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EVOLUTION OF WORKSHOP PROGRAMMING

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Abstract: *CAM software is in permanent development because of need for increased productivity of creation of CNC programmes and, simultaneously,reduced exactingness of programming. The answer appears in the form of the concept of automated programming which is considered to be superstructure and/or a parallel branch of CAM programming. The automated programming results in CNC applications with minimum interventions of the human, particularly for the geometries consisting of basic geometrical features. The role of the human-programmer is limited only to entering of input data and teaching of the system. The use of such software will not only increase the productivity of programming, but will also change the use of numerically controlled machines from organizational and technical aspects.*

Key Words: ***CAM, CNC, automated programming***

1. INTRODUCTION

All users of the CNC machines desire the creation of CNC programme to be fast and to require little resources and capacities. The creators of CAM programmes meet these desires by the fast development cycle gradually introducing more and more efficient tools. Systems for automated programming, most frequently in the form of complements to CAM programming have started to appear on the market. Although those systems have rather limited capacities, their applicability is on the increase. There are many shapes not needing advanced programming techniques. Creation of CNC programmes for machining of such parts can be partly left already today to automated programming. Thus, the companies already appear using the systems for automated programming [10],[11]. The reason of starting to use those systems is usually the specific production process and the sense of such technology on the part of the managing personnel. In the custom production of geometrically similar products, where a new CNC programme would be necessary for each product, the automated programming brings great benefits compensating the investment into such system [7].

In the first part the paper presents the evolution of CNC programming since the beginning till today and in second part presents evolution of CNC programming and the third part defines needs and expectations of users of CNC machines in the future.

2. EVOLUTION OF PROGRAMMING OF CNC MACHINES

Soon after John T. Parsons in early fifties had developed a numerically controlled machine [9], the need for efficient programming emerged. For that reason and because of the development of the numerical control technology of machine tools several programming methods emerged.

2.1 Manual programming

In the sixties and seventies of the preceding century in most cases manual programming sufficed in the industrial practice. Due to limitations of the human mind such type of programming does not make use of all possibilities of the numerically controlled machine. If certain capabilities of the human are compared with similar capabilities of the computer, it can be established that the computer surpasses the human in quite a few respects. The human acquires and stores the information very slowly; for memorizing any information the human brain needs 5 to 10 milliseconds [1]. Computing takes place slower, too, since for comparing two characters it needs 40 milliseconds. However, the human brain has the capabilities, such as efficient recognition of samples, good organization of knowledge and capable searching for knowledge.

However, programming of CNC machines requires also the capabilities for which the computer is much more adequate than the human. Therefore, the computer started early to be used for creation of CNC programmes. In the beginning, entering of the shape to be machined posed a great problem. Therefore, higher programme languages were developed, the most widespread being APT [2],[5], which ensured the entering of the product geometry. Those programme languages relieved the human only in repeating operations. The use of such aids in manual programming can be considered to be the superstructure of manual programming and the intermediate stage of the development up to computer-supported programming. Owing to the use of higher

programme languages the programming of the tool path was simplified and its time reduced mainly for simple product shapes consisting, particularly, of straight lines and circular arcs. However, in such programming the human still always dealt with solving geometrical problems.

While the describing, textual entry of geometry for the 2D or 2.5 D shape is usually relatively simple, it is inapplicable for entering the 3D geometry. Therefore, manual programming is not suitable for programming geometrically sophisticated shapes and today it is often too exacting and too slow even for relatively simple shapes [6]. Therefore, it is less and less used, but it can not be claimed that it is disappearing. It must be borne in mind that the computer-supported programming proceeds from the manual programming and applies the approaches based on manual programming. Thus, the familiarization with manual programming is still always important for good use of the CAM programme [4].

2.2 Workshop programming

Since the beginning of the commercial use of numerically controlled machines it has been possible to program also on the machine itself. The controls always ensure manual operating of the machine along coordinates and often also more advanced programming in the higher-level programme language inherent in the controls. Some authors claim that such type of programming belongs to manual programming [4]. However, special attention must be paid to programming on the machine, since it has developed and persisted till today, while the conventional manual programming has practically disappeared and/or has been transformed into programming on the machine. As programming on the machine has every characteristic of manual programming, a more suitable term for it might be manual programming on the machine.

