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Speciality of HSC in manufacturing of forging dies

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The paper discusses the attributes of the die forging tools manufacturing with high speed milling technology. In the most cases of die forging tools manufacturing high speed milling of hardened material is faster and cheaper manufacturing process than EDM, besides forging tools have better quality and therefore longer tool life. By machining process of in the paper presented die forging tools, milling tool length/diameter ratios of extreme values were applied, what has influence on high speed milling strategy and technology. Whole die forging tool design and manufacturing procedure is realised on a method of long distance work.

1. INTRODUCTION

Nowadays HSC technology is basically constituent part of every modern tool making company. With introduction of HSC into tool shops mould making manufacturing technology has been changed, mostly by manufacturing of mould cavities which represent the most pretentious mould parts so that 40% of mould manufacturing time is used for the manufacturing of mould cavity. According to the objective model for cavity manufacturing technology developing, where milling tool, mould and product related parameters are considered, combination of EDM/HSC or entirely HSC manufacturing technology replaced classic die sinking EDM mould cavity machining [1]. For each mould cavity itself has to be ascertain, which technology – rough HSC milling/finish EDM or HSC milling entirely – is cost and time most appropriate.

2. ATTRIBUTES OF HSC AND EDM

In Table 1 [2] the advantages, disadvantages as well as limits of the EDM and HSC milling are presented. For selection of the most appropriate mould cavity machining technology the energy consumption and ecology are of a great importance too. It is well known that the EDM process has a very high level of energy consumption, therefore it should be used only in cases where, regarding product, milling tool shape or mould related properties does not allow the HSC technology [3].

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Table1
Comparison of manufacturing technologies

Criterion	EDM	HSC milling
Materials	All conducting materials	All cutting materials (steel up to 62 HRc)
Geometry	Free	Limited depth, radius
Sharpedged inner angles	Radius < 0.1 mm reachable	Radius at the bottom > 0.3 mm Radius at the wall > 1 mm
Deep grooves	Depend on manufactured electrode	Up to L/D < 10
Polished surface	Always additional finish machining	+, partly without additional finish machining
Costs of additional finish machining	High	Low
Blur surface	Yes	No
Texture modification	Micro cracks	Compressing
Geometric accuracy	+	++
Dispossession effect	+ by large shapes surface dispossession	+ by small shapes point dispossession
Premachining	Rough EDM	Economy = f (machining costs, volume)
Machining tool	Expensive (milled)	Simple, standard product

Reprinted from: J. Schock, P. von Meiss, HSC-Fräsen im Werkzeug- und Formbau, Werkzeug und Formenbau: Tagung Aachen, VDI Verlag GmbH, Düsseldorf, 1998, p.111

From ecology point of view HSC technology is prevailing EDM for the following reasons:

- Technology using less energy is much more friendly to the environment.
- Permanent decrease of cutting lubricants and coolants leads to dry machining.
- There must be constant monitoring of EDM electrolyte during the process as later on for the waste treatment and disposal [3].

The HSC introduction into tool shops drastically reduces manufacturing times for the mould forming system, however the EDM and HSC technologies are not competitive but they are adjective, since all different forming geometry's can be manufactured with EDM which is not the case for HSC [3].

3. MANUFACTURING TECHNOLOGY OF HOT FORGING TOOL CAVITIES

Very important properties of steels in hot-work applications are temperature strength and thermal shock resistance, which help to determine the material selected for the tool, due to the high operating temperatures existing at the area of the contact between die and workpiece. But one of the most important properties, if not the single most important property, is the toughness. The toughness serves as an indication of the ability to resist the formation and growth of cracks [4].

Combination of HSC technology and milling tools with new coatings (TiAlN) is a ground for successful cost and time reduced hard milling, in range of 46-62 HRc of already hardened tool cavities for hot forging, and therefore reduction of EDM. Tools for forming processes as forging or deep drawing can be almost entirely milled because sharp inner angles basically do not appear. Reachable dispossession effect by hard milling is comparative or even better as by EDM, electrode is unnecessary and surface quality is better [2].

