SUMITOMO CHEMICAL

Ultra-High Heat Resistant Engineering Plastics

SUMIKASUPER™ LCP

Liquid Crystal Polymer

3. Injection Molding

Liquid
Crystal
Polymer

Version 04 / Nov. 2023

SUMITOMO CHEMICAL Co., Ltd. Advanced Polymers Division

4. Injection Molding

4-1 Molding Conditions

The following shows typical molding conditions such as recommended molding conditions and condition ranges for SUMIKASUPER LCP. Resin temperature control is very important for SUMIKASUPER LCP. If there is a difference between the set temperature for the cylinder and the actual resin temperature, it is necessary to control it using the actual resin temperature.

Table 4-1-1 Standard Molding Conditions for SUMIKASUPER E5000, E4000, and E6000 series

		E5000 series		E4000 series		E6000 series	
		Recommended	Range	Recommended	Range	Recommended	Range
Drying temperature (°C)		130	120-140	130	120-140	130	120-140
Drying time (hr)		5	4-24	5	4-24	5	4-24
Cylinder temperature (°C)	Rear	340	330-360	320	310-340	300	280-320
	Center	380	370-390	360	350-370	330	320-340
	Front	400	390-410	380	370-390	360	340-370
	Nozzle	400	390-410	380	370-390	360	340-370
Suitable resin temperature (°C)		400	390-410	380	370-390	360	340-370
Tool (Mold) temperature (°C)		70-90	60-160	70-90	60-160	70-90	60-160
Injection pressure (MPa)		120-160	80-160	120-160	80-160	120-160	80-160
Holding pressure (MPa)		40-60	10-80	40-60	10-80	40-60	10-80
Holding time (sec)		0.2-0.5	0.2-1	0.2-0.5	0.2-1	0.2-0.5	0.2-1
Back pressure (MPa)		0.5-1	0.5-5	0.5-1	0.5-5	0.5-1	0.5-5
Injection speed (mm/sec)		50-200	50-400	50-200	50-400	50-200	50-400
Screw rotation (rpm)		50-250	50-350	50-250	50-350	50-250	50-350
Sack back (mm)		1-2	0-2	1-2	0-2	1-2	0-2

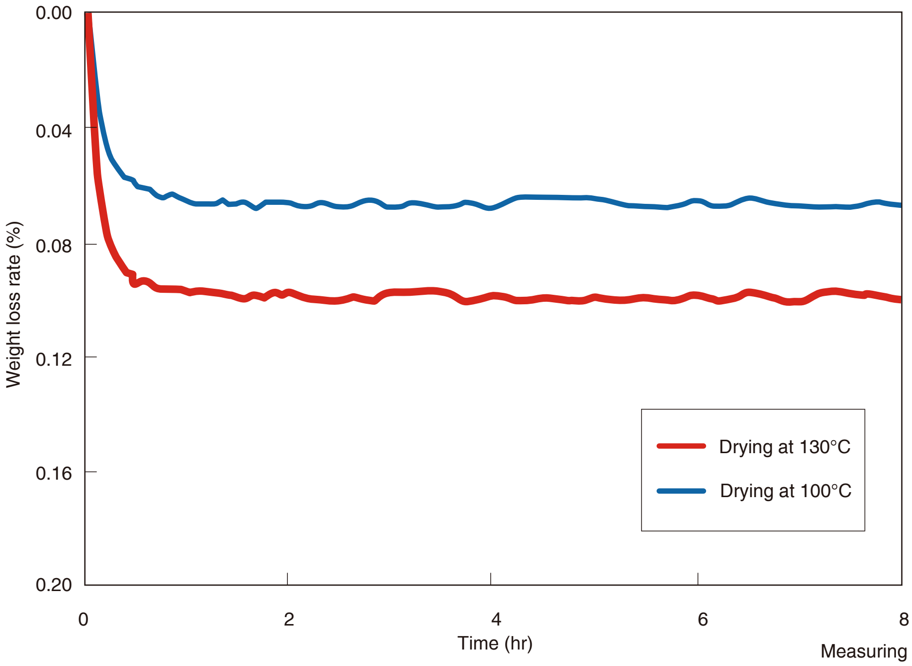
Table 4-1-2 Standard Molding Conditions for SUMIKASUPER SV6000, SR1000, E6000HF, SV6000HF, SZ6000HF, and SR2000 series

		SV6000, SR1000 series		E6000HF, SV6000HF series		SZ6000HF, SR2000 series	
		Recommended	Range	Recommended	Range	Recommended	Range
Drying temperature (°C)		130	120-140	130	120-140	130	120-140
Drying time (hr)		5	4-24	5	4-24	5	4-24
Cylinder temperature (°C)	Rear	300	280-320	300	280-320	300	280-320
	Center	330	320-340	330	320-340	330	320-340
	Front	360	340-370	350	340-370	350	330-370
	Nozzle	360	340-370	350	340-360	350	330-360
Suitable resin temperature (°C)		360	340-370	350	330-360	350	330-360
Tool (Mold) temperature (°C)		70-90	60-160	70-90	60-160	70-90	60-160
Injection pressure (MPa)		80-160	80-180	80-160	80-180	80-160	80-180
Holding pressure (MPa)		10-40	10-80	10-40	10-80	10-40	10-80
Holding time (sec)		0.2-0.5	0.2-1	0.2-0.5	0.2-1	0.2-0.5	0.2-1
Back pressure (MPa)		0.5-1	0.5-5	0.5-1	0.5-5	0.5-1	0.5-5
Injection speed (mm/sec)		50-200	50-500	50-200	50-500	50-200	50-500
Screw rotation (rpm)		50-250	50-350	50-250	50-350	50-250	50-350
Sack back (mm)		1-2	0-2	1-2	0-2	1-2	0-2

Pre-drying

SUMIKASUPER LCP has a very low water absorption rate of 0.02%, so it does not require a long drying time. However, it is recommended to dry it to 0.01% to obtain the best physical properties for molding. It is recommended to dry it using a hopper dryer between 4 to 24 hours at around 130°C. Use a dehumidification dryer or hopper dryer to prevent moisture absorption in the hopper during molding. If the drying temperature is too high, the resin may deteriorate, so make sure that the drying temperature is around 130°C.

Figure 4-1-1 Drying Curve of SUMIKASUPER LCP



Measuring device : MS-70 Heating dry type moisture meter
(Manufactured by A&D Company, Limited)

Molding Temperature Setting

(1) Temperature of front part of cylinder and nozzle part

This is true for all resins, but it is necessary to properly control the resin temperature. Set the temperature at the front of the SUMIKASUPER LCP cylinder to 390 to 410°C for the E5000 series, 370 to 390°C for the E4000 series, 340 to 370°C for the E6000, SV6000, and SR1000 series, and to 330 to 360°C for the E6000HF, SV6000HF, SZ6000HF, and SR2000 series. When forming a complicated shape requiring high flowability, or a large item with a great difference between the long and short axes, set the front of the cylinder to a higher temperature. It is not recommended to set the temperature to more than 10°C above the applicable range because backflow to the hopper side tends to occur with the resin during injection.

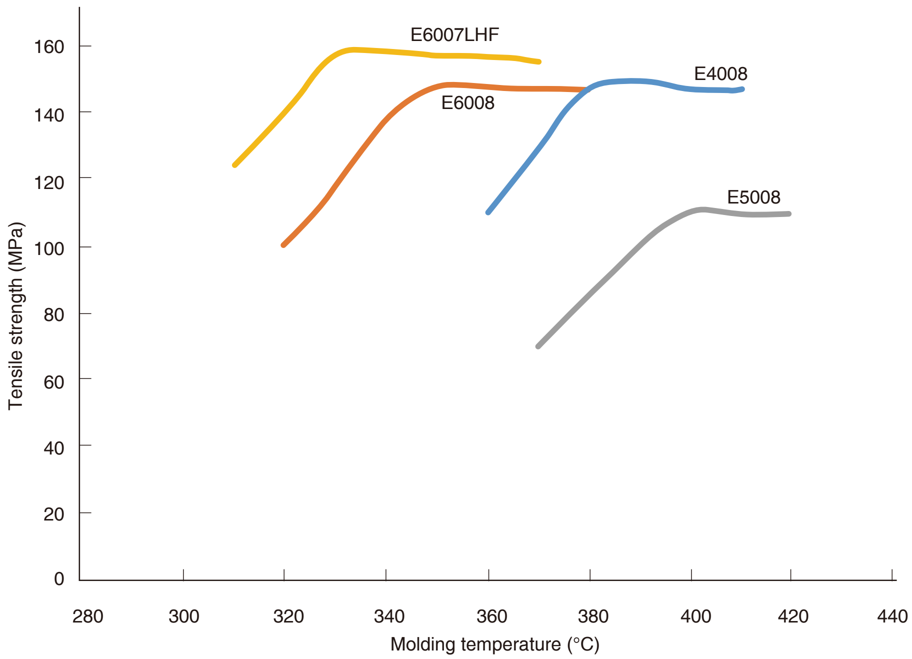
Regarding the cylinder temperature, stable physical properties can be obtained at a molding temperature of 400°C or higher with the E5000 series, 380°C or higher with the E4000 series, 340°C or higher with the E6000, SV6000, and SR1000 series, and 330°C or higher with the E6000HF, SV6000HF, and SR2000 series. For some applications, it is possible to obtain non-problematic physical properties even when molding is performed at lower temperatures, but if the temperature is too low, physical properties may deteriorate.

