Computer aided production process design work methods

Komputerowe metody wspomagania projektowania procesu technologicznego

IZABELA ROJEK*

DOI: https://doi.org/10.17814/mechanik.2017.8-9.119

The article presents the computer aided design methods as applied for arrangement of production processes in the range from the simplest to the most advanced ones. The idea behind the research procedure as conducted by the author was to develop a method, models and expert system that would **resemble a human expert in the field. This goal was achieved** using neural networks.
KEYWORDS: technological process, support, neural network

The technological process details the transformation of raw material (blank) into a finished product that meets the design requirements. This process is very difficult to automate due to the significant share of experience (hidden knowledge) of the technologists at the various stages of design. The traditional design of technological processes is dominated by activities that make great use of the experience of the technology and its skills and intuition. From this experience, the technological processes and their costs depend [1, 2]. The design of these processes has lost its traditional character with the advent of the use of computer techniques. Widespread use of databases of ready-made processes [3].

The use of data exploration methods to discover the knowledge contained in databases of ready-to-use technological processes is a tool that enables the externalization of the experience of the technology in the form of knowledge bases and to carry out in the process of technological process an approximation approach to human reasoning.

Computer aided design of technological process – literature review

Computer aided process planning (CAPP) is used for computer process design. The process of designing a process can be computer-aided in a variety of ways, using a variety of methods and techniques. There are three approaches [3]:

- variant planning, which is based on hi-tech parts; the computer is used to identify similar parts and to edit the technology plan relevant to a particular part;
- generation planning in which the system synthesizes the technological process plan for the new part from the technological processes developed for the elementary surfaces forming that part;
- automatic planning – the process is created directly from the geometric model (CAD).

Another division of methods is shown in [4]. Automated process design can:

- to be implemented using unified technological processes or on the basis of repeated use of individual technological processes,
- rely on the synthesis of the technological process,
- be iterative.

Design using unified process technology consists in assigning by the computer, based on the code of the part classification, a suitable technological process including its structure.

Designing on the basis of re-use of individual technological processes is based on the use of ready-made solutions, assembled in the database of counterparties and their technological processes, at all levels of design.

The design of the technological process is done in such a way that the design process is divided into many simple tasks. Based on the analysis of the structure and characteristics of the technological process, the levels of further specification and optimization of design solutions are distinguished. At the first level, variants of the basic structures of the technological process are established. At the second level, variants of the technological process structure and the most rational variants are implemented. The third level includes the design of technological operations with different variants of the treatments. Among the developed variants, a rational processing system is selected, taking into account the specific means of production.

Iterative design is a modification of the design method, which consists in the synthesis of the technological process. In the iterative design of each surface, the process of its processing is developed and the graph of possible variants of the surface treatment of one type is developed. Designing the structure of a technological process consists in creating – on the basis of the graphs of individual surfaces present in a given part – the graph of all possible variants, which constitutes the basis for choosing the least cost variant.

* Dr inż. Izabela Rojek (izarojek@ukw.edu.pl) – Uniwersytet Kazimierza Wielkiego w Bydgoszczy

Intelligent process design – own research

The idea of the researcher was to develop a method, model, and expert system that would function as a human expert in the field, capable of gathering the necessary knowledge, analyzing data, and solving problems. This has been achieved using neural networks (studies have shown their usefulness and effectiveness in the design of the process). Based on already developed technological processes, machine learning methods (ML) have been used – first to learn the design of technological processes and then to design technological processes for new products. Designing a technological process is a very complex task, requiring the knowledge and experience of the technologist. For the development of the expert system, the design of the technological process was divided into smaller sub-tasks:

- a technological process plan has been set up which sets out the sequence of operations and technological processes;
- for each operation and each treatment, the machine, tool and machining parameters were determined.

This system is recommended for those who do not have sufficient experience in the design of technological processes or are just beginning to work in a particular manufacturing company and do not know well the machine or other means of production (tools, devices). It should be emphasized that such a system is an advisory role, and the decision always belongs to the technologist.

