

Polyacetal copolymer

Dupital[™]

Molding Guide



GLOBAL POLYACETAL

Injection molding of Iupital

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The in-line screw type is the most common forming machine of the Iupital.

1.1 Molding machine selection from injection barrel capacity

The injection barrel volume Q (gr) of the molding machine is preferred to have a 1-shot weight W (gr) including the weight of the sprue and the runner within the following ranges.

$$Q = (1.3 \sim 1.5) \times W$$

If the injection barrel capacity is too small, plasticization may not take place in time, and Iupital is sent to the screw tip before it is sufficiently plasticized/melted. Due to this, the original physical properties may not be obtained as a molded article.

Conversely, if the injection barrel capacity is too large, the residence time in the cylinder becomes long, and the resin can decompose.

The inline screw type is the most common type of molding machine for Iupital.

1.2 Molding machine selection from mold clamping pressure

Either a toggle type or a direct pressure type may be used for molding of Iupital.

Relationship between the projected area of the molded article A (cm²) and the required mold tightening force P (tons) are preferably be in the range given by the following formula:

$$P = (0.5 \sim 0.7) \times A$$

1.3 Nozzle structure

Open nozzles are common for the molding of Iupital.

As shown in Fig. 1.3-1, the nozzles of commercial injection molding machines include (A) open nozzles and (B) shut-off nozzles. In either case, temperature control is required.

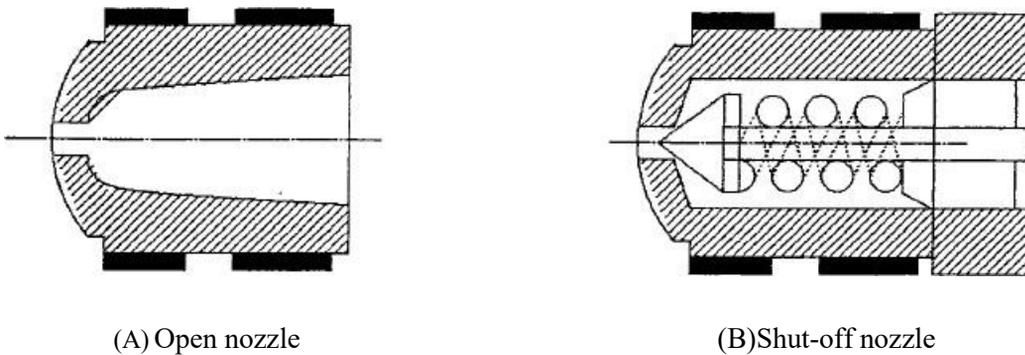


Fig. 1.3-1 Molding machine nozzle

A shut-off nozzle may be used if nozzle tar (drooling) from the nozzle is a concern. However, caution should be exercised because Iupital may stay in the sliding part of the nozzle and cause silver streaks and burning.

1.4 Injection mechanism

The molding machine with the fundamental function of "one-speed, two-pressure" (injection speed constant, injection pressure two-stage control) is sufficient for molding Iupital. However, when molding products with complex dimensions, appearance, and moldability (fluidity, mold releasability), it is best to have program control which can control injection speed and injection pressure.

1.5 About the check ring

In the molding of Iupital, the check ring is indispensable for the screw because the melt viscosity of Iupital is relatively low.

If the check ring is damaged by wear or corrosion etc., the resin in the cylinder during injection (*holding pressure*) flows back to the hopper side. This results in the cushion amount not being maintained, the injection pressure (*holding pressure*) is not effectively applied to the cavity. In such a case, a properly molded article cannot be obtained. Therefore, it is necessary to always pay attention to the cushion amount at the time of molding and its stability in terms of maintenance and management.

The check ring does not require a special type of anti-corrosion and anti-abrasion steel, however it is desirable to use a type of anti-corrosion and anti-abrasion steel when using fillers such as glass fiber, carbon fiber, or other resins that can generate corrosive gases.

