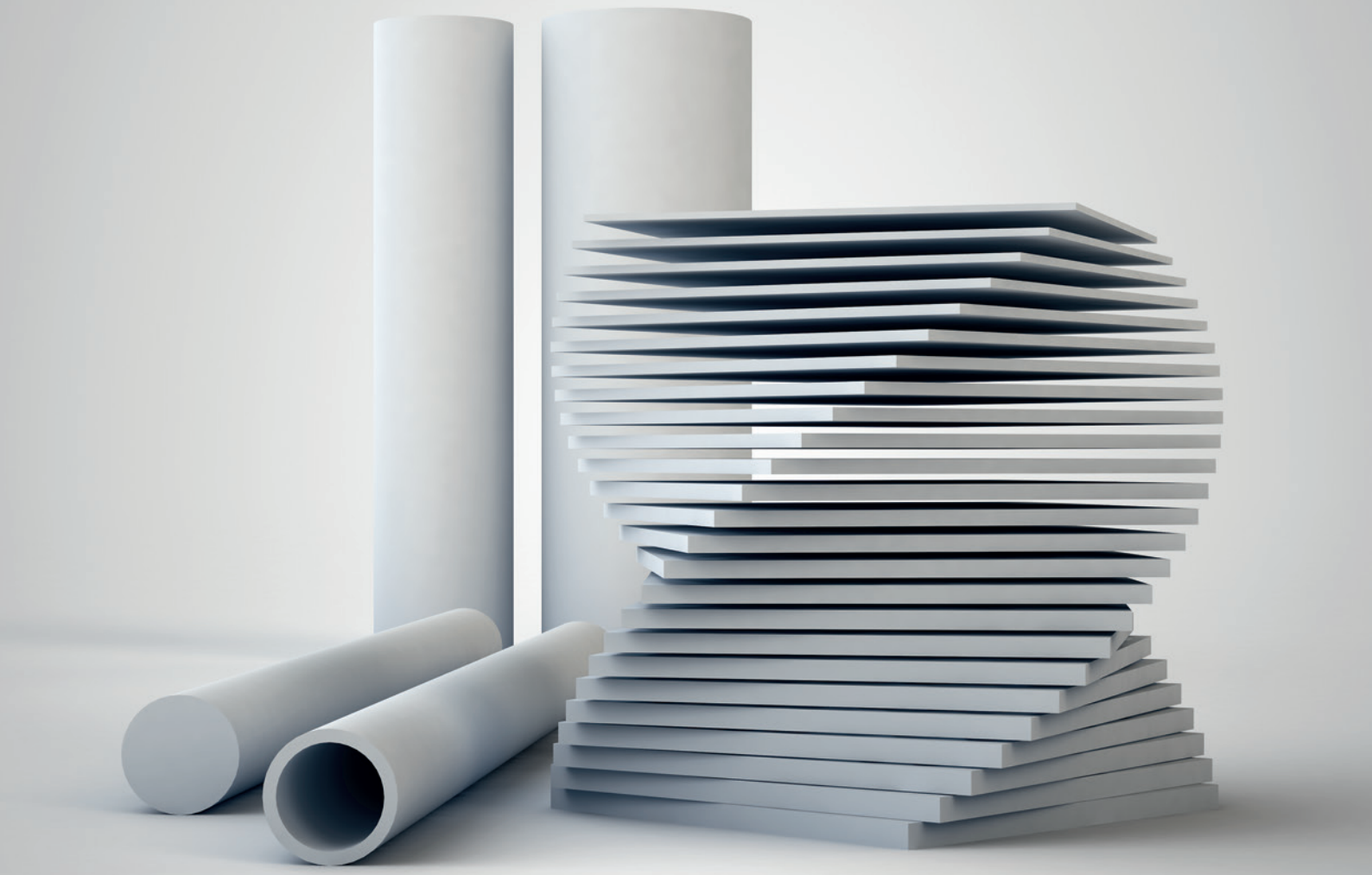
ZELL METALL
ENGINEERING PLASTICS



ZELLAMID®

HANDLING / MACHINING GUIDE

EN

ZELLAMID® plastics are produced with high-end technology and stand out for their excellent quality in numerous applications. To safeguard the properties and features of our products, the following guidelines will provide you with information on transportation, storage and machining. Depending on the purpose of use or kind of application, modifications to these can be made by the buyer or customer.

Protected from high moisture weather conditions and UV light sources

Environmental effects like direct sunlight (UV rays) and moisture can modify the polymeric structure. Prolonged exposure to these can result in moisture expansion, volume changes and discoloration. Stock shapes should be stored at 50 % humidity and at temperatures ranging from 0 °C to +30 °C and protected from UV rays (including some interior lighting systems). Due to the hygroscopic properties of polyamide, panels < 8 mm must be wrapped airtight and stored indoors.

