Some aspects of the informational support of technological processes

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Abstract. The increase of the efficiency of technological processes during the various stages of product development, such as design and manufacture, is in direct connection with their informational support. In this paper are considered the state of the art of modern informational support of processes, and the methods of its realisation. On the basis of informational modelling of technological processes, are considered and analysed the capabilities of the suggested scientific approaches for the assurance of the parameters of its efficiency, including their evaluation. Established is the necessity of a new approach during the modelling of technological processes for parts manufacturing, which would enable to overcome the main problem of their development – the ambiguity of the values of the technological parameters and their influence on efficiency. In order to guarantee the efficiency of these processes, formulated are the tasks and approaches which are to be applied for developing a reliable and up-to-date informational system.

1. Introduction
Modern machining processes in production systems are characterised by the extensive use of CNC technologies; it includes not only the technological equipment, but also the design, control and management of the technological processes, at the core of which is the aim to increase their efficiency [1, 2, 4, 7, 8]. The development of efficient technological processes include the activities of all three stages of their realisation: design, application to real manufacturing conditions, and batch production (established manufacturing process). The basis for the development of an integrated system that enables the increase of efficiency of the technological processes for machining parts is its informational support at each stage of the technological process.

2. Details of the system
The technological processes include three stages of their realisation: design, application to real manufacturing conditions, and batch production.

2.1. Stage 1: Design of manufacturing processes
There are two main approaches of designing manufacturing processes: the application of group technologies, and individual (expert) approach. As a result, its quality depends on the qualification level of the process engineer (expert). Both approaches are based on the method of analogies, so its efficiency depends on the correspondence between the parameters of the modelled and real processes.
The main problem of designing manufacturing processes is the uncertainty of the information connected with the characteristics of the technological system and additional means of automation, parameters of the processes, etc. The large variety of technical and technological solutions, their realisation under various limitations, such as time, economics, qualification level, results in multivariable manufacturing processes. Finding the most optimal values of the many influential factors makes the development of efficient manufacturing processes a task with multiple optimisation parameters.

A large problem of designing efficient manufacturing processes is the uncertainty of making a decision (Figure 1), which can be grouped into 5 groups:

![Figure 1. Groups of uncertainty in making a decision during designing manufacturing processes](image)

Based on the notation in Figure 1, uncertainty in the groups is the result of:

- Group 1 – the result of insufficient experience of those making the decision (a person or team) and the knowledge of factors that influence the decision making;
- Group 2 – the existence of time constraints (e.g. short time period for designing manufacturing processes, which is a condition for the inadequate consideration and evaluation of various candidate solutions), or financial constraints at decision making;
- Group 3 – lack of reliable information for the values of the factors acting during the manufacturing processes, under the conditions of multi-variable occurrence.
- Group 4 – the parameters of the technological equipment (machine tool, main and auxiliary equipment) change in time, which is the result of wear and tear.
- Group 5 – lack of models and methods that would allow the prediction of a specific result out of the interconnected influence of the factors under the conditions of multi-variable occurrence.

The lower the uncertainty during the phase of the design of the manufacturing processes, the more the real process will approach the required process under the given conditions. In order to overcome the uncertainty during the design phase, it is necessary to have informational support that provides information for:

- Regularities connected with the machined parts – here included is information for the structure of the process, clamping schemes, machining schemes, technological equipment.
- Factors and models for defining the cutting conditions and mechanical loads – the necessary information includes material characteristics, cutting tool life and tool strength parameters, stability of the technological system.
- Factors and models for defining the influence of the deviations during manufacturing – information for the geometrical accuracy of the machine tool, geometrical accuracy of the cutting tool and its setting, accuracy of installing the blank using the given scheme, deviations from the mechanical deformations, cutting tool wear rate, stability of the technological system, errors connected to accuracy control.
- Technological costs and models of defining the technological cost price – this information is connected to the general shop floor costs, costs of exploitation of the workplace, such as energy, depreciation, cutting tool costs, salaries.

The more complete and reliable the information is at this stage, the more problems could be eliminated or avoided at the stage of the design of the manufacturing process.
Figure 2 presents systematic and detailed input information, necessary for high quality design of manufacturing processes, and output information for their realisation.

Figure 2. Scheme of the input and output information at the stage of designing manufacturing processes

2.2. Stage 2: Implementation / preparations

At this stage, all missed or unsuccessful solutions from the previous stage will become apparent. The activities at this stage are connected to the preparation of the equipment, setup, testing and ensuring the workability of the process in correspondence with the developed technology.

They are shown in Figure 3.

During the setup of the workpiece on the machine tool it is necessary to correctly orient it in relation to the machine and ensure its stability. In certain cases, it is necessary to perform measurements in order to establish its correct orientation. In order to eliminate scrap, it is necessary to inspect the accuracy of the surfaces of the set up blank. These deviations may be caused by wear, partial damage of the centring surfaces, or by errors of the datum surfaces of the workholding device. The results of these measurements are entered into the control program for their compensation if this is possible. It is necessary to know the limiting values of the deviations, which can or cannot be compensated for. Similar are the requirements for setting the cutting tool.

The stability of the tool is mainly influenced by the condition of the base instrumental surfaces of the machine tool, the auxiliary tools, such as pockets, bushings, and the instrumental datum surfaces of the tool itself. Preliminary data about the conditions of the base instrumental surfaces of the machine tool allow for the positioning of the tool for the finishing operation into the most accurate positions, to
which some tools are particularly sensitive. During machining of rotational workpieces, for example, these are threading tools, tools for grooving and cut off, carbide drill bits, reamers, etc. On the other hand, rotating multitooth cutting tools require symmetrical positioning relative to the rotational axis.