1.6 Peripherals

1.6.1 Material drying

Although Iupital can be molded without pre-drying, drying at 80-90 °C for 3-4 hr. is best for reducing mold deposits. Improved surface appearance is needed. This is especially true in composite systems of Iupital in which various fillers are added. Hygroscopicity of the fillers may affect Iupital physical properties and appearance, making pre-drying necessary. Drying is sufficient in a shelf stage type dryer or a hopper dryer, and may not require a dehumidifying or desiccant type dryer.

1.6.2 Mold temperature control

In order to obtain a molded article with stable dimensions and physical properties, the mold temperature regulation of the Iupital requires the ability to quickly remove the amount of heat that the resin brings into the mold during molding and to keep the mold temperature consistent.

As a mold temperature control system, there is a method shown in Table-1.6-1.

Table-1.6-1 Mold Temperature Control System

Method	Adaptation to polyacetals
Hot water circulation type	It is most commonly used in polyacetals. Note descaling in the flow path after prolonged use.
Pressurized hot water circulation type	Used when mold temperature is 90 ° C. or higher.
Heated oil circulation type	Used when mold temperature is 90 ° C. or higher.
Cartridge Heater	Improper because it is impossible to prevent too high mold temperature. It should be used for auxiliary heating.
Chiller	Effective in preventing localized overheating of cores and other molds.

Which system is to be selected may be selected in consideration of the required quality of the product, workability, relation with die design, etc., but cartridge heater is not generally appropriate.

1.6.3 Local exhaust ventilation system

Dupital is a resin with excellent thermal stability, and although there is no concern under normal molding conditions, formaldehyde is generated by thermal decomposition under some conditions. Formaldehyde is a gas that is highly irritating to the eyes, nose, and throat, and its emission is known by the pungent odor. It is said that this smell is generally felt by 0.2~0.3ppm, although there are individual differences.

Concerning working environmental levels, the American Conference of Governmental Industrial Hygienists and the Japan Society of Governmental Industrial Hygienists recommend "0.1ppm or less." Therefore, it is recommended that formaldehyde levels in workplaces such as in the vicinity of molding machines be controlled to be as low as possible, keeping the levels below 0.1ppm. For this reason, it is necessary to examine the installation of local or whole ventilation equipment, etc. in the molding factory.

In addition, a detector tube for formaldehyde can be used for concentration measurement.

2.1 Pre-drying

Figure 2.1-1 shows the relationship between the drying temperature and drying time of the standard grade of Iupital and the water absorption rate. Iupital has a low water absorption rate and can be molded without pre-drying if it is immediately after opening. 80°C - 90°C and 3 -4 hours of pre-drying are desirable when reducing mold deposits and emphasizing surface appearance.

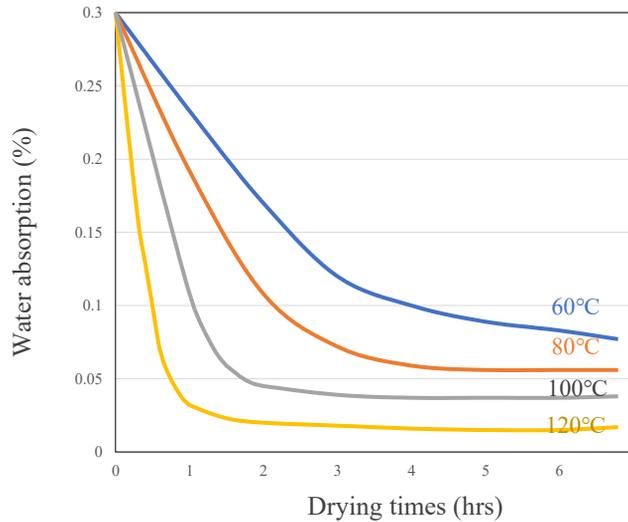


Figure 2.1-1 Relationship between drying time and water absorption

2.2 Resin temperature

Table 2.2-1 shows typical grades of Iupital at standard cylinder temperatures. Since the flow of Iupital is less dependent on the resin temperature, the flow length does not grow as much as expected even if the resin temperature increases. Higher resin temperature may also induce thermal decomposition, which may lead to an increase in mold deposits and the generation of silver streaks. Conversely, if the resin temperature is too low, crystals of Iupital may be injected before plasticizing and melting, and sufficient physical properties of the molded article may not be obtained. Due to this a set temperature of 160 - 170 ° C is required at a minimum for injection molding of Iupital.