Free from chemicals and other liquids

Chemical liquids and gases can also damage the polymeric structure and should be avoided.

Protected from radiation

Energy radiation like X-rays should be avoided as not every type of plastic is resistant to it.

Separate from flammable materials and heat sources

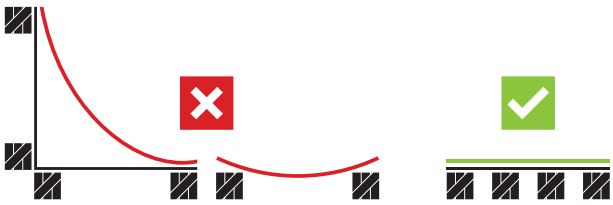
ZELLAMID® products alone do not pose a fire risk. However, some types are flammable, so please store them as regulated by law.

Keep the production code number for traceability

For traceability, certificates and further inquires, please keep the invoice and production code number.

Avoid bending

Store the stock material straight without bending in well supported flat racks, as this can deform the stock material permanently and recovering requires extensive effort. Handle **ZELLAMID®** materials only with suitable lifting jacks and supports. Please consider the safety rules of public authorities.



10/2023

ZELLAMID® | NEW POSSIBILITIES

ZELLAMID® materials offer new solutions to satisfy your customers. Plastics offer many performance advantages in applications where materials like bronze, stainless steel, cast iron, brass, aluminum or ceramic have previously been used. The advantages are easier handling, lower machining costs and excellent mechanical performance. **ZELLAMID®** materials have a wide range of applications in several industries ranging from basic industries like construction equipment and food processing, through to high technology industries like medical, semiconductor and alternative energy. The benefits of cost, weight and machining savings keep the market growing rapidly. Our high performance materials like **ZELLAMID® 1500 X** can be used at temperatures up to 260 °C.

ZELLAMID® | METALS VS. PLASTICS

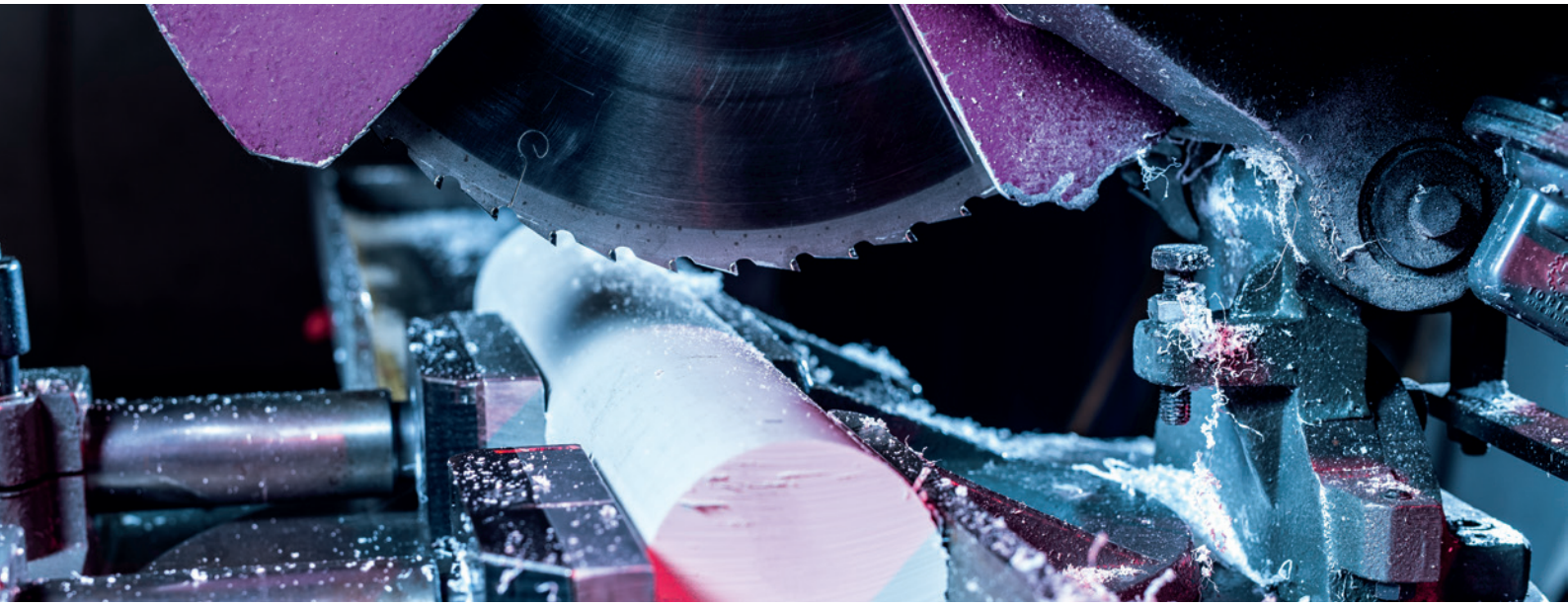
The most important point is cooling. Plastics are thermal insulating and have much lower heat transfer ability than metals.

