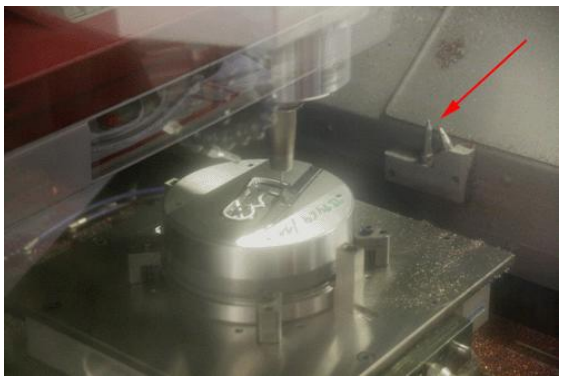
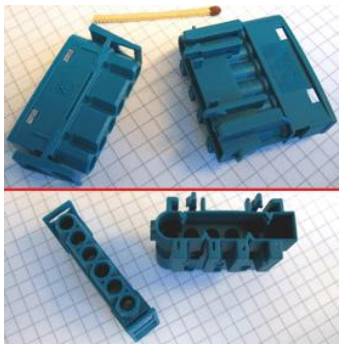
Fast, efficient and highly accurate

Mould making: shop managers report on the benefits of HSC milling of hardened steel

In the "classic" production chain of tool shops, EDM machining plays a key role. For a number of tasks, HSC milling of hardened steel can be an advantageous alternative. Depending on the specifics of the given job, moderate to significant advantages with respect to throughput time, costs and quality can be achieved. Three managers of shops with significantly differing job portfolios share their related experience.

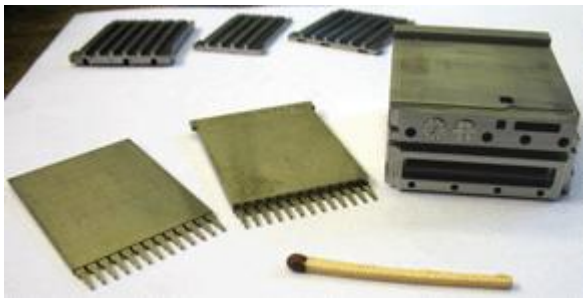


It is a well-known fact that state-of-the-art machining centres and cutting tools make it possible to chip away even hardened steel with a high level of efficiency. But will the related advantages really produce a sufficient return on the additional investment? The standard calculation base for such an investment – the complete replacement of an old plant by a new, more efficient one – will rarely be applicable, mainly due to the technical limitations of the milling process, particularly in the case of deep cavities with steep flanks or deep, narrow slots. The specifics of the plant taken into consideration thus have a major influence on the technical and economic framework defining the advantages and risks of opting for the HSC machining of hardened steel. A complete replacement of EDM operations will rarely be possible. Nevertheless, enriching the available technology bandwidth by fast and accurate milling as an alternative to EDM operations will give the shop manager vital additional degrees of freedom. A major bonus even superseding the cost advantages are substantial gains with respect to throughput time since a complete process step – the milling of electrodes before EDM machining can start – is made redundant. The following report summarizes the experience of three tool shop managers whose job portfolios are markedly different. Common ground for all three is that they use the same plant – a Röders RXP 500 triaxial machining centre.



Ermet: substantial time gains…

"Electronic connectors make up a substantial portion of our business pallet", says Peter Büchler, Production Manager with Ermet GmbH in Bad Windsheim (Germany). This tool manufacturer with a workforce of 38 employees is a subsidiary of a medium-sized plastics technology specialist, the Ermet-Buck Group, which has more than 200 employees and a total of five production sites in Germany and the Czech Republic. The tooling requirements he receives from within the Group make up



