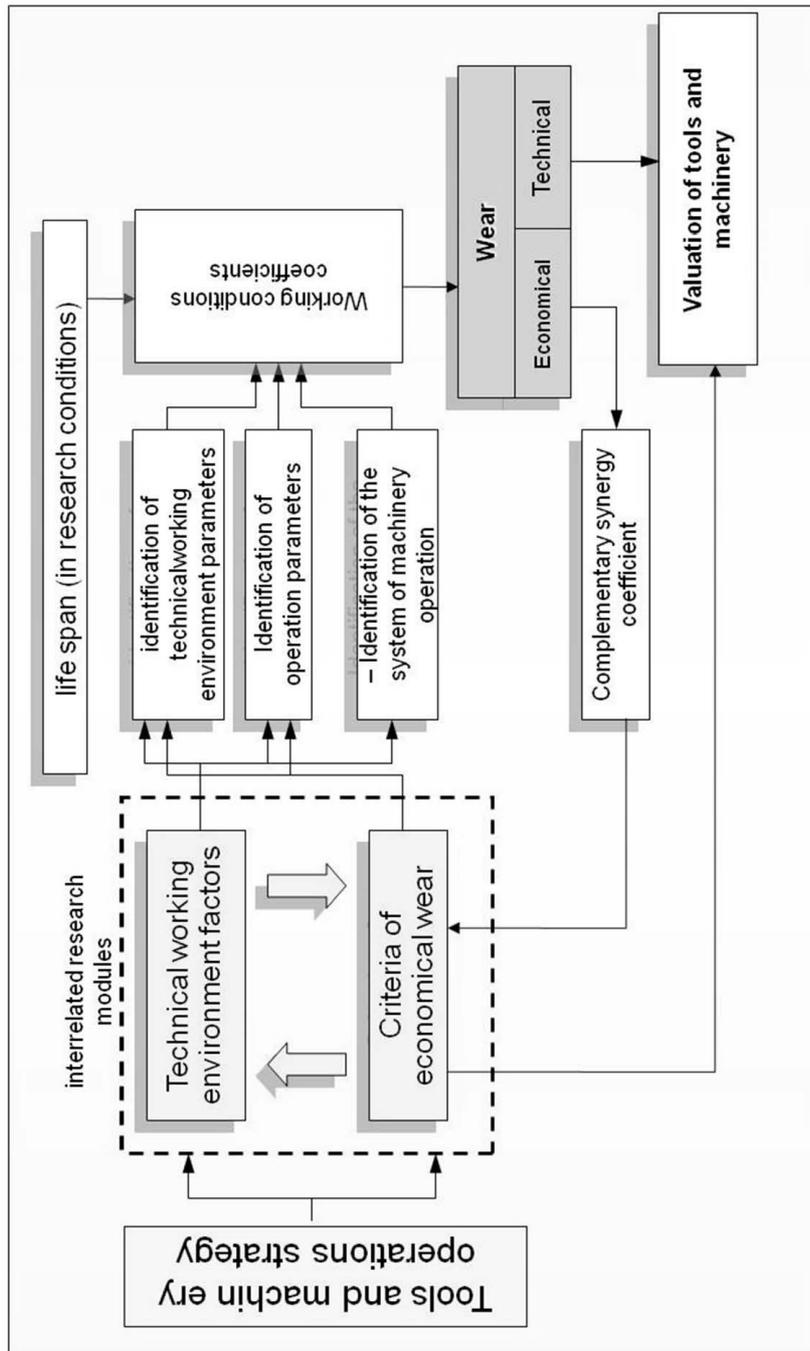


Fig. 1. Research model of assessment the value of machinery and equipment based on MAZTe-M method  
 Source: own research.

The criteria of the economic aspect refer to:

- high power-consumption;
- change of production technologies;
- obsolete design solutions;
- higher profitability of outsourcing;
- non-compliance with environmental policy;
- the starting data for the certificate of technical wear comes from an audit conducted by an expert on technical working environment such as air temperature, humidity, dust, exposure to atmospheric conditions, machine and device overloading;
- in this case, the problem of machinery and device operation is perceived by the owners and the business environment not from the point of view of the operational problems but the results of the operations in particular conditions. This comprises of two kinds of information: which allows users to decide which systems to best apply and for owners to learn about the lifespan of machines and devices in particular conditions;
- the above environmental factors impact significantly on the course of the wear of machines and devices in individual companies. MAZTe-M considers particular operational conditions through the application of corrective ratio in reference to calculated wear values of the algorithm 1. The coefficient values are expressed on the scale 0.9-1.0.

