5.4 HEAVY MACHINE TOOLS

The huge machines amaze laymen, but the knowledgeable expert looks at the crane loading capacity at first. Energy industry, aircraft industry, space industry, mining industry, marine industry, petrochemical industry, chemical industry and nuclear industry – each of them requires to machine very large and heavy workpieces. The design and the structure of a machine tool must be adapted to the machining of workpieces whose dimensions and weight exceed usual values.

The heavy machine tools are understood as such machineries which are determined for chip machining of the workpieces having big dimensions and weight, while the dimensions and weight of the machines themselves are appropriately big too (Fig. 5.4.1). The terms "big and heavy" are not strictly limited. Exactly these properties make these machines extraordinary and unique, which is reflected in the simple name of this technically miscellaneous group. The heavy machine tools are custommade, their manufacture and utilizationare the matter of prestige for both sides. They are presented with difficulties due to their dimensions – in many cases it is very complicated to make a clear photo using a camera. Therefore, they are usually "visualised" by means of drawings, physical models in a certain scale and newly by means of models provided by CAD programs. The heavy machine tools have their specific and characteristic features, properties or parameters which are summarized in the following twelve items.

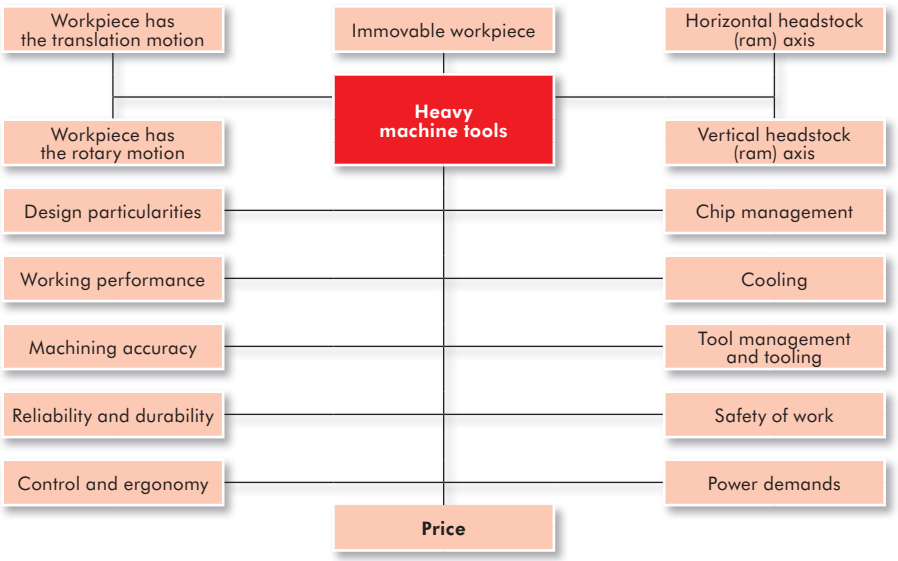

Fig. 5.4.1: Heavy machine tools and their specific features

Design solution particularities

The heavy machining centres have their design particularities which follow from their size, manufacturability and assembly possibilities. The first part of this section will deal with them.

The manufacture and transport of carrying parts of heavy machine tools (columns, tables, cross rails) is very difficult. The highway and railway profile has limited parameters, the bridges have limited loading capacity and the underbridges have limited height. It is not possible to transport them as monolithic units, therefore the parts having big dimensions are connected from more parts. The connection screws are tightened by the exactly defined torque. The connecting material can be heated at the assembly (so that its mechanical properties are not influenced) and the required clamping force is created by the subsequent cooling. Even if the single parts are very big, their connection is performed very precisely and many technicians (laymen in any case) are not able to recognize the connections places at first sight. Fig. 5.4.5 shows a connection example of the largesized chucking table which is equipped with the Tslots on its upper part. Fig. 5.4.6. shows the table made from three parts, which is disclosed by the tool traces and assembly holes. The table will be machined by the machine itself at the assembly finishing and the noticeable marks of connection of a few parts will disappear.

