

Hard machining above 58 HRC replaces die sinking EDM

Tool making: efficient lubrication optimizes tool life



The clocked production line for hard machining at ZF encompasses four Rödgers milling centres as well as a coordinate measuring machine. The port to the EDM line is located at the end of the rail (Photo: Klaus Vollrath)

The performance and efficiency of electric drives depend on the narrowest possible air gap between rotor and stator. The trend towards electrified powertrains thus furthers higher demands on the precision of the stamped parts required for this purpose. The tolerance specifications for the forming and stamping tools used to produce the corresponding sheet metal parts are therefore correspondingly narrow. The mid to lower single-digit μm range is increasingly being specified. The ZF Tech Centre „Tools, Measuring Equipment, and Automation Systems“ in Schweinfurt is therefore investing heavily in this area. Among other things,



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Gerd Ringelmann
(Photo: Private)

the trend is moving from die-sinking EDM to hard machining. Significant increases in tool life have been achieved by optimizing lubrication. Machining takes place 24/7 on a clocked, paperless production line with four HSC machining centres, four wire EDM machines, one die-sinking EDM machine complemented by a cleaning station and two coordinate measuring machines.

“We are responsible for the development and production of tools, measuring equipment and automation devices for the Electrified Powertrain Technology division at ZF,” explains Gerd Ringelmann, Senior Manager Electrified Powertrain Technology and Head of Production at the Tech Centre. The globally active Group with around 150,000 employees and a turnover of approximately € 32 billion has become one of the major international players in the field of e-mobility. Accordingly, the department headed by Gerd Ringelmann focuses strongly on electric drives. Among other things, it produces tools, production and measuring equipment for the manufacture of components for electric motors. In doing so, the Schweinfurt-based company is consistently focusing on networking, Industry 4.0 and synchronized automated

production. For the second time in recent years, the Tech-Centre 2021 was named the overall winner of the German „Excellence in Production“ (EIP)



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Bernd Rudloff
(Photo: Private)

industry competition for the progress it has made. It is thus regarded as the leading tool and die manufacturing company in the German-speaking region. This renowned annual competition has been organized for 18 years by the Machine Tool Laboratory of the RWTH Aachen University and the Fraunhofer Institute for Production Technology (IPT).



The production of electric drives for cars – here a version with 150 kW – requires a multitude of tools for the stamping and processing of high-precision sheet parts (Photo: Klaus Vollrath)

AUTOMATED HSC-HARD MACHINING

“Our cross-technology, fully automated production line for hard machining certainly played an important role in the jury’s decision,” adds Bernd Rudloff, head of machining at the Tech-Center in Schweinfurt. The line consists of two segments, one for EDM machining and a second for HSC hard milling. The systems of both segments are each lined up along a linear rail supporting a handling system which supplies them with workpieces and tools.

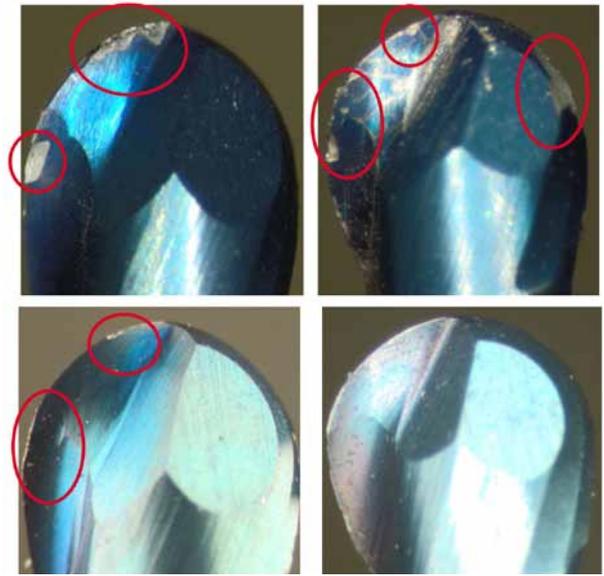
The milling area of the line comprises four milling machining centres from Röders and a coordinate measuring machine from Zeiss. Two of the Röders systems have three axes while the two others have five axes. Programming is performed using Autodesk’s Power Mill CAM software, with programmers also operating the machines.