Acquiring knowledge

The acquisition of technological know-how was an important step in the creation of smart CAPP systems. This knowledge comes from many sources (fig. 1). Data from directories and databases can be obtained easily, but in the case of knowledge, preferences and experience, technology is not enough. It was necessary to create such models and tools to make this knowledge possible in a computer system. Therefore ML methods were used. So far, the technology has been used by tool catalogs, including paper catalogs. In computer systems, for example, the wear of the machine was not included, so it was often necessary to specify other processing parameters than those specified in the catalog. Then the technologist used his own preferences, knowledge.

The design of technological processes is influenced by many factors that the technologist must take into account.

These include: production volume, machining method, workpiece material, machine type, machining type and precision, and machined surface shapes. The creation of intelligent models is necessary in order to incorporate knowledge and experience in the computer system.

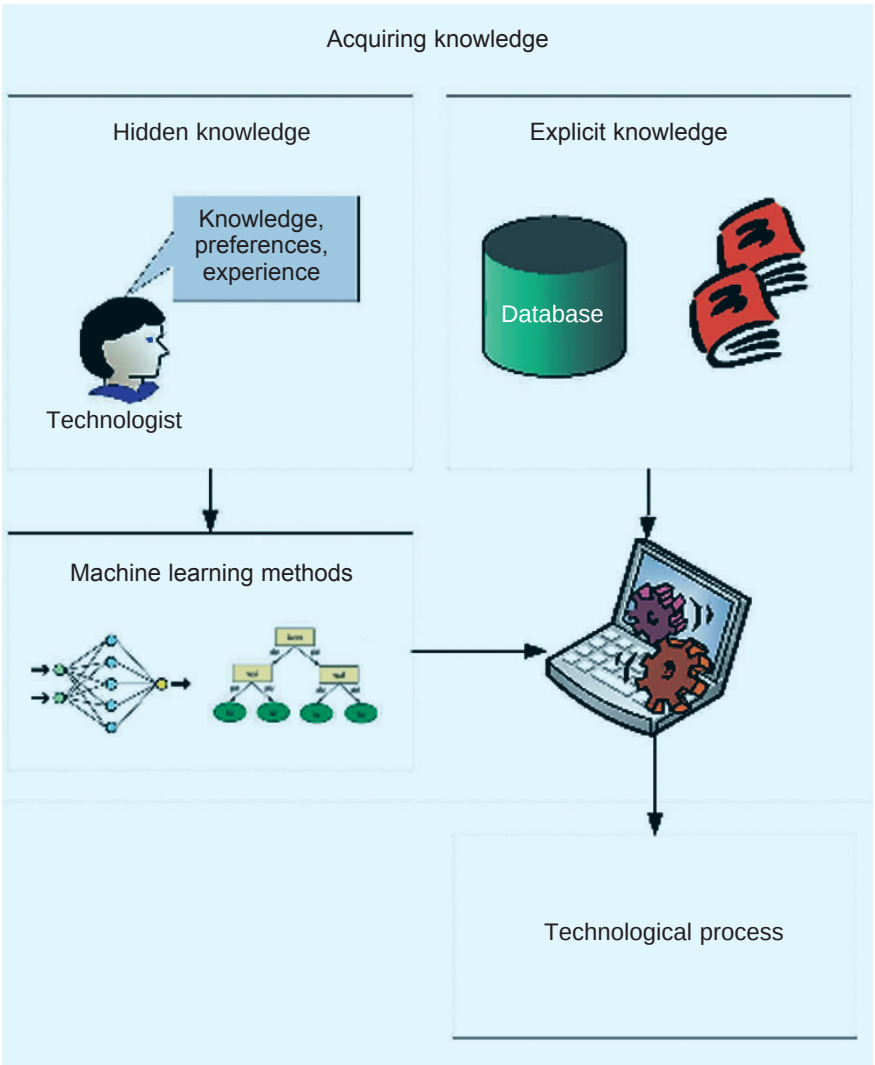

Fig. 1. Acquisition of technological knowledge

ML methods in the design of technological process

By definition, ML deals with the analysis of learning processes and the development of systems that will improve their performance on the basis of past experience [5,6].