The design solution of the frames at the heavy machine tools keeps the concrete foundation as the inseparable part of the machine frame. Considering the frame weight and the workpiece weight, the concrete thickness ranges in metres. The necessary concrete thickness depends most of all on the foundation loading and on

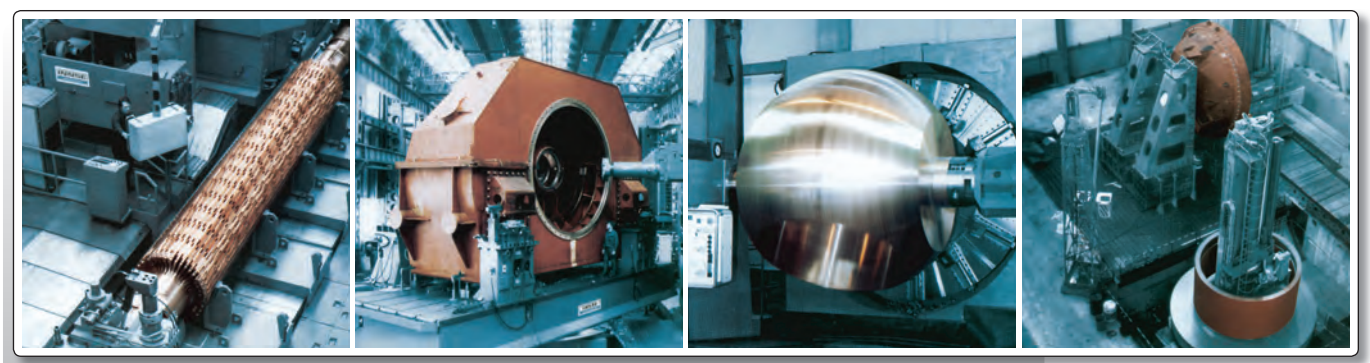

Fig. 5.4.2: Examples of predominantly rotary workpieces manufactured by heavy CNC machines [Innse – Berardi – Retco]

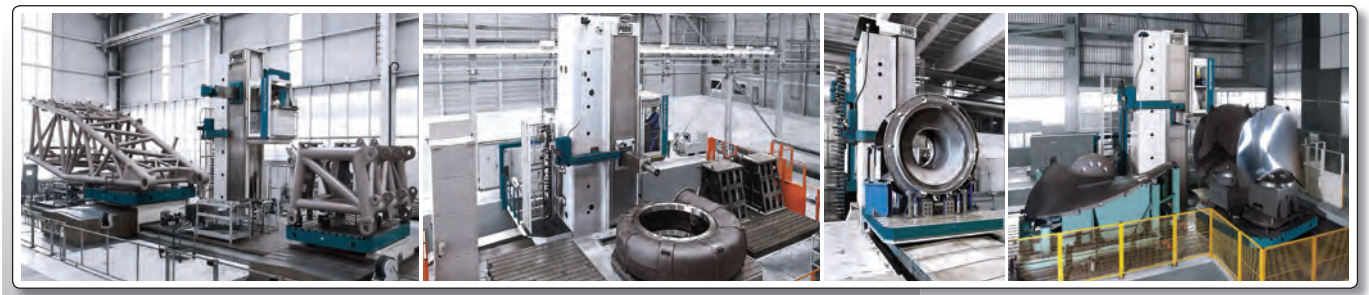

Fig. 5.4.3: Examples of predominantly nonrotary workpieces manufactured by heavy CNC machines [Pama]

the concrete rigidity [Borský 1991 and Borský 1992a], the foundation size also influences the natural frequencies of the whole arrangement. The calculations of the necessary concrete thickness can be found in the mentioned literature. Another design principle of the frame consists in the fact that the columns are not connected directly with the bed, where the movable table or the rotary table is located. The columns are

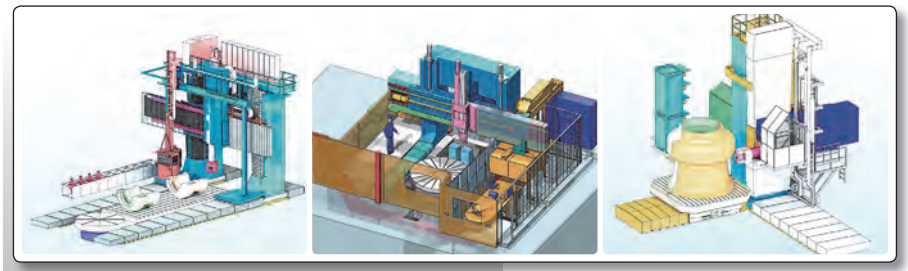

Fig. 5.4.4: Overview of heavy machines [Schiess SMTCL]

