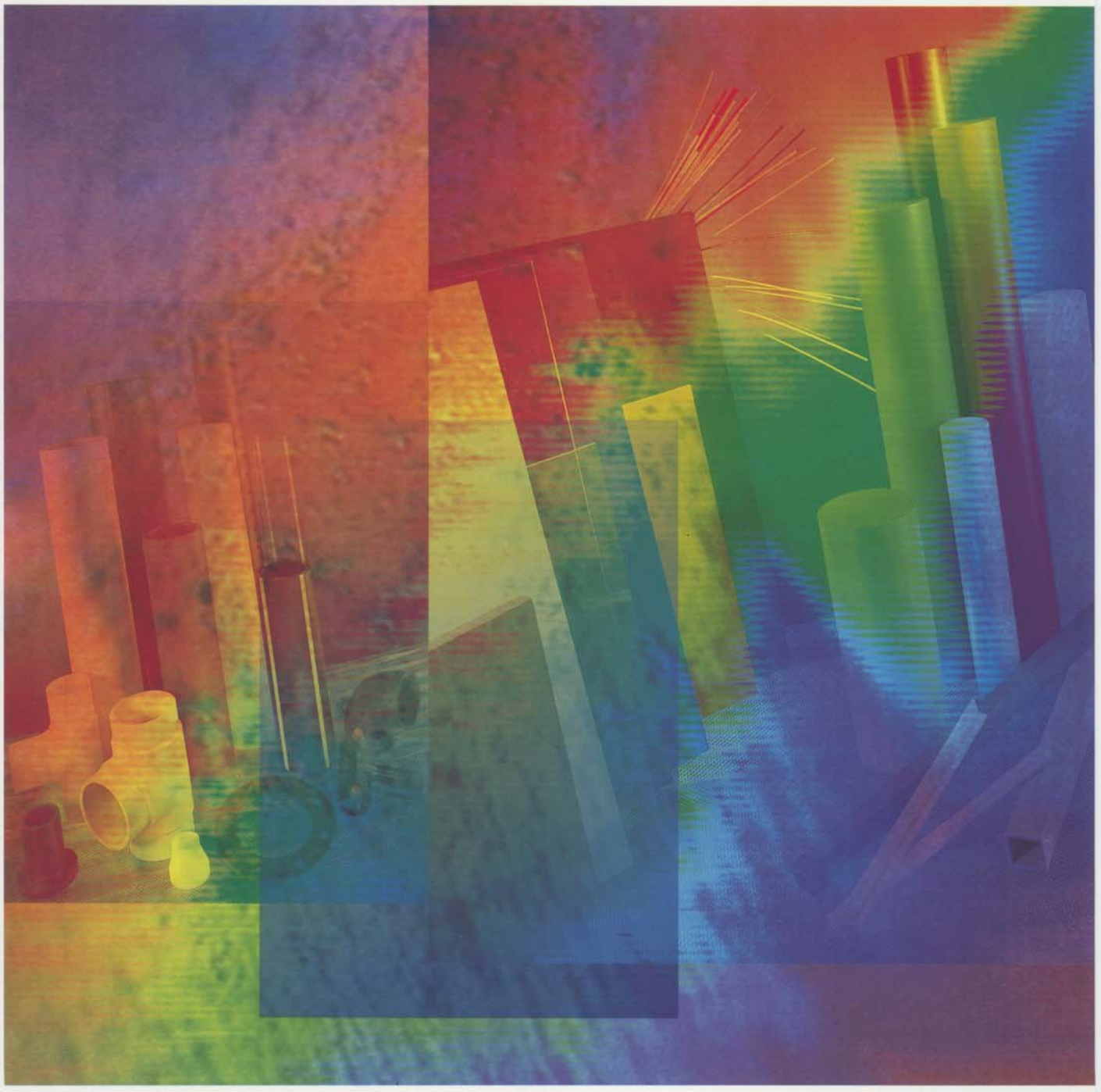
SIMONA



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Product information

Machining

Content

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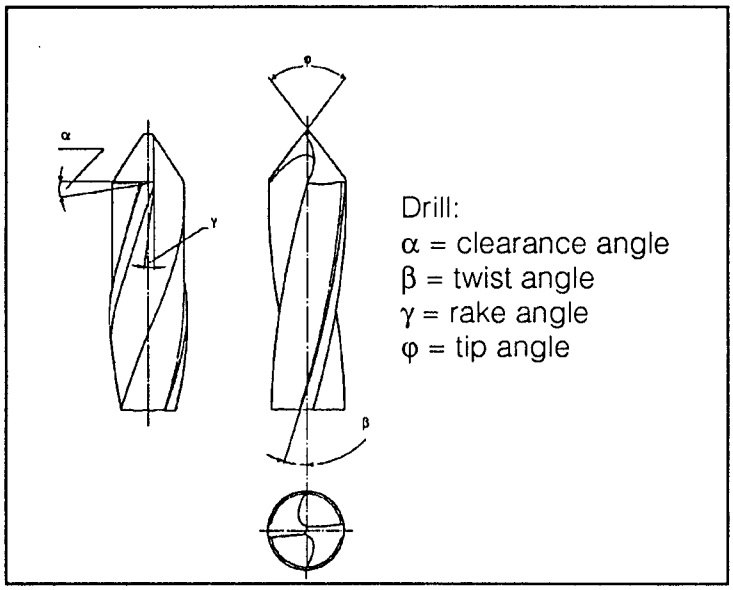
This product information replaces all former editions.

Machines for wood and metal processing may be used for machining thermoplastics. Preference should be given to high-speed machine tools with strong bearing. Machines should be kept sufficiently clear of swarf and dust.

It should be noted that all plastics are bad thermal conductors. Overheating can be reduced by the use of sharp tipped tools and good clearance of machining waste, and can be prevented by cooling with compressed air or water (even drill water). Usual tool steels are sufficient for processing. Carbide tipped tools produce an improved components' surface with increased durability.

1. Drilling

Thermoplastic semi-finished products can be drilled with a standard twist drill. A particular grinding is generally not required. It is however recommended to have a relief-ground cutter with a small twist angle. If the rake angle of the drill is ground negatively, a jamming in of the drill and a tearing out of material is avoided. This is recommended up to a drilling depth of approximately 15 mm. We recommend lifting the drill repeatedly out of the drill hole to achieve a