3.6 AUTOMATIC WORKPIECE EXCHANGE

The assembly groups specified to perform manipulation with workpieces, position setting and chucking of workpieces in the working area of machining centres represent a large group of machineries which are the basis for automation of manufacturing processes, in addition to the automatic tool exchange. It is possible to trace many types as well as designing and technological principles in dependence on the workpiece, its size and e. g. the number of manufactured workpieces.

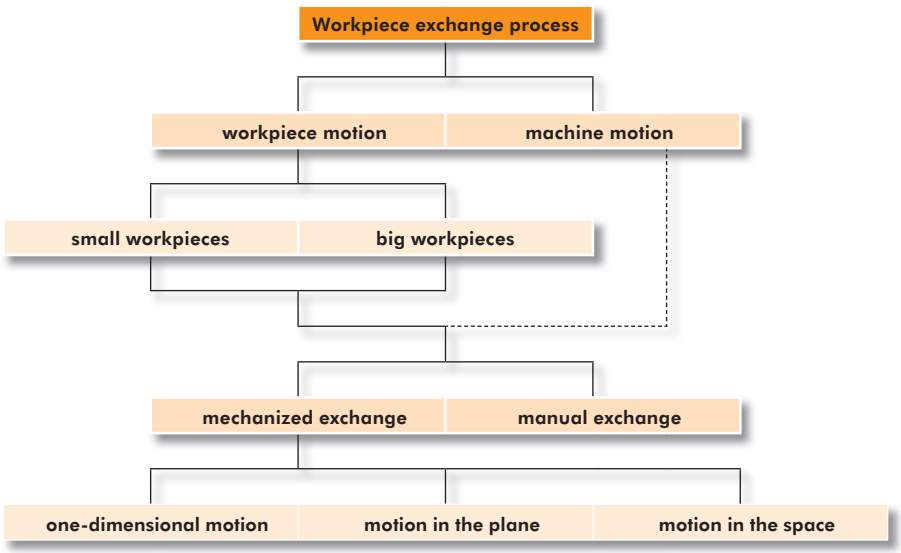

Fig. 3.6.1: Workpiece exchange process

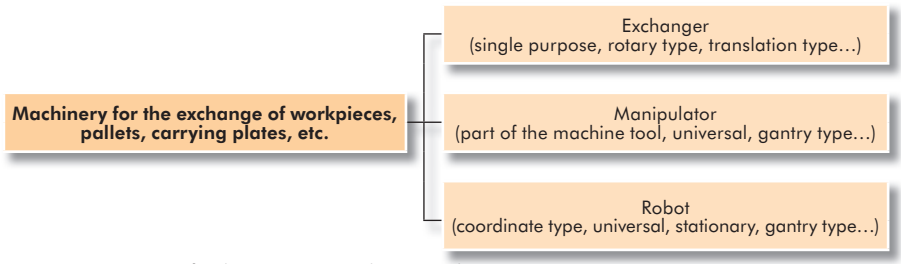

Fig. 3.6.2: Equipment for the automatic workpiece exchange

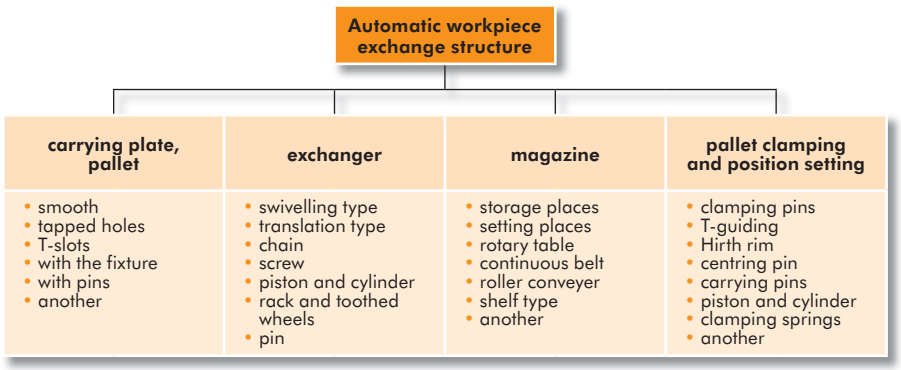

Fig. 3.6.3: Morphology of the automatic workpiece exchange

Manual chucking of workpieces (Fig. 3.6.1) on the working table of the numerically controlled machining centre is often uneconomical, because the machine does not work during the workpiece chucking and position setting. This reduces the degree of its utilization The higher the machine purchasing price is and the more labour intensive and prolonged the workpiece chucking is, the more significant these losses are. This is the reason why the systems are developed which reduce the non productive time to the minimum possible amount (Fig. 3.6.2).