TABLE-2.2-1 Standard molding conditions for each grade of Iupital (unit: °C)

Grade	Nozzle	Cylinder front	Central part of the cylinder	Rear of the cylinder
Standard grade	180 ~ 210	190	180	170
Weather-resistant grade		190	180	170
FG,MF,FB		200	190	180
FC		200	190	180
FT		190	180	170
LO,FX,WA		190	180	170
ST		190	180	170
FU*		190	180	170
ET**		190	180	170
TC		190	180	170

FU*:Recommended mold temp 40°C or less

ET**:.Injection velocity is low

2.3 Injection pressure

Injection pressure is considered to be divided into filling pressure and holding pressure. The filling pressure is generally set higher than the holding pressure. In the case of crystalline resin such as Iupital, holding pressure is applied after the mold cavity is filled to compensate for this shrinkage. It forces additional melt into the cavity as the resin cools and solidifies, ensuring a complete and dense part. Increasing the holding pressure is effective for the elimination of hike and voids, but if it is increased too much, burrs may be generated, and care is required.

2.4 Injection speed

For thin-walled molding and multiple cavity molding with need for dimensional accuracy, higher injection speed is better. Conversely, in a molded article having a large wall thickness, it is better to have lower injection speed. Control of injection speed is also useful for the elimination of jetting and float marks.

2.5 Mold temperature

The mold temperature of Iupital is generally 60-80°C, which is an important point among molding conditions. Molding at a mold temperature of 20- 30°C is also possible for high-cycle molding with a chiller, etc., however there is a danger of warpage due to residual strain in the molded product, and dimensional change due to the operating environment temperature and post-shrinkage with time.

When dimensional stability and surface gloss under a high temperature environment are required, raising the mold temperature to 120°C is effective.

2.6 Molding cycle

2.6.1 Configuration of the molding cycle

The general configuration of the molding cycle is as follows:

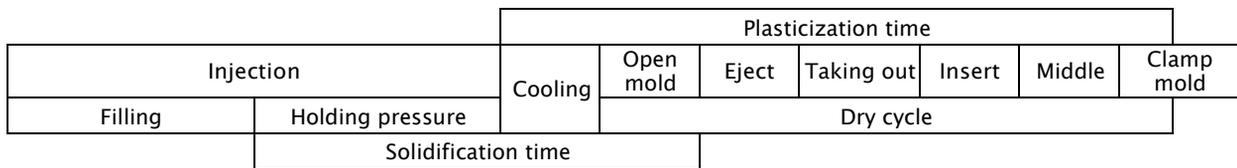


Fig. 2.6-1 Forming cycle configuration diagram

$$\underline{\text{Molding cycle}} \geq \underline{\text{filling time}} + \underline{\text{solidification time}} + \underline{\text{dry cycle time}}$$

2.6.2 Injection speed (filling time, holding time)

Although there are various methods of setting up a molding machine, best practice is considered the following.

$$\text{Injection time (filling time + holding pressure time)} > \text{gate freeze time}$$

Gate freeze time is the time at which the resin at the gate stops flowing and solidifies. As shown in Fig. 2.6-2, the gate freeze time can be regarded as the injection time at the position where the weight of the molded product becomes constant when the injection time is extended. If the holding pressure is increased before gate freeze, the melted Iupital flows back from the gate, and the variation in dimensions and physical properties increases. This often causes warping, hives (*surface imperfection*) and voids.

Gate freeze time can be determined by measuring the molding weight with varying injection time.