A NEW ERA OF MACHINING PHILOSOPHY

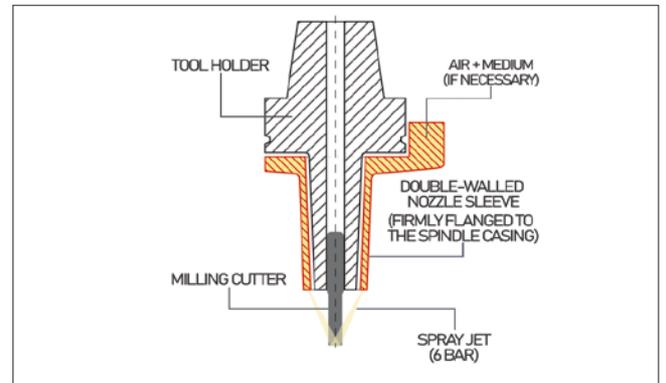
“On this line, 95 percent of the workpieces are hardened up to 65-67 HRC,” says Gerd Ringelmann. In some cases, even tungsten carbides or ceramics are machined. This has become feasible thanks to the enormous increase in the performance of the milling tools in recent years in combination with the integration of a new tool cooling system. The company can thus now skip the previous two-staged machining approach with intermediate



In the setting-up area, workpieces are clamped onto pallets (Photo: Klaus Vollrath)



Ball end solid carbide milling tools after performing finishing tests on a workpiece made of X50CRMoV8-2 with a hardness of 59+1 HRC. Top left without lubrication, top right cooling with compressed air, bottom left lubricating with minimum quantity lubrication using two component jets and bottom right with the supply of an aerosol-fine lubricant with the MHT medium distributor (Pictures: ZF)



The double-walled sleeve of the MHT medium distributor is permanently slid over the tool holder and exchanged with it as a complete unit. Supply of compressed air aerosolized with a hydrocarbon-based lubricant is secured via an adaptor fixed on the Z-axis spindle casing (Graphics: MHT)



During hard machining, lubrication is supplied through the MHT medium dispenser (Photo: Klaus Vollrath)



A special tool clamped onto a pallet in the workpiece buffer of the hard machining line. The smart tag programmable by radio frequency holds the key to all process-relevant information, rendering paperwork obsolete (Photo: Klaus Vollrath)

hardening in favour of single-staged machining in the hardened state. In addition to the reduced throughput time, the workpieces can now also be produced at lower cost. The higher metal removal rates also usually make it possible to do without die-sinking EDM and produce the desired geometries directly by milling or grinding. The upstream EDM line thus features only one die-sinking EDM system.

SOPHISTICATED PATENTED AIR COOLING LUBRICATING TECHNOLOGY

"In hard milling, the supply of cooling lubricants to the cutting area plays a decisive role," Bernd Rudloff knows. A great deal of effort was therefore invested into clarifying these interdependencies. This even became the focus of a diploma thesis. In addition to dry machining, cooling with compressed air and the well-known minimum quantity lubrication using two component jets, the solution advocated by Röders – supplying an aerosol-fine lubricant with the medium distributor from MHT – was also investigated. This technology uses a double-walled sleeve adapted to the geometry of the tool with nozzles arranged bevelled downwards, supplying all tool cutting edges uniformly with air and lubricant throughout the process while at the same time ensuring chip removal. The sleeve does not rotate with the tool, but is flanged to the Z-axis via an adapter and supplied with compressed air aerosolized with a hydrocarbon-based lubricant. The tool and sleeve are stocked together in the tool magazine and are exchanged together as one unit. For the test runs, the Weschu company, as the Röders area representative, provided a demonstration machine specially equipped with the MHT medium distributor.