ML enables you to gain knowledge based on the analysis of expert behavior or experimental data. Data often take the form of examples. ML knowledge is sometimes the only way to build models when expert knowledge is not available or when an expert can not explain their decisions. Machine learning methods include: neural networks and decision trees.

The author's method of designing technological processes using ML methods, especially neural networks, consists in combining three blocks of selected neural networks into one system. Blocks are used for the selection of machine tools, tools and parameters

Fig. 2 shows a system of three blocks of neural networks, which in turn select the machine, tool and ma-

chining parameters in turn. These networks are built for each process step, that is, a collection of neural networks is created separately for each selection. Different types of neural networks (MLP, RBF, Kohonen) with different structures are used for the construction of the model – among them selected networks with the best characteristics.

According to the definition, a technological process can be considered a sequence of specific technological operations, which is a framework technological process. Once the framework process has been defined for each process operation, the proper selection of machines, tools and machining parameters is achieved using the system of three neural network blocks.

The results of all three neural networks – i.e. the machine tool symbol, tool symbol and machining parameters – are passed to the information gathering module for the entire process. Its design ends after the selection of all process frame operations [7]. An exemplary selection for milling operations using an expert system using neural network models is shown in fig. 3.

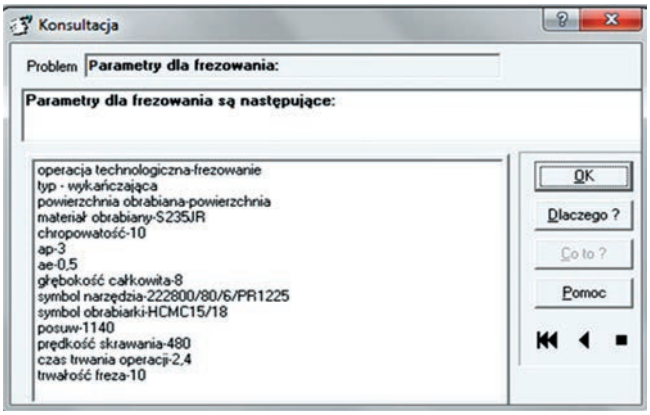

Fig. 3. Result of neural network operation in expert system

Conclusions

The use of the ML method proved to be a very valuable tool for gaining technological knowledge. This is due to the fact that the technology often fails to explain its decision to make it possible to create classic rules in expert systems. Automating the use of examples of technological processes already designed and verified during product manufacturing is a very good way to discover the knowledge that comes from the experience of the technologists. This is especially important in situations, where such knowledge is inaccessible or difficult to formalize, incomplete or uncertain. The knowledge acquisition system, which includes the selection models, can assist less experienced technologists in the design process.

The ML method introduces a new quality to the CAPP systems and allows for the creation of a support system that gathers knowledge automatically and has the ability to adapt. This is particularly important when creating CAPP systems for complex real systems.

