4.3 CNC MULTIFUNCTIONAL MACHINING CENTRES

The term "multifunctional machining centre" started to appear with the development of machining centres. In fact, the multifunctional machining centres are the CNC machines which combine two essential chip machining operations – turning and milling. In addition to this attribute, they have other properties which will be discussed hereinafter.

Characteristics and division

Similarly like at the recent time (year 1980), at the current time the various chip machining operations are also united at one machine with the following target:

- to reach the bigger machining precision – to machine so many operations as possible in one chucking;
- to machine the workpiece completely without its relocation and chucking on another machine in order to minimize idle time;
- to reduce machining time and to increase the machining quality;
- to pay the least possible amount for other machines purchased unnecessarily in many cases.

It could be said that a machine in the machining centre type (Section 4.1 and Section 4.2) is enough to comply with the above-mentioned demands. The characteristic feature for machining centres is that one of two essential chip machining operations is the dominant one. Thus, e. g. turning is the dominant operation and milling is the additional operation, or alternatively. These machining centres are then used predominantly for machining of non-rotary parts (they are sometimes called milling machining centres, which is less correct), or they are used predominantly for machining of rotary parts (they are sometimes called lathe-type machining centres, which is less correct).

The characteristic feature for multifunctional machining centres is that neither of two essential chip machining operations is the dominant one regarding to the output transmission. The current trend is to approximate the installed output differences for the various chip machining operations. Moreover, the machines have big kinematic adaptability in the workpiece and in the tool available – i. e. they are equipped with various heads as well as with tilting and movable tables (Fig. 4.3.1).

The multifunctional machining centres have in their morphology the same building feature as the machining centres.

- enables to use various technological operations (drilling, milling, turning, etc.);
- enables the automatic tool exchange;
- enables the automatic workpiece exchange;

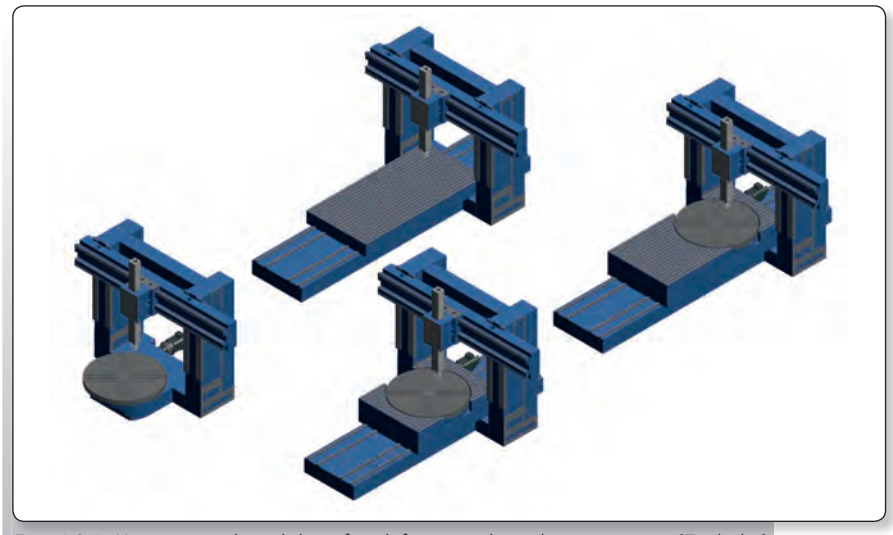

Fig. 4.3.1: Kinematic adaptability of multifunctional machining centres [Toshulin]

This can be e. g. the ram, two columns which the table is located between or different table types (including the integrated turning table) – Fig. 4.3.1. Alternatively, this can be – just as at the lathe-type machining centres – the characteristic horizontal bed with the inclined guideways. The rotary C-axes are situated horizontally on the guideways and the turning tool or the rotary tool moves in three linear axes behind them.

Fig. 4.3.2 shows the division of the multifunctional machining centres.

Term "multifunctional machining centre"

Let us repeat what is understood under the term "multifunctional machining centre". This is the machine which:

- enables to work in the automatic cycle or in the unattended operation;
- has diagnostic and measuring elements available;
- is equipped with intelligence elements.