good removal of swarf for drilling depths exceeding 5 x d. A pilot-drill should be made for drill hole diameters above 10 mm. Drills exceeding 20 mm diameter are better made by double cutting drills with pilot-drills, above 40 mm diameter with circular cutters.



Drill:
α = clearance angle
β = twist angle
γ = rake angle
φ = tip angle

Table 1: parameter for drilling plastics

Drilling			PE-HD	PP	PVC	PVDF
α	clearance angle	°	10-13	5-12	6-10	10-16
β	twist angle	°	12-16	12-16	12-16	12-16
γ_1	rake angle	°	3-5	3-5	3-6	3-6
φ	tip angle	°	60-90	60-90	80-120	100-130
v	cutting speed	m/min	50-100	50-100	30-80	50-200
s	feed	mm/U	0,2-0,5	0,2-0,5	0,1-0,5	0,1-0,5

Cutting speed and feed are dependent on drilling depth. The thermoplastic material must not be allowed to clog (high v for thin walled components).

2. Threading

Threading can be easily effected with conventional thread tap sets. The rake angle of 0° should not be exceeded. Round threads following DIN 405 or insert nuts are preferable for fixings which are often loosened (notched effect). Tapping screws, also referred to as "High-Low-", "Spax-" or window screws, prove their suitability for rarely loosened connections, but not sheet metal screws.

3. Milling

All milling machines with a high number of revolutions normally used for processing metals are also suitable. High cutting speeds and low rake depths are recommended.

