4.1 CNC LATHE-TYPE MACHINES AND MACHINING CENTRES SPECIFIED TO MAKE ROTARY PARTS

The lathe-type machines are the largest group of machine tools with the geometrically defined cutting edge and they also represent the most commonly used type of machine tools specified to machine parts having the rotary shape. The are able to machine outside and inside cylindrical rotary surfaces, conical and general surfaces, front plane surfaces, they are able to perform thread cutting, to drill, to bore, to ream as well as to copy in the longitudinal direction and in the transversal direction, they are able to mill surfaces and grooves, to grind outside and inside cylindrical surfaces, etc.

CNC lathe type machines and lathe type machining centres

Horizontal axis	Vertical axis	Special type
• production machines • multiple spindle automatic machines	• vertical lathe type • inversion machines	• single purpose machines

Fig. 4.1.1: Division of lathe-type machines and lathe-type machining centres

Characteristics and division of CNC lathe-type machines

The lathe-type machines are distinguished by the main cutting motion reached by the workpiece rotation. The working accuracy of the lathe-type machine depends considerably on the bearing precision of the rotating active part (of the spindle, of the table), on its static rigidity, shape precision and on the static rigidity of its bearing. Therefore, the big emphasis is placed on the design and calculation of spindles and tables. The tool (the turning tool in most cases) must be attached to another movable machine part, it must be exchanged and adjusted and guided by the movable part parallelly, vertically or concurrently towards the workpiece axis of rotation. Therefore, the rail heads, slides and rams were developed and therefore, the great attention is paid to the design and calculation of their bodies and guideways [Borský 1992a].

The numerical control brought new working possibilities for lathes, on the one hand the design was simplified and on the other hand the new designing measures were necessary. The numerical control simplified manufacture of shaped (general) rotary surfaces, it simplified thread cutting and it replaced the copying attachment; the kinematic coupling was replaced by the coupling in the control computer. However, designing of CNC machines requires backlash elimination in the feed driving assemblages, their high rigidity, reduction of passive resistances in the gearing mechanisms and in the guideways as well as the suitable sensors for measuring (measuring of the position, of the path, of speed, of the torque or of the current) and for formation of feedback couplings. The variable speed driving motors are used and the number of mechanical gearing ways is reduced [Borský 1992a]. Fig. 4.1.1 shows the division of lathe-type machines and lathe-type machining centres.

Term "lathe-type machining centre"

The single-professional CNC lathe-type machine enables to perform only turning operations (Fig. 4.1.2). If one wants to speak about the lathe-type machining centre (for now it is not important about what type), the machine must have the following features:

- it must enable various technological operations (drilling, milling, turning) – Fig. 4.1.3;
- it must enable the automatic tool exchange (usually the turret carrying magazine) – Fig. 4.1.4;
- it must enable the automatic workpiece exchange – Fig. 4.1.5;
- it must enable to work in the automatic cycle or in the unattended operation;
- it must have diagnostic and measuring elements available;
- it must be equipped with intelligence elements.

In their designing aspect, the lathe-type machining centres are deduced from the single-professional CNC lathe-type machines.

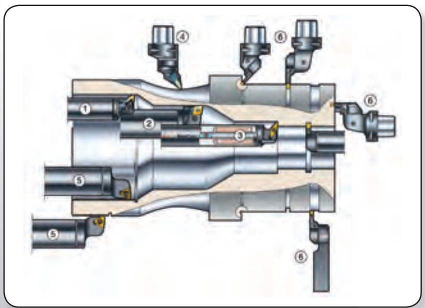

Fig. 4.1.2: Example of turning operations at the CNC lathe [Sandvik Coromant]

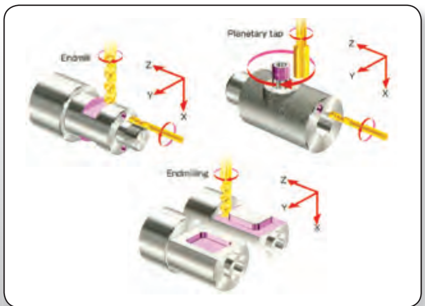

Fig. 4.1.3: Technological operations at the CNC lathe-type machining centre [Miyano]

