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Tool Technology + Processes

A Real Surprise

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Tool Technology + Processes

Hard Machining



Tested with good results: The SRF ballnose cutter is a big hit in the Mould and Die Division of Audi AG, achieving an enormous tool life of up to 20 hrs. - on hard material up to 60 HRC.

A Real Surprise

Milling cutters boost productivity at Audi Mould and Die

The Mould and Die Division of Audi AG is one of the industry's model companies. Continuous process optimization is part of their standard repertoire and this means it's hard to surprise these highly professional toolmakers. The surprise in this case was achieved by a single insert ball nose cutter, the SRF from Mitsubishi Materials that gave tool life increases of up to 100 percent.

The Mould and Die Division of Audi AG, with its three sites in Ingolstadt and Neckarsulm (Germany) and Győr (Hungary), is one of the largest in the industry with a staff of over 1,400 and a real net output of 300 million Euro. The headquarters in Ingolstadt is also a Centre of Excellence for mould and die-making and body manufacturing for the entire VW corporate group.

In-house production and processes are constantly subjected to close scrutiny, with the main objective of these optimization efforts being to shorten the cycle times and to increase value-added activities. That may sound clichéd, but in this type of mould and die-making, with the demands for individual and one-off production, it's not easy to realise.

"It's very important for us", says Anton Habermeier, Head of Machine Technology in the Mould and Die Division, "to increase the proportion of

unmanned machining." As a result of the optimization efforts, unmanned machining has been doubled over the last two years and is still ongoing.

This means that ever more stable processes are in demand with the milling tool playing a very important role, and the type of workpieces machined shows why. Body dies for car shells, large body parts and combined tools for cutting and forming are produced here.

Furthermore, the importance of stable tool life is especially important when milling the freeform surfaces of these workpieces. The parts have a hardness value up to 60 HRC, they contain deep cavities, sometimes with difficult transitions from the hard to the soft material. The cycle times for finishing are up to 20 hrs.; and in order to maintain the required surface finish, this should be achieved in a single uninterrupted



As the topic of "residual material" is hardly relevant here, only a spherical cutter is considered for this heavily fissured die with large differences in height.

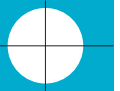
cycle. "We take the approach", says Anton Habermeier, "that virtually no further finishing should be necessary after machining" so every interruption in the finishing cycle inevitably results in a visible mark on the workpiece that requires further attention.

At the beginning of the year an increasing number of dies for hot stamping processes, such as those for high-strength body panels had to be machined. This meant that the

Single process machining

Audi Mould and Die Division were forced to take action. The milling tools used up to that time weren't able to meet the requirements. "It wasn't possible", says Alexander Schiffner, responsible for tool pre-adjustment in the Tool and Die Division, "to completely finish machine these dies in one cycle."

Initial tests with the SRF ball nose cutter from Mitsubishi Materials achieved the breakthrough. The first milling tests were already so positive that the finishing cutter – actually intended for hardened and pre-hardened steel – was also used on cast



steel and cast iron dies. When these tests were also successfully completed, the application engineers ventured into the roughing cycle. Alexander Schiffner sums up his observations, "We were amazed about the tool life achieved even under the changing conditions that the contours generate, and also for example on the boundary of the hard to soft material". It is interesting in this context that – independent of these trials – the Audi Mould and Die Division in Neckarsulm also achieved similar milling results.

Antonio Abrantes, head of Mitsubishi's European Technical Department, was very pleased by the results, "We were surprised that the milling cutter proved its efficiency even during roughing processes with a cutting depth of up to three millimeters. We have now also gained a great deal of experience in achieving

The jack of all trades

The Mould and Die Division of Audi AG was looking for a milling cutter for machining free-form surfaces. It was to be capable of machining both soft steel and hardened cast steel up to 60 HRC. In addition, it was to be suitable for roughing, semi finishing, and fine finishing, and able to reliably achieve a tool life of 20 hrs. Does such a cutter exist? The staff at Audi were surprised themselves when they tried the SRF cutter from Mitsubishi Carbide. In short, all target requirements were achieved. Compared to previous machining, a 100-percent increase in tool life and up to a 20-percent improvement in the feed rate was realized.

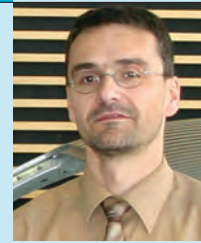
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INTERVIEW

Anton Habermeier, Audi AG

The usage of optimized cutting edge geometry is related very closely to the topics of strategy and finishing allowance, especially concerning 3-D Milling. A single step of the process may take longer, but overall the whole process saves time.



"Increasingly hard materials are required"

Anton Habermeier is the Head of Machine Technology of the Mould and Die Division at Audi AG in Ingolstadt, Germany. We wanted to know what modern cutting tools have to offer.

Mr. Habermeier, what challenges are your cutting tool suppliers faced with - in particular with regard to the machining of freeform surfaces?

The trend here is increasingly towards high-strength materials. Vehicles must not become heavier, however they have to comply with tougher crash test requirements. Consequentially, the dies have to be designed differently, for example using highstrength cast steel, and the related increasing use of hot stamping processes means the dies must be provided with very different surface hardnesses. Here we're talking about cast steel with a hardness range up to 60 HRC.

