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Evaluation of the Technological Modernity of the Machines used in the Metallurgical Industry

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Abstract. The analysis of the modernity of production machines is an important issue due to two aspects. First of all, modernity will have a direct impact on the efficiency of using both the machine and the entire production process (the entire production line), as well as the productivity of this process. On the other hand, this meaning will refer to the qualitative results of the processes that are carried out by the analyzed device. The level of modernity of machines is the starting point in the analysis of the effectiveness of their use and planned organizational changes in the production line. The aim of the paper was to evaluate the modernity of the milling machine CNC, which is used in the production of various types of steel products. The ABC technology method was the research instrument. Individual parts of this machine were divided into 3 subassemblies (parts of main subassembly A, parts of supportive subassembly B, parts of collateral subassembly C) and then each part was evaluated on the basis of Parkers' five-point scale. The analysis showed that despite the fact that the machine is not modern, there is no need to replace it, because the quality level of the steel products produced with it, is high.

Introduction

Nowadays, the tasks of modern production depend to the greatest extent on the use/application of scientific and technical innovations [1,2]. The use of new solutions, both in organizational and technical terms, is the main element of the development / modernity of production systems. The assessment of the modernity level of the production devices is a multifaceted and very complex concept, which should include: place, time, material flow, technologies, and intangible resources (people). Production equipment and machines constitute one of the elements determining the used technologies and the achieved results in terms of efficiency and productivity, which is one of the elements of market competitiveness. The inability to measure the level of modernity in production with one integral measure forces analyzes to be made using a number of partial indicators. These indicators make it possible to determine the level of modernity of the manufacturing processes implemented in the enterprise. The assessment indicators include: assessment of the modernity of the used machinery park, the modernity of the used technologies and organizational solutions influencing the efficiency of the processes. In recent years, there has been a development of multi-criteria assessment methods [3]. Many authors emphasize the usefulness of these methods in the assessment of technical systems [4,5].

The basic criterion for the analysis and assessment of modernity level of the equipment in production is money. All activities performed in the production line generate costs and revenues. These two aspects are directly related to the supervision of the technical condition of devices and the assessment of the capabilities of these machines. And these are possibilities both in terms of the results (production capacity per unit of time) and the necessary inputs (work, time and energy). These two factors are the basis of actions taken in the field of maintenance, which takes into

account the possibility of implementing production plans and the necessity to undertake investment activities [6,7]. The method of assessing the modernity level of the subject should be constructed in such a way as to meet the basic assumptions of the analysis: 1 - credibility of the results, 2 - achievement of the full results of the assessment process (comprehensiveness), 3 - validity, i.e. obtaining a result based on the analysis of facts.

Modernity is directly related (and can be identified) with the concept of the quality. This is due to the strong relationship between the modernity level of the machine and high quality of workmanship (product) [8,9]. Additionally, a detailed presentation distinguishes three aspects of the concept of modernity of devices: 1- technical and constructional modernity (technical level), 2 - modernity as a high level of workmanship, and 3 - functional and operational modernity (quality of use). The broadest scope includes technical and design modernity, which can be defined as the highest level of technical system parameters, in relation to other comparable products [10].

The aim of the paper was to evaluate the modernity of the chosen machine used in the metallurgical industry. The milling machine CNC of the Polish production was the research object. This machine was manufactured in 2007, so it is not so new, however is well equipped and allow to produce big range of products. As a research method, ABC technology method was chosen. It let classify individual parts of the machine according to level of the modernity of production. Such an analysis can show the modernity of the individual parts but also of entire machine and if it should be replaced by new one.

The scheme of the evaluation method shown in the article can also be used in similar situations requiring qualitative assessment, such as biotechnology [11], traffic engineering [12, 13], management [14-17] or quality assurance systems [18, 19]. Moreover, carrying out the evaluation of modernity requires the development of action scenarios, including scenarios of possible failures and their consequences [20-24]. This work can inspire the further development of many data analysis methods [25] based on both quantitative [26-29] and qualitative [30-32] data, thus providing useful tools in many areas of technology [33-36]. Effective predictions, especially explained in an accessible and understandable language, significantly improve the reception of organizational and technical solutions, increasing the general technical culture [37, 38].

Methodology

The ABC technology method is based on the assessment of the value of each of its components through the prism and significance in the total value of the entity being assessed. The analysis makes it possible to determine which elements of the device (more precisely, the evaluation for that element) require a special approach, due to the significant impact on the functionality of the device. The ABC technology method, made for individual devices, facilitates decision-making by the maintenance services and other related departments. The analysis performed in a team and based on the analysis of historical data allows for a quick response (decision) in terms of ensuring continuity of production and improvement of efficiency for the implemented activities [39-42].