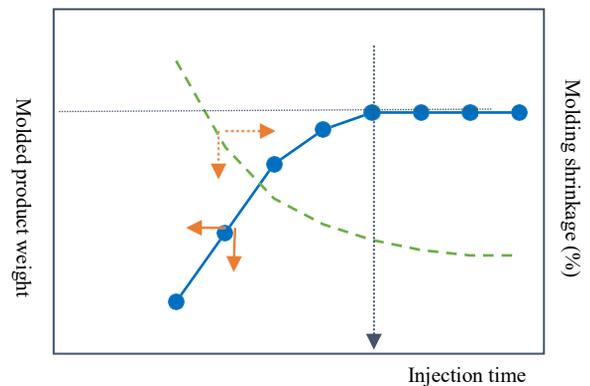


Fig. 2.6-2 Gate sealing time

2.6.3 Plasticization time

If the plasticization time is longer than the minimum required cooling time, the molding cycle will be longer. In such a case, it is preferable to increase the screw RPMs, or to shorten the plasticization time using a molding machine that has a larger barrel size. Some molding machines can plasticize even after opening the mold by a combined operation.

2.6.4 Cooling time

The time required for cooling is the shortest time that the Iupital solidifies after the completion of the holding time and the molded product can protrude without deformation. The cooling time depends on the wall thickness and draft angle of the molded product, the holding pressure, and the mold temperature.

Figure 2.6-3 shows the results of calculating the cooling time required between the thickness of the molded product of Iupital and the mold temperature.

From the figure, it is possible to estimate the cooling time during the molding cycle by determining the time required for solidification of the thick portion of the molded product, which is the rate-determining factor of the molding cycle.

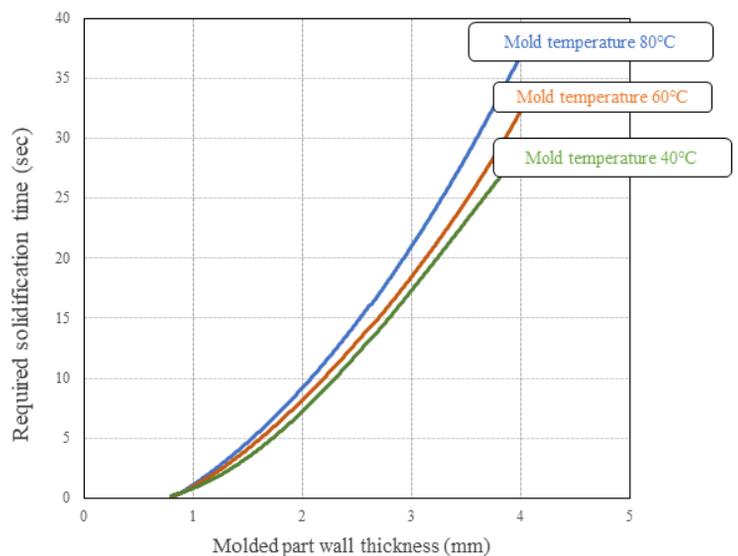


Fig. 2.6-3 Molded product wall thickness and solidification time
(Standard grade, resin temperature: 200°C)

2.6.5 Dry cycle

Dry cycle is a total time such as opening and closing time of dies, ejection time of products, ejection time and intermediate time (*standby time*). These times are determined by the molding model, the shape and mold system of the product, and the structure, vary depending on the conditions of each molding.

2.7 Starting and ending the molding operation, interrupting the operation, and replacing the material

2.7.1 Material exchange

When the Iupital in the barrel is replaced with other materials (*materials that may degrade at the molding temperature of the Iupital, materials that may cause the Iupital to decompose, or materials that differ greatly in the molding temperature*), and vice versa, it is desirable to purge with polyethylene or polystyrene with a wide molding temperature between the materials.

2.7.2 Work interruption/disassembly and cleaning

When the molding operation is interrupted, it is advised to hold the barrel temperature as 150 ° C. or less to prevent contamination of degraded material.

In addition, it is necessary to purge with another resin when stopping the molding operation for a long period of time. Polyethylene or polystyrene may be used as the purge and replacement material.

In the barrel a decomposed resin layer is formed during a long molding operation time. This resin layer is gradually carbonized.

Since the carbonized layer in the barrel gradually thickens, decomposes and can become mixed into the molded article. When this happens, it is advised to purge and clean the barrel.

