Guidelines For Processing and Machining Plastics

General Remarks

- Non-reinforced thermoplastics can be machined with cutting tools of highspeed steel. For reinforced materials, hard metal tools are required.
- In all cases, only properly sharpened tools are to be used.
- Due to the poor thermal conductivity of plastics, provision has to be made for good heat dissipation. Heat is best dissipated via the chips.

Dimensional Stability

- Dimensional stability of parts is conditional on stress-relieved, semi-finished materials which have to be annealed. The heat generated by the cutting tool otherwise inevitably leads to the release of processing stresses and deformation of the part. In the case of high material removal volumes, intermediate heating may be necessary after the main machining operation so as to remove the arising thermal stresses.
- Materials with high moisture absorption (e.g. polyamides) may require conditioning before machining.
- Plastics require larger finishing tolerances than metals. Furthermore, allowance has to be made for the many times greater thermal expansion.

Machining Operations

1. Turning

Guide values for cutting tool geometry are given in the table. For particularly high quality surface finishes, the tip is to be shaped as a broad-nosed finishing tool as shown in Figure 1.

For cutting off, the tool should be ground to the profile shown in Figure 2 so as to avoid a remaining stump.

On thin walled and particularly flexible workpieces, on the other hand, it is better to work with tools that are ground to a knife-like cutting geometry. Figures 3 and 4.

2. Milling

For plane surfaces, face milling is more economical than peripheral milling. For perpheral milling and profiling, the cutting tools should not have more than two cutting edges so that vibrations due to the number of teeth are kept to a minimum and chip widths are sufficiently large.

Optimum removal rates and surface finish are obtained with single-point tools.

3. Drilling and boring

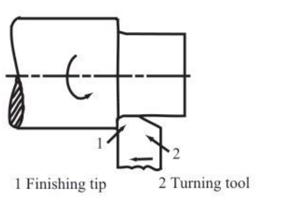
As a general rule it is possible to use twist drills; these should have an angle of twist of 12-16° and very smooth helical flutes for good chip removal. Larger diameters should be rough-drilled or produced by trepanning or internal turning.

On drilling into solid material, care must be taken to ensure that the tools are properly sharpened; otherwise, the developing compressive strain can build up and cause the material to split.

Reinforced plastics possess higher residual processing stresses with lower impact strength than unreinforced plastics and are thus particularly susceptible to cracking. Where possible, these should be heated to about 120°C before drilling or sawing (heating time approximately 1 hour per 10 mm cross-section). This procedure is also recommended in the case of polyamide 6/6.

4. Sawing

Unnecessary generation of heat by friction is to be avoided, since sawing is generally used to cut off thickwalled parts with relatively thin tools. Well-sharpened and heavily crossed sawblades are therefore advised.



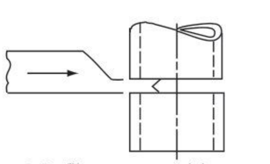
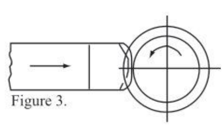
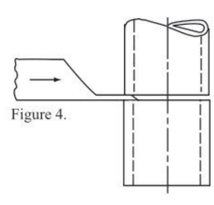
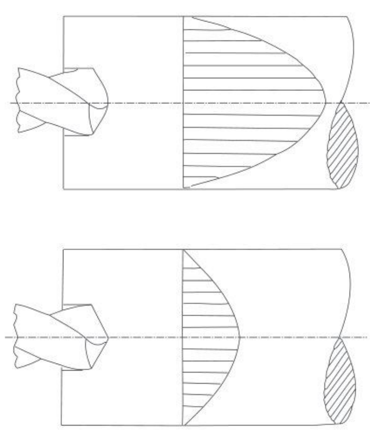