The thermal expansion is up to 20 times higher compared to metals. This difference is substantial when using clamping devices and considering machining forces.

The melting temperature is much lower than the one for metals. Thus, plastics are very sensitive to high temperatures which are generated during machining.

ZELLAMID® | ADVICE FOR MACHINING

- Tools must be sharp and well ground
- Set form feed as high as possible for low development of heat
- Use sufficient coolant (or compressed air) in order to avoid heat
- The tool‘s relief angle should be large enough to keep the chips short
- Remove the chips to prevent queue or jamming
- Store the stock shape in a machining environment for at least 24 hours before machining



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 economically results, therefore diamond coated tools are recommended which are more expensive but however offers longer life span.

2 Machining and clamping the component

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.

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 for metal parts.

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

More about machining-instructions:

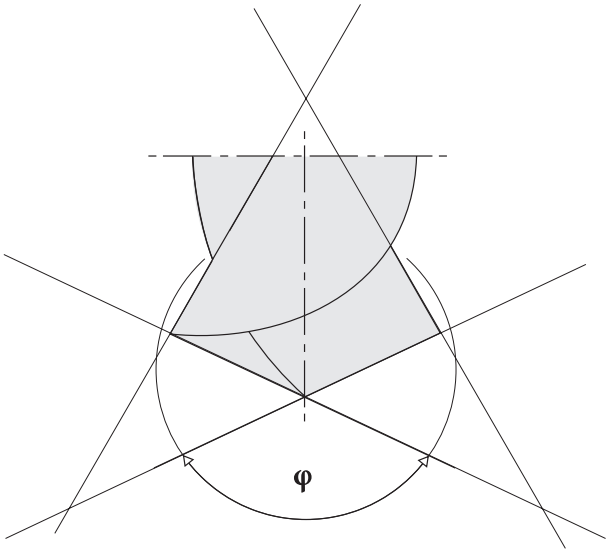
Usual HSS sharpened tools can be used for drilling. Take care of chip removal when drilling particularly deep holes to prevent excessive temperatures, frequent removal of the drill may also be necessary.

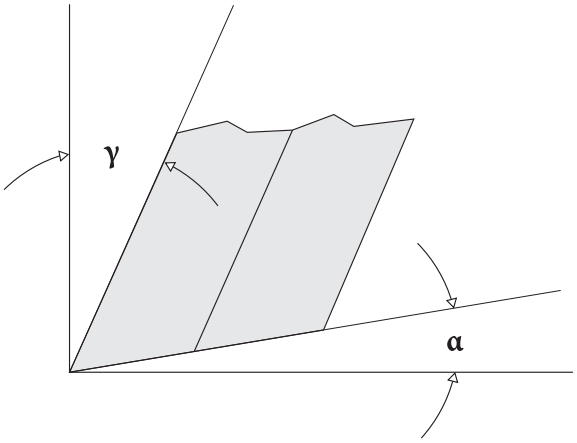
For drilling holes in thin-walled workpieces, it is advisable to choose a high drilling speed and, if applicable, a neutral (0°) effective cutting angle. This prevents the drill from sticking in the workpiece and hinders the associated stripping of the hole or the workpiece being drawn up by the drill.

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 unreinforced 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 GF30** (PA 6.6 + 30% Glass fibre) as well as **ZELLAMID® 1400** and **1400 T** (PET and PET+ solid lubricant), this procedure is recommended.

When drilling especially high-crystalline materials such as **ZELLAMID®**, high temperatures build up on the cutting edges, which cannot be adequately dissipated because of the good insulation properties of the plastics. The heat causes an internal expansion in the material, which causes compressive stress in the inside of the rod section.

This stress can be so high that the rod tears and splits and can be avoided to a great extent if the material is machined correctly. It is advisable to predrill the hole and complete it with a right side tool. The pre-drilled holes should not exceed 35 mm in diameter. Drilled holes in long sections of rod must only be made from one side, as otherwise an unfavourable stress relationship is created when the drilled holes meet in the middle of the rod. That supports the rod section cracking.





