THE INTERNATIONAL CONFERENCE OF THE CARPATHIAN EURO-REGION SPECIALIST IN INDUSTRIAL SYSTEMS
6th edition

IMPROVING THE CAST PA-6 SURFACE DURING MACHINING

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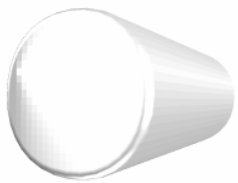
ABSTRACT
In the literature there are many tables offering wide range of cutting, machining parameters for the different semi-finished engineering polymers. It is well-known that the surface parameters of the technical surfaces can influence the potential possibility of a certain machine element. This statement is also true for the machined engineering polymers regarding the load-carrying capacity and tribological behaviour.
From the engineering practice also known that the machining behaviour of the POM C is desired by the technicians. In the frame of a tribological research project we made a practical investigation how to machine the cast polyamide 6 (magnesium catalytic version) to achieve more advantageous machinability and surface properties, because the cast polyamide 6 is a basic, strategic engineering polymer.

1. PA 6 G or POM C ?

In table 1. I show the comparison of the two important materials.

Table 1. Comparison of cast polyamide 6 and POM C

Properties	**Cast polyamide 6 (DOCAMID 6G-H)**		**POM C (DOCACETAL C)**
Mechanical properties		nearly the same	
Thermal properties		nearly the same	
Electrical properties		nearly the same	
Stiffness	better		weaker
Fatigue resistance	better		weaker
Dimension stability in humidity	weaker		better
Wear resistance	better		weaker
Price	more advantageous		more expensive
Machinability	?	?	?
			

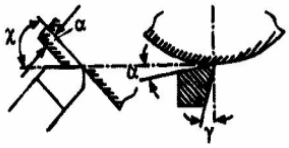
2. MACHINING ACCORDING TO THE GENERAL RECOMMENDATION

If someone starts to cut engineering polymers after machining metals for years, very easy to get an acceptable level using the general recommendations for plastics in the literature. We can find a wide range of machining features and with the extreme values surely possible to find a solution to keep the standard tolerances for a given polymer. Having a skill in plastic machining, easy to identify the different turning, milling etc. differences of the plastics.

Just following the literature database most of the technicians say that the easiest material to turn is the POM C. To achieve the same tolerances and surface quality (roughness) is rather complicated with the cast polyamide 6.

Is it true or false? First let's see the extract of the literature tables (table 2.).

Table 2. Features of turning of POM C and cast polyamide 6.

 α - Side clearance angle [°] γ - Rake angle [°] v – Cutting speed [m/min] s - Feed [mm/ford.] χ – side cutting edge angle [°]	**Properties**	**POLYAMIDE 6**	**POM C**
	α	8	6-8
	γ	5	5
	χ	90	90
	v	280	280

3. RESEARCH SYSTEMS

Our preliminary turning tests proved that the role of the cutting edge inclination and the chip-breaker are essentials. To present our conclusion we made a show test with three different tools without cooling and lubrication.

No.1. hardmetal tip lathe tool, side cutting edge, $\lambda = 4°$ inclination, no chip-braker

No.2. high-speed steel lathe tool, side cutting edge, $\lambda = 4°$ inclination, normal chip-breaker

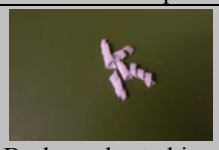
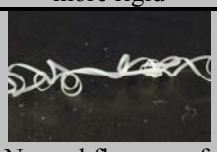
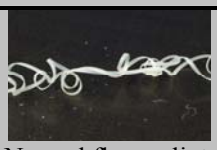
3. high-speed steel lathe tool, side cutting edge, $\lambda = 6°$ inclination, enhanced chip-breaker

The table 3. gives a summary about t he effect of the changing cutting edge inclination and chip-break on the machined surface quality and productivity. The chip removal is very important factor.

We made visual evaluation about the cut surfaces by means of microscope and took the productivity and chip behaviour into consideration to establish a more detailed database for cutting cast polyamide 6. In this case it is possible to improve the load carrying capacity and tribological behaviour of the machined cast polyamide 6 elements and also possible to achieve the productivity of the POM C.

Table 3.