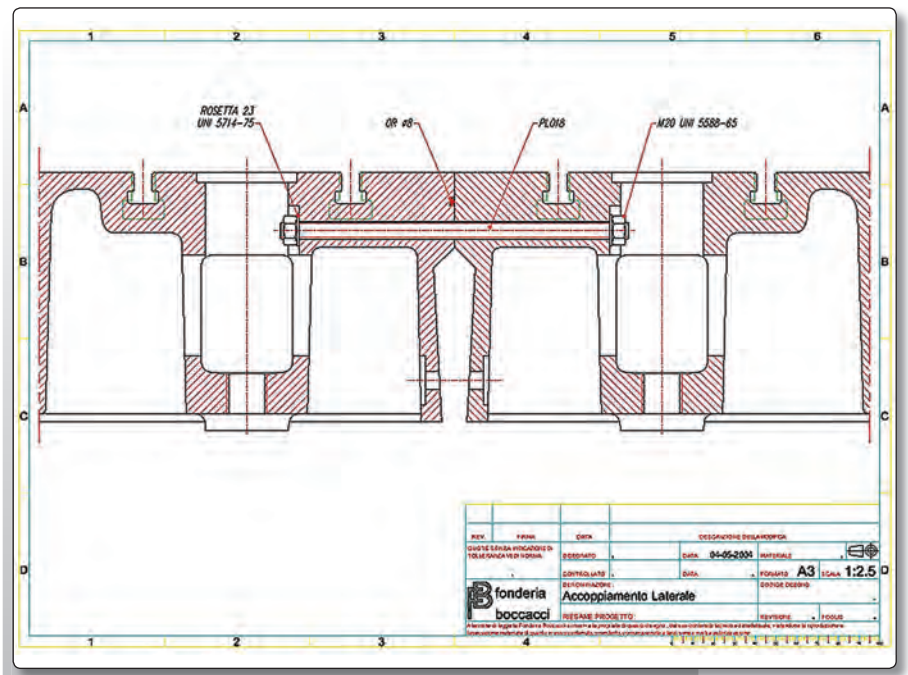

Fig. 5.4.5: Connection example of largesized machine parts [Fonderia Boccacci]

Fig. 5.4.6: Table made from three parts [Bost]

attached only to the concrete foundation. The levelling pads and many forcingoff screws and attachment bolts serve for the exact setting and levelling.

Mechanical and thermal machine deformations have a very harmful effect on the machine operation accuracy. Section "CNC drilling and boring machines" deals with the compensation of the ram deflection and of the frame inclination in details.

The equilibration of very heavy machine parts is significant for the optimum design and utilization of the feed mechanism. The equilibration is provided by hydraulic cylinders, lifting of headstocks, rail heads, etc. by the mechanical counterweight is used less often. The ball screw is still used in the vertical direction (Z axis). The drive must be equipped with the brake so that the ram cannot move spontaneously to the working area (e. g. at a failure of the electric power supply) (Fig. 5.4.7).

Because the rams have big dimensions – it does not matter whether the particular

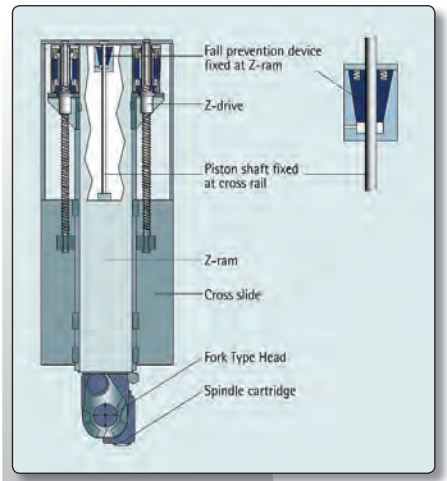

Fig. 5.4.7: Example of the ram safety brake [DST]

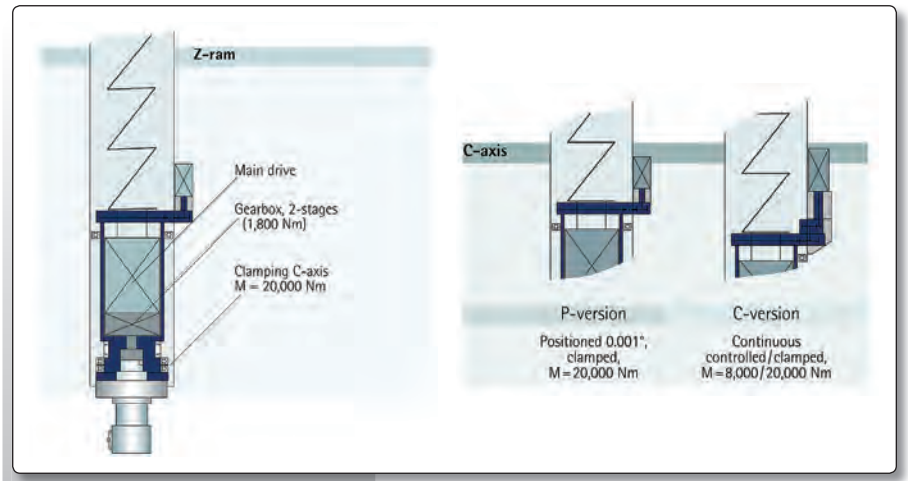

Fig. 5.4.8: Rams having big cross sections can be equipped with the C axis [DST]