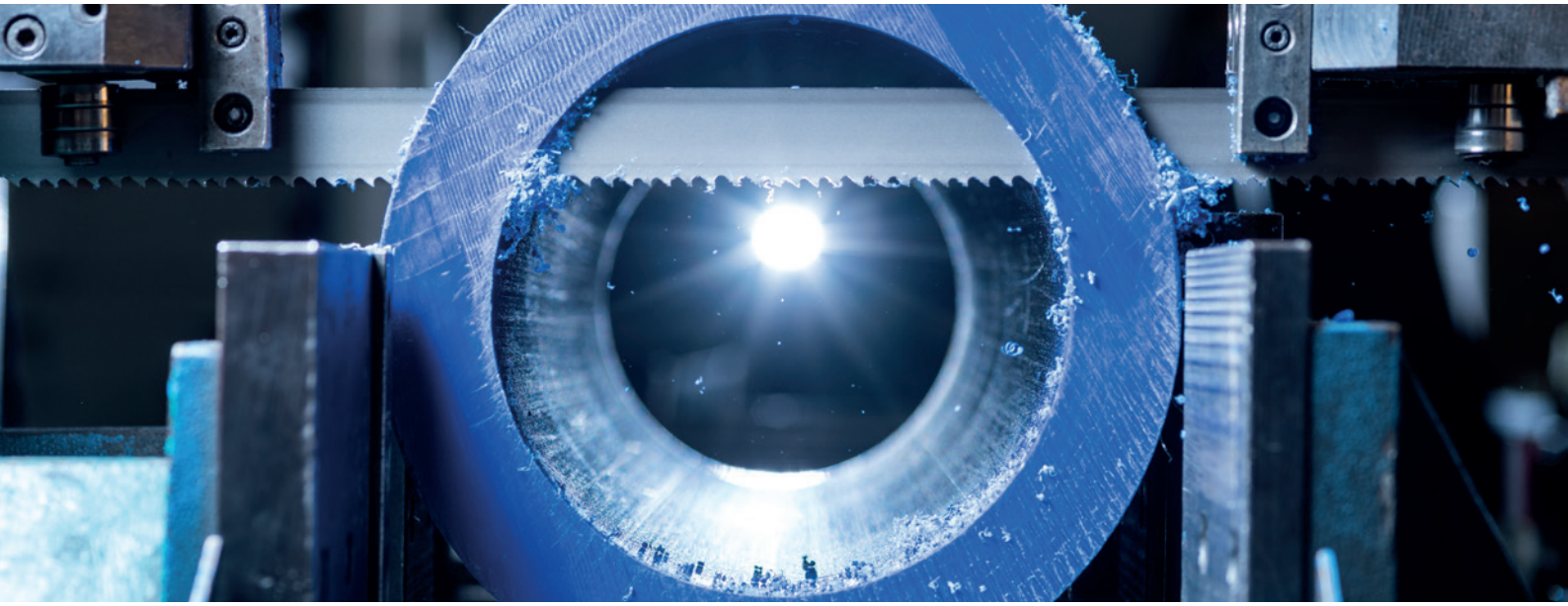
In extreme cases it may be necessary to heat the blank to approx. 50 - 120 °C and pre-drill it in this condition.

The hole can then be completed when the rod has cooled down and when an even temperature has set in throughout the blank. Finishing can take place after complete cooling and achieving a uniform temperature level inside the stock shape.

ZELLAMID® Description	α	γ	φ	V	S
202 (PA 6) | 202 MO (PA 6 + MoS_2) | 1100 (PA 6 C)	5 - 15	5 - 20	90	50 - 150	0,1 - 0,3
250 (PA 6.6)	5 - 15	10 - 20	90	50 - 150	0,1 - 0,3
900 (POM-C) | 900 H (POM-H) | 900 XU ELS (POM-C conductive) | 900 AS (POM-C antistatic)	5 - 10	15 - 30	90	50 - 200	0,1 - 0,3
1400 (PET) | 1400 PBT i	5 - 10	10 - 20	90	50 - 100	0,2 - 0,3
1500 X (PEEK)	5 - 10	10 - 30	90 - 120	70 - 200	0,1 - 0,3
1000 (PEI)	5 - 10	10 - 20	90	20 - 80	0,1 - 0,3
Filled/Reinforced **ZELLAMID®** products i	5 - 10	5 - 10	90	80 - 100	0,1 - 0,3

α side relief angle (°) | **γ** rake angle (°) | **φ** Top angle (°) | **V** cutting speed (m/min) | **S** feed (mm/rev) | Spin angle should be between ca. 12 and 16°

i Reinforced **ZELLAMID®** grades as 250 GF30, 1500 T, 1500 GF30, 1000 GF30, 1900 GF40 and filled grades 1400, 1400 H and 1900 should be pre heated before sawing or drilling a centre hole for rod dia 80 mm or larger and plate thickness of 50 mm or more. A preheat temperature of 100°C to 120°C is recommended with a smooth temperature increase and decrease at a rate of 10 °C per hour. Use only sharpened tools with low feed. All other materials should be heated equally to room temperature before machining! For sawing, we recommend using blades with rakers. Our application technology consultation in word and writing is to support your own work. It is considered as noncommittal recommendation, also in the reference to any patent rights third. We do not assume liability for possible damage, which occur during processing. Changes, which serve the technical progress, we reserve ourselves.



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.