The course of the research process also establishes the life span of a specific machine or equipment exposed to harmful factors. If this period is shorter than the total period, its impact will be relative only to the period of environmental degradation.

The value of machinery and equipment ( $W_f$ ) is calculated according to the following algorithm:

$$W_f = W_o * y \quad (1)$$

where:  $W_o$  – replacement value,

$y$  – product of life span coefficient  $a$  and the complementary synergy coefficient  $b$ .

$$a = \frac{l_e}{l_c} \quad (2)$$

where:  $l_e$  – expected period of utility,

$l_c$  – actual lifespan.

Taking into account of the number of years the machinery has been in operation and the time horizon of its technical wear, one can calculate the longevity coefficient. This coefficient is defined as a ratio of expected period of utility to the actual lifespan of the machine. The calculated coefficient is then used to bring the initial value into compliance with the output market value of the machine.

MAZTe-M method is used to analyze the technical wear process of machinery and equipment in a specific working environment. Five coefficients have been set out to correct the value of machinery and equipment in relation to the impact of degradation in the technical working environment. Table 1 summarizes the *ideal values* of the correcting coefficients, which are applied to estimate the value of machinery and equipment on the basis of operating conditions. The ranges of coefficient values were determined by research in the process of specific valuations.

Table 1. The ranges of coefficient values according to the MAZTe-M method

| Researched machine types   | Temperature     | Humidity       | Dust rate       | Impact of weather conditions | Workload while in operation |
|--|-----------------|----------------|-----------------|------------------------------|-----------------------------|
|  | Coeff. $\alpha$ | Coeff. $\beta$ | Coeff. $\gamma$ | Coeff. $\delta$              | Coeff. $\varepsilon$        |
| Steam and heating boilers  | 0,98÷1,00       | 0,96÷1,00      | 0,98÷1,00       | 0,99÷1,00                    | 0,90÷0,98                   |
| Metal moulders   | 0,93÷1,00       | 0,92÷1,00      | 0,96÷1,00       | 0,95÷1,00                    | 0,91÷0,99                   |
| Machine tools for plastic moulding                                     | 0,94÷1,00       | 0,95÷1,00      | 0,97÷1,00       | 0,97÷1,00                    | 0,93÷0,99                   |
| Machines for general use in agriculture and food industry              | 0,90÷0,99       | 0,90÷0,99      | 0,99÷1,00       | 0,98÷1,00                    | 0,95÷0,99                   |
| Machines and equipment for clinching and compressing liquids and gases | 0,91÷0,98       | 0,90÷0,99      | 0,96÷1,00       | 0,90÷1,00                    | 0,90÷0,98                   |
| Industrial furnaces  | 0,90÷0,97       | 0,98÷1,00      | 0,96÷1,00       | 0,92÷1,00                    | 0,90÷0,97                   |
| Heat Exchange machinery  | 0,94÷1,00       | 0,94÷1,00      | 0,98÷1,00       | 0,93÷1,00                    | 0,91÷0,99                   |
| Other machinery and tools for general use                              | 0,92÷1,00       | 0,94÷1,00      | 0,93÷1,00       | 0,93÷1,00                    | 0,91÷0,99                   |
| Specialised machinery for the food industry                            | 0,95÷1,00       | 0,94÷1,00      | 0,99÷1,00       | 0,98÷1,00                    | 0,94÷0,99                   |
| Cranes and conveyors   | 0,90÷1,00       | 0,90÷1,00      | 0,90÷1,00       | 0,90÷1,00                    | 0,93÷1,00                   |
| Industrial machinery   | 0,92÷1,00       | 0,91÷1,00      | 0,93÷1,00       | 0,90÷1,00                    | 0,91÷0,99                   |
| Means of transport   | 0,92÷1,00       | 0,93÷1,00      | 0,96÷1,00       | 0,93÷1,00                    | 0,93÷0,99                   |

Source: own research.

The essence of the MAZTe-M method is that the market value of the machine is calculated on the basis of its technical condition, which depends on its type, elapsed time of operation, as well as operating conditions. In a dynamic technical environment of the company and against the backdrop of a widespread progress of technology, this method is relevant for machinery and equipment, for which value change econometric models can be determined over the years of operation.