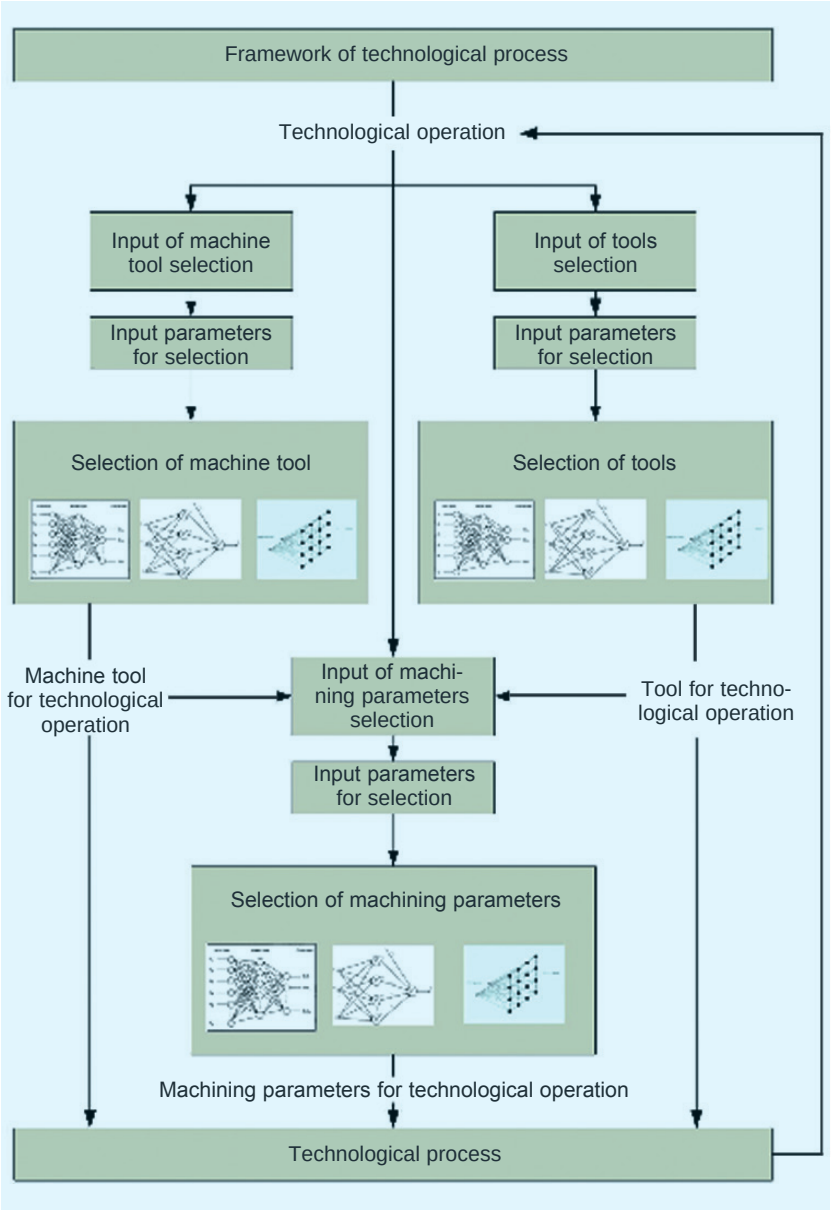

Fig. 2. Method of designing a technological process using neural networks [7]

REFERENCES

1. Pająk E., Klimkiewicz M., Kosieradzka A. *„Zarządzanie produkcją i usługami”*. Warszawa: PWE, 2014.
2. Ociepka P. “Application of the method based on technological knowledge and expertise for adding the design of a technological process”. *MATEC Web of Conferences*. Brasov, Romania: Transilvania Univ Brasov, 2017.
3. Grabownik C., Kalinowski K., Kempa W., Paprocka I. “A Survey on CAPP systems development methods”. *Advanced Materials Research*. 837 (2014): s. 387–392.
4. Gawlik J., Plichta J., Świć A. *„Procesy produkcyjne”*. Warszawa: PWE, 2013.
5. Bandaru S., Ng A.H.C., Deb K. “Data mining methods for knowledge discovery in multi-objective optimization: Part A – Survey”. *Expert Systems with Applications*. 70 (2017): s. 139–159.
6. Bo Z. “Research into technology decision methods of CAPP artificial intelligence”. *ACSR-Advances in Computer Science Research*. 37 (2016): s. 260–263.
7. Rojek I. “Technological process planning by the use of neural networks”. *Artificial Intelligence for Engineering Design, Analysis and Manufacturing*. 31, 1 (2017): s. 1–15.