With hard materials, the use of CBN as a cutting material would certainly be interesting.

Of course, we do use CBN cutting materials in a broad range of applications, just like when we use corner radius type milling cutters. However, we always have to look at exactly which application is involved. CBN tools are ideal when we can let them run continuously with constant cutting conditions. The advantages of a corner radius type geometry can also be fully utilized here. However, if it's a matter of dies for components with a lot of curved surfaces and extreme differences in height, for example a die for an inside door section, then the

corner radius milling cutter simply has disadvantages due to the residual material remaining after machining, and that's why we've never lost sight of the ball nose cutter.

So the right combination is in demand?

Especially with the freeform surfaces, the use of the milling cutters has a great deal to do with the topic of machining strategy and residual material. An individual operation may be longer, but the sum of the overall process saves time.

Another thing is also apparent: simultaneous 5-axis machining is hardly used in the Audi Mould and Die Division. Why is that?

That's right. With the large machines, i.e. the focus of our machining we purposely don't go down the route of simultaneous machining. That's because we've determined that machines are too restrictive today, especially where the head dynamics are concerned. But simultaneous machining certainly has potential. I see advantages primarily in the prefinishing process, with a machining allowance of maybe 0.2 mm. It would also be desirable for fine finishing, but I know of no machine concept in which the spindle head is optimally positioned in every axis, and that's the condition needed for a perfect surface.



Tool Technology + Processes

Hard Machining



They worked the processes together and achieved highly satisfactory results (from right to left): Alexander Schiffner, Josef Amman, Anton Habermeier, Johann Korneli (all from Audi AG Mould and Die Division), Antonio Abrantes, Hans Huprich and Axel Dollinger (all from Mitsubishi Materials).

a tool life of up to 20 hours for roughing a hard material with this type of tool."

The SRF cutter used VP10MF grade Miracle coated carbide inserts. The substrate material for the insert is ultra-fine-grained carbide, which is both extremely wear-resistant and hard, however it also possesses a tough characteristic due to the uniformity throughout the structure. The S-shaped cutting edge has positive geometry and is therefore designed for smooth cutting. This results in low cutting resistance and allows an optimized temperature to be maintained during machining, especially in the centre of the cutting edge, a feature primarily important for the air-cooled dry machining employed at Audi. Also, Mitsubishi's

own Miracle coating provides for an additional combination of hardness and toughness. The inserts are held in a carbide shank, the advantage over a steel shank is that the high resistance to vibration enables extremely smooth cutting; and play a key part in giving a long tool life.

As in most complex moulds, the workpieces contain many deep fissures with several extreme differences in height. Axel Dollinger, Application Technician from Mitsubishi, has advised his customers to use ball nose cutters, "Although I know that Audi uses a lot of corner radius type milling cutters, the ball nose cutter offers clear advantages for these workpieces, i.e. there is hardly any residual material, and therefore little post-machining."

What Users Say

The user

Mould and Die Division of Audi AG

The tool

Ball nose single insert cutters of the SRF range from Mitsubishi Carbide for machining free-form surfaces

Advantage

- Achieves good to very good results in steel, cast steel and cast iron
- Can be used both for roughing (up to 3 mm ap) semi finishing and finishing.
- Very long tool life
- Dependable tool life possible, therefore well-suited for unmanned machining.
- Very smooth operation when carbide shank holders are used

Disadvantages

- None according to the user

Anton Habermeier talks about a 100-percent improvement provided by the use of the SRF cutter and the fact "that we've now achieved a stable process for unmanned shifts", is even more important to him. *pi*

Materialtest: Matriz*^{*}

| | |
|--|---|
| Material | hardened cast steel (60 HRC) |
| Machine | DMC 200U |
| Parameters | |
| Spindle speed n (min ⁻¹) | 3200 |
| Surface speed v_c (m/min) | 200 |
| Feed/Tooth f_z (mm) | 0,4 |
| Table feed v_f (mm/min) | 2500 |
| Depth of cut a_p (mm) | 0,8 |
| Width of cut a_e (mm) | 1 |
| Cutter | End mill |
| Diameter (mm) | 20 |
| Overhang (mm) | 180 |
| Holder | Carbide shank |
| Chuck type | SK 50 |
| Results | |
| Surface finish | very good |
| Chipform | very good |
| Noise | very good |
| Tool life (min) | 385 |
| Chipping | none |
| Wear | Negligible |
| Specials | Dry machining with air blow and low noise levels. |
| | Only very small tool wear, the insert only changed for. |

*Test: Audi Mould an Die

The mould and die test at Audi shows that excellent quality surface finishes were.

Profile

Mould and Die Division of Audi AG

The Division was founded in 1993 and has regularly expanded as a Centre of Excellence for the entire VW corporate group. In addition to manufacturing dies with a weight of up to 15t for passenger-car shells, they are also responsible for manufacturing bodymaking systems. Approximately 75 percent of the tools manufactured are for Audi, with the rest being distributed among the other brands of the corporate group. At a very early stage, intensive efforts were made to introduce "digital" mould and diemaking, ensuring fewer errors in mechanical machining by using prior simulation.