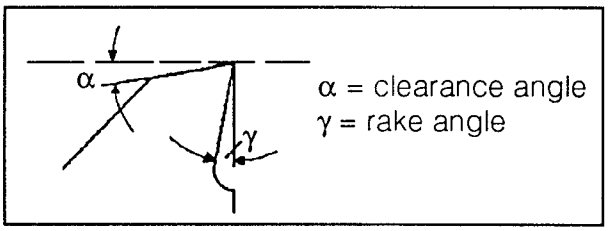


Table 2: parameter for milling plastics

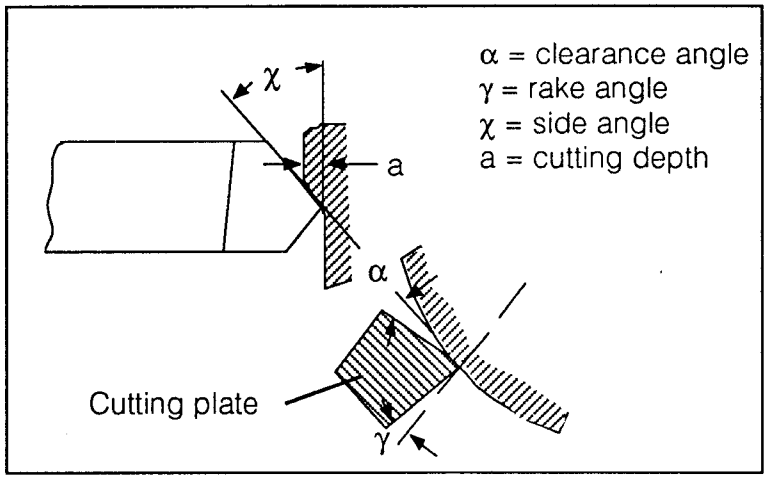
Milling			PE-HD	PP	PVC	PVDF
α	clearance angle	°	5-15	5-15	5-10	5-10
γ	rake angle	°	5-15	10-15	5-20	bis 15
v	cutting speed	m/min	up to 1000	up to 1200	300-1000	200-1000
s	feed	mm/U	0,1-0,5	0,1-0,5	0,1-0,5	0,1-0,5

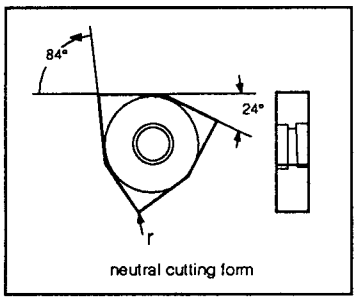
4. Planing

Planing is conducted with normal tools (short, double and wood smooth plane) as well as the usual surface planing and thicknessing machines. Even the shaping machines used in metal processing may with suitable structuring of the planing steel be used for the processing of plastics.

5. Turning

Thermoplastic semi-finished products should be turned with as small as possible feed and a cutting depth as large as possible. Here the cutter should, as is also usual for metal processing, be equipped with a small radius. These measures produce a surface virtually without grooves.





The use of so-called indexable inserts with different cutting forms often allows a good removal of swarf and a smooth cut at high efficiency.

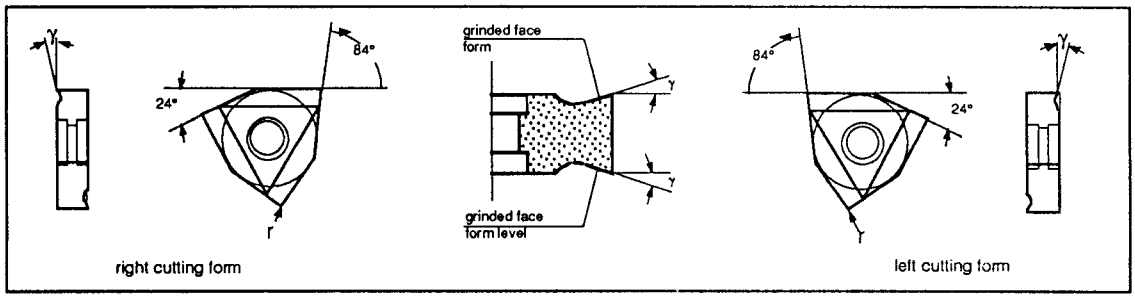


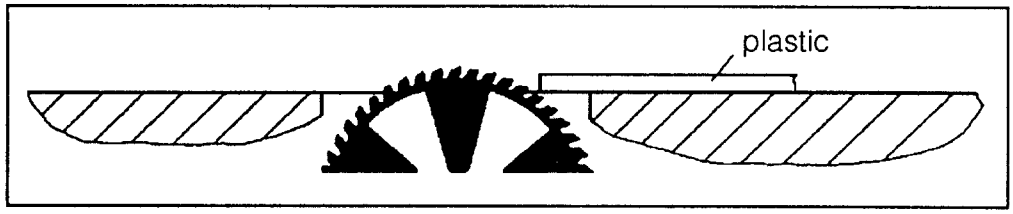
Table 3: parameter for turning plastics

Turning			PE-HD	PP	PVC	PVDF
α	clearance angle	°	5-15	5-15	5-10	8-15
γ	rake angle	°	0-10	0-8	0-10	0-15
χ	side angle	°	45-90	45-60	45-60	45-60
v	cutting speed	m/min	200-500	200-400	200-500	100-300
s	feed	mm/U	0,1-0,5	0,1-0,5	0,1-0,2	0,1-0,3
a	cutting depth	mm	up to 6			
r	tip angle	mm	≥ 0,5			

