INJECTION MOLDING OF TPX

GENERAL PROPERTIES OF TPX

TPX is 4-methylpentene-1 based, crystalline polyolefine. The characteristics of TPX are shown as follows.

a. TPX has high heat-resistance with a melting point of 220 to 240°C0

b. TPX has excellent transparency and its transmittance of visual light is more than 90%. TPX has an especially high transmittance of ultraviolet light (300 to 400nm).

c. TPX doesn't have polar functional groups in its molecular structure and has excellent chemical and oil resistance.

d. TPX has good heat aging and steam (boiling water) resistance.

e. Since TPX is the lightest in all commercialized plastics, it is useful for weight alleviation.

f. TPX has high electric insulation and a low dielectric constant.

g. Since the surface tension of TPX is 24 dyne/cm, it has excellent releaseability and which prevents contamination from clinging to it.

TPX GRADES FOR INJECTION MOLDING

All the TPX grades are possible to carry out the injection molding. The characteristics of the typical grades are shown as follows.

Grades	RT18	RT31	DX820	MX004	MX002
MFR (g/10min)	21	21	180	25	21
Remarks	High rigidity			Medium	Low
		Low odor			
Application	Industrial				
	Food				

EMPLOYMENT OF THE MOLDS FOR OTHER POLYMERS

TPX has an excellent transparency like as PC and PMMA. But unlike amorphous
polymers such as PC and PMMA, TPX is a crystalline polymer and has different
characteristics. Therefore some attention should be paid when using TPX in molds.

a. Physical properties of transparent polymers

They are shown in the following table. TPX has excellent heat-resistance, chemical resistance, and steam resistance, and also has the lowest density in all the polymers.
TPX impact strength is similar to polystyrene and PMMA.
TPX is a crystalline polymer and has a larger shrinkage than amorphous polymers.

PROPERTIES OF TPX

b. Attention on mold designing

Differences in mold design between TPX and other polymers are in gate designs, cooling channels, surface finish and dimensions. They are shown as follows.

1) Pin gate

In gate design, there are side gate, direct gate, film gate and pin gate. The advantage of larger gate like a direct gate is that it conducts injection pressure with the least amount of pressure drop to cavities. However, its disadvantages is that a long cycle is required to solidify the gate and the residual stress is greater because of the excessive injection pressure around the gate during solidification.
With TPX, gate cracks may from with passing times or heat cycles due to residual stress.
A TPX mold does not require a large gate because of its excellent flowability.
Therefore the most suitable gate for a TPX mold is a pin gate.

2) Cooling channels

TPX is a crystalline polymer and has a larger shrinkage than other amorphous polymers.
If the temperature difference between thick parts of the product and thin parts is large due to difference in cooling efficiency, the product will have strain and will cause warpsand cracks. In order to get a good product, sufficient and well balanced cooling channels should be installed in a mold.

3) Surface finish

TPX has a low melt viscosity and the injection product takes on the actual surface of themold. Therefore, in order to get a product with excellent transparency, the surface finish of the mold should be as highly polished as possible.

4) Shrinkage

When a mold with a center gate is used for a shallow container, the product sometimes has a warp. Therefore, the mold with off-center gate should be used. A mold for TPX is usually designed as a shrinkage of 18/1000 and then is modified after checking upthe product.

5) Undercut

An undercut of a TPX mold should be less than 0.2mm. When the mold temperature is in the range of 40 to 80°C and TPX with medium and low rigidity are employed, it is possible to employ slightly higher undercuts.

INJECTION CONDITIONS OF TPX

a. Cylinder temperature
Injection molding of TPX is usually carried out at 290 to 310°C.

b. Injection pressure
TPX shows an excellent processability at 290 to 310°C. In this temperature range TPX can be molded at low injection pressure. In order to get the product free from residual strain, injection pressure should be as low as possible.

c. Injection speed
Since TPX has an excellent processability, it can be also molded at low injetion speed.

d. Injection time
Though injection time depends on the size of the product, TPX can be molded in the range of 7 to 17sec. But the second injection time should be less than 2sec. because excessive time causes residual strain around the gate.

e. Cushions
Cushions should not be employed because it makes fin easily.

f. Drooling
On injection molding with TPX, sometimes molten polymer flows out from an injection nozzle. In such case, employ suck back at 1 to 2mm.

g. Mold temperature
Mold temperature of TPX should be 20 to 60°C.