It is very important to control the temperature of the nozzle since it can easily affect the resin temperature. Therefore, be sure to consider the position of the temperature control sensor and heat retention. If there is a difference between the set nozzle temperature and the actual resin temperature, it is necessary to control it using the actual resin temperature. If the nozzle temperature is too high, drawing and stringing can occur, and if it is too low, cold slag can occur.

(2) Cylinder rear temperature

The temperature at the rear of the cylinder for SUMIKASUPER LCP should be lower than that at the front of the cylinder. Set it to 330 to 360°C for the E5000 series, 310 to 340°C for the E4000 series, and 280 to 320°C for the E6000, SV6000, SR1000, E6000HF, SV6000HF, SZ6000HF, and SR2000 series. When the cylinder rear temperature is high, the resin tends to backflow to the hopper side, which makes it difficult to get a stable metering.

Figure 4-1-2 Dependence of Tensile Strength on Molding Temperature



Injection Pressure and Injection Speed

(1) Injection pressure

SUMIKASUPER LCP has low melt viscosity and excellent flowability, so it does not require an extremely high injection pressure. For example, with the E6000 series, by raising the molding temperature to at least 350°C, sufficient flowability is achieved even at a low pressure of about 40MPa. Since the resin quickly solidifies, there is almost no impact on tensile strength even if the holding pressure changes in the range of 65 to 160MPa.

(2) Injection speed

For thin-walled complicated shapes, it is better to perform moldings at medium to high injection speeds. When molding ultra-thin products (0.2mm or less), the resin may solidify at thin portions, and thus may not be possible to achieve a sufficient flow length. Therefore, it is recommended to use high performance injection molding machines that enable high speed and high response (refer to “High-speed molding”(p.46)).

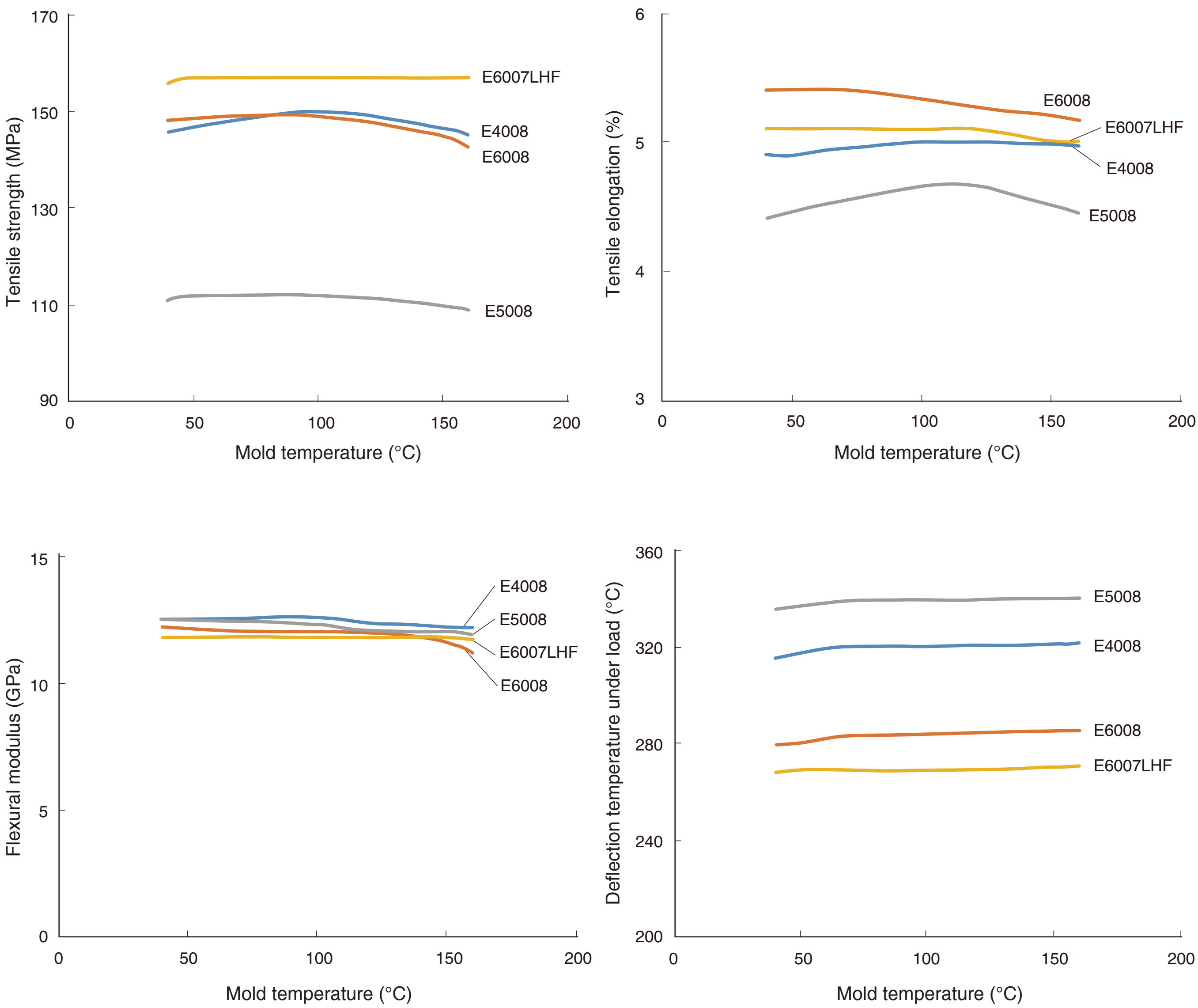
SUMIKASUPER LCP can be molded even at a constant injection speed. However, in order to avoid jetting from the nozzle and the gate, it would be better to lower the injection speed while the resin passes through the sprue or runner, raise the injection speed after passing through the gate. Lowering the injection speed just before filling is completed can also be effective to ensure stable molding.

If there are problems related to the weldlines on relatively thick products, a medium/low injection speed of 20 to 60mm/sec with the appropriate air vent design in the mold would improve them.

Mold temperature

The molecular structure of SUMIKASUPER LCP is rigid rod-like even in the molten state, and its molecules are easily oriented in the flow direction by the shear flow during injection molding. When the molten LCP is cooled in the mold, it can solidify rapidly while maintaining its molecular orientation. Since the solidification rate of SUMIKASUPER LCP is very high, the mold temperature has almost no impact on its properties. Therefore, injection molding can be performed at a very wide range of mold temperatures.
When molding thin-walled products, it is recommended to set the mold temperature to 60 to 100°C if the priority is placed on the molding cycle, 100 to 150°C if the flowability and the weld strength for the thin wall are important, and set it to 160°C or higher if the smoothness of the molded product surface is important. When the product shape is complicated and there are issues with mold release, it is recommended to set the mold temperature to a lower temperature. The surface temperature of the mold is affected by various factors other than the cooling water, so be sure to measure and check it when starting up the injection molding machine or when making major setting changes.

Figure 4-1-3 Dependence of typical properties on mold temperature



Metering (Plasticization) Setting

In order to ensure stable metering (plasticization) of SUMIKASUPER LCP, the temperature at the rear of the cylinder should be lower than that at the front of the cylinder. The recommended temperature range at the rear of the cylinder is 330 to 360°C for the E5000 series, 310 to 340°C for the E4000 series, and 280 to 320°C for the E6000, SV6000, SR1000, E6000HF, SV6000HF, SZ6000HF, and SR2000 series.
It is possible to shorten the metering time by setting a high screw rotation speed. However, if the screw rotation speed is too high, fillers such as glass fiber may be damaged. For small-diameter screws, the metering capacity is determined by the flight depth of the feed zone , and so refer to "Selection of Injection Molding Machine" (p.44) and select the suitable screw.
Since the metering tends to be more stable when the back pressure is low, set this value as low as possible.