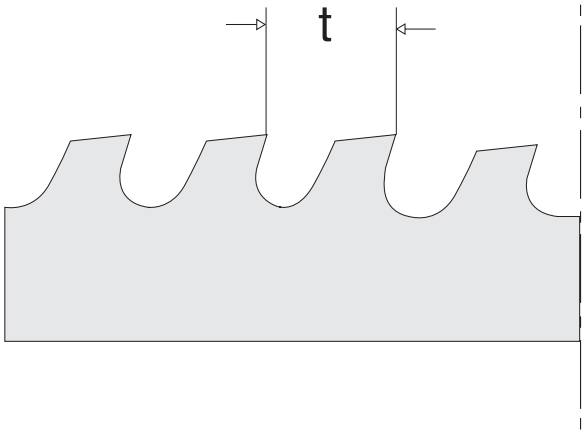
Take care of crosswise teeth setting to prevent clamping of the saw blade. Circular saws are generally used for cutting plates with straight cutting edges.

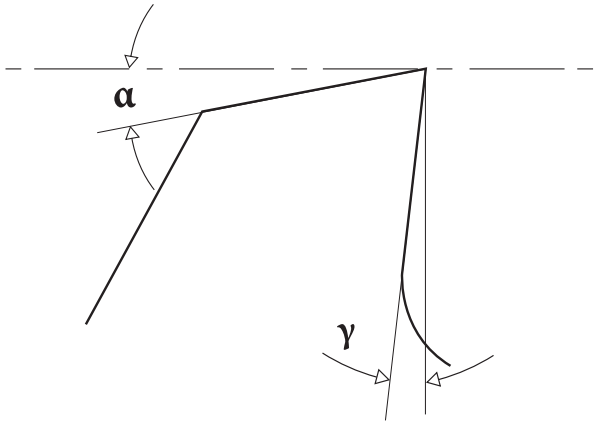
- Work with high feed rates to ensure a good chip removal and to prevent clamping of the saw blade or overheating of the plastic at the cutting edge.

- 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.