Typical injection conditions of TPX

Cylinder temp.	300 °C	Injection machine; MEIKI M-100 Production design; gate: film gate dimension : 120 × 130 × 2 mmt
Inj. pressure (1st./2nd.)	550/470 kg/cm	
Inj. speed	10/100	
Inj. time (1st./2nd.)	4/2 sec	
Cooling time	23 sec	
Mold temp.	60 °C	

h. How to stop an injection machine
When the injection machine operation is interrupted for more than 30min., the cylinder temperature should be lowered 260 to 280°C to keep degradation of TPX to a minimum. On switching off, the temperature should be lowered at first and then switched off in the same manner. On starting again after more than one hour, great attention should be paid to the scattering of the degraded polymer.

i. Exchanging of polymers
When the injection machine contains a foreign polymer in the cylinder, the product of TPX can not have good transparency. Therefore foreign polymer in a cylinder should be removed completely beforehand. Since the melt viscosity of TPX is very low and it takes a lot of polymer to exchange cylinder by TPX, the cylindershould be purged by PP with low MFR at first,

then exchange PP for TPX.

THE MOLD MODIFICATION FROM OTHER POLYMER TO TPX

TO keep conventional dimensions	···	Machining to larger cavities or make smaller cavities	
To require high transparency	···	Higher polish	
Insufficient mold cooling	···	Install additional cooling channels to cores and cavities	
Unfavorable gate	···	Modification of the gate in a range of 0.8 to 1.2 mm ϕ	··· Employ off-center gate for shallow product
Taper and corner edges	···	Taper $>$ 2° Corner edge $>$ 0.5 mmR	
Areas and positions of ejectors	···	Widen areas of ejections	··· Avoid the parts around gates and corners

INJECTION MOLD FOR TPX

a. Structure

The structure of the TPX mold is basically similar to the PP mold, but the ejecting and surface finish is different.

b. Mold material

Though the mold material should be chosen from the points of surface hardness, corrosion resistance, machinability and the numbers of the products to be molded, the mold material for TPX should have the following properties.

(1) The mold material can be polished as fine as lenses.

(2) The mold material is rarely clouded or rusted by the gases which are generated during molding.

The best result Were for STAVAX AISI 420 from Assab which had a high Cr content of the three materials tested (F55C, NAKK55 and STAVAX).

