MILLSTAR® Application Data

Innovative Hard Machining of Forging Die Eliminates EDM

Automotive Steering Trunnion Die is rough-to-finish machined in record time using aggressive machining strategies and off-the-shelf high speed milling tools for hardened metals.

A major US automotive parts manufacturer and Tier One supplier teamed up with Mllstar on an ambitious machining project to improve manufacturing cost and throughput time of a forging die for automotive steering trunnions. The die is made from type M4 high speed steel with a final hardness of 65 - 68 HRc. Milling this tough material at hardness equivalent to a HSS end mill had proven to be very difficult for the parts manufacturer and not economical when compared to EDM machining.

A comparison of the previous traditional EDM process and the current high speed and hard material milling process goals proposed by the manufacturer can be seen below:

Traditional sinker EDM process:	High speed hard metal milling process goals:
Fabricate EDM electrode	Eliminate electrode fabricating and EDM process
EDM the forging die cavities	Machine die cavities in under 2.5 hours
Remove EDM re-cast layer and polish	Semi-finish and finish machine in hardened state
Tool supplier	Maintain 0.001 inch / 0.025 mm total tolerance
	Achieve a fine finish to eliminate all hand polishing
	Use standard off-the-shelf cutting tools
	Minimize tooling cost

Machining Summary

After some initial testing at the customer's facility, Millstar proposed machining strategies, milling parameters and a set of standard tools to fully meet the goals set by the customer. Rough machining strategies for the four half-round channels with annular grooves forming the cavity were developed for both soft and hard material. Semi-finish and finish milling is done in the hard state only, so that accuracy and finish requirements can be met.

Machining Parameters

Customer	US automotive parts manufacturer and Tier One supplier
Workpiece	Forging die for steering trunnions
Machine	MAKINO model A77 horizontal Machining Center
Tool supplier	MILLSTAR
Material:	
Dimensions	4 inch (102 mm) diameter
Material Spec.	High Speed tool steel type M-4 (~1.3344)
Hardness	Test piece machined at 68HRc

Roughing

Roughing is done with a 1/2 inch (12.7 mm) Millstar carbide ball insert tool with stiff carbide shank and V-brazed tool head. The shank is held in a shrink-fit adapter. Cutting strategy is Z-level back and forth along the length of the half-round channels, inside-outside pattern, and ramp engage.

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Semi-Finishing

Tool Adapter	Shrink-fit
Cutting Tool	6 mm (0.236 inch) dia. solid carbide ball mill, 2-flute MILLSTAR
Tool coating	Exalon™ (AlTiN)
Tool path strategy	Zig-zag arc across the cavity, climb and conventional milling
Cut depth / rest stock	0.025 - 0.035 inch (0.63 – 0.89 mm)
Spindle speed	10000 RPM (min/1)
Feed Rate	120 inch (3050 mm) per minute
Step-over / pass (ae)	0.020 inch (0.5 mm)
Material Hardness	Test piece machined at 68HRc

The semi-finishing operation is now accomplished with aggressive feed and speed values, after slightly adjusting the roughing passes to leave more evenly distributed remaining material with less prominent steps.

Finishing

Tool Adapter	Shrink-fit
Cutting Tool	2 mm (0.080 inch) dia. solid carbide ball mill, 2-flute MILLSTAR
Tool coating	Exalon™ (AlTiN)
Tool path strategy	Zig-zag arc across the cavity channels, climb and conventional milling
Cut depth / rest stock	0.004 - 0.005 inch (0.1 – 0.125 mm)
Spindle speed	13500 RPM (min/1)
Feed Rate	140 inch (3556 mm) per minute
Step-over / pass (ae)	0.001 inch (0.025 mm)
Material Hardness	Test piece machined at 68HRc

The finish milling parameters are set at impressive values for this small tool. The current feed rate was increased from the feed rate used earlier of 100” (2540 mm) per minute. The larger feed per tooth results in the benefits of a shorter finish machining cycle and (contrary to conventional wisdom) longer tool life. Tool wear on the 2 mm diameter tool used to finish mill the entire die is held to 0.0006” (0.015 mm). The part accuracy is well within the required 0.001 inch (0.025 mm) total tolerance.

Summary

All goals as set by the customer were achieved or surpassed:

1. Accuracy and finish are well within specifications.
2. Roughing in soft material and semi- and finishing in hard material is done in 1 hour and 45 minutes (roughing in fully hard material adds 30 minutes).
3. Cutting tool costs for rough, semi- and finish machining are $200 or less.

Significant savings are achieved by sharply reduced machining times and the elimination of polishing, less capital equipment is used (one smaller HMC or VMC for the new process vs. a Graphite electrode milling machine and a EDM sinker machine for the old process). The cost of processing, handling, tooling and fixturing is lower.

Conclusion

The customer was very satisfied with the machining results. Production of the dies will be run on a MAKINO model V55 vertical machining center and with Millstar tooling. The combination of willingness of the customer to explore new options, the machine technology of Makino, and the tooling technology and application know-how of MILLSTAR once again proved a superior combination.