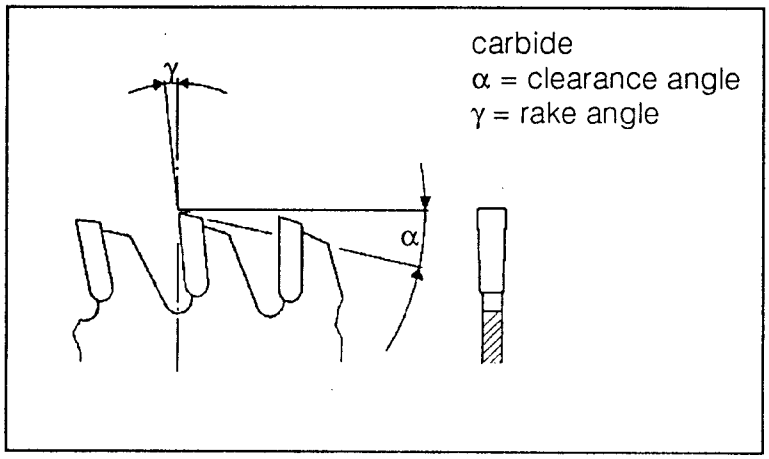
6. Sawing

6.1 Circular saws

Properly sawn edges can be achieved when the saw blade stands only partly out of the plastic sheet being cut.



Sheets up to a thickness of 5 mm can be cut with uncrossed saw blades. Only relief-ground blades should be used over 5 mm. The use of carbide tipped saw blades greatly improves the cutting performance and quality as well as the durability of the saw blade.



Tooth profiles for circular saws (carbide tipped)

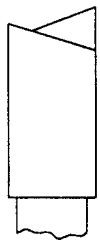
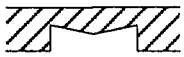
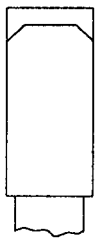
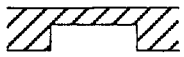
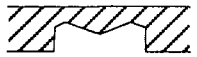
Tooth profile	Section	
	 alternating tooth pattern, sloping, pointed	PVC, PE-HD, PP for PP wide tooth pitch — e. g.: saw blade 220 mm Ø, appr. 28 tooth for PVC narrow tooth pitch — e. g.: saw blade220 mm Ø, appr. 88 tooth
	 alternating tooth pattern, trapeziodal, flat	both sides film covered sheet COPLAST-AS
	 alternating tooth pattern, sloping, chamfered	hard, brittle plastics PVC-GLAS, acrylics

Table 4: parameter for circular saw cutting of plastics

circular saw (carbide HM)			**PE-HD**	**PP**	**PVC**	**PVDF**
α	clearance angle	°	10-15	5-15	5-10	5-15
γ^K	rake angle	°	0-10	0-10	0-5	0-8
t	tooth division*	mm	3-8	3-8	3-5	2-8
v	cutting speed	m/min	1000-3000	600-3000	2500-4000	up to 2500

* choose smaller tooth division for brittle materials

Aside from the material economy and admissible peripheral velocity (product of RPM and blade diameter) determine the appropriate parameter to influence the operating cycle "sawing" practice.

Table 5: maximum permissible speed for sawing = 100 m/sec cutting speed

cutting speed		saw blade diameter [mm]									
	m/sec	100	150	200	250	300	350	400	450	500	600
highest	100	19 000	13 000	9 500	8 000	6 500	5 500	4 500	4 200	3 800	3 200
	80	15 000	10 500	7 500	6 500	5 000	4 500	3 800	3 400	3 000	2 600
economical	60	11 500	7 500	5 700	4 700	3 800	3 300	2 800	2 500	2 300	1 900
lowest	40	7600	5 500	3 800	3 100	2 500	2 200	1 900	1 700	1 500	1 300

6.2 Band saws

Rotating saw blades result in a better heat conveyance. Band saws are best for cutting pipes, blocks, thick sheets and cam shapes. The saw blades need to be perfectly crossed (± 1 mm) and sharp for friction free cutting purposes.

