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Zell-Metall Engineering Plastics

Machining instructions ZELLAMID® - Engineering Plastic Stock Shapes

1. Machines and Tools

Engineering plastic stock shapes can be easily machined on metalworking and woodworking machines with HSS (high speed steel) or hard metal tools. By machining with circular saws it is recommended to use hard metal saw blades. Only use properly sharpened tools.

It is possible to use hard metal tools for machining glass fibre reinforced materials but due to the high wear rates it is difficult to reach good economic results, therefore diamond coated tools are recommended which are more expensive but however have longer life span.

2. Machining and clamping the work piece

Compared to metals, plastic materials show a lower thermal conductivity and modulus of elasticity.
Improper machining leads to heating of the work piece followed by dilation.
High clamping pressure and blunt tools create deformations of the work piece during machining.
Dimension and form variations over range of tolerance are the consequences.

In order to achieve a satisfying machining result, some material specific guidelines must be kept.

- cutting speed should be as high as possible
- an ideal chip removal must be assured to prevent wrapping of the swarf around the tool or work piece
- Tools must be kept sharp. Blunt tools lead to heating which causes distortion and dilation
- Too high clamping pressure leads to deformation of the work piece and imprints of clamping tool
- As engineering plastics are not as rigid as metallic materials it is essential to secure the work piece adequately and to ensure a uniform support
- If necessary, materials with high water absorption (e.g. polyamide) should be conditioned before machining
- Machining tolerances for engineering plastic parts are wider than metal parts

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3. Cooling during machining

Generally, coolants are not necessary for machining thermoplastic materials. When coolants are required, compressed air is recommended. Compressed air has an additional benefit of chip removal from the working area, preventing interference with cutting tools and the workpiece. Usual drilling emulsions can also be used; they are particularly recommended when drilling deep holes and long threads. Furthermore it is possible to achieve higher feed rates which leads to a reduction in machining time.
If drilling emulsions are used, consideration must be given to subsequent cleaning operations to prevent contamination of any additional process such as splicing or varnishing.

4. Characteristic data for different machining operations

4.1 Drilling

Usual HSS sharpened tools can be used for drilling. Take care of chip removal when drilling particularly deep holes to prevent excessive temperatures, frequent removal of the drill may also be necessary. It is also recommended for large holes to drill first with a smaller diameter (ca. 10-20 mm) and then to finish with a single-point cutting tool.

Furthermore the drill has to be cooled to ensure an acceptable chip removal otherwise the plastic heats up to melting point and the materials low thermal conductivity prevents heat dissipation which leads to extreme material expansion in the centre. As the outer wall remains cold a huge area of stress is generated. Notch effect of the tool may lead to material failure (cracking) if above-mentioned rules are not observed. This effect may also appear with high impact strength materials.

As reinforced plastic materials have higher machining residual stress paired with lower impact strength than un-reinforced plastic materials they are especially crack sensitive.
These materials should be heated up to 120°C prior drilling. (Heating time ca. 1 hour per 10 mm thickness) Also with Zellamid® 250 (PA 6.6) as well as Zellamid® 1400 and 1400T (PET und PET+GL) this procedure is recommended.

4.2 Turning

Turning most thermoplastic plastics produces a continuous chip stream. An ideal chip removal must be assured to prevent wrapping or clamping of the chip around the tool or work piece.
Due to the fact that plastics show lower rigidity, long turning pieces can sag and therefore the usage of a steady rest is advisable.

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4.3 Sawing

Engineering plastics can be cut either with band saws or circular saws.
The choice depends on the shape of semi-finished part.

Application of a band saw is especially recommended when cutting rods and tubes. Generated heat is dissipated by the saw blade. Take care of crosswise teeth setting to prevent clamping of the saw blade.

Circular saws are generally used for cutting plates with straight cutting edges. Work with high feed rates to ensure a good chip removal and to prevent clamping of the saw blade or overheating of the plastic at the cutting edge.
Usage of saw blades with side cutters and side scrapers is recommendable.