2.8 Safety precautions

Avoid heating Iupital to a high temperature of 230°C or higher, or keeping Iupital in a injection molding machine barrel of 200°C or higher for a long period of time. If Iupital, as with other polyacetals, is allowed to stand for a long time at a temperature above its melting point, partial decomposition can occur causing formaldehyde gas to escape. It is necessary to provide a standard ventilation at the molding machine. If the Iupital is overheated by mistake, it is necessary to reduce the barrel temperature, purge the barrel, and put the superheated Iupital directly into a water bath so that gas does not escape into the atmosphere of the work environment.

3.1 Dimensional accuracy (tolerance)

SPI dimensional tolerance table is used as a reference for typical dimensional tolerances of Iupital. Fig. 3.1-1 shows the SPI dimensional tolerance table. Be aware that in the case of a large number of samples the dimensional variation is greater than that of a single sample.

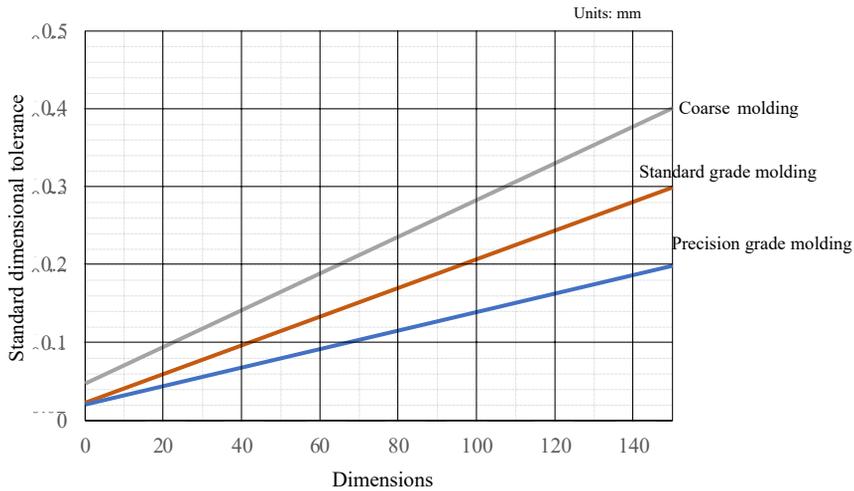


Fig. 3.1-1 Dimensional tolerance of Iupital

3.2 Dimensional Stability

In order to obtain a molded article having a stable dimension, it is necessary to set appropriate molding conditions. In the case of a crystalline resin like Iupital, special attention should be paid to the stability of temperature. The temperature here includes the mold temperature, the hydraulic oil temperature of the molding machine as well as the resin temperature, the molding environment temperature.

Iupital dimensionally varies depending on the mold temperature, but it is necessary for about 48 hours or more for post-mold shrink and stabilization. By determining the relationship between part weight and dimensions via preliminary testing, you can efficiently verify dimensional tolerance immediately after molding by simply measuring the part's weight.

3.3 Measures against molding defects

Table 3.3-1 shows the causes and countermeasures for the defective forming phenomena that occur in the molding of Dupital.