Table 6: parameter for band saw cutting of plastics

Band saw (high speed steel SS)			**PE-HD**	**PP**	**PVC**	**PVDF**
α	clearance angle	°	30-40	30-40	30-40	30-40
γ^B	rake angle	°	0-5	0-5	0-5	2-8
t	tooth division*	mm	2-6	2-6	2-5	2-8
v	cutting speed	m/min	500-3000	1000-3000	up to 2000	500-3000

* choose smaller tooth division for brittle materials

7. Stamping and Cutting

The stamping machines which are normally used are suitable for stamping especially thin wall thicknesses. The quality of the edge cut depends not only on the sheet thickness but on the grinding of the punching tool as well. The cut is generally better with thin sheets than with thick ones. The cutting angle should be below 70° to avoid stresses and tears.

SIMONA® Plastics up to a thickness of 4 mm — depending on the material — can be cut on guillotine shears. Well grinded, undefected knives and a maximum floating of ≤0.1 mm between the moveable and standing knife will offer good cutting results.

8. Grinding and Polishing

Sometimes, surface treatment is required after semi-finished product processing. Grinding is done not just to achieve a uniform matt finish but also after cutting e. g. the welds — to prepare the surface for glueing, painting or polishing. Polishing is done to increase the natural and inherent gloss of the material to match existing components.

Grinding

Preparatory work is done to level the plastic surface. Sanding as a preparation for polishing, is an essential factor for successful finishing. Any welds and projecting edges are removed by means of chisels, rasps, or scrapers. This is followed firstly by sanding with course emery cloth, followed by gradually finer grades until a uniform surface has been achieved and any cracks which are still present are sanded out carefully in the same way. Wet sanding has proved successful, because of heat dissipation. Apart from the normal commercial sandpapers, there are other fabrics in which sanding grit is embedded (Scotch-Brite from 3M, 4040 Neuss 1). Sanding can be done manually or using a suitable sander or orbital sander, of which oscillating sanders are preferred.

Polishing

Polishing is based on melting the surface and requires a very sensitive touch, it is best carried out using rotating polishing rollers. Plastics are poor conductors of heat and therefore tend to smear if overheating is not prevented.

It is best to use two wheels, the first is used to even out any coarse surface roughness. Nettle fibre wheels have proved the most successful for this purpose. Final polishing is then done with a Molleton wheel.

The peripheral speed must not exceed 23 m/s in either case. With the usual speeds of 1,440 rpm this peripheral speed is reached with a wheel diameter of 300 mm.

Waxes

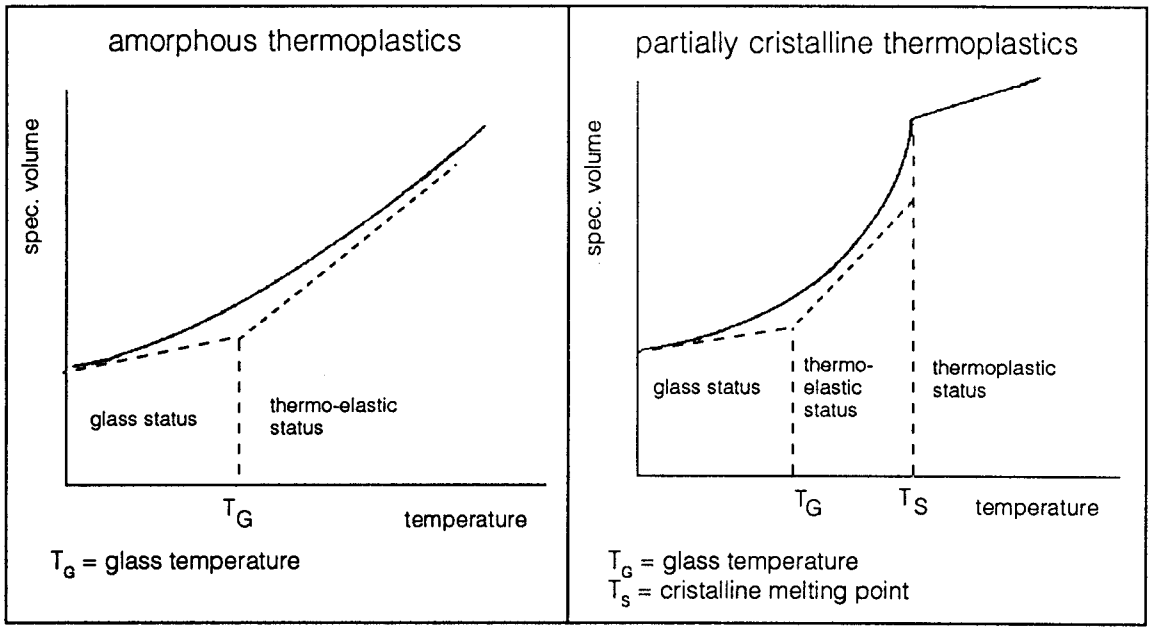
The use of wax for first and final polishing operations improves the appearance of the polished surfaces considerably. MENZERNA-Vorpoliturwachs 113 GZ is suitable for first polishing and MENZERNA-Glanzwachs AT 6 for final polishing. Type 16 is recommended for first and final polishing in one operation. All types of wax are available from MENZERNA-Werk Dr. Ing. W. Burkart GmbH & Co., Gartenstr. 77, Postfach 43 49, 7500 Karlsruhe 1.

