POLISH ACADEMY OF SCIENCES - MATERIALS SCIENCE COMMITTEE
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Conference Proceedings
11th INTERNATIONAL SCIENTIFIC CONFERENCE
ACHIEVEMENTS IN MECHANICAL & MATERIALS ENGINEERING

Technological particularities of high speed cutting*

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High Speed Cutting (thereinafter HSC) machining is more and more replacing Electrical Discharge Machining (thereinafter EDM) in contemporarily toolmakers industry.

HSC has become a cost-effective manufacturing process. Time saving for tool making could be up to 50%, what is showed on a practical example in this paper.

Product quality, achieved by HSC, depends on appropriate machine, CAD-CAM system, cutting tools and knowledge. Knowledge and experiences are the most important factors, which impact optimum efficiency. Preliminary condition for achieving minimal machining costs or optimum efficiency is the correct NC program. The paper includes different possibilities of HSC, CAD-CAM program system Mastercam and appropriate HSC modules. The paper also includes savings by using ˝HIGH SPEED˝ function, which optimizes machining.

1. INTRODUCTION

Fast development of toolmakers industry ensures requests on the market. To assure better tool making management, we have to introduce new technologies. One of them is abovementioned HSC, which is efficiently replacing EDM. Good support of High Speed Machining (thereinafter HSM) is ensured by some of the effective software programs such as Look Ahead and High Speed function. They all help us to shorten machining time as well as machining costs and further to achieve requested surface quality of the workpiece.

2. CAM CONCEPT BY MANUFACTURING APPROACH

Successful HSM is always related with appropriate CAM software. We should use the same CAD-CAM system for development (modeling of a product), design (tool design) and process planning (using CAM program). In this way data transference is not complicated since their formats are not different.

It is important that CAM module includes milling simulation, which enables virtual check before actual machining. Simulation usually shows metal removing dynamics and tool path

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* Authors participate in the CEEPUS No PL-013/02-03 project headed by Prof. L.A. Dobrzański.