In the case of the valuation of the whole enterprise and its assets, we are dealing with a large number of machinery and equipment, classified in different groups of fixed assets, which differ from each other not only in terms of purpose, but also in durability and number of years in service. These include fixed assets in which the economical wear occurs after several years, and those in which technological progress is limited and, consequently, their economical wear is extended in time.

An average price of the machine is calculated on the basis of the determination of one of the characteristics relevant for a particular group of machines. MAZTe-M method allows for the creation of features characteristic for the machine group, which means that in case one wishes to establish the value of a lathe, one treats it as belonging to the group of metal moulders and in the said valuation one uses characteristic features of this group. To determine the average price of the machine, one uses a function describing changes of the technical coefficient of the machine's value over the years of operation. This coefficient is calculated using the following formula:

$$W_T = k_{T1} * e^{-k_{T2} * t} \quad (3)$$

where:

t – is the life span of an asset (in years),

$K_{T2}$  – coefficient dependent on the chosen machine group. Studies have shown its value is in the range of 0.05 to 0.1. The value of 0.01 is assumed for such machinery and equipment, for which technological progress is almost imperceptible, and the economical wear of which progresses at an almost stable rate throughout their life spans. Value of 0.05 is assigned to such machinery and equipment, where technology is changing rapidly and, after a relatively short period of operation, the unit becomes obsolete, and its continued use is no longer cost-effective or possible (this is the case, for example, in computer technology, for which Moore's law is applicable, and where increasing need for better performing hardware and software makes it imperative to replace older IT equipment with newer units.

$K_{T1}$  – this coefficient takes into account the fact that the same group of machines may contain units that are better equipped and more technologically advanced than others within the group. Less sophisticated devices, with no up to date technological solutions, depreciate faster than those in which the manufacturer

applied the latest available solutions. The values of the coefficient determined by way of research are in the range of 1÷1.1.

These graphs show the differences in the technical coefficient depending on the selection of coefficients KT1, T2.

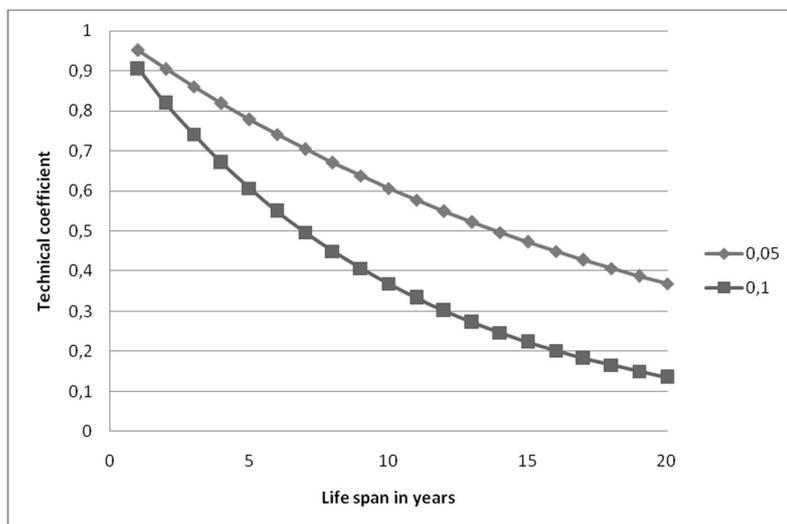


Fig. 2. Technical coefficient values for different values of KT2  
Source: own research.

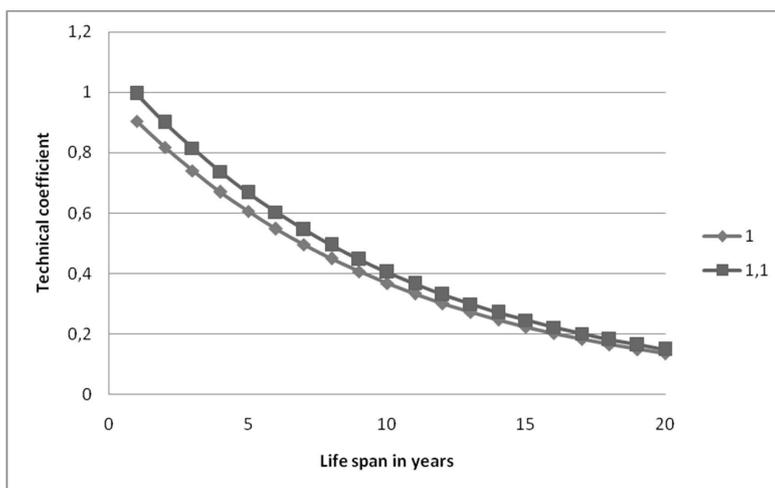


Fig. 3. Technical coefficient values for different values of KT1  
Source: own research.

