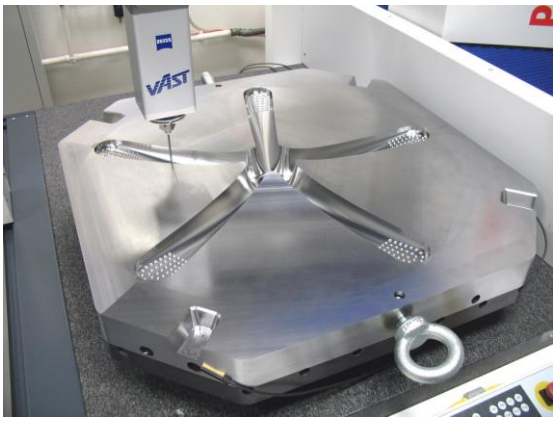
Start of series production of the largest 3-axis machining centre in Soltau – typically fitted with a Röders control system

A highly dynamic 26-ton heavyweight

How big a machining centre does a tool maker need? With respect to this question, Jürgen Röders, CEO of machining centre manufacturer Röders GmbH in Soltau, has his specific philosophy backed by first-hand experience derived from the fact that he not only produces such systems, but also uses them in a highly automated production line turning out dies for PET bottles. Röders is thus able to showcase on his own premises what a cutting edge HSC machining centre should be able to deliver – even if, as is the case with the new 1200 series, it weighs an impressive 26 tons.

Nearly all manufacturers maintain that they can machine 3D-surfaces, that their linear drives achieve well above 100 m/min and that reaching an accuracy of one micron is mere state of the art. So why should one bother to compare? “Because there are still many seemingly small differences that, depending on the given application, can add up to noticeable advantages with respect to precision and dynamism”, says machining centre producer Jürgen Röders. While admitting to buying many machine components, often in complete packages, from big suppliers such as Rexroth, Siemens, GE Fanuc or Heidenhain & Co, he insists that the decisive fine-tuning is performed in Soltau. “The development, adaptation and maintenance of our control software alone requires a workforce of 10 engineers. They focus on aspects such as fine-tuning and optimising machining paths, while at the same time paying attention to the control loops of the machine. The benefits show clearly in the machining results our customers can achieve”. Because according to his experience, Jürgen Röders maintains that there are huge differences between a machining centre fitted with a standard control system that has been fitted with numerous interfaces and subroutines for a wide variety of possible applications, or if a dedicated control system has been specifically matched to the given machine type. “This won’t show when you work along a straight path. But when it comes to machining complex 3D-contours, our control system is able to achieve advantages with respect to machining time requirements well in the double-digit range. At the same time, the Röders control system smoothens the surfaces using patented advanced mathematical operations achieving tangential transitions. This is particularly evident from the absence of steps when overworking edge radii with smaller diameter finishing cutters. Another point is that circles, which often are not optimally converted and executed by postprocessors generating NC-code from CAD-data, are automatically rounded.

An internal comparison clearly highlights the advances between the different development stages of the control system. Back in 1998, it took a Röders machining centre 67 min to produce the die for the bottom of a PET bottle. In 2001, the same task could be performed in 50 min, and the figures dropped further to 46 min in 2003 and just over 44 min in 2006. Over a time period of eight years, especially the newer generations of Röders control software featuring enhanced path control and machining strategies, made it possible to reduce machining time by 27 %. “Milestones in this evolution were certainly the optimised spline interpolation, command line execution times below 0.1 ms and a look-ahead span of more than 10,000 command lines, making it possible, together with the internal positioning resolution of < 1nm, to achieve minimal increments in an order of magnitude between 0.1 to 0.05 µm. This results in outstandingly smooth surfaces as well as extremely high path speeds of theoretically up to 60 m/min and often over 10 m/min with an engaged tool.



Another point that should be highlighted is that just as in the case of this bottle bottom die, most jobs require only minimal machining time to perform roughing and pre-finishing. The fact that these operations often require just a few minutes leaves only minimal opportunities to achieve considerable gains. Jürgen Röders thus maintains that the biggest gains lie within the finishing phase. “This is where tool makers can economise – or waste – considerable amounts of machining time depending on their choice of machine brand and machining strategy.” According to his experience, gains with respect to machining time and quality ranging between 10 - 20 % can be achieved by selecting the suitable programming strategy. “It’s a very basic fact that the performance of the machining centre is extremely dependent on the quality of the NC software! And the potential is often even much higher.” For this reason, the company passes on its know-how by offering instruction courses for programmers. In its application centre, which provides ideal surroundings for the exchange of experience and for passing on tips and knacks about chipping during such seminars, Röders employs a workforce of six NC programming specialists.