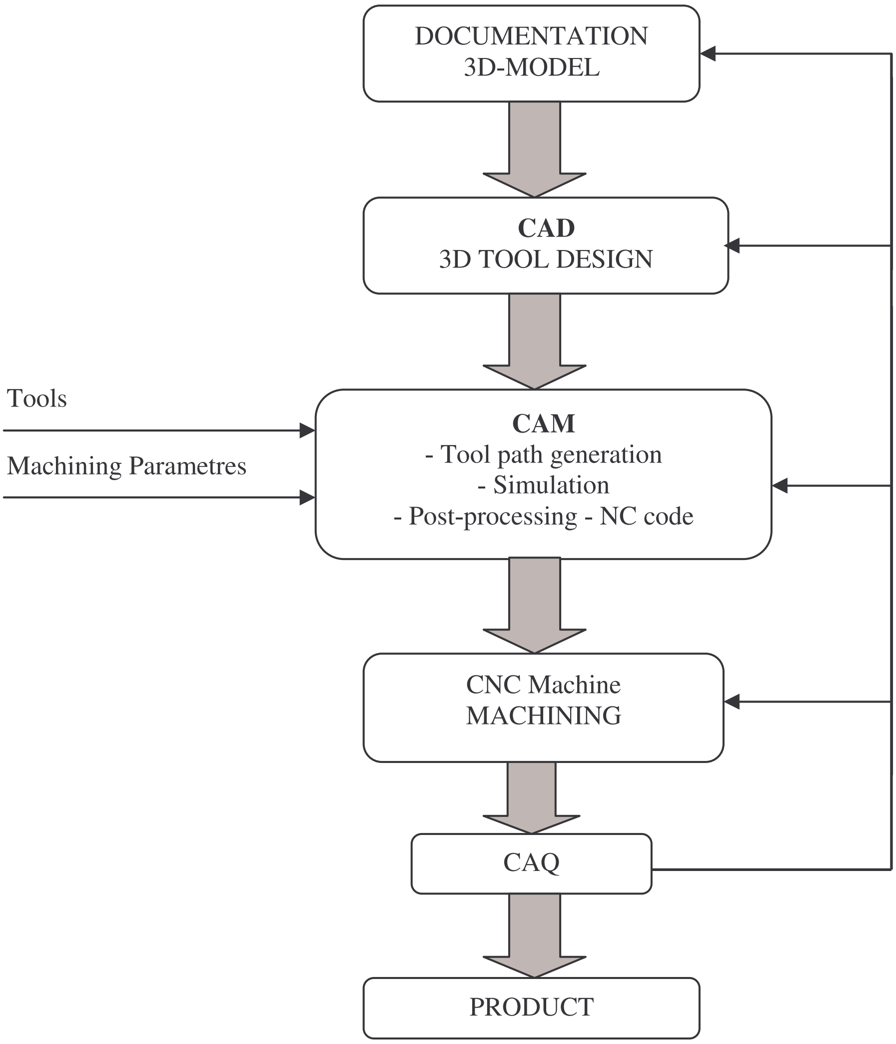


Figure 1. CAM role in manufacturing

CAM module makes universal, standard NC code. This code is further translated into form, which is understood by specific machine controllers. Described procedure is known as post-processing. Each machine controller has specific post-processor, which transforms different code formats.

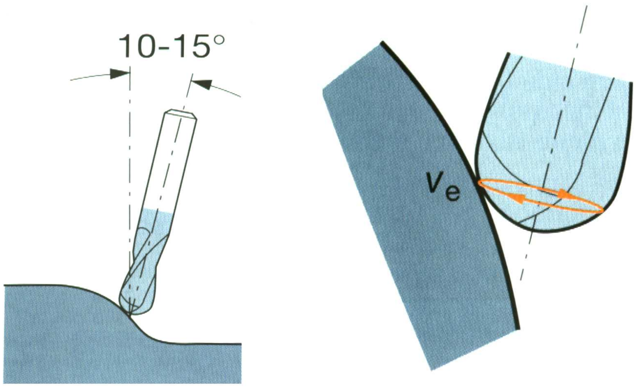


Figure 2. Milling presentations with tool-cutter slope

5-axis milling machine-tool enables main spindle slope, thus ball-nose pencil cutter can be used at a defined angle (10-15 degrees). In this way tool-wear on a cutter tip is reduced.