Current state of knowledge allows for widespread use of MAZTe-M method for the valuation of machinery not only commonly found on the market (where other valuation methods, such as statistical market analysis, can be used), but also specialist equipment, for which there is no available information on prices in the secondary market. This method takes into account not only the technical state of the machine, its running conditions and the course of its operation but also the degree of innovation of the solutions applied by the manufacturer.

The main trend in the development of this method is constant expansion of databases from the market. Although the method itself does not require the user to continuously analyze changes in the market value of machines or to monitor the press, classifieds and exchanges, the data obtained from these sources, both domestic and European, serve to confirm the validity of the algorithm applied in the calculation of the market value or to verify the coefficients chosen in the course of research.

The importance of this method will increase significantly if depreciation functions are developed for all machine groups. This method is also crucial in terms of control because it allows for quick verification of the achieved market value levels. This method is also helpful whenever one needs to determine the value of machinery that is less commonplace on the market, but can still be treated as belonging to a machine group for which it is possible to define the functional dependence of depreciation. The basic problem in this method concerns the determination of initial value of machines currently not in production.

Research on the subject also included an evaluation of the whole system of machinery operation within the enterprise. The diagram in Figure 4 illustrates the range of research in this area. Measured value of machinery and equipment depends on the organization of that system of operation, and in particular on the chain of actions, processes and phenomena associated with the operation of technical facilities. Main activities which impact an assessment of the technical condition of machinery and equipment are those related to its service and operating conditions.

Evaluation of the system of machinery operation is conducted using a 1-3 scale range. Rating of 1 means that the company conducts only recovery repairs, rating 2 means the technical inspections are being carried out in accordance with guidelines issued by the manufacturer, and a rating of 3 means that the system meets technical guidelines for machinery and equipment maintenance, and that the devices are serviced securely. If the system receives a rating of 1, a progressive approach is assumed in relation to technical wear, which means that as time passes, depreciation will take place faster.

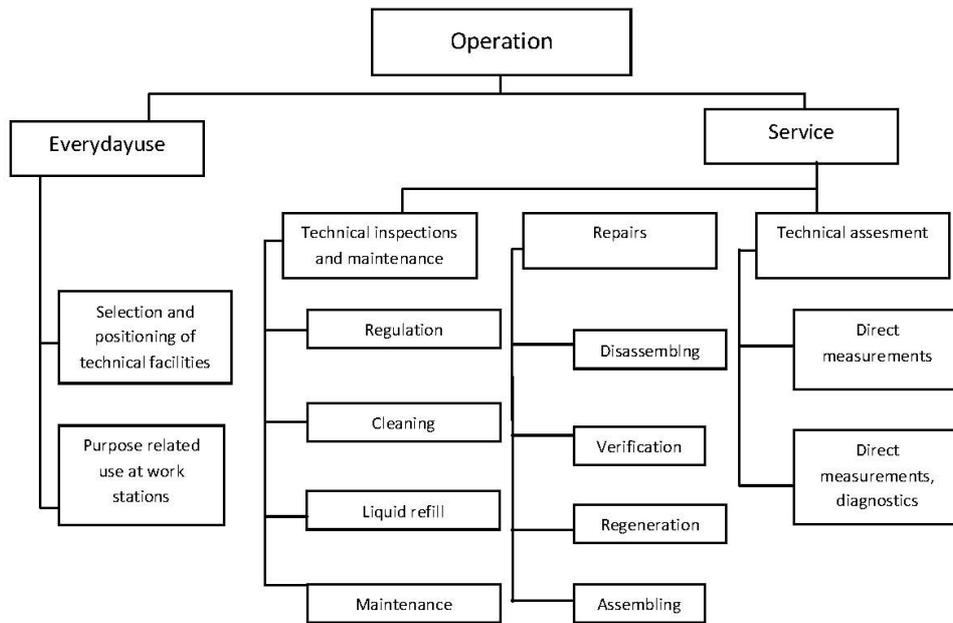


Fig. 4. Machinery operating system range of research chart  
*Source: ownresearch.*



