Machining process automation of large-size elements

Automatyzacja procesu obróbki elementów o dużych gabarytach

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In the paper factors which there were indicated determine manufacturing process of machine tools predestined for large-size elements machining, especially in the range of automation. The essential problem, considering in this paper is fact that machine tools often and often have modular structure.
KEYWORDS: automation, machine tool, large-size element, manufacturing process.

Production process is a series of activities aimed at creating a final product for specific tasks. Its structure is first and foremost a technological process, whereby components of the product are given specific shapes and features that allow them to perform these tasks effectively.

Analyzes of the possibilities and effectiveness of manufacturing activities automation were performed on the example of machine tools used for machining large parts (EWg). Such machines are increasing, as the demand for these types of devices is increasing [1, 7]. Because of their intended purpose, such machines are also characterized by large dimensions, which imply certain characteristics and limitations in the automation of their manufacturing process. An important issue is that machine tools are increasingly modular.

The aim of this paper is to identify factors determining the process of manufacturing the large-size machine tools, especially in the scope of its automation. The results obtained can be useful both for the constructors and manufacturers of not only this group of technological machines.

Structure of the manufacturing process

Two main phases can be distinguished in the manufacturing process (fig. 1). The first one is the processing of the elements that make up the individual kinematic pairs. The second phase consists in assembling the elements into a whole or, in the case of complex constructions, into components or assemblies.

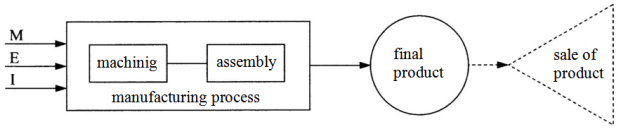

Fig. 1. Elements of the manufacturing process structure with marked inputs: M - mass, E - energy, I – information

As a result of the manufacturing process, a final product is created which can have very different constructional structure, from the simplest (e.g. paper clip) to a very complex (e.g. CNC machining center). In the professional literature, e.g. [5], it is conceived that the manufacturing process also includes the sale of the final product manufactured. According to the authors, however, it is debatable.

Modular structure of cutting machines

Structurally, a cutting machine is a machine (M) in which the structure has functional assemblies, each of which fulfills a different task, the assemblies being most often an integral module. It can therefore be assumed that the machine tool is a set of functional units (Z_i) configured to suit the superimposed tasks – fig. 2.

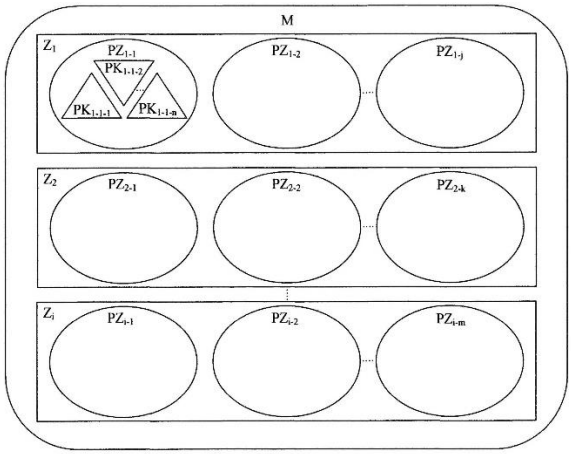

Fig. 2. Schematic diagram of a machine tool with a modular structure

Complex assemblies (PZ_j) consisting of simple or complex kinematic pairs (PK_n) may exist in the structure of assemblies, and the number of individual sets and subsets is usually different and dependent on the

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functions they are to perform. This confirms the carried out analysis of the constructional forms of a number of machine tools [3]. An example of a machine for machining large elements is shown in fig. 3.

Fig. 3. Machining center with the possibility of working displacement in axes: X = 14,700 mm, Y = 4,000 mm and Z = 2,050 mm

Functional modules of machine tools usually have very advanced constructions, the production of which with the necessary quality requires a good experience and well-equipped production facilities. These requirements make the production of individual modules available to specialized companies in the narrow assortment range (e.g. spindle makers, control systems, tool magazines). In each of these assortment groups, one can list the world's leading companies [3]. Such specialization makes the machine tool manufacturers to some extent - sometimes large - their constructors.

The structure described, observed in both large and small machines, directly contributes to increased accuracy and indirectly also to the expected quality of their performance. Obtaining these positive qualities requires meeting specific requirements [6, 8]. The modular structure also makes it easier to assemble the machine as the dimensions and weight of the individual units are smaller.

Automation of the manufacturing process

Activities carried out in fig. 1 of the two phases of the manufacturing process are completely different. The ability and desirability of automation in each of them is also varied [4].

- **Automation of machining.** Automation of machining results from the use of CNC machining centers. In the modular structure of machine tools, machining is of the utmost importance. Its dimensional accuracy and shape will depend on the accuracy of the whole machine.

It is very important to keep track of tool status in EWg automatic machining. During machining, the tool blades wear out, resulting in the surface at the beginning of the machining has different characteristics than at the end. This applies both to surface topography and dimensional deviations. In machining, such a phenomenon is a natural thing, but it does not generate significant effects on the machining accuracy. For large components, the tool wear process can result in deviations that exceed the limits. For this reason, in the NC machining programs, in addition to monitoring tool status, the positioning of the tool should also be considered, preferably in 3D.

The important issue for the quality of EWg machining is the attachment of the machine tool and the inter-stand transport. Because of the possibility of deformation under its own weight, carefully select the support points. For the same reason, it is important to properly support the workpiece during transportation (if present). It may be technically justified to mechanize transport in case of repetitive production.

- **Automation of assembly.** In the case of the production of complex technical objects, and such are certainly modern cutting machines, a separate issue is the automation of assembly. Functional units (modules) of EWg machine tools are also predominantly elements of large dimensions. Production of machine tools with such a purpose is scarce - practically it has a unitary character. In such production, there is no economic or technical justification to automate assembly operations. However, it may be justified to automate assembly of individual modules of such machine tools. The magnitude of their production is significantly higher as they can occur in different types of machine tools, and the dimensions of the components are smaller, and hence their weight. Assembly activities are therefore easier, their automation also. In practice, manipulators with the right number of degrees of freedom are used for this purpose. However, the economic aspect of such activities should always be considered.

Conclusions

On the basis of the considerations, it can be stated that the processes of producing the large-sized elements have characteristics, which differ from those of dimensions not qualifying as EWg [2]. As regards the automation of the manufacturing process, the most important characteristics can be considered:

- the need to monitor state of the tools, especially in machining, and to correct their position in 3D relative to the workpiece - compensate for the effects of the wear process,
- because of small amount of production, it is not technically and economically justified to automate the assembly process of EWg machines,
- mechanization of inter-stand transport of EWg components is considerable.

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