FEED OF THE TOOL

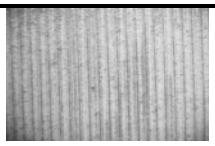
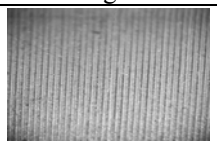
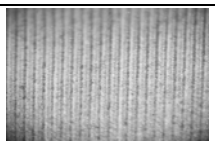
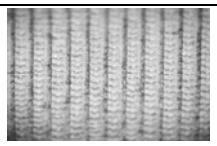
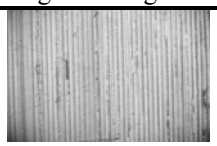
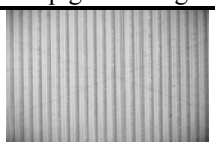
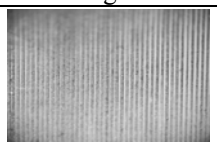
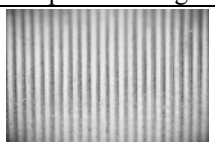
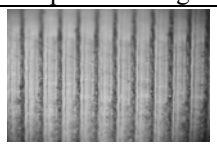
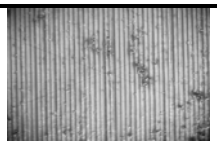
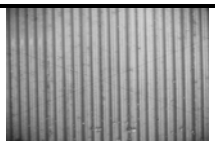
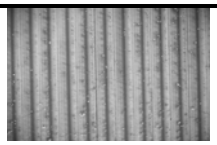
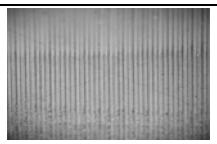
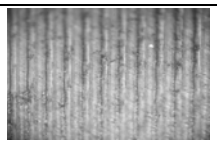
CHIPS BEHAVIOUR		I. feed 0,1 mm/rot finishing	II. feed 0,187 mm/ rot normal cutting	III. feed 0,375 mm/ rot roughing
No.1. tool  **Hardmetal tip**	**PA 6 G-H**	 Stiff splint	 Stiff, flow swarf	 Normal flow splint
	POM C	 Cylindrical flow chips, relatively rigid behaviour	 Spiral and cylindrical flow chips, more rigid	 Broken, short chips, Burry surface
No.2. tool  **high-speed steel with normal chip-break**	**PA 6 G-H**	 Spiral, stiff splint	 Normal flow swarf, stiff behaviour	 Even flow swarf, normal surface
	POM C	 Cylindrical flow chips, relatively rigid behaviour	 cylindrical flow chips, more rigid	 Broken, short chips, Burry surface
No. 3. tool  **high-speed steel with enhanced chip-break**	**PA 6 G-H**	 Shrinked chips, easy removal	 Normal flow splint, getting rigid removal	 Even flow chips, more rigid behaviour, not burry surface
	POM C	 Cylindrical flow chips, rigid behaviour	 cylindrical flow chips, more rigid	 Rigid, broken fragments, burry surface

CHIP-BREAK

λ – cutting edge inclination

FEED OF THE TOOL

Table 3.

Cut surfaces Microscope, 30x magnification		I. feed 0,1 mm/rot finishing	II. feed 0,187 mm/ rot normal cutting	III. feed 0,375 mm/ rot roughing
No.1. tool  **Hardmetal tip**	**PA 6 G-H**	 Even surface, elastic grooves with slight edges	 Even surface	 Even surface
	POM C	 Even surface, sharp groove edges	 Still even surface, sharp groove edges	 Scaled, burry surface, rigid behaviour
No.2. tool  **high-speed steel with normal chip-break**	**PA 6 G-H**	 Even surface, elastic grooves with slight edges	 Even surface, more rigid behaviour, sharp outline edges	 Even surface, more rigid behaviour, sharp outline edges
	POM C	 Even surface, sharp groove edges	 Still even surface, sharp groove edges	 Scaled, burry surface, more rigid behaviour
No. 3. tool  **high-speed steel with enhanced chip-break**	**PA 6 G-H**	 Even surface with shrinked swarf, rigid removal	 Ideal, nice, even surface	 Nice, even surface, sharp outline edges
	POM C	 Even surface, sharp groove edges	 Still even surface,	 Scaled, burry surface

CHIP-BREAK

λ – cutting edge inclination

4. CONCLUSIONS

- The machining data from the literature give reliable solution for marching of the semi-finished engineering polymers. It is possible to keep the standard marching tolerances.

- The tests proved that the practical rule regarding the easy machinability of POM C is true. The POM C was nearly insensitive against the changing tool geometries and machining condition.

- Over the general database the turning productivity and surface quality can be improved regarding the cast polyamide 6.

- Increasing feed does not spoil the surface quality of cast PA6.
- Chip removal can be improved with the application of higher cutting edge inclination.
- Chip removal can be improved with enhanced chip-breaker.
- Comparing to the reference POM C, it is possible to obtain the same productivity with the higher feed, higher cutting edge inclination and stronger chip-braker.

- Taking into the above mentioned into account, much cheaper and more reliable surface or machine element can be produced front he cast polyamide 6 material.

ACKNOWLEDGEMENT
The project were supported by OTKA T42511, and TéT B-1/04 research funds.

References:

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