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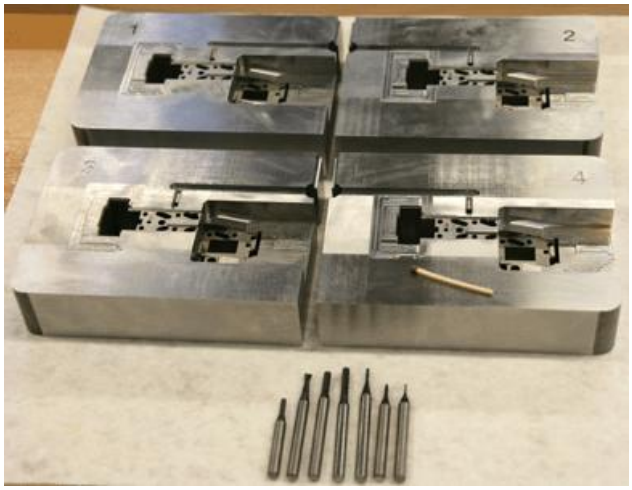
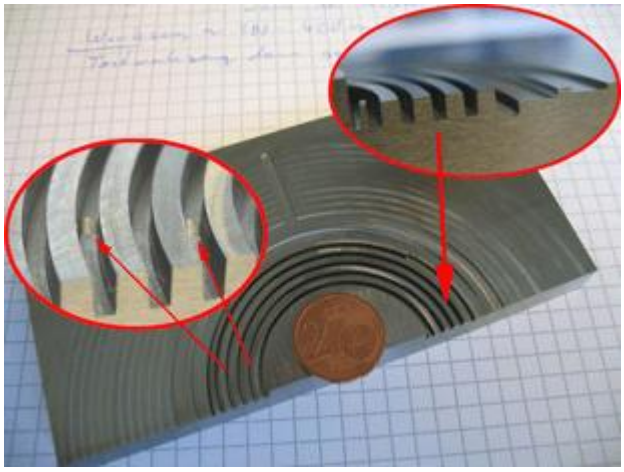
for about 70 % of his order income, the rest having to be acquired on the free market. The main customers for the parts produced with these tools are the automotive industry and its suppliers, the electronics industry, as well as medical and laboratory device manufacturers. These customers not only demand the highest quality, they also emphasize aspects such as realization time and flexibility with respect to specific demands. Many of the tools Ermet has to produce, e.g. for electronic connectors or for the embedding of metal grids, are for highly automated production. Their filigree components have to fulfil very high requirements with respect to dimensional accuracy.



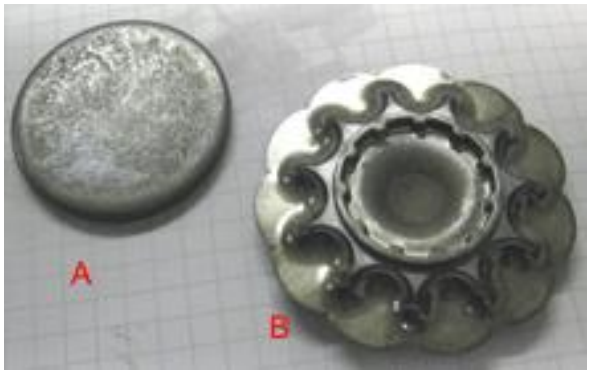
even with geometries that are difficult to machine

"Even a short glance at the tools we have to make for the electronics sector reveals that shifting from EDM to milling is an all but easy task", reveals P. Büchler. These intricate tools are characterized by a multitude of tightly intertwined components with narrow contours, small radii , high aspect ratios and sharp edges. Stringent prescriptions with respect to the dimensional accuracy of the plastic parts they serve to produce imply the highest precision requirements for the tool components – down to ±5 µm and occasionally even lower.

HSC milling of hardened tool steel with the new Röders RXP started in August 2005. Meanwhile, the plant is used for two shifts a day. Putting it even more precisely, its spindle is engaged for about 3200 hours per year. Most of the machined steels have a hardness of 52-54 HRC. Tool diameters usually range between 2-3 mm and sometimes up to 8 mm. The smallest tool diameters are 0.5 mm for steel and 0.2 mm for copper. During the ramp-up period, copper electrodes accounted for about 80 % of the jobs. Machining of hardened steel was stepped up in small, cautious steps. Since then, its share has soared from 20 % to 60 %. Even very thin and deep grooves – e.g. 9 mm deep with a width of only 1 mm – are now machined into the hardened material with full reliability of the process. The main advantages experienced by the new machining approach are shorter realization times and lower costs, as well as enhanced accuracy of the parts. Seats and precision fits can often be milled directly instead of having to finish the parts by grinding in a second processing step. Further benefits are increased surface quality and easier demoulding of plastic parts during production.