Suck-back

Suck-back (screw decompression) should be set to the minimum value when necessary. If the suck- back is too large, air can easily get caught in the nozzle, resulting in molding defects such as blisters. Drooling from the nozzle can be controlled by adjusting the drying temperature of the resin and the nozzle temperature, or, if necessary, using a dedicated nozzle for LCP.

Purging Method

Since SUMIKASUPER LCP has extremely low melt viscosity compared to other resins including purging materials, it is necessary to make sure there is no residual resins or purging materials in the cylinder or nozzle when replacing them by purging. To make it easier to replace the SUMIKASUPER LCP during purging, it is recommended to lower the cylinder temperature by about 20 to 30°C compared to normal molding condition in order to increase the melt viscosity of SUMIKASUPER LCP. When performing purging, especially for the E4000 series and E5000 series, please keep in mind that due to the high processing temperature, there may smoke or blow out of gas or resin from the nozzle.

■Recommended Purging Material

Commercially available purging materials can be used for the purging of SUMIKASUPER LCP, and the following purging materials have been proven in use. Please note that purging material may decompose if it remains in a high temperature cylinder for a long time.

- ASACLEAN PX2 [Asahi Kasei Corporation]
- Z CLEAN S29 [Nissho Corporation]
- CELPURGE NX-HG [Daicel Miraizu Ltd.]

■When the same grade is used after molding is suspended

If molding needs to be suspended for 15 minutes or more, discharge the resin from the cylinder and lower the cylinder temperature to about 250°C. When resuming molding, perform purging according to the following procedure. If the injection molding process is restarted using the same grade after the machine has been shut down for several hours, the following purging procedure can also be applicable.

Table 4-1-3 Purging procedure when injection molding is suspended or shutdown

1 End of molding	Discharge the prior resin completely from the hopper and inside the cylinder.
2 Purging material input	Purge with a purging material at molding temperature.
3 Purge continuation	Set the cylinder temperature to 20 to 30°C lower than molding temperature.
4 Resin replacement	Supply SUMIKASUPER LCP immediately after discharging the purging material. Replace the inside of the cylinder with SUMIKASUPER LCP.
5 Operation suspended	Set the cylinder temperature to 250°C, or Shutdown the injection molding machine.
6 Resume operation	Set the cylinder temperature to 20 to 30°C lower than molding temperature.
7 Pre-purging	Purge with SUMIKASUPER LCP (at least 5 shots) while maintaining the temperature 20 to 30°C lower than the molding temperature.
8 Start of production	Purge the cylinder with at least 5 shots of SUMIKASUPER LCP after the cylinder temperature has been raised to the molding temperature and start production. (Note) When only changing the color of the same grade, skip steps 5, 6, and 7 above.

■When switching to SUMIKASUPER LCP from other resins

When molding of the prior resin is completed and changeing it to SUMIKASUPER LCP, perform the following procedure.

Table 4-1-4 Purging procedure when switching materials to SUMIKASUPER LCP

1 End of molding	Discharge the prior resin completely from the hopper and cylinder.
2 Cylinder temperature set	Set the cylinder temperature to 20 to 30°C lower than molding temperature.
3 Purging material input	Purge with a purging material immediately after the temperature reaches to the above set point.
4 Resin replacement	Supply SUMIKASUPER LCP immediately after discharging the purging material. Replace the inside of the cylinder with SUMIKASUPER LCP.
5 Resume operation	Set the cylinder temperature to the molding temperature of SUMIKASUPER LCP.
6 Start of production	Purge the cylinder with at least 5 shots of SUMIKASUPER LCP after the cylinder temperature has been raised to the molding temperature, and start production.

Flash Characteristics

SUMIKASUPER LCP solidifies quickly and has high thermal conductivity, so it causes little flash although it has high fluidity. This flash characteristic make SUMIKASUPER LCP suitable for molding thin-wall and small electronic components.
Figure 4-1-5 shows the results of SUMIKASUPER LCP flash characteristic evaluation. This figure shows the range of molding conditions that can produce good molded products (no flash) and the range of molding conditions that cannot (flash or short shots). SUMIKASUPER LCP has a relatively wide range of molding conditions that can produce good molded products, however, PPS and PBT can easily cause flash and short shots, making it difficult to secure good molding conditions for thin-wall molded products.

Figure 4-1-4 Mold for Evaluating Flash Characteristics

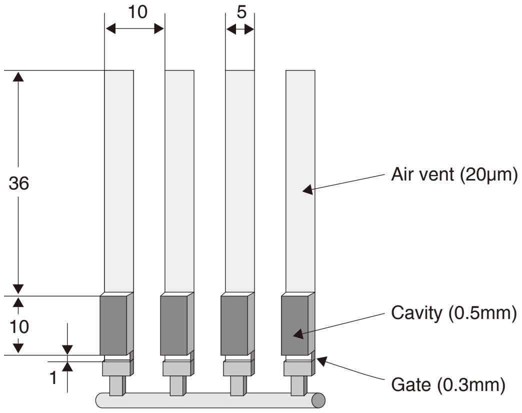
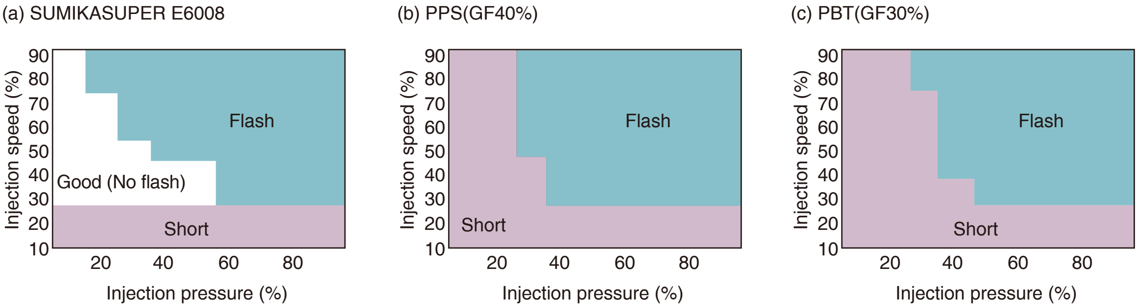


Figure 4-1-5 Comparison of the range of molding conditions that do not cause flash for LCP, PPS, and PBT



Molding machine : PS10E1ASE (Nissei Plastic Industrial Co., Ltd.)
Injection speed : 32cm³/sec
Injection pressure : 100% = 200MPa

4-2 Moldability

Apparent Melt Viscosity

Figure 4-2-1 and 4-2-2 show the shear rate dependence and temperature dependence of the apparent melt viscosity of SUMIKASUPER LCP, respectively. Compared to other engineering plastics, the apparent melt viscosity of SUMIKASUPER LCP is greatly affected by both the shear rate and temperature. Therefore, moldability depends greatly on the injection speed, cylinder temperature, and shear heat generated during injection molding. The low viscosity and high shear rate dependence of SUMIKASUPER LCP make high-speed injection molding possible since the pressure does not easily increase even at high injection speed. Its viscosity becomes extremely low under proper injection molding conditions, making it easy to fill thin-walled or complicated-shaped products. On the other hand, for stable production, it is necessary to properly manage the injection speed and cylinder temperature, and to monitor changes in shear force caused by wear or other factors.