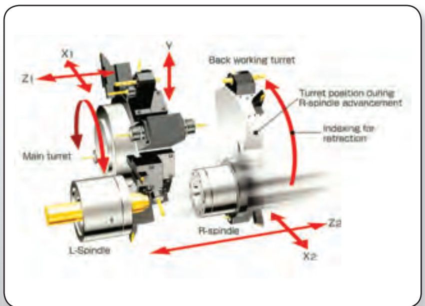

Fig. 4.1.4: Automatic tool exchange at the CNC lathe-type machining centre [Miyano]

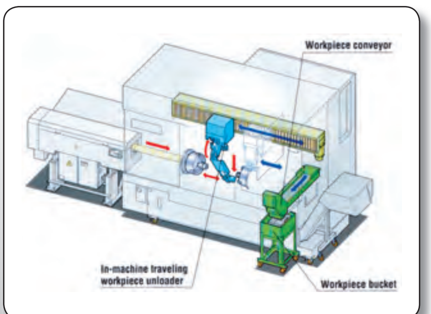

Fig. 4.1.5: Automatic workpiece exchange at the CNC lathe-type machining centre [Mori Seiki]

Production lathes and machining centres

Characteristics and design of main assembly groups

The bed is the essential carrying machine part which must provide the high rigidity, especially the high flexural rigidity and the high torsional rigidity. The shape rigidity represents a special requirement. The good flexural and torsional rigidity is obtained by the suitable bed profile which must be closed and stiffened by ribs, if possible. The bed must enable good chip removal, because crowding of hot chips causes thermal dilatation, which influences accuracy

(Fig. 4.1.6). The guideways, driving mechanisms (racks, lead screw, etc.) must be protected by suitable protective guards so that falling chips cannot cause failures, damages or quick wear. Moreover, the design solution must enable the simple and cheap manufacture. The bed is usually made of grey cast iron or of other materials (Fig. 4.1.7). Another requirement is represented by the low weight, because the bed is the machine part having the biggest dimensions and therefore, it has the great significance for economic utilization of material for its manufacture. The efforts to reduce the weight must not affect unfavourably the good static and dynamic rigidity [Borský 1992a].

The lathe rail head is the connection link between the tool and the bed. It catches and transfers forces arising during the machining process. It consists of the composition of a few parts movable along each other. At their designing it is necessary to consider not only their parameters of the torsional, flexural and pressure rigidity, but first of all the contact rigidity of connections of the particular parts which are predominantly sliding ones (Fig. 4.1.7). It is necessary to take account of backlash influences in the particular guideways which will influence the total rail-head deformation measured on the tool and due to this, they will also influence accuracy [Borský 1992a].

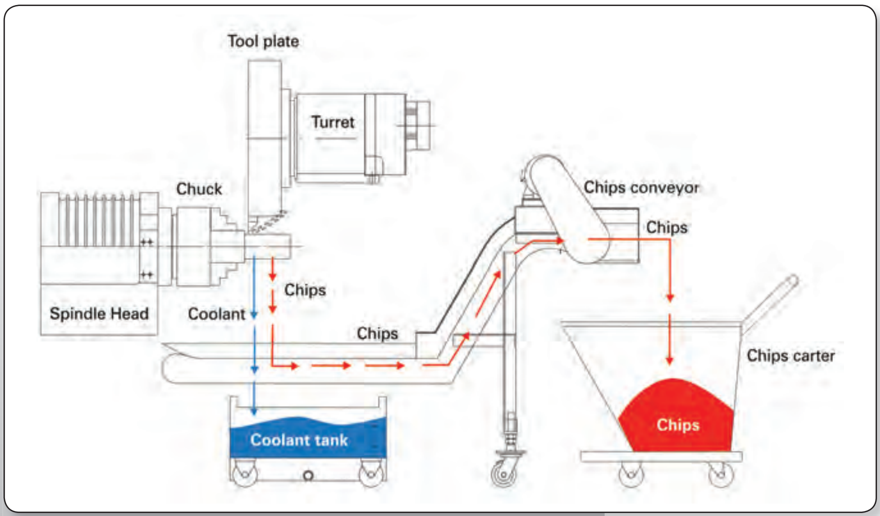

Fig. 4.1.6: Chip removal from the working area at the CNC lathe [Litz]