Implementation of this technology change required a lot of brainstorming e.g. in view of new tool design rules suiting milling instead of EDM operations. One must also provide for sufficient programming capacity for the creation of NC programs. The company entrusts this task to the machine operators.



"HSC machining of hardened steel will not completely replace EDM operations, but it gives us an additional degree of freedom we urgently needed", sums up Peter Büchler. Certain geometries can still only be tackled using EDM machining. On the other hand, in addition to the advantages already described, the transfer of many jobs to the milling centre has contributed to significantly easing the partly critical bottleneck with respect to EDM machining capacity the company had run into before acquiring the new plant.

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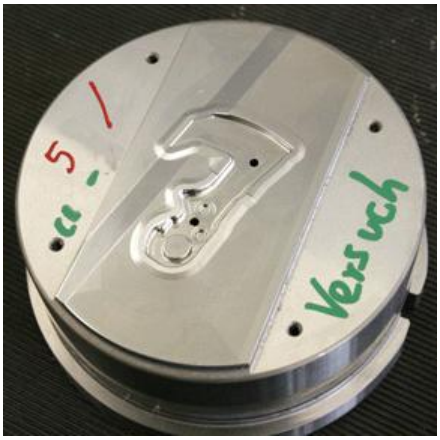
Heckler: dies in large numbers…



"The forces exerted during cold forming are so immense that our stamps crack as a result of high cycle fatigue before they stand any chance of being worn off", explains Peter Heckler, CEO of Heckler AG in Niefern-Öschelbronn (Germany). The company has specialised in the production of cold-formed precision parts made of steel or aluminium. The main customers for the machined and finished parts are the automotive as well as the lock and builders' hardware industries. Many parts are used in life-saving equipment such as security belt emergency tighteners and hence have to meet the highest requirements with respect to precision and quality. Production processes are markedly large-scale with lot sizes partly reaching a double-digit million order of magnitude. Of course, cost aspects are of prime interest, but additionally the customers require the highest flexibility with respect to production batch sizes and short-term reaction capability. In view of the limited die service lifespan – typically just 20,000 to 60,000 production cycles – as well as of stringent customer expectations with respect to start of production delays for new products, the tool shop has to excel with respect to productivity and short throughput times.

are produced faster and with better accuracy than before

"Switching from EDM machining to HSC cutting of hardened steel yielded production time gains of up to 70 %", explains Claudio Sandrini, Plant Manager of Heckler AG. Their Röders RXP equipped with a fully automatic 8-fold workpiece pallet exchanger was put to service by mid-2005 and operates in three shifts. Meanwhile, it produces 60-70 % of all tools. A tool magazine with 100 positions provides for a sufficient number of identical replacement tools, a precondition for continuous automatic production even if a given cutter is rejected by the integrated condition monitoring system. The dies leaving the milling centre haven proven to be so accurate that quality control expenditure could be reduced to occasional dimensional control of samples selected at random. Most of the dies are produced from cold-work tool steels with a hardness range of 56-60 HRC.

Further advantages the company reports are a better surface quality – a result of the omission of the "white layer" characteristic for EDM machining – as well as a 50-60 % reduction in polishing expenditure. In this context, it is of particular interest to note that the hitherto indispensable manual polishing operations can be completely omitted. The remaining polishing passes can largely be performed automatically. Furthermore, demoulding slopes and the so-called outflows – the flow paths for excess material surrounding the shaping contour of the die – can now be produced automatically. And, last but not least, the service life expectancy of the milled dies has proved to exceed that of their EDM counterparts by as much as 10-15 %. Nevertheless, here too a complete substitution of EDM machining by HSC milling is not on the agenda, although the share of jobs performed by EDM machining has markedly receded.

A basic prerequisite for this successful implementation of fully automatic production of dies is the full control of the production process. Thanks to its high stiffness and dynamics, as well as to its specially optimized control system, the RXP 500 perfectly meets these requirements.