Chemical composition of Assab's STAVAX

Chemical components	C	Si	Mn	Cr	Ni	V	Fe
%	0.38	0.3	0.7	13.6	0.8	0.3	83.92

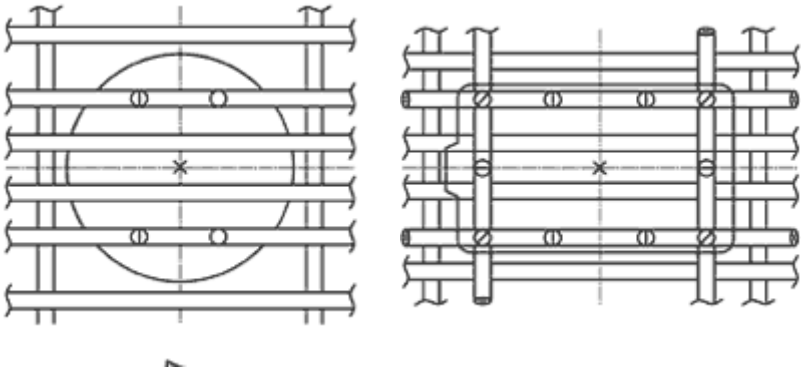
c. Surface finish

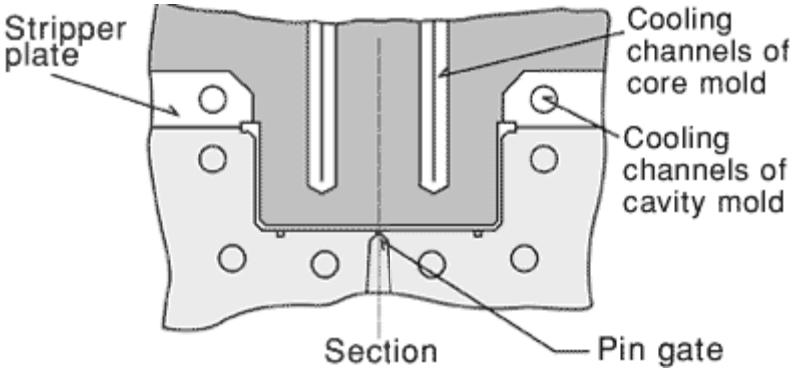
The surface finish of the mold determines the transparency of the product because the flowability of TPX is very high. Therefore, the mold should be polished as fine as possible. A proper thickness of the plating is 0.015 to 0.02mm. Since TPX is unusually molded at around 300°C, it sometimes generates gases and the mold tends to be cloudy and rusty. As the countermeasure for this, the mold should be swept with cloth and covered with anti-corrosion agent after molding.

d. Cooling channel

If the mold has insufficient cooling channels, it affects appearances – transparency and flatness –, dimensions, strength and processing cycles of the product. The mold temperature for TPX should be controlled at 20 to 60° C by using the mold temperature control system. Typical examples of the cooling channels are shown below.

In the case of a box – or cylindrical – shaped product, it is necessary to put a sufficient cooling channels around the open edge of the wall, the flanges, thicker parts, and gates.

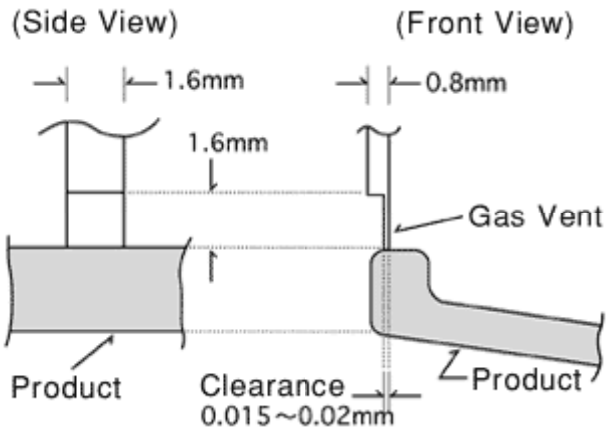




e. Gas venting

TPX mold should have gas vents because the processing temperature is relatively high and gas is generated during molding. Their clearance should be between 0.015 to 0.020mm. A mold without gas vents may result in products with acloudy surface, poor transparency, burning or voids.

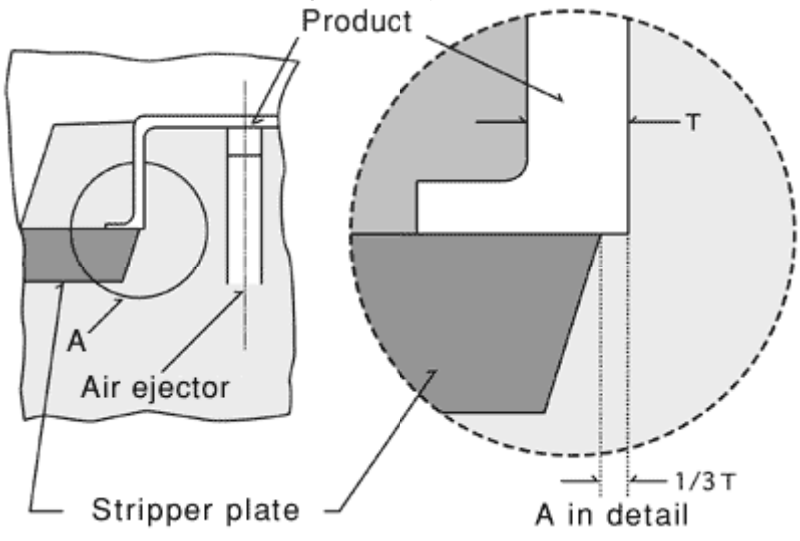
Gas vent



f. Ejector system

An ejector system should be chosen by the shape of the product. In the case of a flat product, ejection pins should be chosen, with a careful decision on the number of pins.
The stripper plate system is the best for a box – or cylindrical – shaped product, and ejection can be improved by using air ejectionjointly.