Table 3.1-1(1) Causes of defective phenomena and countermeasures

Defective phenomenon	Causes	Measures
Silver streak	<ul style="list-style-type: none"> Moisture in the pellets Air entrapment during plasticization Over-thermal decomposition of the resin (there is a localized heating or residence time in the cylinder or nozzle) 	<ul style="list-style-type: none"> Drying of pellets (80°C-90°C, 3-4 h). Higher back pressure and higher degassing during plasticization. Decrease the temperature of the overheated part. Clean the retention area or replace it with a part without a retention area.
Tarnish or burn	<ul style="list-style-type: none"> Thermal decomposition of resin Residence time is too long Air entrapped in the pellets 	<ul style="list-style-type: none"> Inspection of stagnation and mating sections of cylinders and nozzles Optimization of cylinder temperature Use of a molding machine with an appropriate injection capacity Increase the back pressure and the degassing effect
Localized discoloration or burning	<ul style="list-style-type: none"> Heat from trapped air due to poor mold venting 	<ul style="list-style-type: none"> Provide an air vent in the mold Reduced injection speed
Fouling point of the resin	<ul style="list-style-type: none"> Foreign substance or other resin contamination 	<ul style="list-style-type: none"> Cleaning the Hopper, Cylinder and Nozzle Precautions when storing resin and charging hopper
Dark brown or Black spots	<ul style="list-style-type: none"> Peeling of the decomposed resin coating formed gradually on the inner wall of the cylinder 	<ul style="list-style-type: none"> Reinforcement of cylinder purge cleaning before forming
Air bubbles on the surface or inside (voids)	<ul style="list-style-type: none"> The shrinkage during solidification of the molten resin is not supplemented by the holding pressure. Short shot 	<ul style="list-style-type: none"> Increase holding pressure Longer holding time (more than gate freeze time) Avoid clogging of the nozzle Reduce the wall thickness as much as possible Increase the gate thickness Confirm gate is located in the thick portion Confirmation of cushion amount
Burr	<ul style="list-style-type: none"> Shortage of mold clamping force Injection pressure too high Injection speed too high Wear of the mold Melt viscosity of the resin too low 	<ul style="list-style-type: none"> Increase in mold clamping force Reduction of injection pressure and holding pressure Reduced injection speed Repair or replace mold Change to higher-viscosity resin

Table 3.1-1(2) Causes and measures for poor molding

Defective phenomenon	Causes	Measures
Defective Release or deformation during release	<ul style="list-style-type: none"> • High ejection force is required. • Reduced pressure between the mold and the part • Ejection force is not making contact between the molded product and the mold • The molded article is not sufficiently cooled at the time of mold release 	<ul style="list-style-type: none"> • Reduction of injection pressure • Attach a punch taper pin • Improve the polish of the mold • Provide a device to break the vacuum in the mold. • Reduce the mold opening rate • Increase the protruding pin • Lower the mold temperature • Increase cooling period
Insufficient filling	<ul style="list-style-type: none"> • Cylinder temperature too low • Hold time too fast to solidify the runner • Mold temperature too low • Uneven filling of each cavity • Insufficient supply of molten resin • Inadequate venting in the mold 	<ul style="list-style-type: none"> • Cylinder temperature rise • Enlarging the runner size • Increase in mold temperature • Consider changing the flow path, gate balance, etc. • Increase shot size • Improvement of venting in mold (gas vent, etc.)
Wave and beat patterns on the part edges	<ul style="list-style-type: none"> • Resin temperature is low • Mold temperature is low • Injection pressure and holding pressure are low. • Injection speed is low • Insufficient resin flow 	<ul style="list-style-type: none"> • Increase in resin temperature and nozzle temperature • Increase in mold temperature • Increase in injection pressure and holding pressure • Improvement of injection speed • Improving the resin flow
Flow marks (jetting, cloudiness near the gate)	<ul style="list-style-type: none"> • The injected resin is cooling before the mold cavity is filled 	<ul style="list-style-type: none"> • gate size reduction • Reduced injection speed • Changing the gate position • Increase in mold temperature and resin temperature • Improving the flow of the resin
Weld lines	<ul style="list-style-type: none"> • Generated when molten resin merges at the flow tip • Venting failure in the mold 	<ul style="list-style-type: none"> • High-speed injection with high resin and mold temperatures • Increase the gate size • Provide a gas vent in the mold

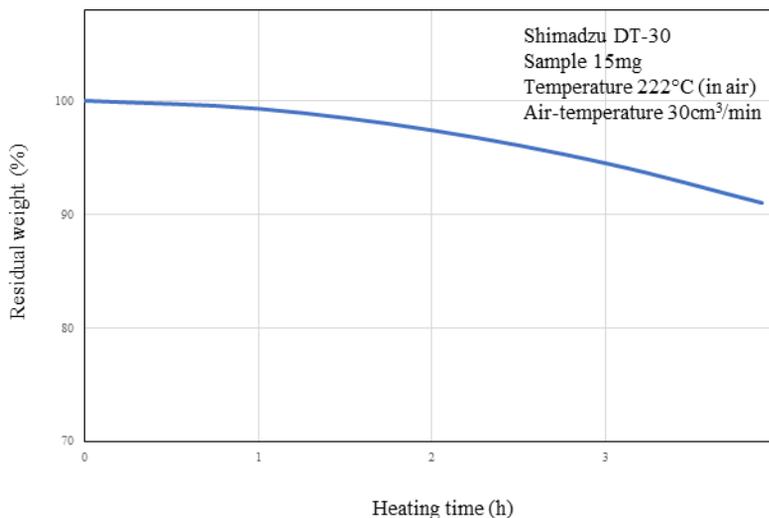
Table 3.1-1(3) Causes and measures for poor molding