As reinforced plastic materials have higher machining residual stress paired with lower impact strength than un-reinforced plastic materials they are especially crack sensitive.
These materials should be heated up to 120°C prior sawing.

4.4 Milling

High chipping performance paired with good surface quality and accuracy can be achieved with high cutting speed and moderate feed on usual mills.

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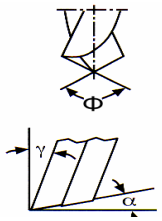
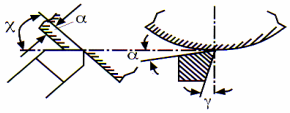
DRILLING



α: side relief angle (°)
γ: rake angle (°)
Φ: Top angle (°)
V: cutting speed (m/min)
S: feed (mm/rev)

Spin angle β should be between ca. 12 and 16°

TURNING

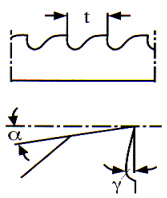


α: side relief angle (°)
γ: rake angle (°)
X: setting angle (°)
V: cutting speed (m/min)
S: feed (mm/rev.)

Edge radius r should be minimum 0,5 mm

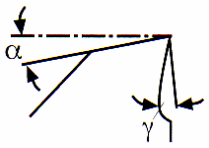
Zellamid®	α	γ	φ	V	S	α	γ	χ	V	S
202 (PA 6)	5 - 15	5 - 20	90	50 - 150	0,1 - 0,3	6 - 10	0 - 5	45 - 60	250 - 500	0,1 - 0,5
250 (PA 6.6)	5 - 15	10 - 20	90	50 - 150	0,1 - 0,3	6 - 10	0 - 5	45 - 60	200 - 500	0,1 - 0,5
250 GF30 (PA6.6+30%GF)	6	5 - 10	120	80 - 100	0,1 - 0,3	6 - 8	2 - 8	45 - 60	150 - 200	0,1 - 0,5
900 (POM)	5 - 10	15 - 30	90	50 - 200	0,1 - 0,3	6 - 8	0 - 5	45 - 60	300 - 600	0,1 - 0,4
1400 (PET)	5 - 10	10 - 20	90	50 - 100	0,2 - 0,3	5 - 15	0 - 5	45 - 60	300 - 400	0,2 - 0,4
1500 (PEEK)	5 - 10	10 - 30	90-120	70 - 200	0,1 - 0,3	6 - 8	0 - 5	45 - 60	250 - 500	0,1 - 0,4

SAWING



α: side relief angle (°)
γ: rake angle (°)
V: cutting speed (m/min)
T: pitch (mm)

MILLING



α: side relief angle (°)
γ: Rake angle (°)
V: cutting speed (m/min)

Zellamid®	α	γ	V	t	α	γ	V
202 (PA 6)	20 - 30	2 - 5	500	3 - 8	10 - 20	5 - 15	250 – 500
250 (PA 6.6)	20 - 30	2 - 5	500	3 - 8	10 - 20	5 - 15	250 – 500
250 GF30 (PA6.6+30%GF)	15 - 30	10 - 15	200 - 300	3 - 5	15 - 30	6 - 10	80 – 100
900 (POM)	20 - 30	0 - 5	500 - 800	2 - 5	5 - 15	5 - 15	250 – 500
1400 (PET)	15 - 30	5 - 8	300	2 - 8	5 - 15	5 - 15	250 – 400
1500 (PEEK)	15 - 30	0 - 5	500 - 800	3 - 5	5 - 15	6 - 10	180 - 450

Zellamid® 250GF30
Zellamid® 1400

Warming before sawing and drilling at the centre
(Rods from 80 mm up diameter and plates from 50 mm up thickness)
To avoid machining problems we recommend warming up the material to ca. 120 °C.
Use only sharpened tools with low feed.

All other materials should be heated equally to room temperature before machining!