The machining tests were performed using parts made of two steels (X50CRMov8-2 with 59+1 HRC and X230VCr8-5-4 Vanadis 8 with 62+2 HRC) on a Röders RXP 601 DSH. Feed rates of up to 3,000 mm/min and spindle speeds of up to 40,000 rpm were used for machining. Toroidal and ball end solid carbide milling tools were used for the roughing and finishing tests.

The evaluation of the test results was performed according to a number of criteria such as tool wear and tool life or surface quality of the test pieces. In all categories, the MHT solution performed best, in some cases by a considerable margin. For

finishing runs, tool life increases of 50 percent were achieved. In the case of roughing, in addition to the same increase in tool life, the machining time was also halved by increasing the forward feed. With the other three process variants, doubling the feed rate quickly resulted in tool breakage due to overloading of the tool cutting edges. In view of these convincing results, the MHT medium distributor was selected as the superior system and retrofitted on all Röders machining centres. Practical experience after the retrofit confirmed the expectations: Savings of 13 percent were achieved in tool costs calculated over all parts, as well as increases in output of 10 percent. In addition, there were other significant advantages such as the partial or complete substitution of die-sinking EDM by milling, better cleanliness – a factor that is becoming increasingly important, especially in highly automated manufacturing processes – and the elimina-



In other shops of the Tech-Centre in Schweinfurt, three-axis Röders machining centres are used for jig grinding (Photo: Klaus Vollrath)

tion of polishing treatment due to the good surface quality. Further qualifications as well as investigations focusing on "high-gloss milling" are pending.

MANUFACTURING ORGANIZATION

„On another note, we were also able to achieve decisive breakthroughs throughout the Tech Centre with regard to our production organization," says Gerd Ringelmann with a smile. Particularly noteworthy, he says, are the transition to clocked flow production and the paperless handling of all processes. A clock cycle comprises one day: within this time period, the trolley with the parts received by a department must be completely processed in order to become available for the next scheduled station on the following day. The logistics software takes into account the availability of materials and machines as well as the availability of employees throughout the entire process chain. All documents relating to the job are completely managed within the IT system and are available at the respective workstation in a constantly updated version. This perfection is all the more important because the average number of parts per job is only 1.7 – so the majority of the parts are individual items, which virtually excludes any allowances for errors or delays.

LONG TERM PARTNERSHIP WITH RÖDERS

"Our decision in favour of Röders for the procurement of the milling machines for the hard machining line was based not only on the performance of the systems but also on many years of good experience with the manufacturer," recalls Bernd Rudloff. The first Röders system was installed in Schweinfurt more than 20 years ago. Since then, their specific technology has been able to score points, especially in the field of hard machining, due to their cutting performance and the surface quality achieved on the workpieces as well as the precision of the parts that can be produced. Röders' advice and support during the introduction of the MHT media distributor was also convincing. The personal commitment of Herbert Merz, Managing Director of MHT, also made an important contribution to its efficient use. In order to exploit the full potential of the MHT technology, the CAM strategy and the processing parameters also had to be adapted to the extended capabilities.

Another convincing aspect is the control concept of the Röders milling machines, which is based on two industrial PCs and impressed with its user-friendliness and the possibility of easily updating the control system. Further plus point was the robustness of the machines, which excelled by low susceptibility to defaults and long maintenance intervals. The oldest milling machine now integrated into the line, an RHP 600, dates from 2006 and still impresses with its outstanding accuracy. The results are also convincing in terms of spindle service life. Originally, an expected service life of 3,000 hours had been assumed based on experience with other brands. Currently, this value is shifting more towards 10,000 operating hours for the Röders systems.

Independently of the four milling machining centres in the new milling line, two other Röders systems are currently in use as stand-alone machines. They are used for jig grinding and are characterized not only by their high performance but also by the good quality of the surfaces they produce.

Klaus Vollrath, b2dcomm.ch

"In summary, I can say that the Röders company has proven itself in more than 20 years through good products, expert advice and efficient service. On top comes the participation as a competent partner in joint development projects."

Gerd Ringelmann

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