ProForm: embedding metal grids calls for extreme precision

"Dies used for the embedding of metal grids in plastic parts must be extremely precise", explains Matthias Person, Plant Manager of ProForm Formenbau GmbH in Pforzheim (Germany). In the process, tightly intertwining mould components ensure that the injected plastic melt will coat only predefined parts of the metal grid while certain areas remain uncovered. Only the utmost precision of all mould components will prevent penetration of the highly pressurized plastic melt in interstices, resulting in flashes that would interfere with subsequent processes. Removal of

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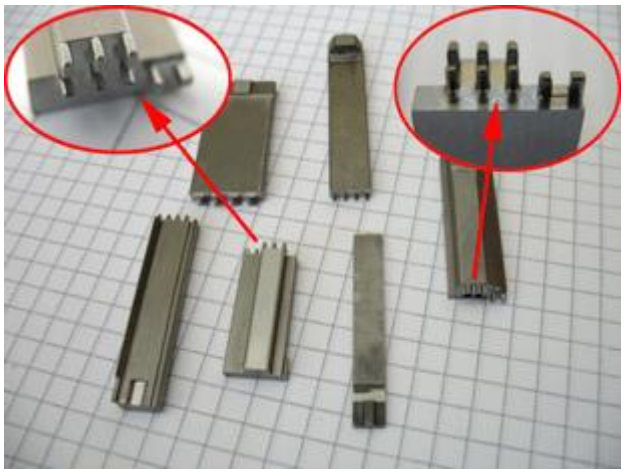
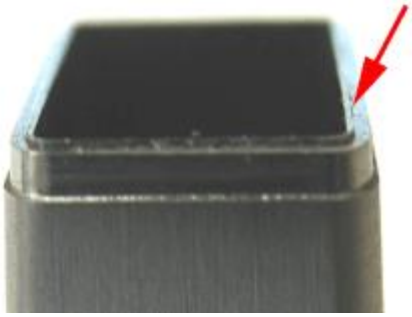
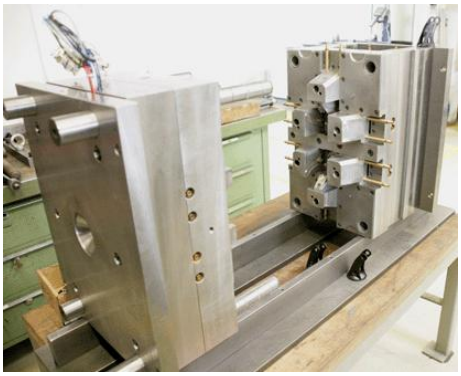
such flashes requires additional process steps and related costs. Another aspect is that the small, filigree components are prone to damage and then have to be replaced. This too calls for extreme precision of the components in order to minimize readjustment operations after their replacement. In producing the individual components of its moulds, ProForm thus literally fights for every single micron in accuracy. Of course, here too HSC milling of hardened steel is not the only processing method. The company also uses other technologies such as EDM machining or PTW grinding.



HSC machining with the highest degree of accuracy

"Compared to the system we previously used to perform the same tasks, the new Röders excels by a whole range of advantages", says M. Person. Particular highlights are the prolonged service life of the milling cutters, which last up to 80 % longer, as well as the reduction of workforce requirements by 60 %. Additionally, the enhanced accuracy of the parts has resulted in a 50 % reduction of refinishing expenditure. Another benefit is the process reliability of the plant, making it possible to load the Röders RC2 workpiece pallet exchanger with up to eight jobs that can be performed overnight without human assistance. Most of the tool steels the plant processes have a hardness of about 54 HRC while some jobs are performed on harder materials (up to 60 HRC). Tool diameters range from 10 mm down to 0.3 mm. M. Person particularly highlights the accuracy he is able to achieve with the new plant. With some moulds he produces this has helped him reduce refinishing expenditure by as much as a full working week.





In this context, the automatic compensation of spindle length deviations resulting from temperature changes is a key factor, together with the integrated laser tool dimension control system. As a result, the new plant is able to attain workpiece tolerances of between 3 µm und 5 µm while in Z-direction, height deviations attributable to tool changes are well below 5 µm. The high degree of accuracy thus obtained makes it possible to directly proceed to PTW grinding of machined parts without intermediate process steps. Another positive result of the high level of part accuracy is that for moulds with intricate parting plane geometries, levelling press operations can be largely omitted.