Figure 4-2-1 Shear Rate Dependence of Apparent Melt Viscosity

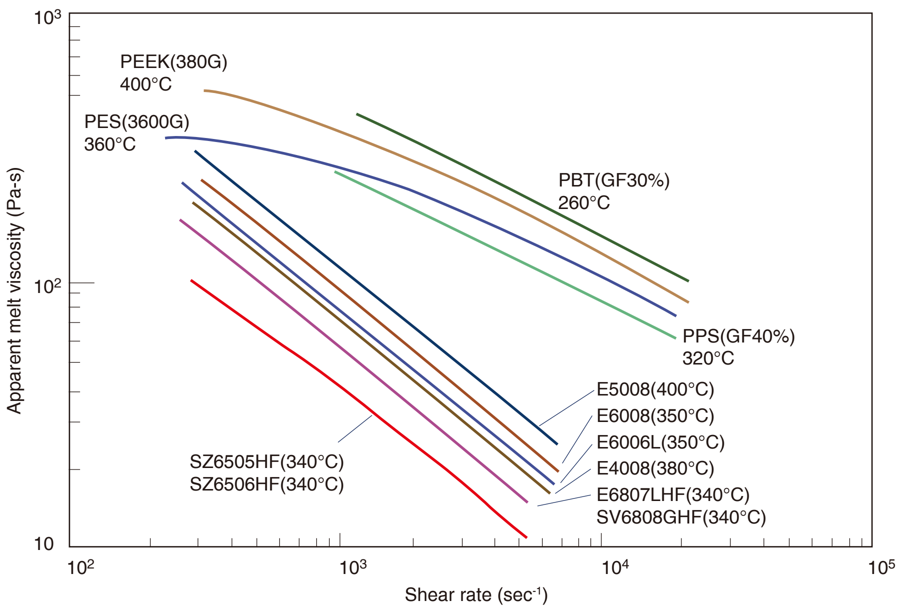
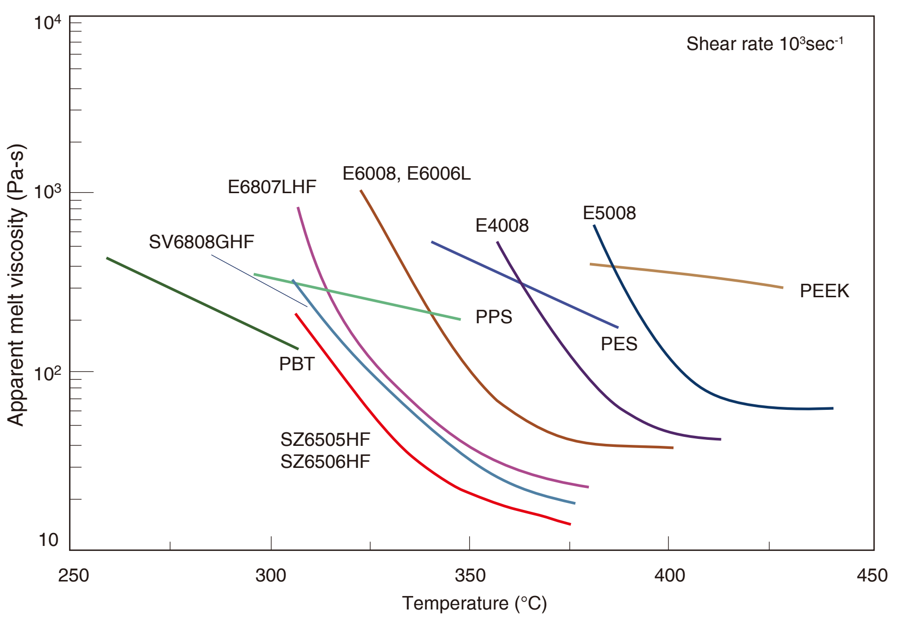


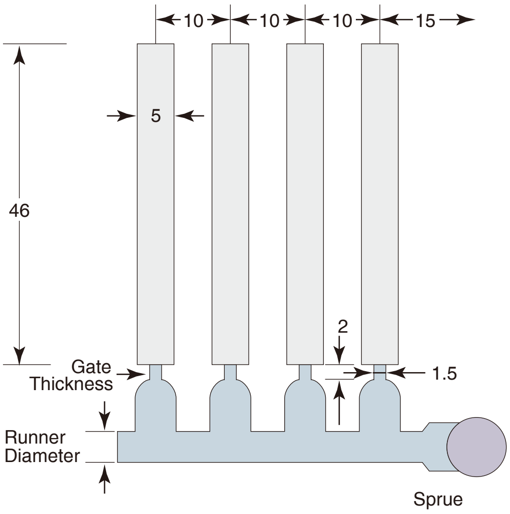
Figure 4-2-2 Temperature Dependence of Apparent Melt Viscosity



Thin-Wall Flowability

SUMIKASUPER LCP has excellent thin-wall flowability compared to other engineering plastics. Figure 4-2-4 shows the thin-wall flowability (thickness : 0.2, 0.3mm) of each grade, where flowability is measured using the tool shown in Figure 4-2-3, and Figure 4-2-5 shows the bar flow length with a thickness of 1mm.

Figure 4-2-3 Mold for Thin-Wall Flow Length Measurement (Unit : mm)



Product thickness : 0.3mm
Runner : 4.0mm φ
Gate : 0.3t×1.5w×2.0L
Flow length is 4 cavities average

Product thickness : 0.2mm
Runner : 3.0mm φ
Gate : 0.2t×1.5w×2.0L
Flow length is 4 cavities average

Molding machine : PS10E1ASE (Nissei Plastic Industrial Co., Ltd.)
Injection pressure : 0.2mm thickness : 90MPa
0.3mm thickness : 60MPa
Injection speed : 0.2mm thickness : 95%
0.3mm thickness : 60%
Mold temperature : 130°C

Figure 4-2-4 Thin-Wall Flowability

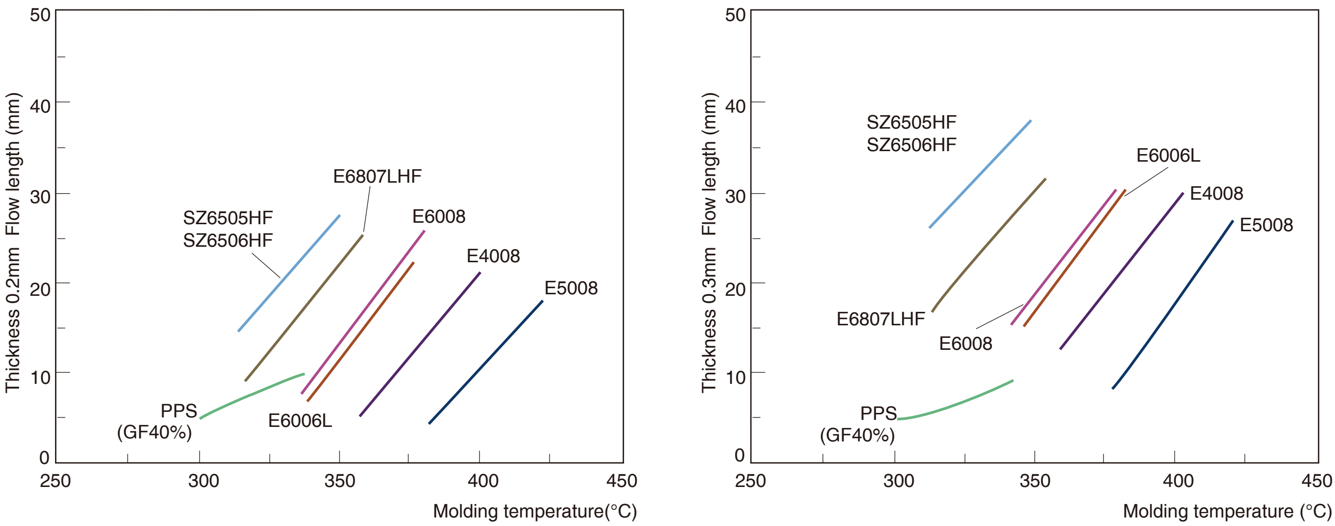
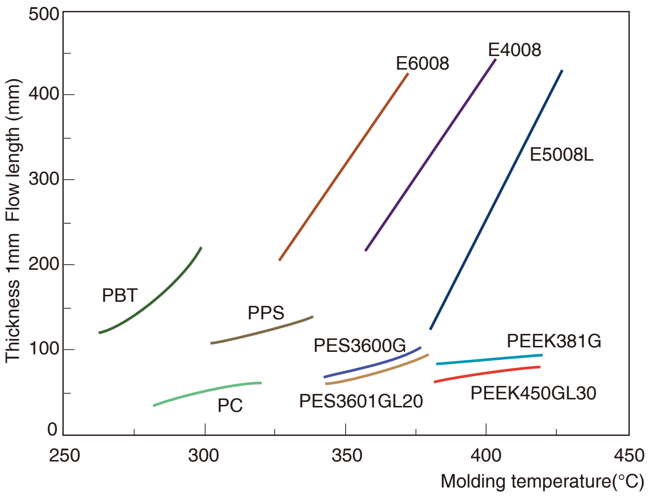


Figure 4-2-5 Flowability of Various Engineering Plastics at 1mm Thickness



Thin-Wall Flowability

The thin-wall flow length of SUMIKASUPER LCP depends on the molding conditions and mold shape. Figure 4-2-7 shows the results of thin-wall flow length evaluation for various grades molded at the same injection speed and pressure using the same mold as shown in Figure 4-2-6. SUMIKASUPER LCP has high flowability even a product thickness of 0.1mm, and a wide range of molding conditions can be applied, allowing it to be utilized in products of various shapes.