Programming on the machine and/or workshop programming, similarly as the manual programming, gradually started to acquire more complex commands and functions, supported in the machine controls in distinction from the computer-aided manual programming (such as APT). Those functions include, particularly, the machining cycles, the repeating operations and the operations executed according to the sample and logical operations [4]. However, these advanced capabilities of the controls are not very applicable, particularly, due to the difficulties in communication and interaction between machine and human. Further, the level of knowledge required for utilization of the capabilities of controls is too high for machine operators. As a rule, the machine operators are not able to make use of the capabilities of controls. Moreover, the productivity of such programming is low, since it does not considerably exceed the productivity of manual programming. Anyhow, the human is the principal performer of the computing operations and, in the same time, the limiting factor.

Such type of programming of machines is mostly used for machining simple parts in custom production. Programming on the machine eliminates the need for the programmer and for computer-supported technologies, thus reducing the costs and facilitating the organization. On the other hand, by using the programming on the machine, the benefits of the available modern technologies are given up.

2.3 CAM

With the development of the hardware and software the manual programming by means of the computer gradually progressed to computer-aided manufacture. At first, those systems mastered only the geometrical part of programming. Though the term CAM comprises fairly more than only computer-aided programming of machines, this paper will be focussed only on this CAM function. The beginnings of the CAM reach back to the seventies, i.e., to the time of the programme language APT and Compact II, but the development became appreciated only in the eighties of the previous century. The computer technology advanced, graphic interfaces ensuring intuitive and interactive entering of geometry were presented. The three-dimensional CAD models became the principal carriers of information about the product. The fast development of the technology led from wire CAD models to 3D solid models. In the nineties that development proceeded so far that the personal computers became the principal aid of designers and CNC programmers [3]. The surface and solid models and the 3D accelerated shaded computer graphics with high resolution came into use. The development of CAD models was followed by the development of CAM programmes making use beneficially of the increasingly accurate and comprehensive geometrical information from the CAD model. Due to growing applicability of CAM programmes and accessibility of platforms for driving those programmes, the CAM programmes became very widely used by the programmers of CNC machines.

Creation of CNC programmes by the CAM software became irreplaceable, particularly for complex workpieces and/or sculptured shapes. With the expansion of the application area of CNC machine also into the field of custom production, the need for productivity and simplicity of the CAM software increased. The users of CAM programmes must be highly qualified and experienced experts combining the technological know-how and the programming knowledge.

3. NEED FOR AUTOMATED PROGRAMMING

Today, practically all CNC programmes are created in two ways; i.e., by manual programming executed mainly on the machine and by CAM applications taking over the major part of process of creation of CNC programmes. These two manners of programming can be distinguished as to where the programme is formed and as to what technical means are used to that end. On the one side there is the capable and demanding programming by CAM programmes affected in the office and on the other side there is the relatively simple and time-consuming programming on the machine:

- CAM supported programming applicable for programming of the most complex CNC machines and the most exacting machining operations. The programming is exacting, it requires highly qualified programmers-

technologists. They must posses in addition to programming skills, also the technological knowledge and experience. For programming the CAD model of the product and blank is needed.

– Programming on the machine (control). It is applicable for programming of manufacturing of simple shapes, particularly in custom or small-series production. It is largely used in the workshop use of CNC machines. Programming can be affected by the machine operator with relatively little knowledge; he must have the technological knowledge and experience. CAD models are not needed. Its deficiencies are low productivity; the machine is occupied during programming, lots of defects resulting from the human factor.

Due to the deficiencies of CAM programming, already mentioned, the users need a system which is simple for use such as programming on the machine and which makes use of the benefits of CAM programming. For simple, particularly 2D and 2,5D products, especially in the custom workshop production the programming on the machine is often used. For more exacting shapes the CAM programming is used. However, the programming on the machine is less and less competitive.

Programming on the machine does not belong to the CAx chain of technologies. Nowadays, from conceiving to managing of the life cycle of the product the CAD models are used. Thus, during manufacture of the product the CAD model and/or all components of the product are at hand. With the exit from the CAx chain in the manufacture the potentials, assured by modern technologies in this area such as simulation of cutting, simulation of the machine and optimization, are abandoned.

Due to the modern CAx support to the manufacture, the opportunity to meet the need for a new programming method, combining the benefits of manual of CAM programming, has appeared. What is needed is a highly automated programming, simple for use and suitable particularly for simple problems. Simple problems are meant to be technologically non-exacting machining operations, particularly on the products built from geometrical features. Automated programming will assure high productivity in creation of programmes and will eliminate the need for highly qualified personnel for programming of CNC machine tools. This new method of creation of programmes will require very few interventions and decisions from the human.

