Prospects of complete machining in machining centres

Freedom in production

In machining which involves chip creation, coplanar workpieces with turning contours present particular challenges. Complete machining operations can mostly only be performed through clamping changeovers or the use of special procedural solutions involving the machines or the tools themselves. Using mechatronic tooling systems, such as the KOMET KomTronic® U-axes, new freedoms are now created in machining production on flexible machining centres.

The wide variety of components with complex geometries such as cylinder heads, axle casings, wheel mounts or turbochargers, etc. seem to be constantly increasing. The contours of these components usually require a range of different machining processes in shape forming, from milling to drilling, threading, etc. through to lathe turning. As a result of this alone, kinematically different types of machine are also required. Provided that components of this sort are manufactured in large series production quantities, interlinked systems with specialised machining stations are an adequate solution. They allow machining to be performed in one clamping operation, save on changeover costs and offer benefits where quality is concerned. As batch sizes become smaller, the wide variety of variants increases and product life cycles become shorter; however, other aspects emerge which draw the benefits of such systems into question from the point of view of cost-effectiveness, and determine the trend towards standard machines or flexible machining centres. However, due to the different types of processes involved, complete machining operations in one clamping arrangement present a great challenge in this regard.

Even when components such as those mentioned above have contours which represent turning profiles, they are, as a whole, not suitable for mill-turn centres. In such cases, machining such components which are rotationally not symmetrical is dependent on the contours and, if at all, is only feasible subject to considerable balancing requirements, which in addition leads to an increase in dynamic loads. Lathes can therefore only be used to a limited extent for this range of components.
The choice of the means
In contrast to this situation, machining centres provide the choice of the means. Against a background of low quantities and complex machining operations, they are flexible in their use. However, since even they also do not allow processes which involve chip creation (explicitly lathe turning) and classic facing slide tools cannot be used in this case, changeover operations are often still necessary for complete machining operations. Alternative machining possibilities can be provided by circular interpolation milling or circular interpolation turning. In circular interpolation milling, the tool is guided on a helical path. In the process, those points of the path at which an axis changes direction (quadrant transitions) are problematic. Circular interpolation milling is therefore contour-dependent and has disadvantages in respect of machining duration and surface quality. Another factor is that, in the case of complex turning contours, form milling cutters are required which have to be specially manufactured for the contour which is to be machined. The leads to higher tool costs and longer tool-change times.

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Using the technique known as circulation interpolation grooving, the principle of recess turning can be transferred from a lathe to a machining centre. The tool is guided into the stationary workpiece on an interpolation path produced by the control system around the workpiece. In the process, the cutting edge is positioned vertically to the tangent of the drill cylinder at every point of the circular path. The tool therefore only turns once around its own axis during one circuit in the workpiece. Surfaces are produced without the typical faceting created by circular interpolation milling. However, this requires corresponding control preconditions on the machine side. The spindle must be bearing-adjustable in relation the Cartesian axes and the equivalent speed must only be generated via the Cartesian axes and, consequently, quite limited. In addition, the process results in a high level of axis wear if used frequently.

More or less complicated special tool solutions can be found in other alternatives such as ball and flat face tools for machining the ball segments in open differential housings. Such solutions offer no flexibility and give rise to high investment and permanent-use tool costs as well as, on occasion, high tooling costs.

Highly flexible tooling systems
More flexible solutions are offered by some machine tool manufacturers in the form of integrated setting kinematic systems in the spindles. Modern mechatronic tooling systems represent complete, highly flexible tool-centred alternatives. With their KOMET KomTronic® U-axis systems, the KOMET GROUP is one of the innovation leaders. These tooling systems are used in machine spindles as exchangeable drive units with axis function, adjustable speed blade and application-specific snap-on tools. The drive unit allows the cutting edge to be adjusted radially to the axis of rotation. For flexible contour machining operations and grooving operations, the U-axis is moved by interpolation with the Z-axis (spindle feed axis) of the machine, which makes it possible to perform complex longitudinal turning operations in one contour pass.

These systems essentially consist of a compact facing head and single slide which is driven by a servo motor and threaded spindle. The power supplied to the electronics and the drive is transmitted contact-free and inductively to the U-axis system. Similarly, the data is exchanged inductively with the U-axis system. A „stator“ is attached on the spindle side. It is segment shaped in design. The ring-shaped inductive transmission unit (rotor) on the U-axis side ensures reliable data and energy exchange in every angular position, even when coolant is being used. The mechatronic U-axis systems are therefore automatically exchangeable NC axes from the tool magazine. Programming is carried out in the usual NC programming language and is integrated into the machine control system. All the functions of normal ISO programming are available.
Complete NC axes for exchanging

KOMET KomTronic® U-axis systems extend the kinematic conditions in machining centres. They make it possible to perform longitudinal turning operations in a machining centre and, in this way, create the freedom for complete machining operations in one clamping arrangement. So that they can adapt to a variety of different machining tasks, machines and NC control systems, KOMET KomTronic® systems are modular in design. The KOMET GROUP range encompasses solutions in the sizes HSK 40, 50, 63 and 100. In addition, the KOMET KomTronic® HPS U-axis systems feature high-speed turning versions which can be used at speeds of up to 8,000 rpm.

In view of such performance, it is bound to be apparent that imbalances will occur due to the weight of the U-axes and because of the change in position of the masses in the tool head required for adjusting the cutting edge. With the new HQB (High Quality Balance) technology, the KOMET GROUP have succeeded in finding a design whereby the balancing weights have been placed in front of the slide in one plane close to the centre of gravity for tool and slide. Thus, by using balancing weights in one plane, it is possible to achieve a close to multi-plane balance, which, due to the design, can be realised irrespective of the stroke. In addition, the centrifugal forces are converted into reaction forces at coupling points so that the centrifugal forces of the compensator and the slide tool system in the drive chain do not simply add up. The result is a drive torque which is largely separated from the centrifugal force formula. A not inconsiderable factor for the smooth running of these systems is the miniaturisation and therefore also the reduction in weight of the modular components, both of which the KOMET GROUP has developed and promoted.

Conclusion and prospects

In the final analysis, mechatronic tooling systems promote the use of standard machines rather than special machines, which, as a whole, reduces investment costs. In addition, the integration of turning operations in machining centres saves the otherwise necessary clamping arrangements on lathes. Furthermore, flexible contour machining with U-axes includes the advantage of a reduction in the number of tools. Complete machining on one machine also has a positive effect on costs per piece by shortening the machining and throughput times. Fewer tool changes and, where applicable, the omission of circular machining operations also reduce the costs per piece. Savings can be achieved even in regard to operating costs. For instance, workpieces do not have to be rotated and the power requirement is minimal. By combining different functions in one machine, an improvement in competitiveness is achieved – mainly through the more favourable cost situation – as well as, from a technical point of view, often an improvement in quality as well. Machining operations performed in one clamping arrangement bring about great qualitative benefits. Avoiding clamping changeovers allows always the same reference system for the production units to be maintained, thereby enabling optimal positional relationships between geometrical features to each other. Even the integration of measurement and inspection tasks is part of cutting edge technology through the use of plug gauges or callipers. The KOMET KomTronic® U-axis systems create the basis for achieving the highest levels of workpiece quality through taking measurements while operations are in progress.

The KOMET GROUP is one of the leading single-source suppliers of precision tools. The internationally successful group, based in Besigheim, has been at the forefront of innovation in the sector for over 90 years. The company currently employs more than 1,450 staff in its 20 subsidiaries and is represented in around 50 countries.