Thin wall flowability measurement conditions (0.10mm, 0.12mm, 0.15mm, 0.20mm, 0.30mm)

- Injection molding machine : ROBOSHOT S-2000i30B (FANUC Corporation)
- Resin temperature : Standard molding temperature
- Mold temperature : 120˚C
- Injection speed : 200mm/sec

Figure 4-2-6 Mold for Thin-Wall Flow Length Measurement

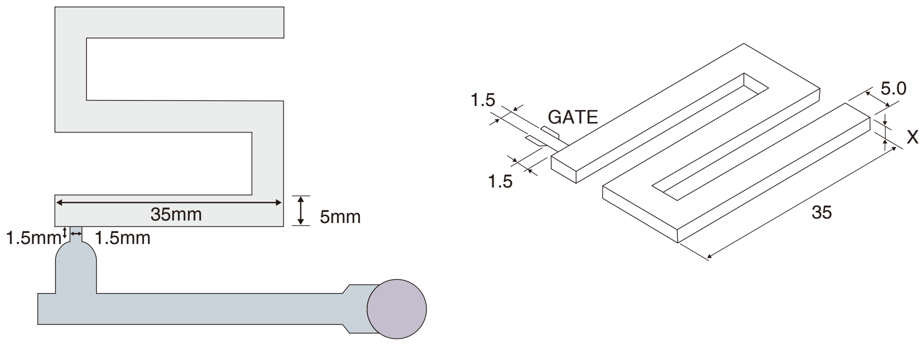


Figure 4-2-7 Thin-Wall Flow Length

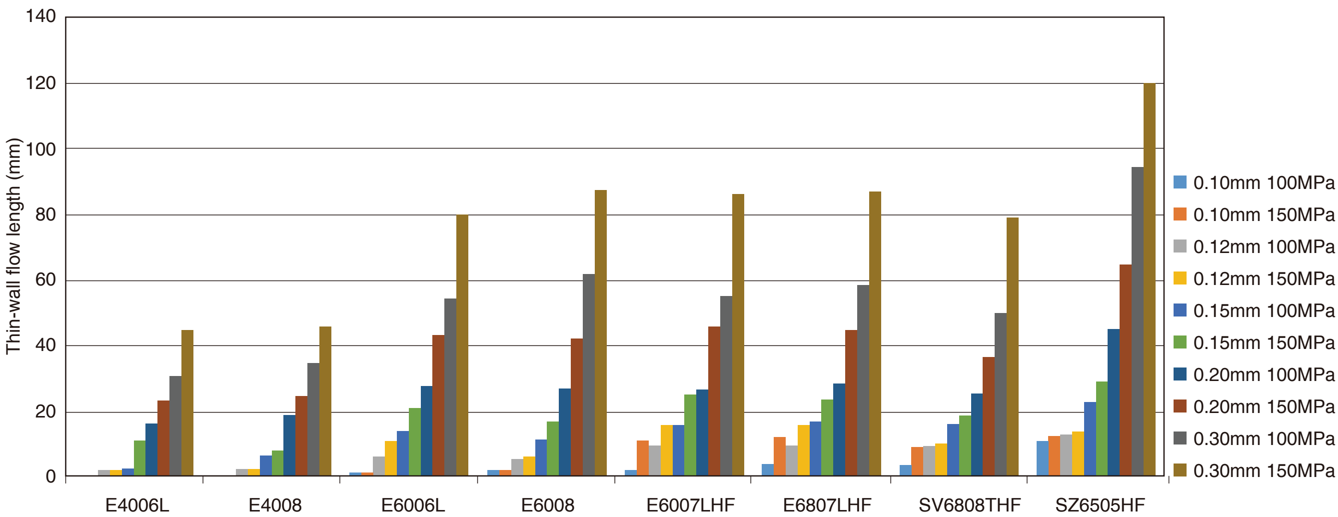


Figure 4-2-8 Thickness Dependence of Thin-Wall Flow Length 1

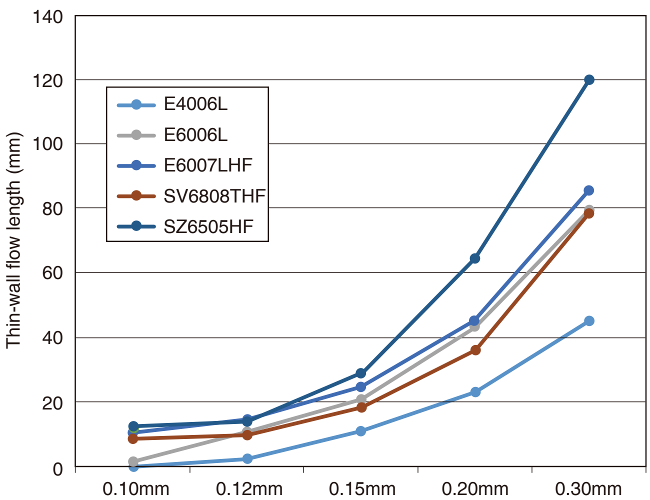
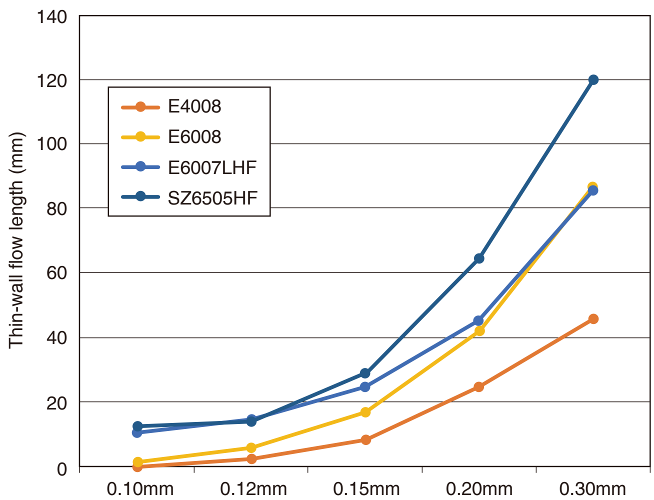


Figure 4-2-9 Thickness Dependence of Thin-Wall Flow Length 2



4-3 Injection Molding Machine and Mold Design

Selection of Injection Molding Machine

SUMIKASUPER LCP can be molded using both the standard inline type and plunger (preplasticating) type of injection molding machines. However, for E5000 series, it requires a higher molding temperature (up to 420°C), and thus the injection molding machine with high temperature specifications (450°C) is required.

Screw and Cylinder

- Since glass fiber is filled for most grades of SUMIKASUPER LCP, it is recommended that the wear-resistant materials be used for screws and cylinders.
- A standard full flight type screw is good for SUMIKASUPER LCP. Sub-flight screws and high mixing screws are not recommended because metering time will be extended.
- A typical screw design suitable for SUMIKASUPER LCP is as follows.
  - L/D (screw length [L]/screw diameter [D]) : approx. 18 to 22
  - Compression ratio : around 2.0 to 2.2
  - Ratio of each zone:
    - Feed zone : around 55%
    - Compression zone : around 25%
    - Metering zone : around 20%
- Screw heads for inline type injection molding machines are recommended to be equipped with backflow prevention mechanism.
- As the flow characteristics of SUMIKASUPER LCP are sensitive to temperature, it is necessary to use a PID controller to keep the cylinder temperature properly.
- Screws and cylinders require proper maintenance. Regularly monitor the check ring and the clearance between the cylinder and the screw to ensure that they meet the molding machine manufacturer's specifications.

Nozzle

- For the material of the nozzle, the same as those in "Screw and Cylinder" can be used.
- Open nozzles should always be used. Shut-off nozzles should not be used, as they have excessive dead space that can trap and retain resin.
- The nozzle heater must have a temperature controller (PID controller) that is independent of the cylinder.
- If their is a nozzle specifically designed for LCP, it is recommended to use it. It can be helpful in improving drooling and stringing problems.
- It is not recommended to use an extension nozzle. When using it, be sure to select one that enables uniform temperature distribution.

Injection Unit and Its Control System

- It is possible to use a general open-loop control type or closed-loop control type molding machine.
- Since the melt viscosity of SUMIKASUPER LCP depends greatly on the shear rate and it solidifies rapidly when cooled, it is recommended to use a high performance injection molding machine that enables high speed and high response when molding thin-walled products.