The reduction of non productive time due to the workpiece setting can be performed in two ways. There are usually two or more working areas next to each other in the case of big and heavy workpieces. These working areas are created by one large table and e. g. there is also a solution possible at horizontal boring and grinding machines, when the rotary table stands next to the fixed machine table. The machine having the flexible frame (Fig. 3.6.1 and Fig. 3.6.4) is adapted so that it can perform machining in all chucking areas (see also section CNC boring machines). While the workpiece is being set on one place, machining is performed in the neighbouring working area (on the other table part) (3.6.5). This way how to accelerate production implies safety risks. In order to prevent an operator's injury, the area where machining is performed and the area where the workpiece is being set are separated by mobile barriers. However, operator's increased caution is reasonable. Smaller machines can be equipped by stationary protective guards but these guards disable to change flexibly the area size in dependence on the workpiece dimensions.

The machine tool table can have the circular, rectangular or square shape, the immobile tables can include the built in rotary tables, angular chucking plates, etc. T grooves are usually on the chucking plates and tables [Borský 1991]. Clamps (mechanical clamps, hydraulic or pneumatic clamps or complete fixtures) are situated on the chucking table (Fig. 3.6.4). In the case of heavy workpieces with big dimensions, the workpiece exchange is performed by the operator using the crane having the appropriate carrying capacity. In the case of the machines having the mobile frame, if the machining operations are short or if there is a rational reason available, manipulation with smaller workpieces or semi products can be provided by the manipulator (robot).

Another principle which is the main subject of this section is based on the workpiece motion to / from the machine working area (Fig. 3.6.1). There are a few essential design solutions available (Fig. 3.6.2) which find their utilization in dependence

Fig. 3.6.4: Principle of the doubled workplace [Rottler USA]

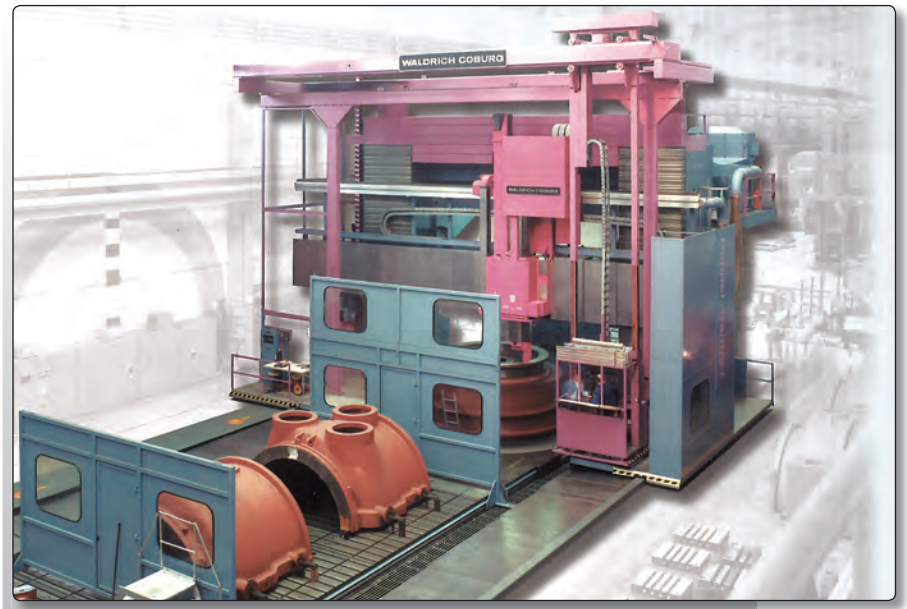

Fig. 3.6.5: Machining a setting of more workpieces on one machine [Waldrich-Coburg]

on the workpiece kind (rotary workpiece or non rotary workpiece), on the workpiece size and weight, on the machine type, on the required velocity and accuracy of the workpiece exchange and on the quantity of manufactured workpieces related to it (production capacity). The workpiece itself is usually very significant at the selection of the suitable workpiece exchange – the workpiece size, the possibility how to chuck it, its rigidity, machining operations which are performed on the workpiece, the risk of a collision between the tool and the clamps and many other factors.