Figure 2: Profile prevents remaining stump







Processing/Machining Plastics

MACHINING OPERATIONS	TURNING					MILLING			DRILLING AND BORING					SAWING				SPECIAL MEASURES
	α Clearance angle (°) γ Rake angle (°) X Side angle (°) V Cutting speed ft/min S Feed mils/rev The nose radius r must be at least 0.020 in.					α Clearance angle (°) γ Rake angle (°) V Cutting speed ft/min The feed can amount to up to 0.020 in./tooth			α Clearance angle (°) γ1 Rake angle (°)b Side angle (°) V Cutting speed ft/min S Feed mils/rev The angle of twist β of the drill bit should be approximately 12 to 16°.					α Clearance angle (°) γ Rake angle (°) V Cutting speedft/min t Pitch mils				
RAW MATERIAL GROUP	α	γ	X	V	S	α	γ	V	α	γ1	b	V	S	α	γ	V	t	
POLYCARBONATE	5-10	6-8	45-60	950	4-20	10-20	5-15	950	8-10	10-20	90	150-300	8-12	15-30	5-8	950	115-310	In the case of fluid cooling only use pure water
ABS (ACRYLONITRILE-BUTADIENE-STYRENE)	5-15	25-30	15	650-1600	8-20	5-10	0-10	950-1600	8-12	10-30	90	150-650	8-12	15-30	0-5	950	75-310	In the case of fluid cooling only use pure water
PPS (POLYPHENYLENE SULFIDE)	6-8	2-8	45-60	500-650	4-20	15-30	6-10	250-350	6	5-10	120	250-300	4-12	15-30	10-15	600-950	115-195	Preheat to 240°F before drilling or sawing
POLYSULFONE	6	0	45-60	1150-1300	4-12	2-10	1-5	800-1600	3-10	10-20	90	50-250	4-12	15-30	0-4	1600	75-195	Preheat to 240°F before drilling or sawing
PVDF (POLYVINYLIDENE FLUORIDE)	10	5-8	10	500-1600	4-12	5-15	5-15	800-1600	10-16	5-20	130	500-650	4-12	20-30	5-8	950	75-195	
NYLON 6/6	6-10	0-5	45-60	800-1600	4-20	10-20	5-15	800-1600	5-15	10-20	90	150-500	4-12	20-30	2-5	1600	115-310	
ACETAL	6-8	0-5	45-60	950-1950	4-16	5-15	5-15	800-1600	5-10	15-30	90	150-650	4-12	20-30	0-5	1600-2600	75-195	
PET (POLYETHYLENE TEREPHTHALATE)	5-10	0-5	45-60	950-1300	8-16	5-15	5-15	950	5-10	10-20	90	150-300	8-12	15-30	5-8	950	115-310	Preheat to 240°F before drilling or sawing
ACETAL HOMOPOLYMER (DELRIN®)	6-8	0-5	45-60	950-1950	4-16	5-15	5-15	800-1600	5-10	15-30	90	150-650	4-12	20-30	0-5	1600-2600	75-195	
PPO (POLYPHENYLENE OXIDE) (NORYL®)	5-10	6-8	45-60	950	4-20	10-20	5-15	950	8-10	10-20	90	150-300	8-12	15-30	5-8	950	115-310	In the case of fluid cooling only use pure water
POLYETHERETHERKETONE (PEEK)	6-12	5	45-60	950	15	5-15	5-15	550-750	12	10-20	118	400	2-8	15-30	10-15	600-950	115-195	Preheat to 240°F before drilling or sawing
POLYETHERIMIDE (ULTEM®)	15	5	5	1000-2000	5-20	15	5	650-1300	5-10	5-20	70-90	300	5-15	15-30	5-10	3000-5000	100	In the case of fluid cooling only use pure water
REINFORCED ENGINEERING PLASTICS*	6-8	2-8	45-60	500-650	4-20	15-30	6-10	250-350	6	5-10	120	250-300	4-12	15-30	10-15	600-950	115-195	Use hard metal cutting tools