Ejection system

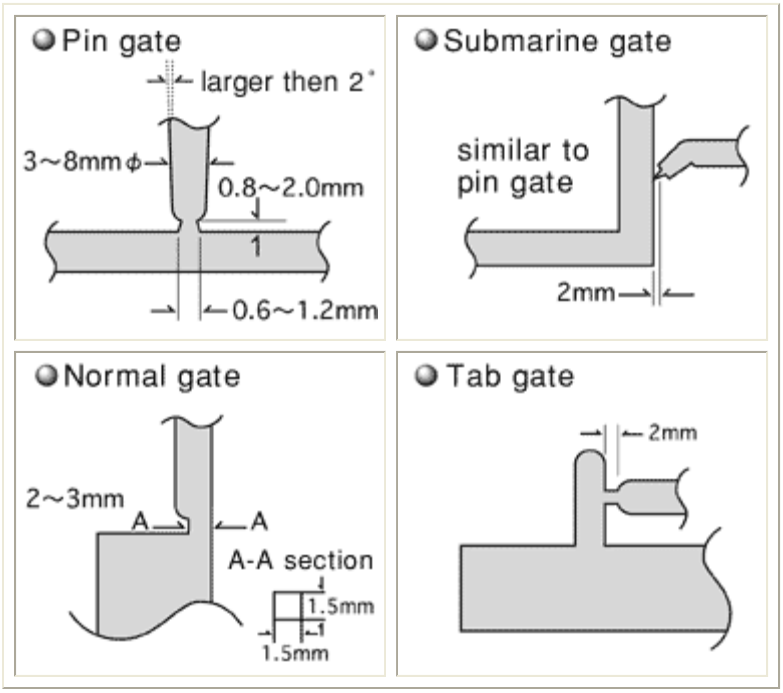


g. Gate and Runner

1) The kind and the position of the gate

As for the kinds of gates, there are pin gates, direct gates, normal gates, film gates and submarine gates. In the case of a TPX mold, employ a pin gate or normal gate on the sides of the product for the flat product, and employ a pin gate at the off center position for a box – or a cylindrical product without warpage.

Typical gates



As a reference, the type, size and position of a gate are shown for a MWO tray.

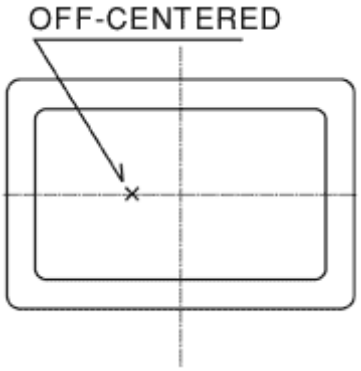
a. A pin gate is employed.

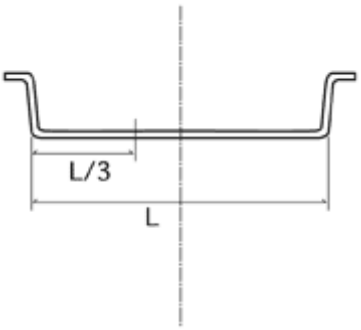
b. The size of the gate is 0.8mm to 1.2mmϕ.

c. In order to prevent warpage of the product, take care to position the a gate.

・In the case of a product whose height is less than 40mm, the gate position should be off-centered.

・In the case of a product whose height is more than 40mm, a center gate can be used.





2) Runner

a. Cold Runner

For the shape of the runner, a circular cross section is the most popular and a trapezoid and half circle are also used. The area of the cross section varies depending on the length of the runner and the number of cavities, but in the case of a cold runner, the diameter of the cross section is usually more than 6mmϕ. And in the case of an insulated hot runner, it usually is more than 20mmϕ, or 25mmϕ with a long runner.

b. Hot Runner

A hot runner system can be used for a TPX mold. In this case, it should be used considering that the residence time of the polymer is prolonged and the color is hardly changed.

Generally, a cartridge heater or a plate heater is used to maintain the runner temperature. The shape of the section should be circular; other shapes will create a dead space. The diameter of the cross section should be larger than 10mm. The capacity of the heater should be carefully calculated to attain 380°C. In case of a multi-cavity mold, all the temperature of the chips should be kept within 10°C. A hot chip with a valve is the best one and SPEAR type can also be used.