The workpiece can move in the manufacturing process:

- freely;
- on the carrying plate (technological pallet);
- on the machine pallet (this is the integral part of the machining centre);
- on special clamps and fixtures.

The one dimensional motion at the workpiece exchange can be the rotary one as well as the translation one. Lathe type centres, multiple spindle automatic machines or centreless grinding machines with the continuous workpiece motion can be mentioned as the examples of the motion which is only rotary. The semi product passes through the hollow chuck (Fig. 3.6.6). The plane workpiece motion, whether the translation motion, the rotary one or the combination of both types, is dominant at production lines. It is often completed by the short stroke in the plane perpendicular to the main motion plane. This motion is necessary to clamp the machine pallet at machining centres. The multiaxial manipulator, the universal robot, etc. gives the independent workpiece or the workpiece on the carrying plate or on the machine pallet to the spatial motion.

If the workpiece moves freely between the storage place and the machine (by means of the feeder or the manipulator) or if the workpiece moves freely among more machines, it must comply especially with the following preconditions for this manipulation kind (the sequence is given without any demand put on importance:

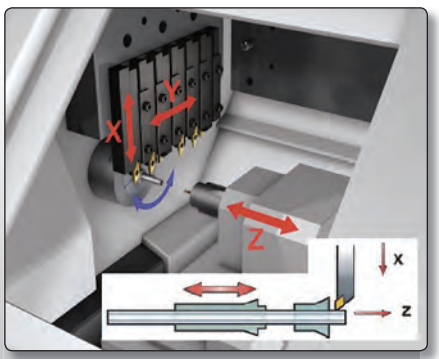

Fig. 3.6.6: Workpiece exchange principle at long rotative automatic machines [Sandvik Coromant]

- chucking of the free workpiece is simple (it can be realized automatically) with the sufficient accuracy;
- spatial orientation of the workpiece for chucking in the chucking assemblage on the machine is simple (the first requirement on the workpiece orientation in the machine or towards the tool);
- the workpiece includes surfaces which enable to grip it in the end manipulator effector and simultaneously in the chucking mechanism on the machine at one moment;
- if there is another requirement on workpiece orientation (towards any significant plane, the related element, there is an orientation hole on the workpiece, etc.), this orientation must be also simple and it can be automatized;
- the workpiece is sufficiently rigid and it does not deform by its chucking directly in the machine;
- the workpiece can be efficiently stored by automation devices, it can be gripped easily and moved from the storage place (in process store, magazine) to the machine tool by these devices;
- velocity of gripping the workpiece by the manipulator, workpiece orientation, workpiece chucking, etc. are sufficient for machining needs of the particular production;

- it is not necessary to identify the workpiece in a complicated way (e. g. the workpiece is always the same one).

If it is not possible to comply with one of the mentioned requirements (of course, there are many other technical and technological requirements in practice which are not mentioned here), the workpiece shall be located on the carrying plate (technological pallet), where it is chucked until the required manufacturing operations are performed.

The free motion of the workpiece (of the semi product) with its automatic exchange can be applied to machining centres, it can be very often found at single purpose machine tools and production lines. Figures shows the workpiece examples – railway wheels, brake wheels of cars which comply with the above mentioned items. It can be noticed that manufacture of railway wheels has many specific features. In Fig. 3.6.7 it can be also seen that the table enables to chuck the wheel by means of two jaw types, in dependence on the side of the wheel which is just machined. The manipulation way with brake wheels is shown in the next figures.

Whether the workpiece moves freely or it is located on the carrying plate, the effort is always to reach the shortest possible time necessary to replace the machined workpiece with another one which is not machined yet. For manipulation with workpieces at automatic lines it is necessary to determine manipulation on one workplace taking into account the whole line (or plant). The independent section writes about the workpiece exchange at automatic lines.

In many cases the production lines and the single purpose machine tools can be replaced by the "general purpose" machining centres adapted for large lot production and mass production. At these machining centres it has been possible to utilize advantageously the design solutions and principles which were sooner connected with machines for so called hard automation. Small centres specified to make non rotary workpieces and determined to be used in high efficient production also utilize the workpiece exchange principle, when the workpieces are