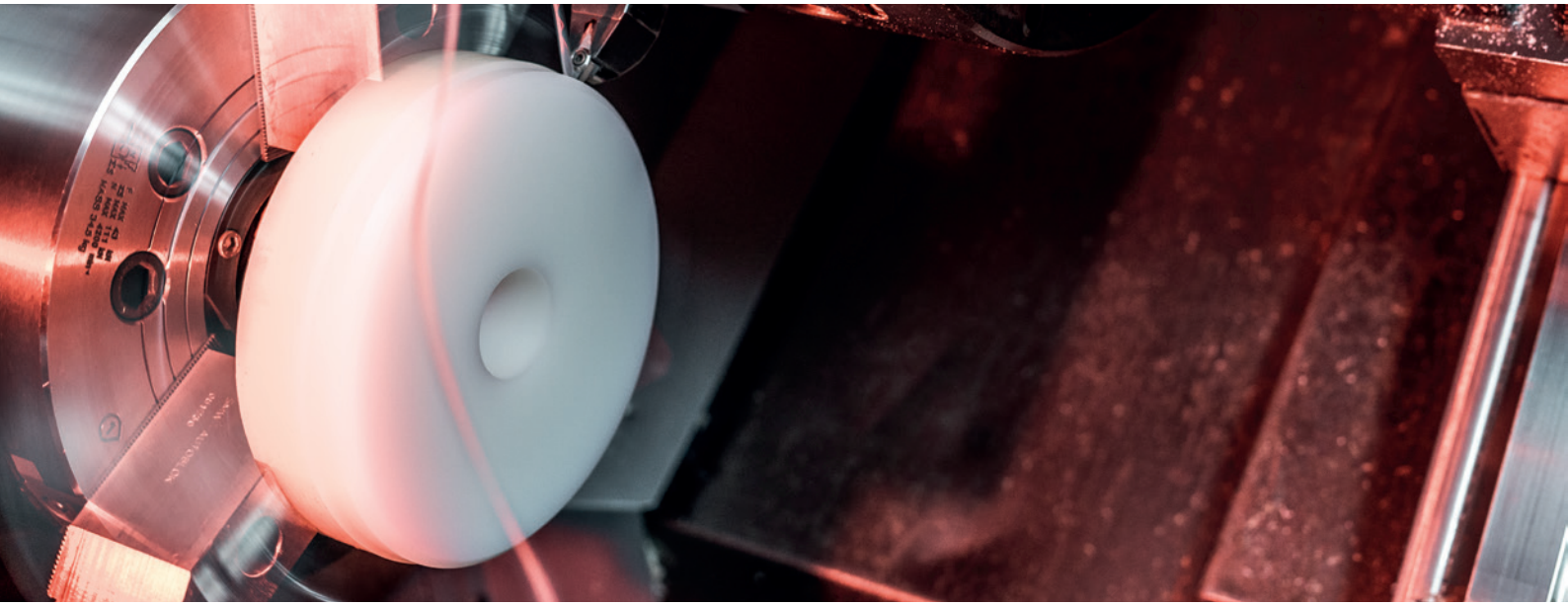




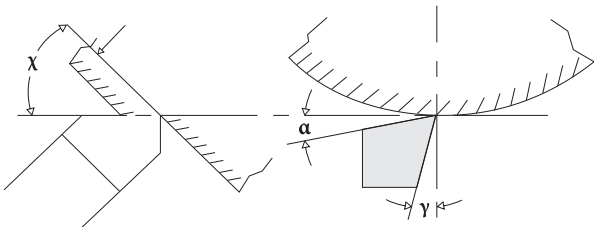
ZELLAMID® Description	α	γ	V	t
202 (PA 6) | 202 MO (PA 6 + MoS_2) | 1100 (PA 6 C)	20 - 30	2 - 5	500	3 - 8
250 (PA 6.6)	20 - 30	2 - 5	500	3 - 8
900 (POM-C) | 900 H (POM-H) | 900 XU ELS (POM conductive) 900 AS (POM-C antistatic)	20 - 30	0 - 5	500 - 800	2 - 5
1400 (PET) | 1400 PBT [i]	15 - 30	5 - 8	300	2 - 8
1500 X (PEEK)	15 - 30	0 - 5	500 - 800	3 - 5
1000 (PEI)	15 - 30	0 - 4	500	2 - 5
Filled/Reinforced **ZELLAMID®** products [i]	15 - 30	10 - 15	80 - 100	3 - 5

α side relief angle (°) | **γ** rake angle (°) | **V** cutting speed (m/min) | **t** pitch (mm)

[i] Reinforced **ZELLAMID®** grades as 250 GF30, 1500 T, 1500 GF30, 1000 GF30, 1900 GF40 and filled grades 1400, 1400 H and 1900 should be pre heated before sawing or drilling a centre hole for rod dia 80 mm or larger and plate thickness of 50 mm or more. A preheat temperature of 100°C to 120°C is recommended with a smooth temperature increase and decrease at a rate of 10 °C per hour. Use only sharpened tools with low feed. All other materials should be heated equally to room temperature before machining! For sawing, we recommend using blades with rakers. Our application technology consultation in word and writing is to support your own work. It is considered as noncommittal recommendation, also in the reference to any patent rights third. We do not assume liability for possible damage, which occur during processing. Changes, which serve the technical progress, we reserve ourselves.



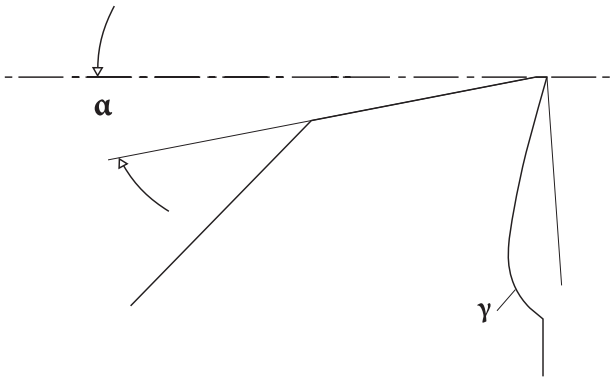
Turning most thermoplastic plastics produces a continuous chip stream. An ideal chip removal must be assured to prevent wrapping or clamping of the chip around the tool or work piece.
Due to the fact that plastics show lower rigidity, long turning pieces can sag and therefore the usage of a steady rest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



ZELLAMID® Description	α	γ	χ	V	S
202 (PA 6) | 202 MO (PA 6 + MoS_2) | 1100 (PA 6 C)	6 - 10	0 - 5	45 - 60	250 - 150	0,1 - 0,5
250 (PA 6.6)	6 - 10	0 - 5	45 - 60	200 - 500	0,1 - 0,5
900 (POM-C) | 900 H (POM-H) | 900 XU ELS (POM-C conductive) | 900 AS (POM-C antistatic)	6 - 8	0 - 5	45 - 60	300 - 600	0,1 - 0,4
1400 (PET) | 1400 PBT	5 - 15	0 - 5	45 - 60	300 - 400	0,2 - 0,4
1500 X (PEEK)	6 - 8	0 - 5	45 - 60	250 - 500	0,1 - 0,4
1000 (PEI)	6	0	45 - 60	350 - 400	0,1 - 0,3
Filled/Reinforced ZELLAMID® products	6 - 8	2 - 8	45 - 60	150 - 200	0,1 - 0,5

α side relief angle (°) | **γ** rake angle (°) | **χ** Top angle (°) | **V** cutting speed (m/min) | **S** feed (mm/rev) | Spin angle should be between ca. 12 and 16°