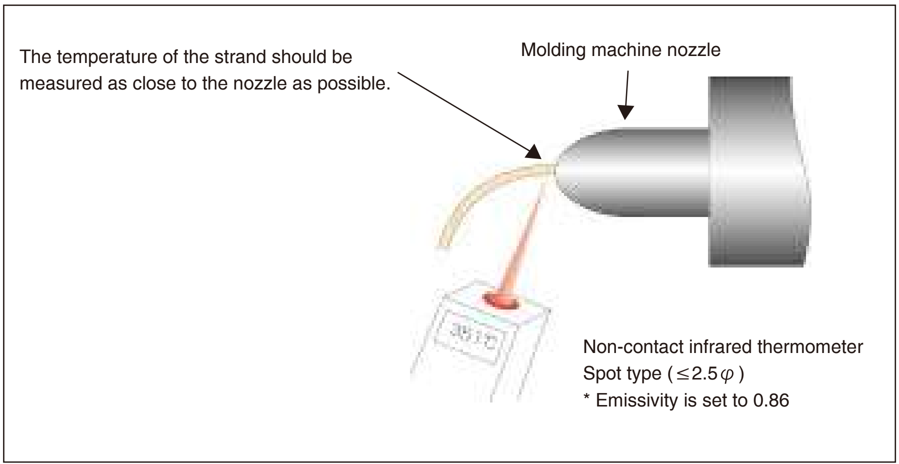
Injection Capacity

- It is recommended to select a molding machine whose shot size is about 1/3 to 3/4 of its maximum injection capacity. If the shot size is too small, the residence time of resin in the high temperature cylinder will be longer, and various molding defects are more likely to occur.
- When performing high cycle (short cycle time) molding, the shot size would need to be less than 1/2 of the maximum injection capacity to shorten the metering time.

Resin Temperature Control

Since the properties of SUMIKASUPER LCP molded products are highly dependent on the resin temperature during molding (cf. Figure 4-1-2), it is necessary to mold SUMIKASUPER LCP at an appropriate resin temperature. On the other hand, as the standard molding temperature for SUMIKASUPER LCP is extremely high (320 to 400°C), there may be a discrepancy between the setting temperature of the molding machine and the actual resin temperature. In this case, the potential of SUMIKASUPER LCP can not be fully utilized.
In order to prevent such problems, it is recommended that the resin temperature in the cylinder be monitored. The actual resin temperature can be measured, for example, by using an infrared radiation thermometer that can measure the temperature of a small area.

Figure 4-3-1 Measuring Method of Resin Temperature



High-Speed Injection Molding

As SUMIKASUPER LCP has a rapid solidification nature when cooled, it does not easily cause flashes during injection molding although its melt viscosity is very low.
However, when molding ultra-thin-walled products (<0.2mm), there are cases where the resin solidifies in the thin-walled part and sufficient flow length cannot be obtained. As a countermeasure in such cases, the injection molding machines with high speed and excellent injection response characteristics, such as electric injection molding machines or hydraulic injection molding machines with accumulators, are effective.

Figure 4-3-2 Maximum Flow Length without Flash Generation

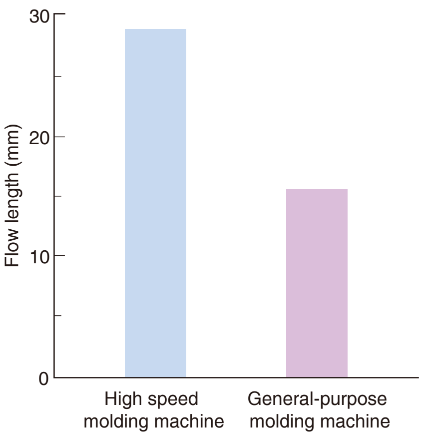
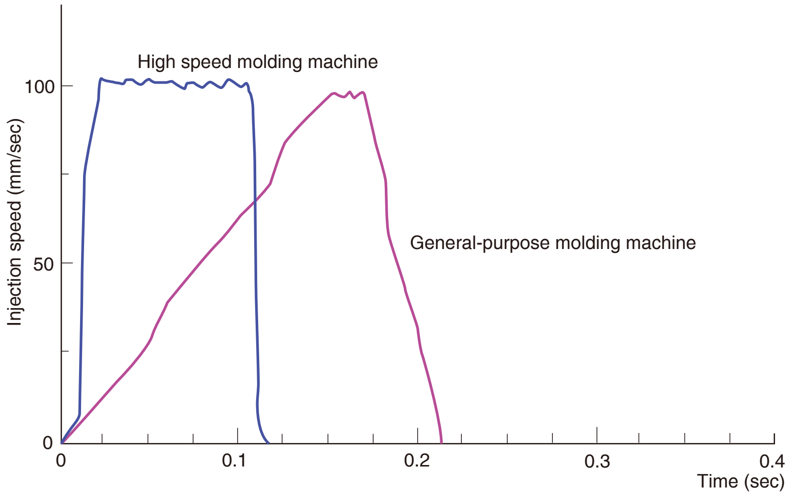


Figure 4-3-3 Comparison of Injection Response Characteristics



Hydraulic injection molding machine : UH-1000 (Nissei Plastic Industrial Co., Ltd.)

Electric injection molding machine : SE/SV series (Sumitomo Heavy Industries, Ltd.)

Electric injection molding machine : FANUC ROBOSHOT α-Si series (FANUC Corporation)

Electric injection molding machine : LP/TR series (Sodick Co., Ltd.)

(As shown above, when compared to general-purpose molding machine, the high speed molding machine provides the high injection speed in the initial period and thereafter molding is performed at the specified injection speed.)

Flow Length Measurement Mold : Use the one shown in Figure 4-3-5

Molding temperature : 360°C Grade : E6008
Injection speed 100mm/sec
V-P switching pressure 60MPa

General-purpose molding machine : PS-40E5 ASE (Nissei Plastic Industrial Co., Ltd.)
Injection speed 90% Injection pressure 90MPa

Mold Design

When SUMIKASUPER LCP is molded by injection molding, its molecules can be easily oriented in the flow direction due to shear flow. As a result, a molded product with high strength and modulus can be obtained, but at the same time, it must also possess anisotropy.
It is important to pay close attention to how the flow pattern in the cavity will be when designing the mold.

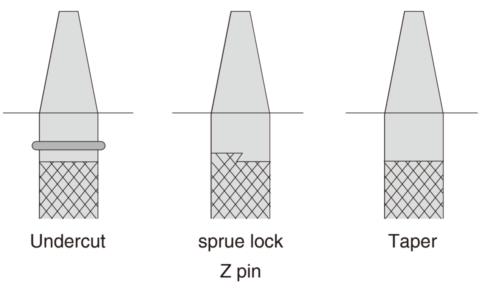
Mold materials

- For prototyping and small lot molding, carbon steels such as S55C can be used, but quenching is recommended when sliding parts are present.
- Since glass fiber is filled for most standard grades of SUMIKASUPER LCP, for the molds that require high dimensional accuracy or for mass production, it is recommended to use steel materials with a hardness of HRC55 to 62, SKD11 or its equivalent materials (HPM31, PD613, RIGOR, etc.), or higher.
- Since almost no corrosive gas is generated by SUMIKASUPER LCP, it does not cause mold corrosion and general mold materials can be used. However, when using a material with a mold hardness of less than HRC55, be sure to carefully consider any potential problems in advance.

Sprue

- The appropriate taper angle for sprues is 1° to 2° (one side).
- In order to remove the cold slag, it is recommended to provide a cold slag well at the sprue end. (4 to 5mm $\varphi \times$ 5mm or more)
- It is recommended to install a sprue lock to improve sprue release.

