Extra large 2,000 x 1,800 mm with 5 µm stitching gauge

High-precision 3-axis milling and jig grinding

With a working area of 2,000 x 1,800 x 800 mm, the RXU 2000 is suitable for fast and high-precision milling and grinding, even of extremely hard workpieces (Photo: Röders)

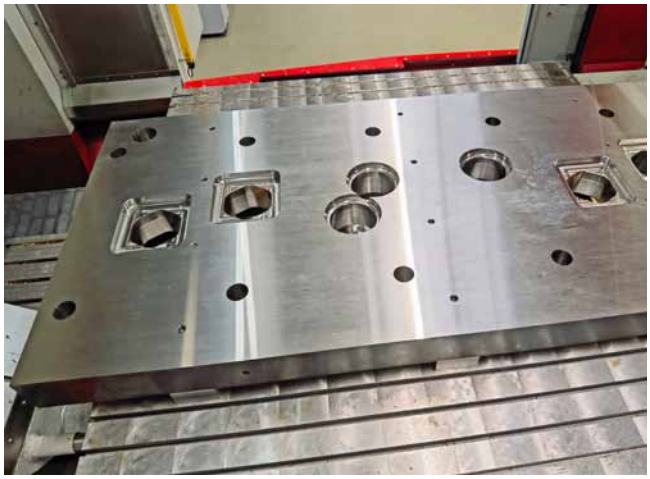
In many industrial sectors two twinned trends can be observed: customers ask for components with larger dimensions while at the same time requiring enhanced accuracy and surface quality. This not only affects tool and mould making, but also other high-tech application areas such as mechanical engineering, the electronics and metrology sector, or medical technology. How did a medium-sized machine tool manufacturer take these aspects into account when developing a machine for such tasks?

"Our new RXU 2000 milling machining centre can shape even particularly large-format components with maximum precision," says Dipl.-Ing. Jürgen Röders, Managing Director of Röders GmbH in Soltau. The RXU 2000 3-axis milling and grinding machining centre, which has been newly developed for such purposes, has a working area of 2,000 x 1,800 x 800 mm and achieves within this a pitch accuracy of less than 5 µm as well as roundness values of 1-2 µm, depending on the size of the bore. The table load capacity is 5t. In line with the company's philosophy, emphasis was placed on offering the user the greatest possible degree of precision in the work result, regardless of the system's high cutting performance. In view of the dimensions and the high machining performance, this presented a real challenge.

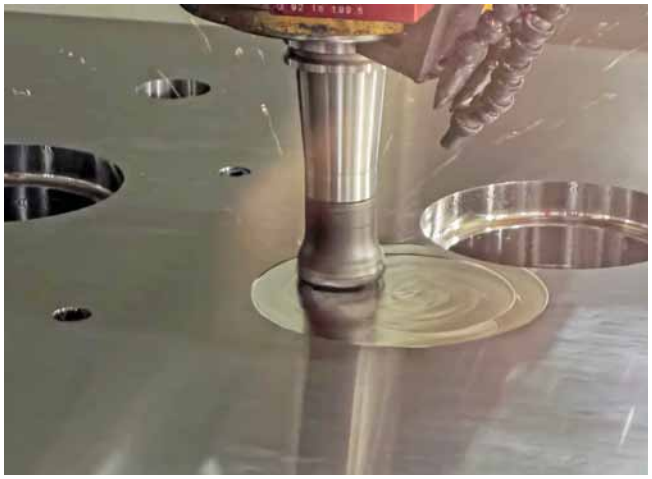
"Due to our experience in tool and mold making, we build our plants in such a way that they can also machine very hard workpieces with a high performance level" *Dipl.-Ing. Jürgen Röders*
(Photo: Klaus Vollrath)

MACHINING IN THE HARDENED STATE IS THE TRUMP CARD

"Based on our experience in tool and die making, we build our machines in such a way that they can machine very hard workpieces with a high performance level," explains J. Röders. For instance, the standard spindle of the RXU 2000 has a torque of 101 Nm at 22,000 rpm. Depending on the application, however, spindles up to 80,000 rpm can also be used if a reduced roughing performance is accepted. Compared to the conventional philosophy of pre-machining workpieces in the soft state first, then hardening them, and only then finishing them, this offers considerable advantages. On the one hand, time and costs are saved because the workpiece only has to be loaded onto the machine once. Transport costs and time delays due to intermediate quenching and tempering treatment can also be completely eliminated. With respect to high accuracy requirements, an additional advantage is that quenching deformation of the work-pieces is avoided. With the old machining strategy this distortion resulted in additional costs due to safety oversize allowances during soft machining, which then had to be machined in the hard state, thus increasing costs. Another significant advantage of the machine concept is that the system can be used for both milling and jig grinding. Furthermore, variants such as profile grinding are also possible. Since all operations are performed in the same setup, there is no need to worry about deviations caused by unclamping and reclamping: the part comes out of the machine ready to go



Base plate for a progressive die made of X33CrS16 (1.2085) with a hardness of 48 HRC as a demonstration workpiece (Photo: Klaus Vollrath)



The standard spindle (101 Nm, 22,000 rpm) is milling the test workpiece with a cutter head with a diameter of 52 mm (Photo: Klaus Vollrath)

with a measurement report. In addition, minor dimensional deviations detected after roughing can still be compensated for during finishing since measuring is performed in the same setup.