In their designing aspect, the multifunctional machining centres are deduced from the CNC lathe-type or milling machining centres. The multifunctional machining centre is understood as the CNC machine tool which has the following features:

- properties of the machining centre;
- moreover, the value added based on the fact that various chip machining types have the approximated installed output (or torque) sizes, compared with the machining centre determined for various chip machining operations;

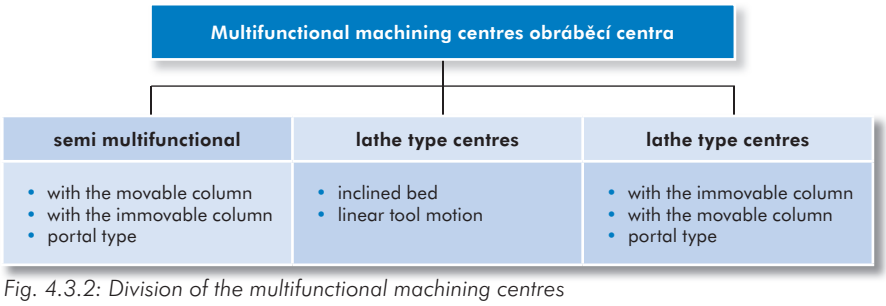

Fig. 4.3.2: Division of the multifunctional machining centres

- big kinematic adaptability in the workpiece and the tool;
- the manufacturer enables to the biggest possible extent to machine different workpiece shapes in one chucking and with one machine (e. g. turning and milling of boxes, rams, etc.);

At some manufacturers it is possible to notice the designs which are halfway between the machining centres and the multifunctional machining centres. The turning table (milling machines) or the milling spindle (lathe-type machines) is inserted to their motion axes, but the installed parameters which can be technically utilized (output, torque) differ more considerably. Such machines are called semi-multifunctional machining centres.

History of the multifunctional machining centres

The first ones in the world were in Kovosvit

In 1973 the work was started to perform the state task which a thousand million Kč was earmarked for – the development of machine tools of the 3rd development grade. In September 1973 a group of eight designers was concentrated in TOS Trenčín (two were from

VÚOSO Praha, two were from ZPS Gottwaldov, two were from TOS Trenčín and two were from Kovosvit Sezimovo Ústí) under the leadership of VÚOSO. The task was to elaborate the projection designs of the machines of the third development grade determined to machine flange, shaft and rod workpieces during four months, i. e. until the end of 1973. This task was not prepared sufficiently and even the designers who were working at this task were not properly acquainted with its goals. The design of the particular machines was elaborated to the required deadline, after many inspection days where great numbers of people participated. The manufacture was divided into the particular enterprises in the following way:

- two prototypes of machines for flange workpieces should be manufactured in ZPS Gottwaldov;
- two prototypes of machines for shaft workpieces should be manufactured in TOS Trenčín;
- one prototype of the machine for shaft workpieces and one prototype of the universal machine should be manufactured in Kovosvit Sezimovo Ústí.

The manufacture of the machine for rod workpieces was considered to be the most difficult one. The manufacture of the particular machine assembly groups was also divided among the particular enterprises in order to provide it jointly for all prototypes. The development of the particular machines was running in 1974 and 1975. At the same time, the discussions were performed about the incorporation of the machines into the flexible production systems (PVS). The flexible production system for machining of flanges should be built in ZPS Gottwaldov, the flexible production system for machining of shafts should be built in TOS Trenčín and the flexible production system for machining from rods should be built in Kovosvit. Before the study work was begun, the general director of the TST trust gave the command to Kovosvit to use the machines of the 3rd development grade for the flexible production system for machining from rods.

Kovosvit elaborated the realization study of this task with utilization of these machines in a few variants. The variant created by three machines connected by the manipulator was chosen from the study.