Photo 1. Devices operating in an environment heavily dusted with ore

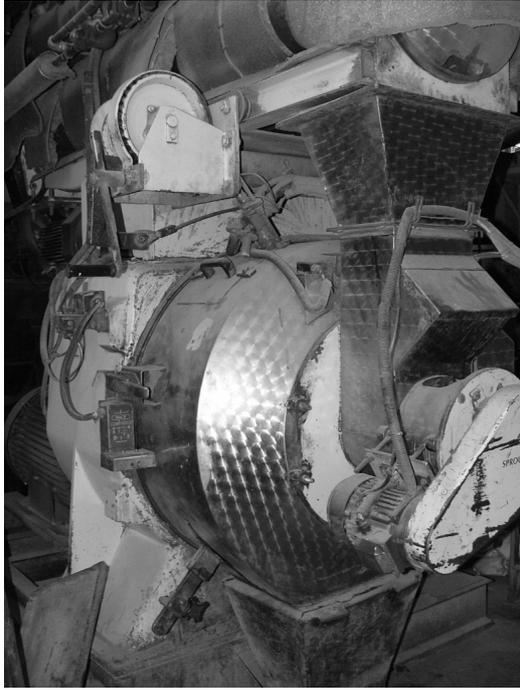


Photo 2. Devices operating in an environment dusted with particles of plant material



Photo 3. Devices operating in low temperatures



Photo 4. Devices operating in high temperatures and high air humidity



Photo 5. Devices operating at room temperature



Photo 6. Devices no longer in use, stored in closed rooms

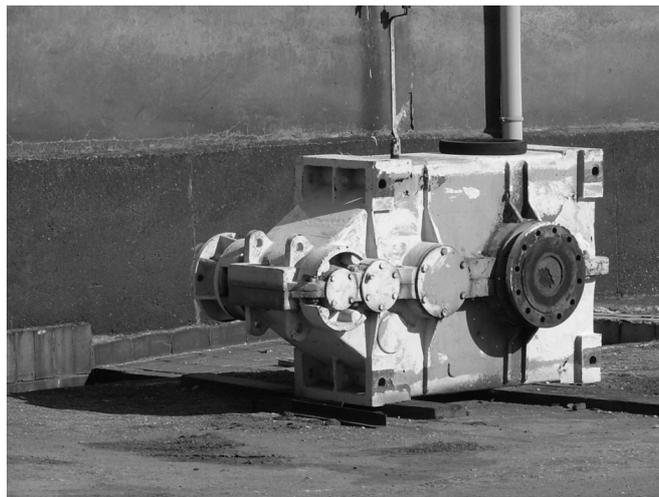


Photo 7. Devices no longer in use, stored in an open space

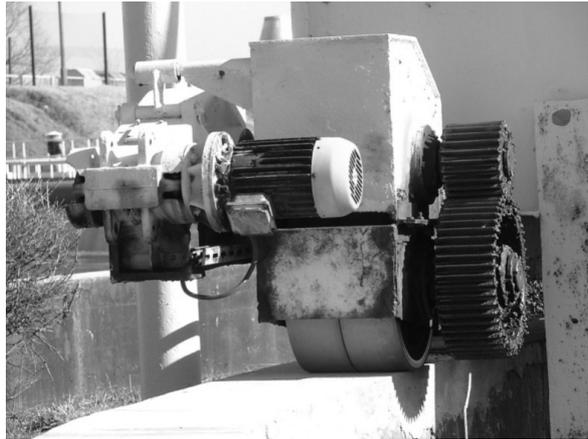


Photo 8. Devices currently in operation,  
directly exposed to changing weather conditions

**In the case of technical wear of machines and other devices**, a so called complementary synergy coefficient is calculated, taking into account the process of scrapping machines and devices under the supervision of the owner. The synergy coefficient is calculated as follows:

**1. Factors which impact the depreciation of the machine:**

- Disassembling costs,
- Value loss after disassembling,
- Costs of technical preparation of machines intended for sale,
- Pre-sale costs (press advertising, costs related to bidding).

When calculating the complementary synergy coefficient, if the expected life span of the machine does not extend beyond the 3 year period, scrap price value is assumed for that machine.