The Quadroguide principle with four guide rails at the four corners gives the Z-axis particularly high rigidity Photo: Klaus Vollrath)

Double function: In addition to milling cutters and drills, grinding pins and wheels from Krebs & Riedel are also used in this application (Photo: Klaus Vollrath)

ENHANCED RIGIDITY THANKS TO QUADROGUIDE AND LINEAR DIRECT DRIVES

"In order to withstand the high loads during roughing over the long term, both the Z and Y axes were designed using a quadro-guide approach," explains J. Röders. With this concept, the Z-axis does not have two guide rails, as is usually the case, but four in all four corners. This significantly increases the rigidity and robustness of these axes. Another key feature is the precise and highly dynamic linear direct drives in all three axes. These show their full potential thanks to the unique Röders control system, which uses 32 kHz controllers to quickly and precisely compensate for the smallest deviations due to machining, mass or friction forces.

SINCE HEAT IS THE ENEMY OF PRECISION...

"For our AMB trade show presentation we chose a workpiece quenched and tempered to 48 HRC made of the chrome steel X33CrS16 (1.2085)," adds J. Röders. The geometry realized with this is based on that of a real base plate for a progressive tool. Rough machining is performed with standard indexable insert tools and high-precision finish grinding using grinding tools from Krebs & Riedel. This steel has a coefficient of thermal expansion of about 10.5 µm/(m * K) in the room temperature range. With a temperature increase of just 1 K, the diagonal of a flat workpiece with the dimensions of the table surface would thus increase by almost 30 µm. Seen the other way around, in order to maintain the guaranteed stitch size accuracy of 5 µm, its temperature change during the machining process should not exceed 0.15 K. In the comparatively small work envelope of approx. 3 cubic metres, the milling spindle alone generates up to several kW of power. Added to this are the linear motors of the three main axes. Keeping the temperature level of the workpiece and work area within 0.1 K under these conditions during long machining times required a deep dive into the bag of tricks.

The laser unit for tool measurement is just one of numerous measuring devices that the system uses to monitor itself and optimize the machining processes
(Photo: Klaus Vollrath)

The standard spindle (101 Nm, 22,000 rpm) is milling the test workpiece with a cutter head with a diameter of 52 mm
(Photo: Klaus Vollrath)

...TEMPERATURE CONTROL MEASURES HAD TO BE STAGGERED MULTIPLE TIMES...

"The RXU 2000 therefore has a whole range of different temperature control circuits, all of which are kept to 0.1 K," says J. Röders. Particular attention was paid to the spindle as well as the linear drives, which therefore have powerful primary cooling circuits to carry away the heat generated there as quickly and directly as possible. Furthermore, the decisive elements are again thermally separated from the surrounding construction elements such as axes or the machine bed by additional „heat traps". This prevents heat not captured by the primary cooling system from diffusing into the basic structure. The massive machine bed made of prestressed UHPC concrete (Ultra High Performance Concrete), a high-tech material used, among other things, in highly stressed bridge structures, also has its own tempering ducts. Compared with mineral casting, a material often used for making machine beds, this concrete has no plastic content and thus offers a significant deformation resistance. "For us, this approach is standard technology and also provides for optimum thermal stability in our other machine models," says J. Röders. "The particular challenge with the RXU 2000 was the large scale at which this had to be implemented."

...AND BY ADDITIONALLY RESORTING TO GRINDING OIL AND AIR CONDITIONING

"Another measure for thermal stabilization is the use of grinding oil instead of water-based cutting fluid emulsions," notes J. Röders. The disadvantage of water-based mixtures is the evaporation of their water content, which is not controllable and thus massively impairs the temperature stability inside the workspace. By comparison, the grinding oil, which is kept within a very narrow temperature range by its own circuit, considerably contributes to equalizing the temperature conditions in the workpiece and in the machine. As the icing on the cake, the RXU 2000 also provides for air conditioning of the working chamber. For this purpose, air drawn in from the hall is conditioned precisely to the temperature required in the work area and then blown through the machine. Before being discharged into the hall, it is of course filtered.

MEASURING AND COMPENSATING

"Notwithstanding all these provisions for temperature control, it is true that accurate work results can only be ensured by constantly measuring the results," J. Röders sums up. To this end, the RXU not only features an interchangeable measuring probe, but also numerous other means such as reference bodies, measuring lasers for the tools, structure-borne sound detectors with diamond surfaces for grinding tool detection, and a dressing spindle for the grinding tools. Thanks to the sum of all these measures, the machine zero point of the RXU 2000 "stands still" even for jobs lasting more than ten hours. The result is workpieces with outstanding dimensional accuracy. "Incidentally, we already delivered a the first RXU 2000 at the end of 2021. The customer is so satisfied that he is already thinking about purchasing another system," says J. Röders happily.
Klaus Vollrath, b2dcomm.ch

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