All machine components are divided in three groups: Technologies of level A (subassembly A), also known as main technologies, are basic technologies, fundamental for business. They help to give special attributes to produced products. Technologies of level B (subassembly B) are the enabling technologies of a general nature, available to all companies in a given industry. The company does not show interest in development, but benefits from such progress during the purchase of the machine. Technologies of level C (subassembly C) are supporting technology which are usually part of the overall business. These technologies are associated with its own machinery or equipment and are not subject to the innovative activity of the entity using it [6, 7].

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The evaluations of individual parts of the machine can be made on the basis of Parker's five-point scale [6, 7]. Level 1 concerns of easy the machine parts manufactured with use of craft technologies. Level 2 concerns of the machine parts manufactured with unchanging technologies used for years. Level 3 concerns of the machine parts manufactured with more complex technologies, requiring technical skills and knowledge. Level 4 concerns of the machine parts manufactured with modern technologies. Level 5 concerns of the machine parts manufactured with the most modern, unique technologies, not known by other producers.

The milling machine CNC was selected for the research presented in the paper, however, for legal reasons, the manufacturer and the number of the machine were not disclosed. The machine was manufactured in 2007 in Poland. It is equipped with a work table with dimensions (width x length) 500 x 1400 mm. Numerical control enables work in an automatic cycle with circular or linear interpolation in three-dimensional space. The machine's feeds in the X/Y/Z axes are respectively 800 mm, 500 mm and 500 mm. The CNC milling machine weighs 4500 kg. A fourth axis can be connected to the machine control panel. The machine has a hydro-mechanical quick-change device and hydraulic console relief. The machine is also equipped with stepless regulation of the spindle speed. The machine is used during production process of different types and shapes of steel products.

Results

The modernity research was conducted for the chosen milling machine CNC. The first stage of the analysis was to specify the different parts of the machine and their division into individual subassemblies, and then to evaluate each part. Evaluation of modernity level of individual parts of the research machine and average evaluation of each group was presented in Table 1.

Table 1. Evaluation of the modernity of the parts of the milling machine CNC [own study]

No	**Parts of main subassembly A**	**Evaluation**
A1	Control system	4
A2	Control panel	4
A3	Programming system	3
A4	Stepless regulation of the spindle speed	3
A5	Hydro-mechanical quick-change device	3
A6	Hydraulic console relief	3
A7	Stationary breaking cap	2
	Average	**3.14**

No	**Parts of main subassembly B**	**Evaluation**
B1	Utilities connection system	3
B2	Main power transmission system	4
B3	Feeders	4
B4	Start-up system	2
B5	Safety barrier	2
B6	Integrated power units	2
B7	Height adjustment mechanism	3
	Average	**2.86**

No	**Parts of main subassembly C**	**Evaluation**
C1	Fan	1
C2	Shields	2
C3	Sensors	3
C4	Wires	2
C5	Switch key	2
C6	Control buttons	2
C7	Lighting	2
C8	Machine construction	3
C9	Foundation	2
	Average	**2.11**

a) b) c)

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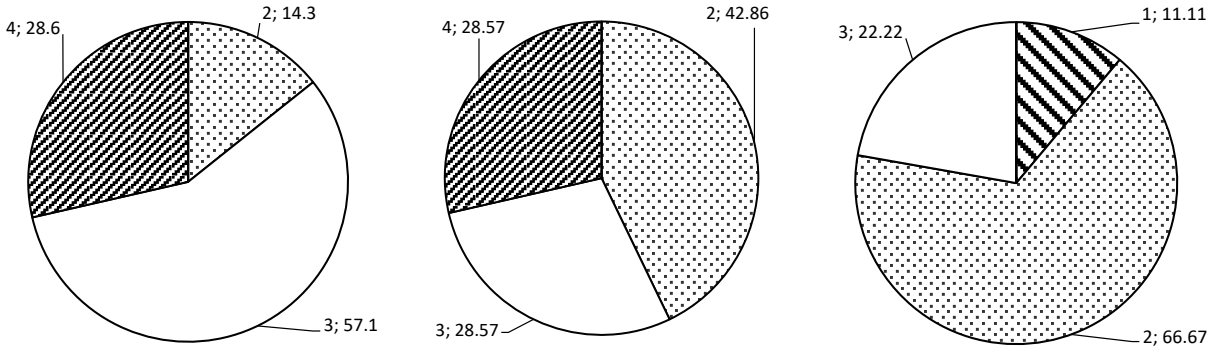

