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Multiple Solutions: Different Drive Concepts for Machine Tools

When looking at machine tools, the details of the installed drive technology usually remain concealed. There are, in principle, various possibilities for selecting main, feed and auxiliary drives for the movements that need to be carried out.

Main drives

For main drives it is predominantly closed-loop controlled, electric synchronous and asynchronous motors that are used. Their applications include kit or housed motors for use in turning, milling and grinding machines as well as in machining centers. The traditional spindle drives with housed motors – mostly air-cooled – are widely popular as main drives. In comparison with motor spindles they are less costly when taking into consideration the secondary costs of both systems. On the one hand, the interposition of gear boxes enables the rotational speed and torque to be tuned to the machining task; On the other hand the gear boxes cause unwanted radial forces, noise and increased wear.

Meanwhile the main drives using kit motors with an integrated spindle have become technically sophisticated. Since gearbox and clutch can be eliminated, these drives make a centric rotational movement possible without suffering from shearing force.

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They stand out thanks to their long-term running smoothness and minimal wear and are used especially for high performance machining. The generation of higher torques is currently still quite costly, since either a (planetary) gear has to be integrated into the spindle or a higher motor power needs to be selected. In order to carry out preventive maintenance and servicing, it will become the standard to integrate monitoring sensors into the spindle to allow the acquisition of measurement data. Cooling with oil, air or glycol is still always necessary!

Feed drives

For the drive technology of the feed drives the choice is between either electromechanical or hydraulic systems. In order to make this choice the specific advantages and disadvantages of each system need to be considered. In the case of the electromechanical feed drives the electric servomotor with ball-screw assembly currently dominates worldwide. It converts the rotational movement into a linear movement. Here synchronous housed motors are preferred, as they need to cope with higher requirements in terms of positioning, synchronized operation and dynamics, more so than the main drive.

Due to its high static rigidity this drive system is suitable for a wide variety of applications and is also considered traditional – but it is prone to wear. Depending on installation conditions and the strength of the torques that need to be generated,

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the servomotor is connected to the spindle either directly or, for example, via a synchronous belt. Although the principle of the electric linear motor was invented as early as the 19th century, the technology has only found its way into machine tool applications since the beginning of the 1990s. Back then Rexroth equipped the first series machine with linear motors. The combination of resistance to wear, high rigidity and dynamics results in a desirable optimum quality of the drives. This means that higher precision with trouble free operation can be guaranteed in the long term than with a comparable ball-screw assembly with indirect position measuring system.

The load regime of the drive is one aspect limiting its use. Of course this does not mean that, when processing with large forces, ball screw assemblies and hydraulic drive solutions can be dispensed with. The other main criterion is the fact that supporting machine elements such as the swarf cover with its maximum permissible sliding speed and the carriage guide with its damping behavior, can also limit the area of application. The benefits of linear motor drives are counteracted by the associated investment costs, and this has so far prevented a worldwide breakthrough of this drive technology.

Hydraulic feed drives are in demand when their benefits have a significant impact. This relates in particular to the installation in confined spaces, the demand for high

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dynamics and the generation of great feed forces. And it goes without saying that the hydraulic feed drive needs to be able to position accurately to the micrometer. The practical applications demonstrate time and again, that the hydraulic linear drive works free of play, is long-lasting and tends to be more durable than a comparable drive with ball-screw assembly. With electric feed drives each specific performance (torque and rotational speed) needs to be installed, whereas the hydraulic axis can draw energy according to demand from a hydraulic fluid accumulator. This means that the installed input power can be reduced by up to 80 percent.

Auxiliary drives

The auxiliary drives reflect a wide variety of solutions. Across the whole spectrum of auxiliary drive functions in machine tools there is neither a significant trend, nor do certain tried-and-tested solutions stand out. The choice will depend on the solution that best fits the actual drive situation. And it is then not unusual for one machine group with a closed sequence of functions to combine drive types of various technologies. There are examples of this in applications where electromechanical drives for vertically or diagonally moved carriages are used in combination with hydraulic or pneumatic weight compensation. Here, the weight compensation can be understood as a passive auxiliary drive in the widest sense, its task being to compensate the weight force of the moved mass. Weight compensation can be achieved in a number of ways, the hydraulic solution with a hydraulic fluid

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accumulator being very popular. If the weight force that needs compensating is small a pneumatic gas spring can carry out the compensating function. The advantages of these solutions lie in their adaptable dynamic behavior as well as their favorable energy balance.

Pneumatic drives are ideal for installing in handling devices thanks to their low weight, their simple control structure and the rapidity of their movements. This applies to feed and load units for smaller masses, which are thus integrated into the workpiece flow of the production process. Clamping of the tools and workpieces within machine tools is of extremely high importance, as the quality of the processing result is significantly influenced by the accuracy and repeatability of the clamping process. Hydraulic clamps represent a special type of auxiliary drive and are used particularly in machines with unattended workpiece load and unload, thanks to the fact that they are easily automated. The high force density of the clamping elements favors the construction of clamping devices in the smallest spaces.

Conclusion

There is a wide range of electric, hydraulic, electromechanical and pneumatic drive concepts available as solutions to drive tasks in machine tools. The design engineer and his or her team need to decide which type of drive concept is right for the task,

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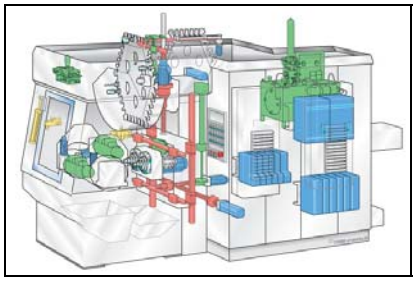
taking into account a wide range of constraints. A good automation supplier who has expertise in all of these technology groups will consider and advise customers in these decisions.

Photos & Captions:

Main spindle drive with housed motor.

Electromechanical feed drive with static screw spindle and nut driven via synchronous belt.



Drive systems in a machining center.

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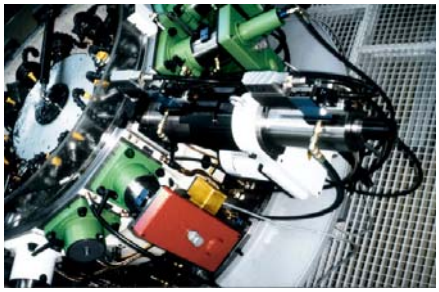
Hydraulic clamping fixture for valve housing.



Hydraulic linear drive with revolving transfer machine.

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