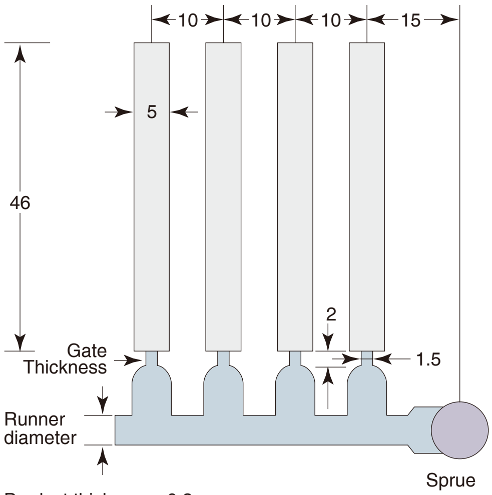
Figure 4-3-4 Sprue Diagram



Runner

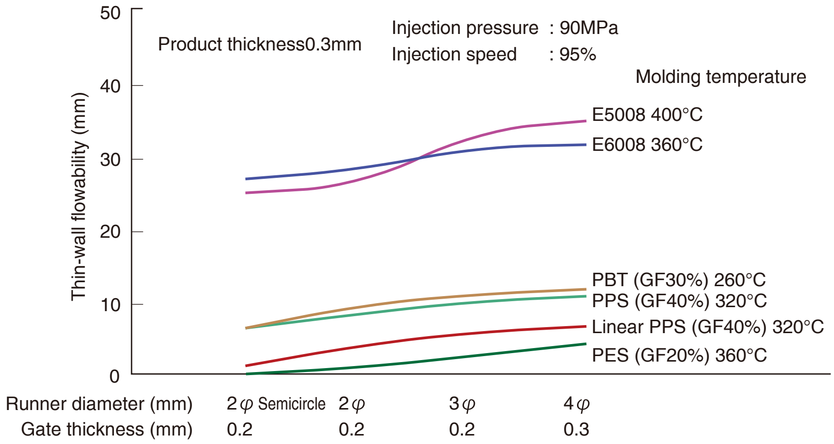
- Standard runners having either a circular, semicircular or trapezoidal cross-sectional shape can be utilized. However, it is recommended that runners having a circular or trapezoidal cross-sectional shape be used, as they are most efficient in terms of pressure loss and processability. As SUMIKASUPER LCP possesses excellent flowability, runner diameters can be decreased. Standard runner diameter is 2 to 5mmφ and guideline for runner diameters is 2/3 to 1/2 of that used for PPS and PBT (smallest: 1.5mmφ).
- When using multi-cavity molds, it is recommended that runners be correctly balanced so that individual cavities will be filled simultaneously with resin. Cold slug wells should also be installed at the ends of runners.

Figure 4-3-5 Mold for Thin-Wall Flow Length Measurement (Unit : mm)



Product thickness : 0.3mm
Flow length is 4 cavities average

Figure 4-3-6 Thin-Wall Flow Length

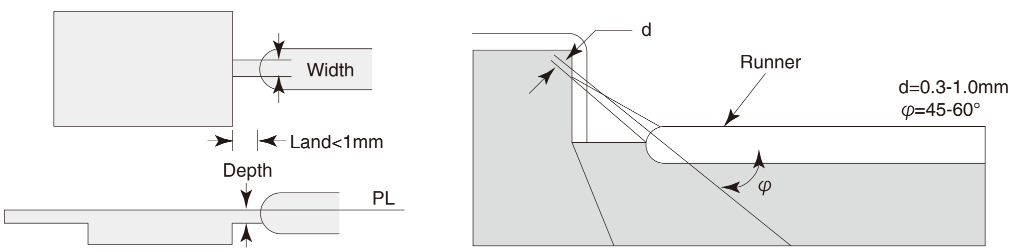


Gate

As the weld strength of SUMIKASUPER LCP is lower than that of other engineering plastics, it is necessary to limit the number of gates to only 1 to 2 places and give careful consideration to where to locate the gate, in order to avoid the formation of welds.

- Side gate
  The appropriate land length is 1mm or less, with a width of no more than 5mm. The land depth should be 70% of the wall thickness of the molded products, with a minimum depth of 0.2mm.
- Pinpoint gate
  The appropriate gate diameter range is from 0.3 to 1.5mm, with a land length of up to 1mm.
  If the gate diameter is increased, stringing and gate warpage may occur.
- Submarine (tunnel) gate
  The appropriate gate diameter is 0.3 to 1.0mm.
- Although the utilization of film gates and ring gates is possible, they are not commonly used in LCP molding.

Figure 4-3-7 Gate Diagram



Draft Angle

- The ideal draft angle is : 0.5° (1/90) to 1° (1/60) for thin-walled moldings; and 1° (1/60) to 2° (1/30) for thick-walled moldings.
- Using MR grades, moldings can be released from tool easier than general grades. The releasing force with MR grades is nearly the half of that with general grades. However, draft angle must be enlarged when moldings have greater depths.

Air Venting (Gas Drainage)

- As SUMIKASUPER LCP is often molded under high-speed injection molding conditions, the installation of mold air venting is recommended, in order that the air remaining in the mold can be discharged effectively.
- When welds occur in thin-walled products or at the ends of the flow, short shots defect tend to occur and weld strength will be insufficient. Therefore, it is recommended that air venting be installed to remedy this problem.
- SUMIKASUPER LCP has low melt viscosity and excellent flowability. However, as solidification occurs extremely rapidly, flash defect will not occur easily, even with the installation of air venting.
- The recommended depth for air vents ranges from 0.005 to 0.02mm.

Applying Hot Runner

During long-term continuous molding, resin can remain in dead spaces inside the molding machine, and the remaining resin may deteriorate or become colored. LCP can easily remain in such dead spaces since it has an extremely low melt viscosity. Therefore, when applying hot runners, it is necessary to pay sufficient attention to prevent black spots and cold slag caused by resin retention.

Points to be noted When Applying Hot Runners to SUMIKASUPER LCP

When selecting a hot runner for SUMIKASUPER LCP, please take note of the following points.

- The system must be capable of producing high levels of heating with a uniform temperature distribution.
  Heater integrated type is preferable. The manifold and nozzle temperatures should not be maintained too high.
  The areas coming into contact with the mold (gate areas) must be maintained at high temperatures.

Table 4-3-1 Temperature Specifications of Hot Runner

	Temperature specification of hot runner (MAX)
E6000HF series	up to 370°C
E6000 series	up to 380°C
E4000 series	up to 400°C
E5000 series	up to 420°C

- The hot runner design must be as free as possible from dead space within the flow channels.
  (To avoid the generation of black spots due to the long time retention of resin in the dead space.)
  External heating should be used, rather than internal heating, and the use of narrower flow channels will help to reduce the creation of dead space.
- The hot runner should be designed such that cold slag cannot easily contaminate into the hot resin.
  (To avoid the contamination of cold slags into the molded products.)
  When using open gates, it is recommended that the installation of sub-runners be considered (sprue-less molding).

Application of Hot Runners to SUMIKASUPER LCP

Table 4-3-2 Application of Hot Runners to SUMIKASUPER LCP

		Runner part		Gate seal			Application to SUMIKASUPER LCP		Remarks
		Internal heating	External heating	Open	Valve Gate	Thermal seal	Full hot runner (runner-less)	Sprueless molding	
JU-OH INC. 614 System		-	✓	-	-	✓	-	G	φ4 Electromagnetic induction heating
DMK JAPAN Inc. Mini Runner		-	✓	✓	-	-	B	A-E	*1
SEIKI Corp. Spear System	Type B (conventional)	✓	-	-	-	✓	B	B	
	EH Type	-	✓	-	-	✓	B	G	*2
Mold-Masters Corp Ltd. Master shot		-	✓	✓	✓	-	B	A-G	
FISA Corp. Plagate System		-	✓	-	-	✓	B	A	

E = Excellent : Application examples to SUMIKASUPER LCP are available.
G = Good : Applicable to SUMIKASUPER LCP.
A = Average : There are no examples of application to SUMIKASUPER LCP.
B = Bad : Not applicable to SUMIKASUPER LCP
*1 : When using multiple gates and extension nozzles for a sub-runner,it is better to control the temperature of each extension nozzle individually. It is also good to control the temperature of each nozzle individually for the molding of E5000 series which require high molding temperature.
*2 : Internal heating system for chip part

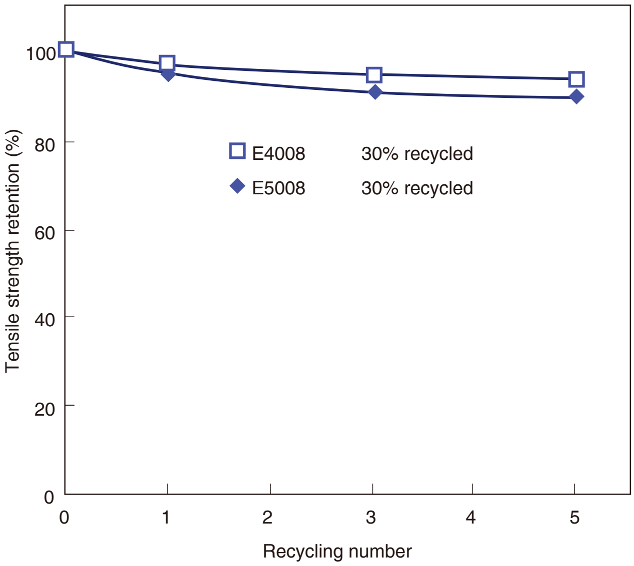
4-4 Use of Recycled LCP

SUMIKASUPER LCP shows excellent thermal stability when molding is performed under proper molding conditions, and it is able to retain its physical properties even after repeated recycling.