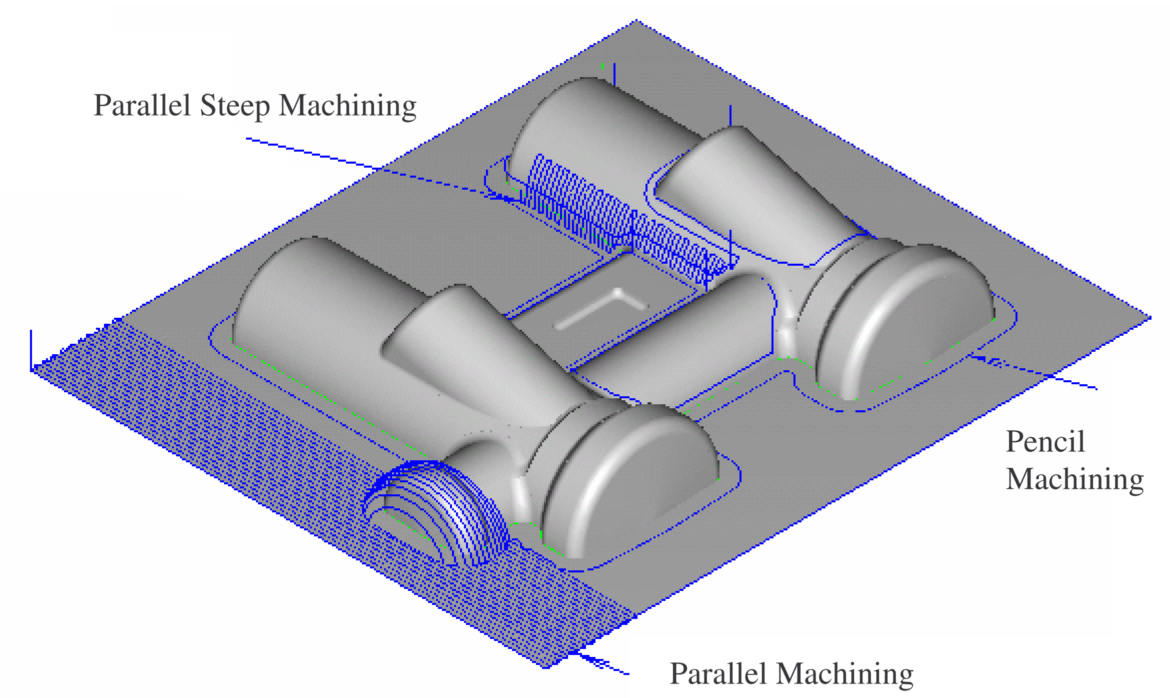


Figure 3. Contour machining

3-axis finish milling contains the following types of machining:

- Parallel machining (Figure 3) considers workpiece shape. It is used to achieve final size of a model in terms of dimensional accuracy.
- Radial finishing is similar to rough radial machining, except it contains some finishing parameters.
- 2-D machining is usually used for simple engraving.
- Parallel steep machining (Figure 3) is supplementing parallel machining. It is used for cutting steep walls on solid, which were insufficiently machined beforehand. Parallel steep machining is accomplished perpendicular to beforehand parallel machining.
- Pencil machining (Figure 3) is used for cutting remaining rounding. As a result constant inner corners rounding are achieved.

3. CHOOSING APPROPRIATE PROCEDURE IN TOOL-MAKING

HSC in tool-making is mostly used for machining different types of dies. Machining procedure depends on die shape, material, hardness, design, dimensions, tolerances and cutting sequence. Dies for thermoplastics injection moulding are made of heat-treated steels, with hardness of 40 HRc or alloyed plastic mould tool steels (W.Nr.: 1.2343, 1.2344, 1.2379), hardened to 56 HRc.

Hardened tool steels are used for die casting of aluminium or aluminium alloys. Dies for sheet metal forming are made of cold work tool steels (W.Nr.: 1.2080, 1.2379) of hardness 62 HRc. Sintered steel (ASP 23, ASP30, ASP60) dies hardness reach 68 HRc.

In regards to product and tool design we choose one of the following machining procedures:
- HSC,
- EDM,
- Combination of both procedures.

Machining of different dies made of various steels and hardness is usually done in the next sequence:
a.) Machining of heat-treated dies

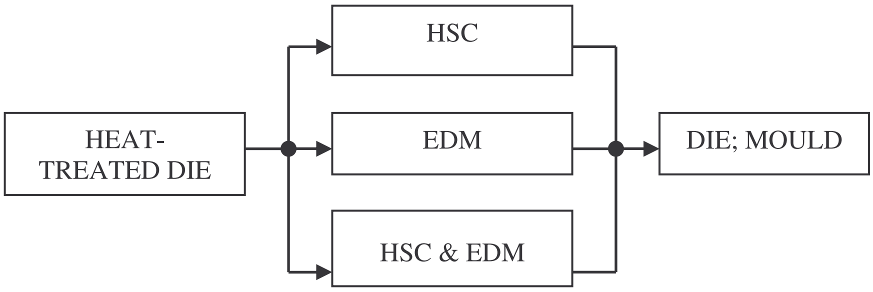


Figure 4. Heat-treated steel die of 40 HRc

b.) Machining sequence includes rough and semi-rough machining followed by heat treatment and final machining of HSC, which ensure excellent accuracy and high surface quality.