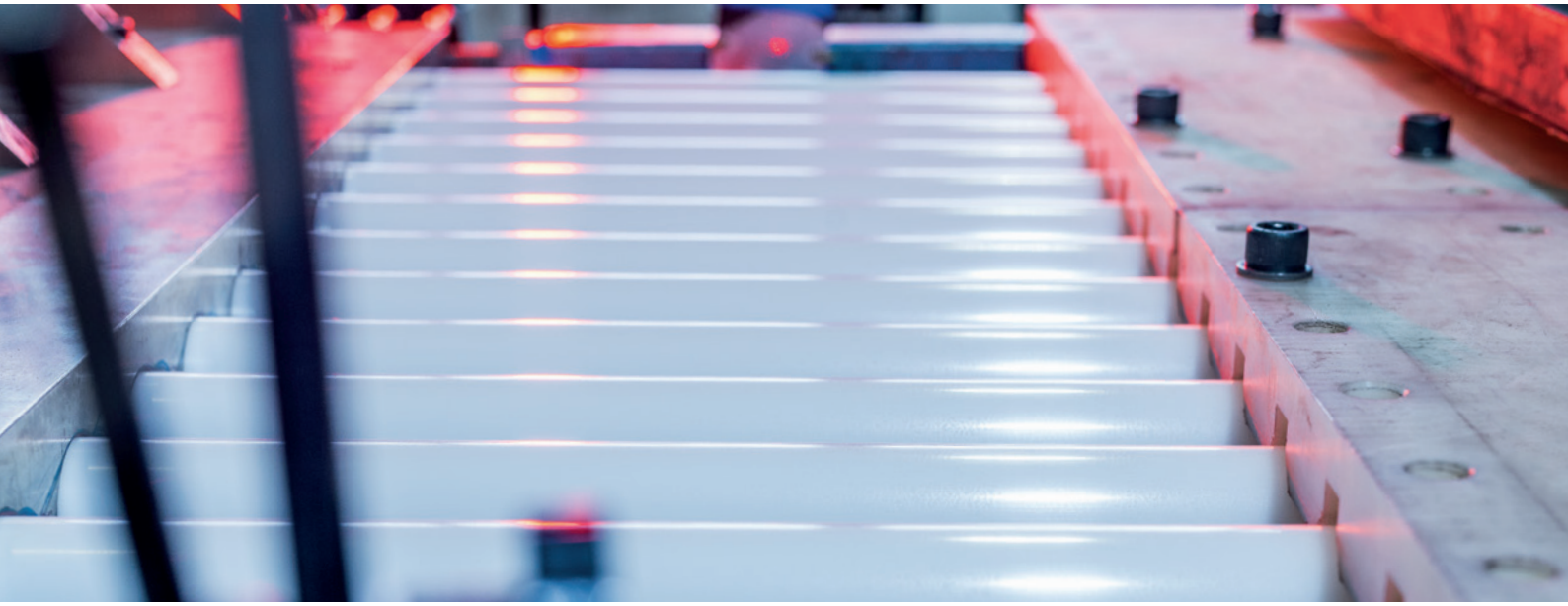
High chipping performance paired with good surface quality and accuracy can be achieved with high cutting speed and moderate feed on usual mills.



ZELLAMID® Description	α	γ	V
202 (PA 6) | 202 MO (PA 6 + MoS_2) | 1100 (PA 6 C)	10 - 20	5 - 15	250 - 500
250 (PA 6.6)	10 - 20	5 - 15	250 - 500
900 (POM-C) | 900 H (POM-H) | 900 XU ELS (POM-C conductive) 900 AS (POM-C antistatic)	5 - 15	5 - 15	250 - 500
1400 (PET) | 1400 PBT	5 - 15	5 - 15	250 - 400
1500 X (PEEK)	5 - 15	6 - 10	180 - 450
1000 (PEI)	2 - 10	1 - 5	250 - 500
Filled/Reinforced ZELLAMID® products	15 - 30	6 - 10	80 - 100

α side relief angle (°) | **γ** Rake angle (°) | **V** cutting speed (m/min) | Feed rate can be set up to 0,5mm/tooth

ZELLAMID® | ACCURACY, POST-ANNEALING, CONDITIONING



Accuracy

Even after annealing processes of our **ZELLAMID®** stock shapes at our production site, internal tension can be created by incorrect machining. Try to use raw material with similar dimensions to the desired finished part. To achieve tighter tolerances increase the number of machining steps and implement intermediate annealing.