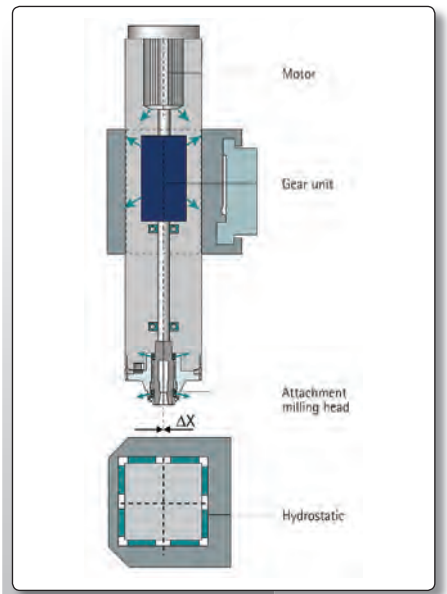

Fig. 5.4.9: Example of the ram safety brake [DST]

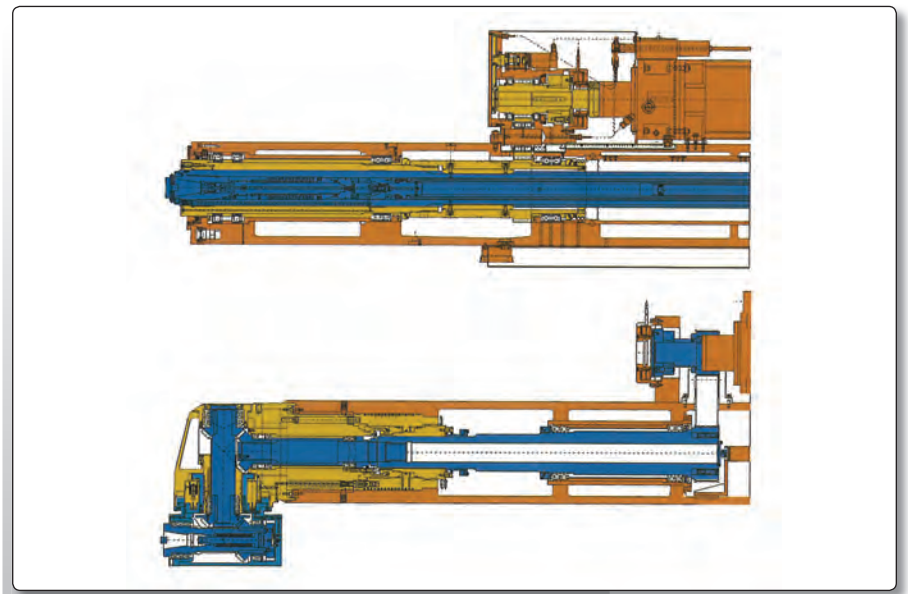

Fig. 5.4.10: Example of the rotary tool drive and of the tailstock sleeve at the horizontal boring and milling machine [Škoda Machine Tool]

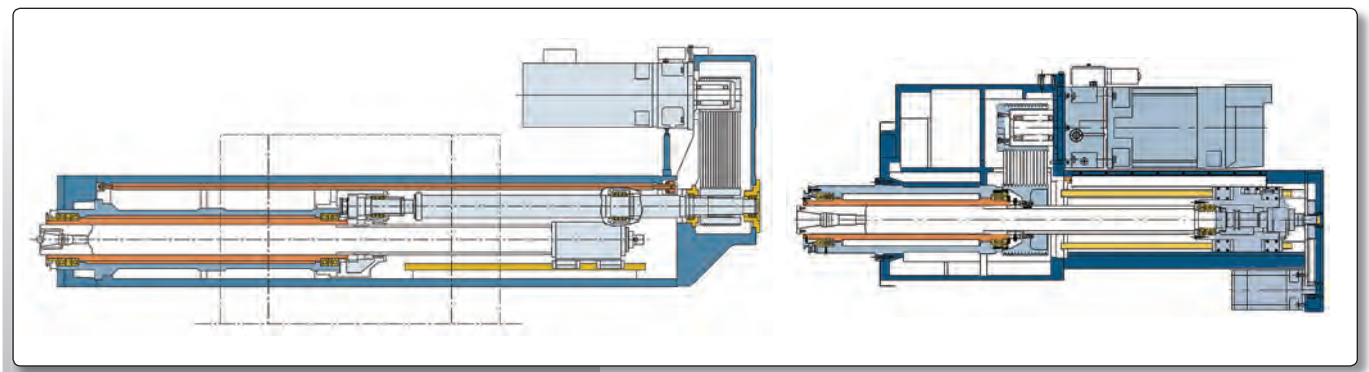

Fig. 5.4.11: Drive kinematics of the ram and of the headstock [Union]