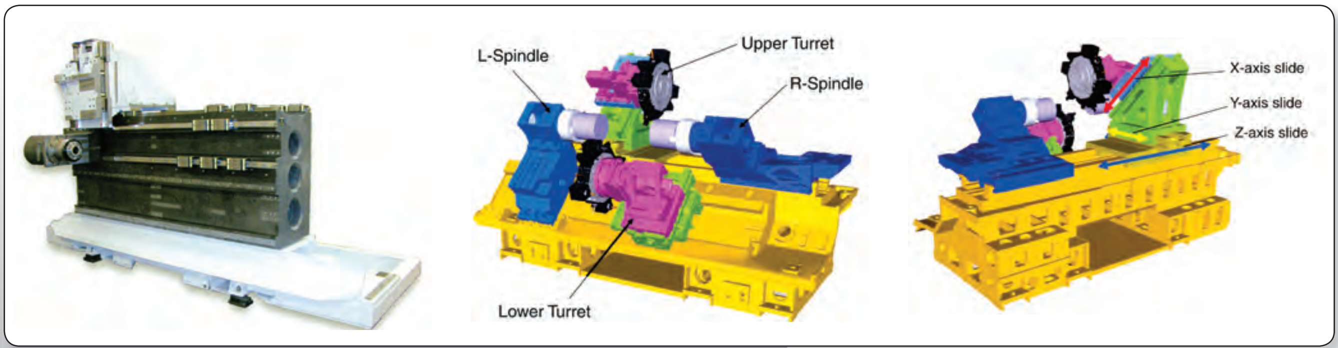

Fig. 4.1.7: Profiles of lathe beds and guiding example of motion groups [Nakamura], [MAG]

The arrangement of the guideways of the particular feed axes plays the equally important role. Fig. 4.1.8 shows the possible arrangement of guideways which results in the more favourable resulting stress of bearing packs by cutting forces in the profile guiding with bearing packs.

The headstock represents the essential nodal point of the composition influencing considerably the whole machine quality. It must be sufficiently rigid, it must catch safely the radial and axial load caused by the cutting process and the workpiece weight. At the up-to-date concept of lathes the headstock forms the independent group determined only for the optimum bearing of the working spindle. The driving servomotor and the gearbox are located separately (Fig. 4.1.9), if it does not concern the drive performed by the torsion motor. The spindles at small and partly also at middle-sized lathes have the demountable

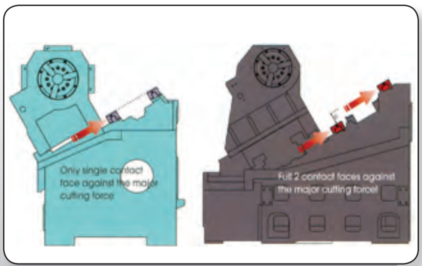

Fig. 4.1.8: Possible arrangement of guideways [Akira Seiki]

universal chuck and the table specified for workpiece chucking. The table is firmly located and attached to the spindles at big and partly also at middle-sized lathes. The spindle task is to put the workpiece into the precise revolving motion. The spindle is located in the front bearing and in the back bearing so that it can transfer radial and axial forces. The spindle seating in the front bearing has the deciding influence on the accuracy of its revolving motion. The spindle nose is suitably adapted (standardized) for the application of the chuck, of the table, of the workpiece centre or of the chucking collet [Borský 1992a].

It is possible to mention the following ones of all requirements put on the machine-tool spindles [Borský 1992a]:

- run accuracy; this accuracy is determined by intensity of the radial run-out and of the axial run-out;
- the perfect guiding (bearing) is necessary, i. e. the spindle must not change its position in space if its loading changes the direction and the sense;
- losses in the spindle bearing must be as small as possible (passive resistances, position and backlash changes due to warming, function deterioration);
- the spindle must be as rigid as possible, its deformations together with run inaccuracy have the decisive influence of the working accuracy (on the workpiece precision) in the radial direction as well as in the axial direction.

The spindle rigidity has the considerable influence on the working accuracy and dynamic stability of the machine. The spindle rigidity is usually stated on the spindle nose, where the chucking device is mounted together with the workpiece, because the deformation in this place has the direct influence on the working quality and accuracy.

The tailstock primarily serves for workpiece chucking between tailstock centres. Its type execution has the similar influence on the machine rigidity as the spindle rigidity. For the reason that the working accuracy must be the same one along the whole length of the machined part, the tailstock radial rigidity must be performed in the same quality as at the spindle or as at the whole headstock, if

Fig. 4.1.9: Type executions of spindle drives and spindle bearings – examples [Viper]