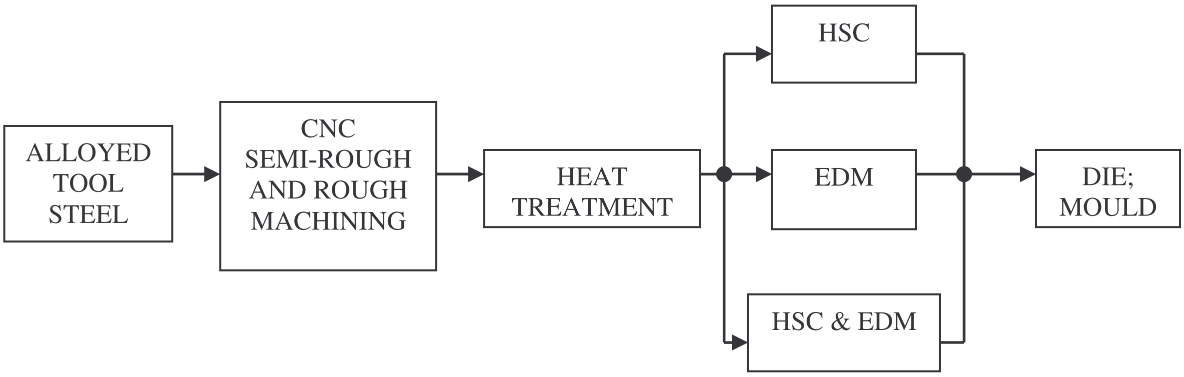


Figure 5. Alloyed dies of 67 HRc

c.) Machining of a smaller dies made of alloy tool steels in their hardened state up to 62 HRc has become a cost-effective manufacturing process. HSC in combination with various cutting-tools (hard-metal cutters, drills, plan and angle cutters) is cost and time saving procedure.