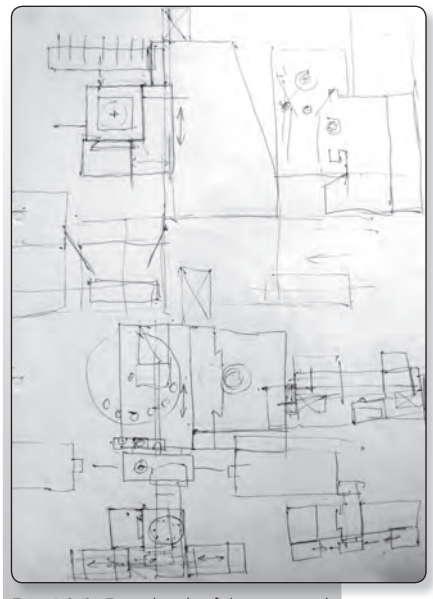

Fig. 4.3.3: First sketch of the state task new solution [Borkovec]

Two outer machines machined from a rod from the first side, and after the workpiece was gripped by the transport clamp and it was cut-off, it was transported by the manipulator to the middle machine, where the other side was finished. The workpiece was then again transported by the manipulator to the storage station where it was unloaded. The flexible production system was compiled of two trios of such machines. However, it appeared that this manufacturing and transport way of workpieces has many drawbacks, that it would be difficult to put it into operation and that it would not represent the solution for repeated manufacture.

The task to build the flexible production system of the machines of the 3rd development grade was cancelled at ZPS Gottwaldov and TOS Trenčín, this task was changed and only one machine should be built as a workplace. The fact that no flexible production system had been provided meant that the funds earmarked for the development from the state budget would be used without the appropriate effect, or that people would be still finishing or remaking the machines and other considerable funds would be spent without any significant success. Ladislav Borkovec, "Baťa follower" sketched the idea about the different machine solution in dependence on his visions one a piece of paper (Fig. 4.3.3)

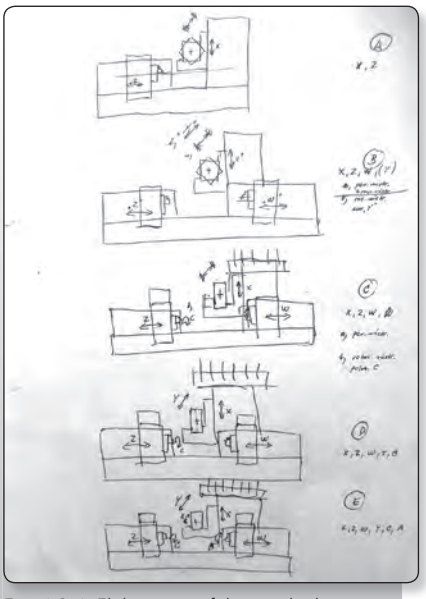

Fig. 4.3.4: Elaboration of the unit-built system of the MCSY machine new solution [Borkovec]

4.3 CNC MULTIFUNCTIONAL MACHINING CENTRES

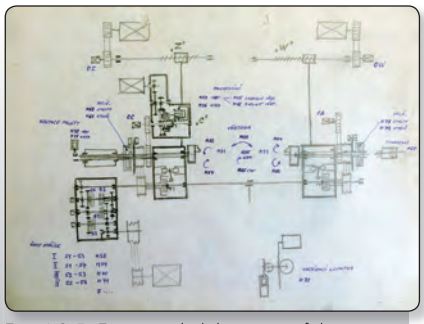

Fig. 4.3.5: Functional elaboration of the motion groups at the MCSY machine [Borkovec]

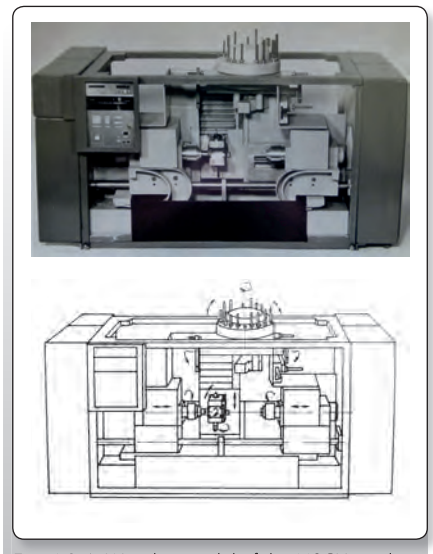

Fig. 4.3.6: Wooden model of the MSCY machine and its kinematic diagram [Borkovec]