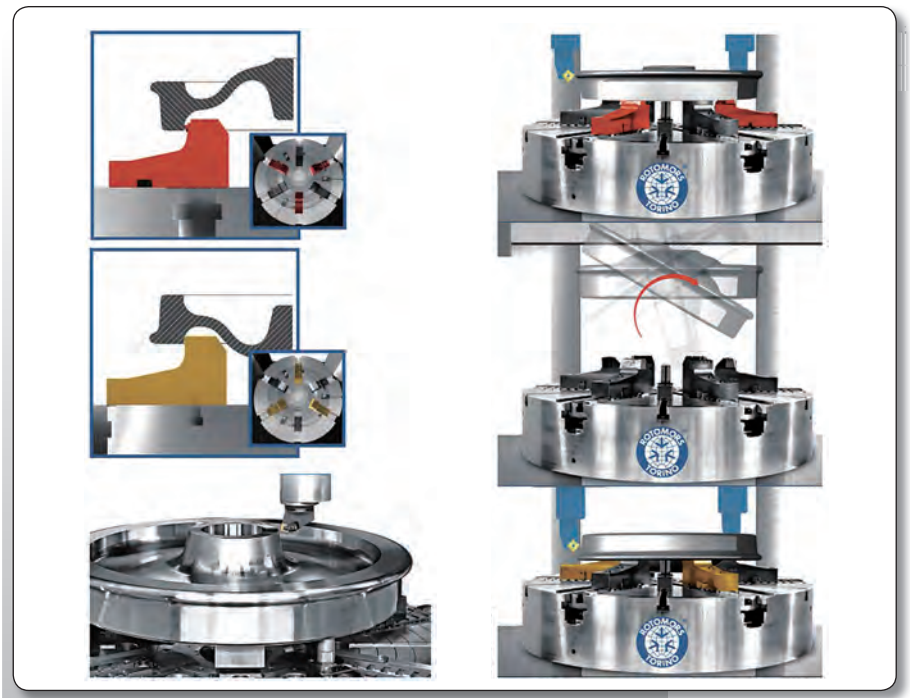

Fig. 3.6.7: Workpiece moving freely in the manufacturing process [Rotomors]

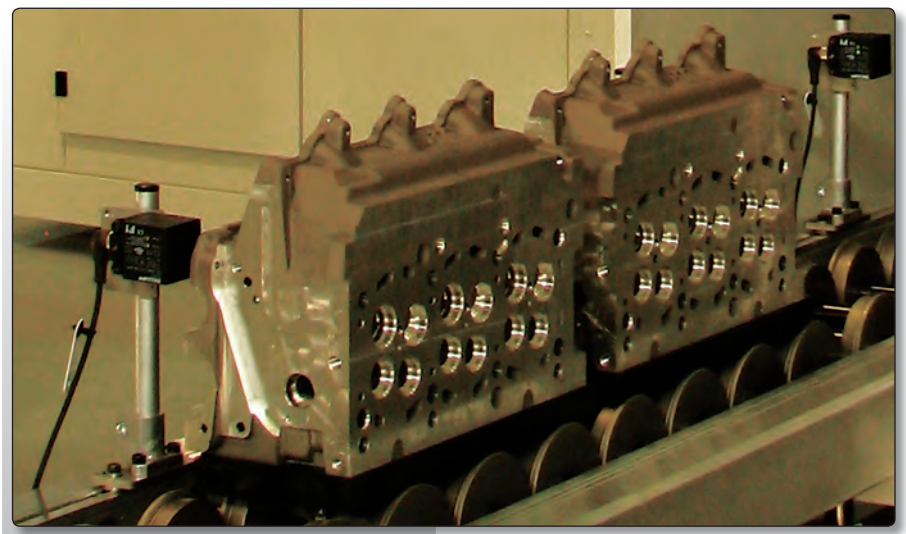

Fig. 3.6.8: Part of the internal combustion engine located on the carrying plate [Grob]

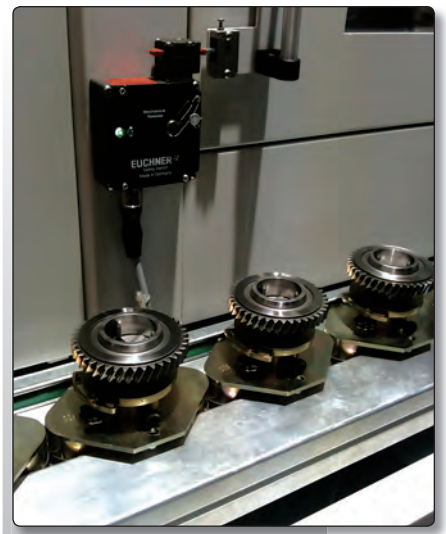

Fig. 3.6.9: Carrying plate for rotary workpieces [MAG]