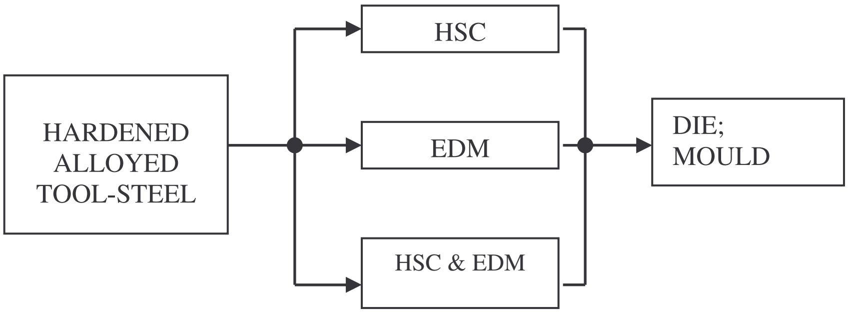


Figure 6. Hardened dies of 62 HRc

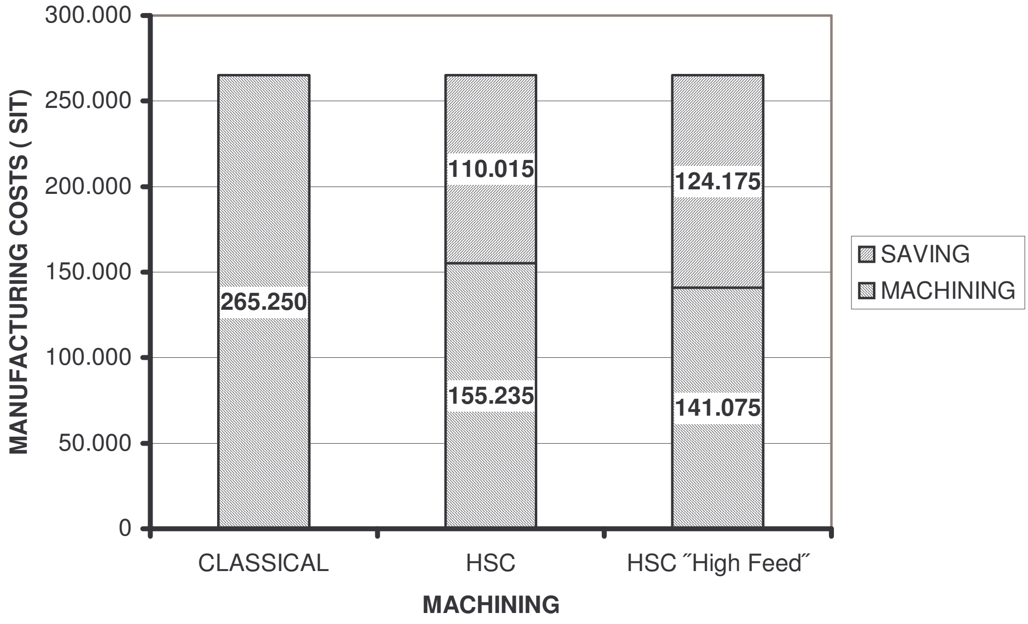
Table 1 Procedure and machining time of CNC and EDM machining

DIE TOOLING PROCESS			
Process Operation		Description	Machining Time (Hours)
1	MATERIAL CUTTING	Material W.Nr. 1.2343 Dimension 50x105x235 mm	0.5
2	ROUGH MILLING	Rectangular solid machining with 0.4 mm extra	1
3	CNC MILLING	3D programmed milling	8
4	TOOL-MAKING OPERATIONS	Drilling and machine tap wrenching	2
5	HEAT TREATMENT	Hardening to 55 +/- 1 HRc	
6	GRINDING	Outline grinding, groove grinding	6
7	COORDINATE GRINDING	Borehole grinding (tolerance H7)	1.5
8	SINKER EDM	Metal removing by electrode	20
9	WIRE EDM	Groove wire-cutting (tolerance H7)	4
10	TOOL-MAKING OPERATIONS	Finish polishing and die setting	8
TOTAL MANUFACTURING TIME			51

Table 2 Structure of manufacturing costs

		CLASSICAL		HSC		HSC»HIGH FEED «	
Process Operation	SIT/Hour	Hours	SIT	Hours	SIT	Hours	SIT
MATERIAL CUTTING	2800	2	5.600	1	2.800	1	2.800
ROUGH MILLING	4250	1	4.250	1	4250	1	4.250
CNC MILLING	4900	16	78.400	-	-	-	-
HSC MILLING	7080	-		17	120.360	15	106.200
GRINDING	2740	6	16.440	1.5	4.110	1.5	4.110
COORDINATE GRINDING	6000	1.5	9.000	-	-	-	-
SINKER EDM	4500	20	90.000	2	9.000	2	9.000
WIRE EDM	4050	4	16.200	-	-	-	
TOOL-MAKING OPERATIONS	3270	13.5	45.360	4.5	14.715	4.5	14.715
TOTAL		64.5	265.250	27	155.235	25	141.075

Diagram 1 Process Operation – Manufacturing Costs



All described theoretical advantages of HSC are confirmed on a practical example of die tooling. HSC is opening the way to a lot of practicabilities of quality tool-making with shortening machining time and low manufacturing costs. Procedures applied with »HIGH FEED« function are even more cost-effective.

4. CONCLUSIONS

HSC principles in tool-making should be already applied in product planning and tool design. It is important to cooperate tool and product design. The object of this cooperation is adaptation of product design, which should include as much HSC as possible.
HSC is shortening manufacturing time hence lowers tool-making costs. HSC is above all replacing EDM and manual tool-making operations. Survey of practical results shows that HSC is more than two times faster in comparison with classical machining procedures. Total HSC time saving is 57% i.e. 37.5 hours or 5 working days. HSC machining costs are reduced by 41% or 46% when »HIGH FEED« function is applied.

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