9. Annealing to reduce stress

9.1 Internal stresses and their relief

All plastic semi-finished products as well as fabricated components will possess internal stresses. These internal stresses cannot be traced back to an influence of external forces. They become visible once the internal stress is disturbed. The plastic melt, plastified during the extrusion, is extruded through a tool gap into the open air. The still plastified and hence easily mouldable semi-finished product is led over several rollers, cooled down and thus cured. The heat conveyance exclusively takes place on the outside of the semi-finished product and cooling from the inside is not possible. Following on from this, there is a lower temperature on the outer face during extrusion (higher cooling speed), and a higher temperature inside the material (lower cooling speed). This is based on the bad thermal conductivity of plastics. Volume contractions take place within the semi-finished product (outside - inside) because of different cooling speeds.

Illustration: Dependance of specific volume on temperature



This means: Yield stresses inside the semi-finished product and compressive strains on the outer surface result thereof.

9.2 Annealing

The balanced stress level can be disturbed, especially with one-sided machining. Deformations, for example; buckling or distortion of the material may then ensue. Remedy can be offered by the possibility of a superimposed thermal treatment i.e., stress reducing annealing. A series of influences needs to be taken into consideration as the thermal treatment temperature has to be chosen depending on material, to achieve the largest possible success.

Amorphous materials are tempered above glass temperature, partially cristalline thermoplastics about 10 to 20 °C below the cristalline melting point (see illustration).

The temperature, defined as a sum of heating, retention and cooling time, is determined by

- maximum thickness of the component to be tempered
- position of the tension profile in the wall cross-section

The components to be tempered should be placed in the temper oven in such a way that large surfaces can be reached by the required temperature. A circulating air oven with an even temperature performance is most suitable here.

Table 7: Guide values for annealing SIMONA® thermoplastics

	Thickness	Heating		Cooling
	mm	Temperature °C	Retention time h	
PE	20 40 60 80 100 120	120	2 3 4 5 6 7	per 1 h 10 °C temperature decrease; at 50 °C (after ≈ 8 h) turn of oven; remove pieces at ≈ 25 °C
PP	20 40 60 80 100 120	140	2 3 4 5 6 7	per 1 h 10 °C temperature decrease; at 50 °C (after ≈ 10 h) turn off oven; remove parts at ≈ 25 °C
PVDF	10 20 30	150	1,5 2 2,5	

A thermal treatment time of 1 hour at the required temperature peak is generally sufficient for wall thickness of <10 mm. It is recommended to keep the cooling time both locally and temporarily as low as possible to avoid the development of internal stresses during the cooling process. General rule: The higher the temperature, the lower the cooling time should be.

9.3 Guide values

A very low cooling time has to be achieved — especially with temperatures of 150 to 100 °C — for example, tempering polypropylene at 150 °C (result of tests at our works). The component can be taken out of the oven at surface temperatures of 50 °C. Based on the difference between 50 °C and room temperature, with free convection a slow cooling time due to the low quantity of heat will result.

Even solid rods made of thermoplastic polymers have the potential for internal stress. Please note, when machining, first test a specimen of the fabricate as deformations caused by internal stresses will occur and keep on changing after annealing.

Process to the final size by the appropriate machining (to avoid further deformations), if the test specimen available is nearly stress-free. The low tension level of the component will allow relatively narrow process tolerances.

Generally annealing of thermoplastics only makes sense if a deformation because of thermal expansion can take place unhindered. Should this not be the case here (e. g. with plastic sheets fixed in a metal frame), thermal stresses will be produced. It is for this reason that the moment for tempering process during an operation needs to be chosen carefully.

10. Advice

Further information on the processing of the thermoplastic chosen can be obtained from the respective product information.

Our Sales and Technical Application staff have much experience with respect to the processing and use of thermoplastic semi-finished products. We will be pleased to give you any further advice you may require.