According to Röders, another highlight of his control system is how easily updating and upgrading can be performed. For example, replacing industry-standard printed circuit boards in the control system of a 10-year-old Röders machine will boost computing capacity and processing speed to such a degree that the overall performance will increase by 20 %. “Another important point is the improvement of product quality”, adds Jürgen Röders. “We have switched from the industry-standard glass measuring scales with 20 µm accuracy to the ultra-high precision 4-µm version produced by Heidenhain, making it possible to move machine axes in 50 nm increments.” While this in turn limits max. speeds to 60 m/min, which has only minimal impact on machining times if one takes into account the typical job mix of tool-making shops characterised by idle periods of around 10 % and the speed limitations imposed by the high level of hardness of the workpieces.

Comparable aspects apply for the weight. “A mass of 26 metric tons can be a limiting factor if an important fraction of it has to be moved around in the case of a gantry system – or a clear quality advantage if it is mainly concentrated in the machine base and column where it helps to dampen vibrations”, explains Jürgen Röders with respect to the design philosophy of his new, large-scale machining centre, the RXP 1200. Additionally, all Röders machining centres are equipped with a patented function which, within a range predefined by the operator, determine the ideal HSC spindle rotating speed for the given configuration of machine and workpiece. “With respect to chipping performance, the difference between e.g. 36,000 or 37,000 RPM doesn’t count much, since the optimal value may lie anywhere between 30,000 and 40,000 RPM. For this reason, our machine performs a test run to determine the rotational speed causing the lowest vibration level”, reveals Jürgen Röders. This knack ensures optimal surface quality of the workpiece.

Another feature developed by the technology freaks from Lower Saxony for the same reason is the tool-cleaning functionality. The RXP is equipped with cleaning nozzles to ensure no lubricant layer will interfere with its laser tool dimension measuring system. The patented cleaning system starts by spraying a solvent onto the tool. “This has to be done using a low rotational speed, otherwise air turbulences around the tool would prevent the solvent from reaching it”. Afterwards, the tool is dried at high rotational speed. The whole cycle takes just half a minute.

The importance of such a cleaning feature is underscored by the fact that the best results are achieved using gush cooling. “This gush of cooling-lubrication fluid helps achieve a uniform temperature within the workpiece.” Additionally, the gushing cleans cavities and flushes away chips much more efficiently than in the case of minimal quantity lubrication or dry machining.

A further highlight of the machine aimed at achieving the highest precision comprises up to ten cooling circuits. The temperature can thus be defined and controlled with an accuracy of 0.1 °C. “The zero point of the machine thus remains unchanged”, assures Jürgen Röders, basing his statement on numerous reference measurements carried out by customers with comparable machine concepts. “A stable zero point is especially important when machining large tools or dies requiring long machining times in order to avoid mismatches when chipping away residual material.”

The final highlight of these measures is the cooling system prohibiting temperature drifts in the spindle by encasing it in a cooling sleeve. “The second cooling circuit thermally separates the spindle completely from the cast base of the Z-axis. So we don’t have to bother about spindle length compensation”. And this is particularly important in its main application field, the manufacture of large dies for plastic injection moulding with typical job durations of 10, 15 or even 20 hours.

Just as for enhanced precision requirements, such long job durations are, according to Jürgen Röders, a state-of-the-art trend. “Only 10 years ago, tools able to withstand such long campaigns simple weren’t available. Since then, we have witnessed enormous progress”. Modern cemented carbide tools exhibit enormous improvements with respect to performance. “They come with cutting edges with only minimal radii. And with these high-quality carbide tools you can achieve excellent results”, says Jürgen Röders. One can even observe that many customers are still too cautious with the forward feed “potentiometer”, thus scratching away the metal rather than actually chipping. “On a general note, the forward feed per tooth parameter must be sufficient. That’s the HSC machining philosophy.” While steel was initially machined at 2 m/min, the current state of the art is 4-5 m/min. “And provided you use suitable tools, our machines are fit for performing 7-8 m/min at robust infeed rates – while aluminium may even be chipped away at 40 m/min”, outlines Jürgen Röders.