Defective phenomenon	Causes	Measures
Wrinkles near the gate	<ul style="list-style-type: none"> • Gate is frozen before the cavity is completely filled 	<ul style="list-style-type: none"> • Expand the gate size • Examine the proper injection speed
Warping and deformation	<ul style="list-style-type: none"> • Uneven shrinkage of the molten resin • Uneven wall thickness of molded products • Uneven mold temperature • Uneven mold internal pressure • Anisotropy of molding shrinkage 	<ul style="list-style-type: none"> • Injection pressure and holding pressure increased • Ensure uniform mold temperature (<i>Number of cooling lines, and cooling line pattern</i>) • Uniform wall thickness of molded products and symmetrical design • Examination of appropriate injection speed • Extended hold time in the mold • Consideration of gate position and expansion of gate cross-sectional area

4.1 Thermal analysis

A TGA (*Thermogravimetric Analysis*) method for evaluating the thermostability of plastics has been developed to investigate the behavior of the weight-loss associated with the thermal decomposition of polymers at high temperatures. Show in Figure -4.1-1

From the weight-loss curve by TGA, it can be seen that the Iupital is excellent in thermostability.



Weight-loss properties (typical-grade) according to Fig.-4.1-1 TGA.

4.2 Residence discoloration

Figure 4.2-1 shows the color change characteristic curves for the residence time of Iupital in the molding machine. This is based on the case of continuous molding at a resin temperature of 190 ° C., showing the relationship between the resin temperature and the residence time when $\Delta E=2.0$.

※ The time-temperature at which the color difference changes by $\Delta E=2.0$ with respect to the color difference (ΔE) when molded at 190°C is shown.

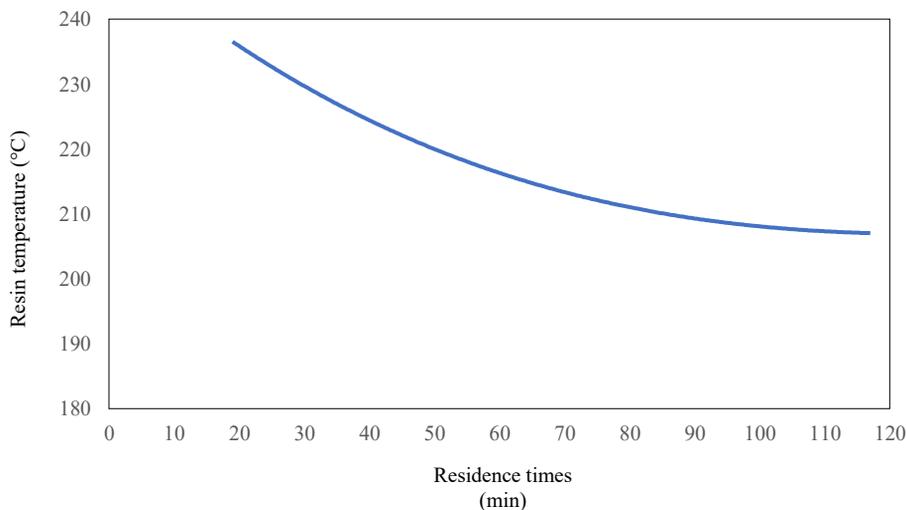


Fig. 4.2-1 Residual color change in forming machine (F20-03)

4.3 Regrind use characteristics

Iupital is capable of regrind (*recycling*) during molding because of its superior thermal stability. Changes in strength, molding shrinkage, and color of Iupital standard grades with regeneration rates of 100%, 50%, and 30% are shown in Figures 4.3-1 to 4.3-4. Even if regrind use is repeated for 10 generations at a rate of 100%, the deterioration of the physical properties is hardly observed, but the color tone and the molding shrinkage ratio are slightly changed. No change in strength, molding shrinkage, or hue was observed in the regrind use of 50% or less, and it is considered that the performance equivalent to that of virgin material can be retained.