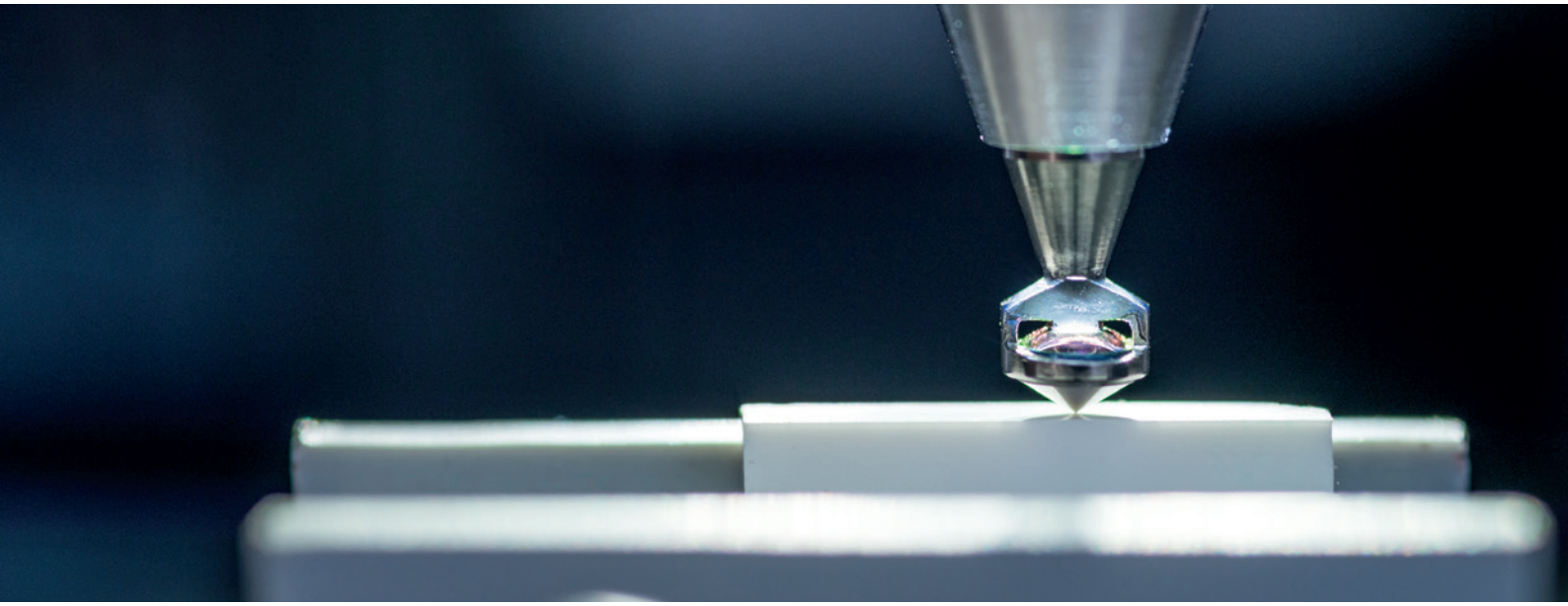
Post-Annealing

Annealing is a temperature treatment of plastic to relieve internal stress. The surrounding temperature should be slowly and continuously increased and decreased. This process should not be accelerated as changing the temperature too fast can thermally shock the material, actually increasing the internal stress and reducing dimensional stability of the finished part. The warming and cooling rate should be between 10 °C and 20 °C per hour. The holding temperatures for the different materials are listed below. The holding time should be approx 6 minutes per cm of wall thickness.

ZELLAMID® Description	°C
202 (PA 6) | 900 (POM-C) | 1100 (PA 6 C)	150 - 160 °C
250 (PA 6.6) | 1400 (PET) | 1400 PBT	170 - 180 °C
1500 X (PEEK)	220 - 240 °C

Conditioning

ZELLAMID® 202, **250** and **1100** have a higher moisture absorption rate than other **ZELLAMID®** materials, they should be conditioned in a warm water bath before machining. The water temperature should be 80 °C and the duration recommended is 1 day per cm of wall thickness. The impact strength can be improved for the application.



Reinforced **ZELLAMID®** products have glass, carbon fibres or ceramic fillers integrated in the polymer matrix in order to modify mechanical properties. Those materials are especially difficult to be machined.

The most important advice for machining are the following:

- Deploy intensive cooling (external and internal)
- Avoid heat by increasing the feed rate
- Check the sharpness of the tools regularly
- Use diamond equipped or special coated tools
- Preheating

Preheating

Reinforced **ZELLAMID®** products like **250 GF30**, **1500 XT**, **1500 XGF30**, **1500 XCA30**, **1500 XC20**, **1000 GF30**, **1900 GF40** and unreinforced products like **1400** and **1400 BPT** should be pre heated before sawing or drilling (rods from 80 mm and plates from 50 mm thickness). The temperature should be between 90 and 120 °C with a heating and cooling rate of approximately 10 °C per hour. All other materials should have room temperature before machining.

Diamond tipped tools

Reinforced products should be machined with diamond equipped tools, which are expensive, but perform excellently in the endurance of sharp edges.

klepsch group - the plastic power network

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