On the other hand, what’s the point of chasing ever higher, even ultimate precision? “You’re rewarded with an extremely good dimensional accuracy, mostly sparing you the need for levelling press operations and related costly refinishing expenditure”, says Jürgen Röders in favour of the HSC technology, which is the precondition for reliably achieving higher levels of accuracy within narrow tolerance bandwidths. “With just a minimum of setting expenditure, our machining centres make it possible to achieve accuracies of ± 5 µm for smaller workpieces while for larger parts, ± 10 µm are attainable”, explains Jürgen Röders with respect to the accuracy of his systems. And hinting at additional features already in the pipeline, he points to the fact that customers need systems with as many functions as possible since every re-fixing of the workpiece will result in an additional deviation of some 5 µm. “In addition to milling, our machines should be suitable for drilling, if possible also deep-hole drilling, especially with regard to ducts for cooling agents. In view of such applications, we offer a 30,000 RPM spindle with huge power reserves able to drive 8-12-mm pin drills with inner cooling up to 300-400 mm into the workpiece”.

A further very specific highlight of the machining centre is to be found right at the top of the system. Here we find two flexible bellowed vacuum hoses used for another patented feature of the system. “With these vacuum hoses, we counterbalance the weight of the Z-axis. This system works without any friction and thus generates no heat within the Z-axis assembly no matter how frequently it has to move. We thus avoid thermal expansion and related inaccuracies linked to other solutions”, says Jürgen Röders, outlining the “chain reaction” his specific machine design prevents from occurring.

The bottom line is that the new Röders RXP 1200 presents itself as the best symbiosis of size, dynamism and precision to date. “You won’t find many machining centres on the market able to accommodate workpieces weighing up to 3 metric tons in a workspace of 1200 x 1000 x 500 mm that still are able to machine even very fine contours. That’s the challenge we decided to take up. And with the sophisticated digital optimization schemes used to determine machining paths, we even compensate for tool deflection, a factor that depends to a great extent on tool length”. But Jürgen Röders wouldn’t fit into his family tree if he weren’t set upon contributing to the next chapters of the HSC story. As one of his next projects, the CEO of an enterprise with a workforce of 270 already has another RXP in the pipeline, probably featuring a rotary/ tilting table for 5-axis machining, and a number of interesting features interfacing with additional handling and automation equipment.

Harald Klieber

Profile of the RXP 1200

Start of the series production of the new system exhibited at the EMO was delayed until March 2008 due to delivery problems for the giant cast iron machine bases and columns of the 26-ton heavyweight. “Since then, we have achieved a normal supply situation”, says Jürgen Röders. Delivery of the first system is scheduled for April 2008. This customer will benefit from a number of advantages:

- The nearly squared footprint of the workspace is ideally suited for die and tool makers.
- The extraordinarily high mass of the machine guarantees good stability and dampens away vibrations

- The three-point bearing design guarantees a stable stand.
- Compared to a gantry-type machine, the column approach with one axis for the table and two axes for the spindle ensures easy access from two sides and provides for compactness and high dynamism.
- Together with an additional side door, the front slide door greatly facilitates workpiece loading/ unloading either by crane or automatic handling equipment
- For the RXP 1200, the user can opt between different spindles: from 30,000 RPM with the HSK F63 and robust bearings with large balls suited for deep hole drilling in hardened steel to a 60,000 RPM version with the HSK E32.
- Table accepting loads of up to 3 metric tons equipped with six bearing slides ensuring even distribution of loads on the machine base.
- The RXP 1200 is only available with a linear drive system and a dedicated control system developed in-house.
- Up to ten cooling circuits ensure the machine is kept at stable temperature. The hysteresis of the cooling liquid is ± 1 °C. According to Röders, this ensures a stable zero point.
- Tool exchange systems are available in different types and sizes
- Available options include tool cleaning system, rotational speed optimization, HG-Sensor, a minimal step size of 50 nm, a function for tangential transitions and control system updates for digital performance enhancement

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Source:

Harald Klieber, Special Tooling, April 2008