3.1. Hard milling with high L/D ratio

Forging part geometry defines parting plane and therefore required milling tool length/diameter (L/D) ratio. The latter have great influence on machining accuracy and surface quality.

High spindle speeds increase the severity of vibration at the tool tip. To protect tool life and surface quality, we have to favour more rigid tools. For end mills this means using of shortest tool as possible and favouring a tool with shorter flutes, which brings a larger and more rigid central core [5].

On the other side, the ability to take lights cuts quickly makes the milling machine more efficient with delicate tools that are very long relative to their diameter. This helps in at least two cases:

- milling deep cavities or deep slots,
- milling fine details with very small tools [5].

At high L/D ratios milling tool deflection increases, which is consequence of large run out of milling tool and low tool rigidity. Tool deflection and milling strategy affect on dimension accuracy and surface roughness of machined tool cavity. HSM – dry cutting is by milling of 50HRc materials very successfuly too [6].

3.2. Industrial example of hard milling of deep cavities and fine details

On Figure 1 and Figure 2 cavities of die forging tool are presented, which was made of steel WNr. 1.2343 hardened on 50 HRc and applied for hot die forging of steel WNr. 1.0570.

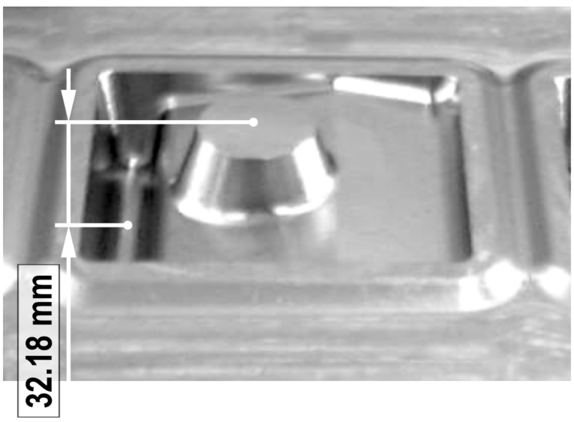

Figure 1. Cavity of first forging phase with maximum depth.

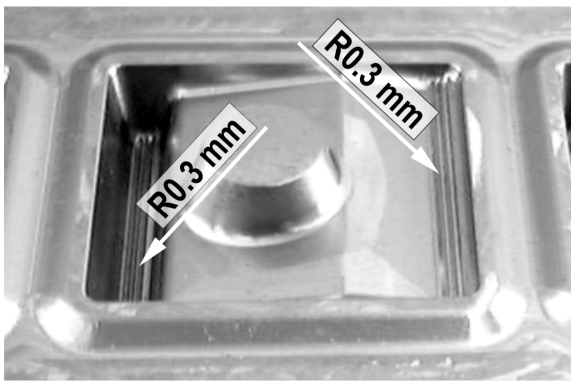

Figure 2. Cavity of second forging phase with small inner radii at maximum depth.

In Table 2 parameters for machining of specific section of cavities are presented. Tool life of this HSC milled forging tool was approximately 30% longer than the same EDM machined forging tool (customer feedback information).

Table 2
Machining parameters

	Figure 1	Figure 2
Tool	Ball end mill D4R2 mm	Ball end mill D0.6R0.3 mm
Coating	TiAlN	TiAlN
L/D ratio	8	/
Shank diameter [mm]	4,6	6
RPM	20000	20000
a_p [mm]	0.08	0.04
a_e [mm]	0.13	0.05
Strategy	Semifinish + finish of whole cavity	Semifinish + finish of fine details

4. CONCLUSIONS

Generally, the reduced need for EDM in tool manufacturing is increasing whenever it is possible. Thus HSC milling technology with two extreme applications, hard milling and milling at high length/diameter (L/D) ratios, increasingly replaces EDM by manufacturing of all those exacting tool cavities details, where EDM would typically be used. Low cutting forces by HSM ensure successfully product [7].

Still applicable L/D ratio value depends on material hardness, required dimension accuracy, required surface roughness and required minimal inside corner radius. At this stage a combination of both procedures is convenient for tool manufacturing for products with low and middle surface roughness and dimension accuracy requests.

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