3.1 Expectations of users

In 2005 the conference "Manufacturing vision", organized and financed by the European commission, discussed the development orientations in the field of manufacture. By a questionnaire survey, experts were enquired about the need for selected technologies in development. Also the expectations of users and the time frameworks, within which the users expect the selected technology to become established, were verified. It was found out that, in the field of machining, the experts expected most of the automated programming of CNC machines. Only a little less than 10% of those surveyed ascribe smaller importance to the development of automated programming (Fig. 1). In addition, almost 70% of those surveyed expect that the automated programming will be introduced into practice within the next ten years (Fig. 1).

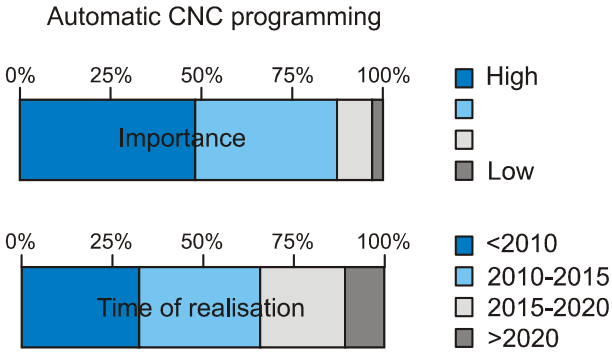

Fig. 1. Importance for industry and expected time of realisation of automatic CNC programming (adopted from [8])

Similarly, much is expected also of improved simulations and/or virtual machines [8] in the machine controls. Also the time frame, within which the virtual machine is expected to be created, is similar. Automated programming of CNC machines is associated with the implementation of virtual machines, since due to absence of the expert's evaluation of the programming results a system for reliable evaluation of quality of the CNC programmes is needed. Experts expect, particularly, the increase of competitiveness of the automated programming of CNC machines (Fig. 2). Like everywhere, where the degree of automation of processes is increased, also here the introduction of automated programming increases the productivity and reduces the need for human resources, engaged in the manufacture.

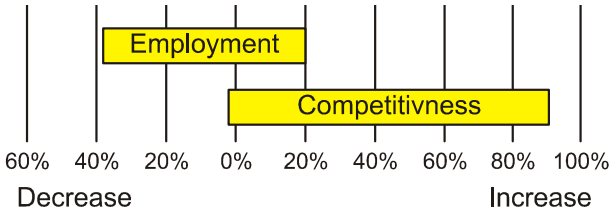

Fig. 2. Anticipation of difficulties in introducing automated programming (adopted from [8])

When implementing the automated programming, the users anticipate most difficulties in searching for technical solutions as shown in Fig. 3. As there are not yet any wide-spread solutions on the market, it is understandable that the users do not yet see the solution. Experts anticipate difficulties also in the area of education and difficulties due to shortage of finances for the development (Fig. 3).

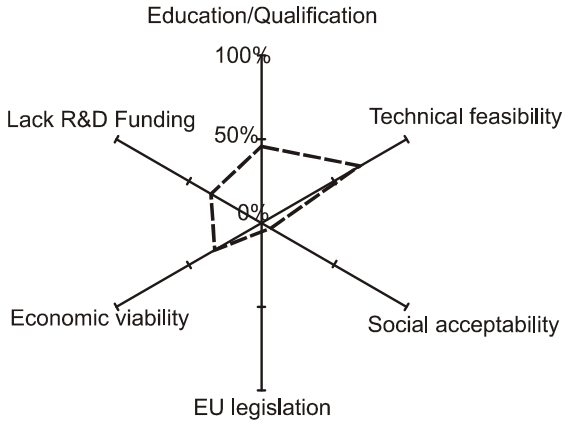

Fig. 3. Anticipation of difficulties in introducing automated programming (adopted from [8])

Users are aware of the applicability of automated programming and the necessity of development and, later on, the use of the automated programming technology in order to reach higher productivity and competitiveness in the future. Though the users mostly do not doubt the advent of automated programming, they are aware, particularly, of the technical and organizational difficulties, which must be overcome to ensure the use of automated programming in the future

4. CONCLUSION

Switching over to geometrical modelling of solid bodies with the use of geometrical features has ensured the use of more advanced techniques of creation of CNC programmes and increasing automation of programming. The CAM applications develop in the direction of automated programming. The use of this technology will not only facilitate programming, but will redefine the concept of work with CNC machines. Due to simplified creation of CNC programmes those machines will become more usable and more adaptable; shortly, they will become more applicable in the conventional concept of workshop production.

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