Changes in Properties When Recycled Materials are Mixed

For representative grades of SUMIKASUPER LCP, changes in properties were evaluated when the use ratio of recycled materials and their recycling number were varied. (see Figure 4-4-1 ,4-4-2 and Table 4-4-1) The use of recycled materials slightly degrades the properties of SUMIKASUPER LCP, but they are not degraded significantly even when the recycling number of recycled materials is increased.
When using recycled materials, it is necessary to carefully manage the quality of the recycled materials. In addition, the ratio of recycled materials to be used and the limit on the recycling number should be determined based on the required characteristics and quality of the molded products.

Figure 4-4-1 Relationship between the Number of Recycling and Tensile Strength Retention



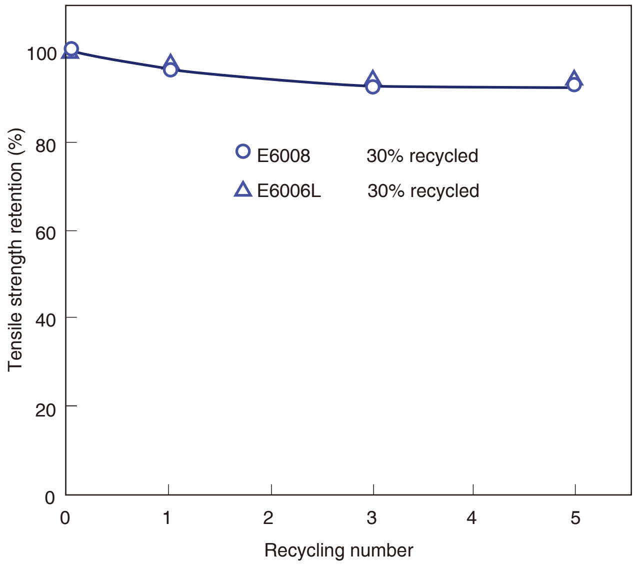
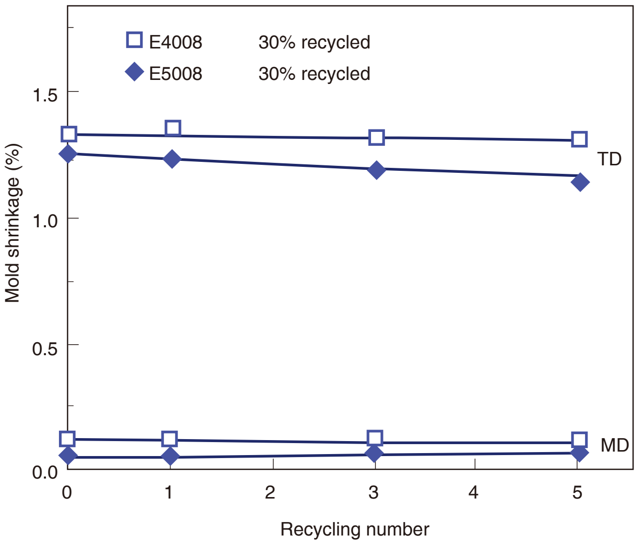


Figure 4-4-2 Relationship between the Number of Recycling and Mold Shrinkage



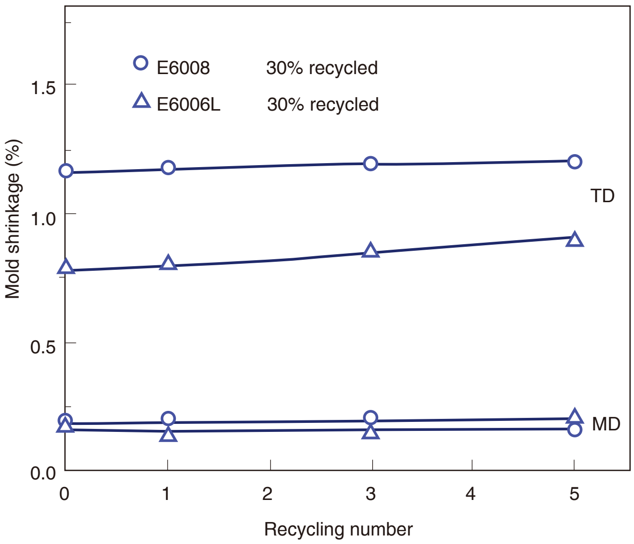


Table 4-4-1 Property retention rate of SUMIKASUPER LCP relative to virgin materials when the use ratio of recycled materials is 50%.

Unit : Retention (%)

		Test method	E6007LHF		E6807LHF		E6808UHF		SZ6505HF	
			50% 3 times recycled	50% 7 times recycled	50% 3 times recycled	50% 7 times recycled	50% 3 times recycled	50% 7 times recycled	50% 3 times recycled	50% 7 times recycled
Tensile strength		ASTM D638	99	99	94	96	100	98	91	95
Tensile elongation		ASTM D638	97	97	97	99	100	94	88	92
Flexural strength		ASTM D790	99	98	98	99	97	99	99	99
Flexural modulus		ASTM D790	99	99	100	99	98	99	99	99
Izod impact strength	Unnotched	ASTM D256	99	99	100	96	96	89	100	100
DTUL	1.82MPa	ASTM D648	98	98	99	99	98	99	99	100

Property Retention of SUMIKASUPER SV6808THF When Recycled Material Ratio Is Changed

Test Method
- Injection molding conditions : Resin temperature 350°C, Mold temperature 130°C
- Recycling method : The molded product is crushed in a pulverizer to produce recycled material.
- Use ratio of recycled material : 25, 50, 70, 80, and 100% (Uniformly mixed with virgin material)
- Number of times materials are recycled (Recycling number) : 1 to 3 times

Table 4-4-2 Property retention rate of SUMIKASUPER SV6808THF
when the use ratio of recycled materials and the recycling number are varied.

Unit : Retention (%)

		Test method	Virgin	25% 1time	25% 3times	50% 1time	50% 3times	70% 1time	70% 3times	80% 1time	80% 3times	100% 1time	100% 3times
Specific gravity		ASTM D792	100	100	100	100	100	100	100	100	100	100	100
Mold shrinkage rate(*)	MD	Internal	0.22	0.22	0.22	0.22	0.21	0.22	0.21	0.22	0.21	0.21	0.21
	TD		0.56	0.56	0.56	0.58	0.57	0.58	0.58	0.58	0.58	0.59	0.59
Tensile	Strength	ASTM D638	100	98	100	96	96	96	95	93	88	92	85
	Elongation		100	102	103	99	96	97	96	94	94	96	82
Flexural	Strength	ASTM D790	100	100	102	99	99	100	96	96	91	96	88
	Modulus		100	101	101	102	101	100	101	101	101	101	100
Izod impact strength	Unnotched	ASTM D256	100	101	98	96	94	95	81	90	77	95	63
DTUL	1.82MPa	ASTM D648	100	99	99	98	99	97	98	98	97	97	96
	0.45MPa		100	99	100	99	99	99	98	99	97	98	96
Blistering temperature		Internal	100	100	104	104	104	104	100	100	100	100	100
Thin-wall flow length 100MPa	0.1mm	Internal	100	100	104	104	104	105	113	102	111	109	118
	0.2mm		100	99	101	104	106	104	111	105	114	109	122
	0.3mm		100	100	105	108	110	108	117	108	124	111	133
Thin-wall flow length 150MPa	0.1mm	Internal	100	103	102	106	102	108	111	107	107	109	113
	0.2mm		100	100	102	103	106	102	107	104	111	106	120
	0.3mm		100	102	103	105	106	104	110	106	112	108	118
Thin-wall flexural strength	0.1mm	Internal	100	96	95	99	101	99	95	98	99	94	97
	0.2mm		100	101	99	98	96	97	93	98	93	95	89
	0.3mm		100	98	101	107	104	103	100	102	95	100	82

*Mold shrinkage is measured on a 64mm x 64mm x 3mm flat test piece.

TECHNICAL NOTE

Ultra-High Heat Resistant Engineering Plastics

SUMIKASUPER™ LCP

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