Fig. 1. *The modernity structure of subassemblies of the milling machine CNC in: a) main subassembly, b) supportive subassembly, c) collateral subassembly [own study]*

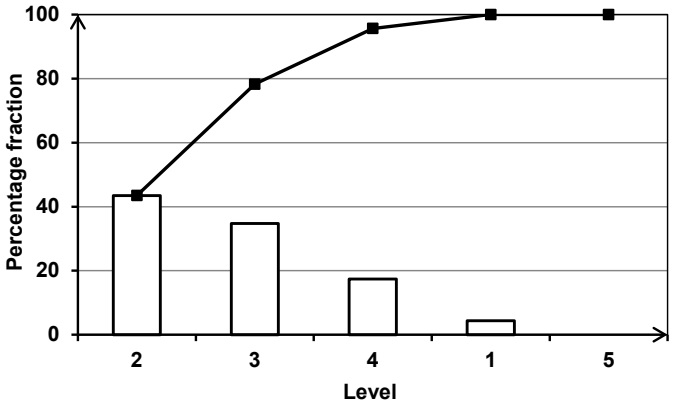

Fig. 2. *ABC analysis of the modernity level of the milling machine CNC [own study]*

The structure of modernity level of the research machine for each individual subassembly was presented in Fig. 1 in form of the pie chart, while the final result of the ABC analysis for the research machine was presented in Fig. 2, in form of the Pareto chart.

Individual parts of the milling machine CNC, according to Table 1, Fig. 1 and Fig. 2 were classified in following way:

– parts of main subassembly A: in over 57% are on level 3, in over 28% are on level 4, in over 14% are on level 2. So 3 was the most often given evaluation (4 times). The highest evaluated parts (level 4) were: control system and control panel. No part of this subassembly received evaluation 1 or 5. This group had the highest average evaluation (3.14). This means that the average part of the subassembly was manufactured with more complex technologies, requiring technical skills and knowledge.

– parts of supportive subassembly B: in almost 43% are on level 2, and in almost 29% are on level 3 and 4. So 2 was the most often given evaluation (3 times). The highest evaluated parts (level 4) were: main power transmission system, feeders. No part of this subassembly received evaluation 1 or 5. The average evaluation was 2.86, which means that parts of this subassembly were manufactured with more complex technologies, requiring technical skills and knowledge or with unchanging technologies used for years.

– parts of collateral subassembly C: in almost 57% are on level 2, in over 22% are on level 3, in over 11% are on level 1. So 2 was the most often given evaluation (6 times). The highest evaluated parts (level 3) were: sensors and machine construction. No part of this subassembly received evaluation 4 or 5. The average evaluation of all subassembly was 2.11, which means that on average, parts of this subassembly were manufactured with unchanging technologies used for years.

Average evaluation of the entire machine was 2.65, which means that most of the parts were manufactured with more complex technologies, requiring technical skills and knowledge or with unchanging technologies used for years. It can be also concluded that evaluations 2 and 3 were the most often given evaluation to individual parts of the research machine (respectively over 40% and almost 40%). Evaluations 4 and 1 had little impact on the overall evaluation of modernity of the research machine. Evaluation 5 did not appear during the analysis. It means that the research machine is not modern.

It should be emphasized, however, that the quality of the products manufactured with the use of the research machine is quite high, and the analysis of nonconformities that appeared mostly were caused by factors other than the milling machine CNC. The results of this analysis will not be shown in the paper, but they prove that despite the fact that the machine is not modern, it allows for obtaining products with appropriate parameters and quality level. This means that it does not need to be replaced in the nearest future.

Summary

One of the main and important resources of each enterprise is technical equipment in the form of machines, which is used during the production process, and which affects not only the efficiency of the production process, its productivity, but also the quality of manufactured products. One of the factor that helps in the evaluation of equipment is the modernity of machines. To evaluate it, the ABC technology method can be used, which is a simple research instrument that uses the 20/80 principle, e.g. that roughly 80% of consequences come from 20% of causes.

In the paper the indicated method was used to evaluate the modernity of the milling machine CNC, which is used in the production of various types of steel products. Average evaluation of the entire machine was 2.65, which means that most of the parts were manufactured with more complex technologies, requiring technical skills and knowledge or with unchanging technologies used for years. So it was concluded that the machine is not modern. However, the analysis showed that despite the fact that the machine is not modern, there is no need to replace it, because the quality level of the steel products produced with it, is high.

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