When calculating disassembling costs, the degree of sophistication of the device need not be considered, as this factor is regulated by involving a larger number of employees in the process, as and when required. Concerning certain devices with pneumatic installations, it has to be remembered that their disassembling process is more complex, stretched in time, and, as such, more expensive.

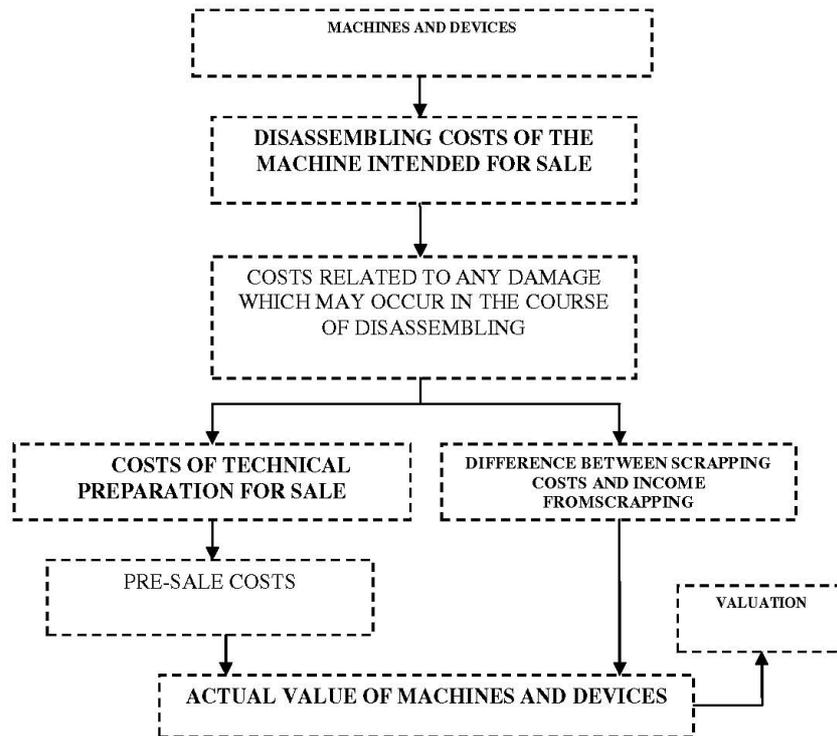


Fig. 5. Algorithm chart for calculating complementary synergy coefficient  
 Source: own research.

## **2. Calculation of the complementary synergy coefficient components**

In the process of calculation of the components, one takes into account the total number of machines and devices under valuation and the total number, given in per cent, of devices treated as scrap.

### **3. Costs breakdown**

#### **3.1. Disassembling costs**

Disassembling costs are calculated in relation to the time needed for disassembling, the number of people directly involved in the process and the cost of their remuneration.

#### **3.2. Costs related to possible damage in the process of disassembling**

**Potential disassembling related damage has been estimated to stand, as loss of value, given in percentages, at approx. 8,5%.**

### 3.3. Costs of technical preparation for sale.

The above include:

- Cleaning and maintenance costs,
- Technical inspection,
- Determination of utility value.

### 3.4. Pre-sale costs.

These include:

- Remuneration for salespersons (employees involved in the organisation of the bidding process),
- Cost of press advertisements, leaflets, folders etc.

The above costs have been estimated to stand at approx. 30%.

### 3.5. Costs and income from scrapping.

The difference between the value of scrapped machines and the income acquired through selling for the price of scrap is negligible. The income from selling at scrap price constitutes 92% of estimated value of the machine intended for scrapping.

Life span forecasts for machines operating in specific conditions give users information and feedback allowing solutions to be applied in machinery operation. Optimisation procedures in the system should lead to prolonged life spans of machinery through the alleviation of the impact of the technical environment in which these devices operate.

## **Conclusion**

Praxis of economy presents us with new issues related to the building and operation of machines, stemming from the necessity to evaluate fixed assets, which include machines and devices in constant operation for commercial purposes, such as credit cover, insurance purposes or ownership supervision.

These aims fall well outside the scope of conventional technical diagnostics, because the possibility of technical inspection is excluded. The machines are continually in operation, therefore it is not possible to conduct technical diagnostic tests. The MAZTe-M method constitutes a significant methodological contribution to the field of diagnostic tests.

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