Klaus Vollrath

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"HSC machining of hardened steel will not completely replace EDM operations, but it gives us an additional degree of freedom we urgently needed. The main advantages experienced with the new machining approach are shorter realization times and lower costs as well as increased accuracy of the parts" Peter Büchler (Photo: Klaus Vollrath)

"HSC milling of hardened material boosted productivity and speed in our tool shop" Peter Heckler (Photo: Klaus Vollrath)

"Particular highlights are the prolonged service life of the milling cutters, which last up to 80 % longer, as well as the reduction of workforce requirements by 60 %" Matthias Person (Photo: Klaus Vollrath)

Proposals for captions

Workhorse: all three tool shops perform HSC machining with a Röders RXP 500 featuring linear direct drives for the highest precision and dynamics. The photo shows the plant installed at Ermet (Photo: Klaus Vollrath)
Success model: the RXP owes its outstanding accuracy to special features such as an automatic compensation of spindle length deviations resulting from temperature changes and an integrated tool dimension control system equipped with a laser, complemented by a tool cleaner (arrow) (Photo: Klaus Vollrath)
Challenges: tools for electronic connectors are characterized by narrow contours, small radii , high aspect ratios and sharp edges (Photo: Klaus Vollrath)
Space puzzle: the complex dies consist of a multitude of intertwining components. The accuracy achieved by HSC machining often makes it possible to mill seats and precision fits directly instead of having to grind them in a second leg (Photo: Klaus Vollrath)
Job example: a typical mould with the related cutters. Even very thin and deep grooves are now machined into the hardened material with full reliability of the process (Photo: Klaus Vollrath)
Moment of truth: prior to taking the decision to acquire their new plant, Ermet asked for the machining of this test piece. It includes a number of key difficulties such as filigree lands with rounded end portions (right) as well as abrupt steps at the bottom of narrow grooves (left) (Photo: Klaus Vollrath)
Life-saver: cold forming transforms the steel blank (left) into a precision part for security belt emergency tighteners (Photo: Klaus Vollrath)
Heavy labour: the straining of the tools during cold forming is so intense that they will crack as a result of high cycle fatigue after only a few 10,000 work cycles (Photo: Klaus Vollrath)

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Series production: in view of the large number of dies the company needs, productivity and short throughput times of the tool shop become key factors for success (Photo: Klaus Vollrath)
Endurance performer: at Heckler, an RC2 workpiece pallet exchanger and a tool magazine with 100 positions provide for continuous three-shift operation of the Röders RXP 500 machining plant (Photo: Klaus Vollrath)
Stand-in: in injection moulding tools used for embedding metal grids in plastic parts, tightly intertwining mould components ensure that the injected plastic melt will coate only predefined parts of the metal grid. In this context, every micron of accuracy counts (Photo: Klaus Vollrath)
Border area: this circumferential rim produced by milling is just 0.15 mm high (Foto: Klaus Vollrath)
Wave form: the intricate parting plane geometry of this mould is a particular challenge for the accuracy of the milling centre (Photo: Klaus Vollrath)

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The RödersTEC RXP 500
The RXP 500 triaxial machining centre has been designed as an HSC milling workhorse able to process even hardened steel in tool shops. The axles have working ranges of 500 x 500 x 300 mm. Its design emphasizes productivity, ruggedness and dimensional accuracy when producing 3D-contours. “Classic” roller guides have been combined with frictionless linear direct drives excelling by their dynamism and precision. Compared to conventional recirculating ball-screw drives, linear direct drives exhibit not only higher path accuracy: at comparable power consumption, they also convince by the fact that they are not subject to wear and tear since they contain no moving parts in direct mechanical contact. The spindle with a power rating of 14 kW reaches 42,000 RPM.
Sophisticated temperature management, highly accurate spindle length compensation as well as an integrated laser tool measuring gauge ensure a precision significantly exceeding the standard offered by comparable plants up to now. Another factor contributing to this is the plant’s additional function as a high-precision coordinate-measurement device.

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