![Scheme of the input and output information at the stage of implementation of the technological operation](image)

**Figure 3.** Scheme of the input and output information at the stage of implementation of the technological operation

High speed methods for dimensional setup, such as off-machine setup, setup using reference surfaces, automated setup on the machine tool (contact and no-contact based), define the position of the blank and cutting tool in a static position, without actual cutting. This way the dynamic errors occurring during machining of the workpieces cannot be taken into account. The only method that allows for taking into account the dynamic errors and its compensation is the method of trial cuts, if the cuts are performed on a real workpiece and under real cutting conditions (depth of cut, feed rate, cutting speed). The disadvantage of this method is increased machine down time which in general increases the manufacturing costs. Trial cuts of workpieces are performed in order to avoid scrap in cases of uncertainty of the results during machining as a result of:

- insufficient accuracy of the initial static setup; for high accuracy surfaces compensations are introduced in the direction of repairable scrap;
- for following up the load (elastic deformations), vibration resistance, during machining difficult to machine materials.

Based on the obtained results, the permanent dynamic error and the error of the initial setup are calculated.

The aim of dynamic dimensional setup is to define the dynamic error. This is necessary when machining high accuracy surfaces. It is performed based on the results of machining a small batch (3-5 parts). This way the constant errors are compensated, and an approximation of the reliability of the obtained quality parameters is performed. Testing of the process aims at more accurate definition of the dynamic error, which allows more accurate initial setup of the next batch, and especially at the approximate evaluation of the reliability of the process. It is performed during surveying and inspection of the machined batch of 10-30 parts.

At this stage occur those errors that had been made in the scheme of workpiece setup and manufacturing of the workholding device (insufficient stability and vibration resistance), incorrect cutting tool selection. Visible become all incorrect solutions that lead to difficult chip removal, improper application of cutting fluids, elimination of the flow of the material at the start and end of the machined surface, etc.
Regardless of the way the CNC program had been developed, it has to be tested on the machine tool. The aim of the test is to eliminate visible errors and collisions, corrections for more rational realisation of the machining operation (optimisation of empty passes and motions). This stage of the implementation can only be avoided if a CAM system is used for the analysis of collisions [5]. This is possible if all components of the technological system are entered into the model with their real 3D dimensions. This, however, is not always possible due to missing information and time constraints.

At this stage also become visible omissions of unforeseen locksmith or cleaning operations, connected with the conserving and packing operations.

Implementation is a stage where the machining of the first batch is performed. Another important task is elimination of mistakes and irrational decisions, making the technical documentation up-to-date including all related instructions and suggestions. During the machining of the next batch, after using the information from the implementation stage, only remain activities connected to the preparation of the technological system and its setup (described in Figure 3 in *Italic*).

2.3. **Stage 3: Batch production**

This is the stage of the established manufacturing process (Figure 4), during which the following tasks are solved:

![Figure 4. Scheme of the input and output information at the stage of implementation of the operation](image)

- Maintaining the workability of the process and the quality parameters of the machined surfaces that may be altered by the disturbing factors. Some authors call this task process control [3].
- During the first, and sometimes also the next batch, data are collected and the possibilities of its optimisation during machining the next batches is analysed.

3. **Conclusions**

The following conclusions can be made:

1. In order to improve the quality of technological activities it is necessary to provide systematic and easily accessible information for the regularities connected to the:
   1.1. development of the structure of the designed technological process;
   1.2. machining scheme;
   1.3. theoretical and empirical models for the definition of errors during machining, including instructions of their practical realisation;
2. In order to reduce the implementation time of a technology it is necessary to have information for the actual (at the moment of their execution) values of the technological parameters of the machine tools, workholders, cutting tools, auxiliary tools, and blanks used by the process;
3. The reduction of setup time requires the development of algorithms, instructions, and program applications for making the work of the operator easier and reducing the influence of his level of competency;

4. CNC programs alone are not sufficient to hold all information, connected to setup. In order to reduce setup time and scrap rate and avoid collisions, which are most likely at this stage, the program has to be accompanied by a scheme that can give dimensional information for the position of the work coordinate systems relative to the machine tool.

5. During testing the CNC program and its simulation testing, it is necessary to have updated 3D models of the blank, workholder, cutting tools and auxiliary tools;

6. The designed manufacturing process has to provide information for the organisation of events that can reduce machine down time to a minimum at the subsequent phases;

7. The designed manufacturing process has to provide information for the inspection of the qualitative parameters of the parts, including the inspection scheme, equipment and tools. Special attention should be paid on operational inspection if it is not automated.

8. After the implementation of the manufacturing process are formulated output data which should be saved and implemented during the preparation for machining the next batch;

9. For efficient control of the manufacturing processes at the phase of established manufacturing, it is necessary to have actual information, including real-time data for automatic control of the quality parameters of the machined parts, and also the means for its processing and interaction.

Acknowledgments

The study was supported by contract of University of Ruse “Angel Kanchev”, № BG05M2OP001-2.009-0011-C01, " Support for the development of human resources for research and innovation at the University of Ruse “Angel Kanchev”. The project is funded with support from the Operational Program " Science and Education for Smart Growth 2014 - 2020" financed by the European Social Fund of the European Union.

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