for the then technical deputy at one of the enterprise conferences in 1977. The technical deputy commented on the sketch with the words that such a solution was unfeasible, that Ladislav Borkovec had big phantasy. Nevertheless, Ladislav Borkovec thought further about this new machine solution way and he sketched it in ideas. VÚOSO then came with the requirement to start study work at a new state task. During his spa treatment after his operation in Karlovy Vary in October 1977, Ladislav Borkovec was permanently thinking about the new machine solution and he was creating a unit-built system which would be able to cover most of technological operations at one machine (Fig. 4.3.4).

After he had returned from the spa, he was surprised by the design submitted by the then technical deputy. The design development chief of VÚOSO in Prague tried to convince Ladislav Borkovec to work on the design submitted by the technical deputy. Ladislav Borkovec did not consider this solution to be the right solution solving the requirements put on the flexible production system and showing the development progress and he refused this cooperation. Because there was no understanding for his design and his idea of the new machine, he worked at home in evenings and at weekends to elaborate the particular machine groups functionally in more details (Fig. 4.3.5). At the same time, he was making the demonstrative model of wood true-to-scale 1:10 with all functional properties (Fig. 4.3.6). Doing this, he elaborated the universal integrated unit-built system which was also demonstrated on the model, which enabled to comply with the solution of the machine for the flexible production system for machining from rods in Kovosvit and which also provided the compilation of the machine for flange, shaft and box workpieces and due to this, which helped to fulfil the state tasks solved in other TST trust enterprises.

After he had finished his model, Ladislav Borkovec presented it to rationalization technicians, to the design development chief as well as to the development chief and he made them acquainted with the unit-built system possibilities and with working possibilities. The development chief liked the model and the model complied with his visions. Then, the model was examined by employees of Kovosvit. After the improvement proposal had been submitted of the machine solution, by means of which the requirements would have been fulfilled put on the machines for the flexible production systems and which would have provided repeated manufacture of the flexible production system, the comparison of both variants was pushed through in the enterprise. This concerned the variant by the technical deputy and the design variant in dependence on the submitted improvement proposal. The technical and economic assessment was performed and the suitable variant was selected.

The solution by Ladislav Borkovec won, but the task was newly specified. Because the development realization shall be accelerated and the functional sample shall be made as soon as possible, in a very short time period Ladislav Borkovec made and submitted the dimensional sketches with dimensions and function description according to the detailed dimensional model and group functions to the technicians solving the particular assembly groups. He submitted the necessary documents also for the tool magazine solution which was transferred to VÚOSO in Prague. Due to this, in the very beginning he enabled to start the development work by more people together. Even if nobody asked Ladislav Borkovec to make the model or to work at the designing elaboration, this was just the thing which enabled to implement the design, because the realization would have not been put through without the model presentation and the next development work was considerably accelerated, after the studies and designs had been elaborated.

Main technical data of the MCSY machines		
Maximum turned diameter from a rod	mm	50
Maximum turned flange diameter	mm	250
Maximum turned shaft diameter	mm	200
Maximum length from a rod	mm	120
Maximum flange length	mm	160
Maximum shaft length	mm	630
Maximum dimensions of a box-shaped workpiece	mm	200 x 200 x 200
Main spindle speed	rev.min^{-1}	71–4 000
Maximum main motor power output	kW	25
Spindle position setting continuously		fluently 360°
Rapid traverse	m.min^{-1}	10
Stroke in the Z, W-axis	mm	750
Stroke in the X-axis	mm	650
Stroke in the Y-axis	mm	250
Number of tools		18
Tool magazine		
Number of positions		24
Tool taper		ISO 40
Tool spindle speed	rev.min^{-1}	45–2 500
Maximum tool motor power output	kW	6

Fig. 4.3.7: MCSY 50 functional sample and its technical parameters [Kovosvit MAS]