However, attention should be paid to the possibility of contamination with foreign matter when using regrind. In addition, in the case of grades containing fillers, since the mechanical properties are greatly reduced due to the crushing of the fibers, regrind use is not recommended.

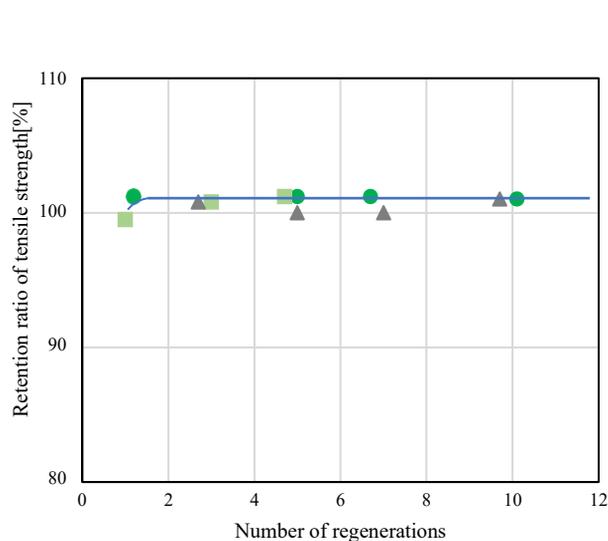


Fig. 4.3-1 Change in tensile strength

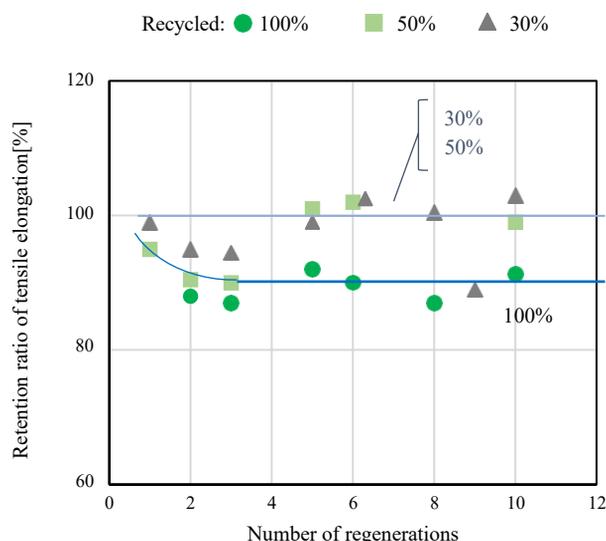


Fig. 4.3-2 Change in elongation at break

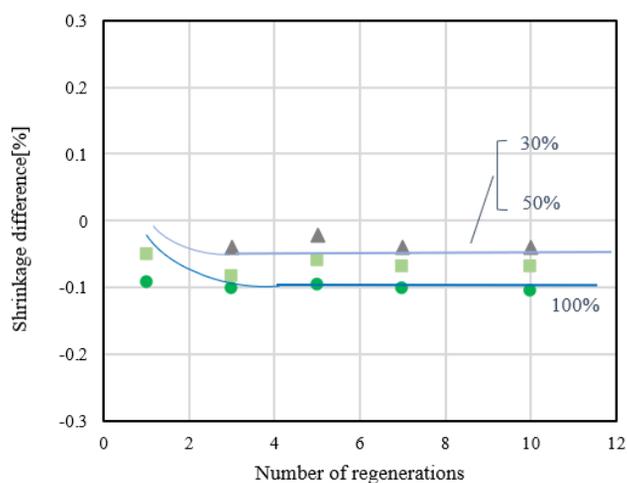


Figure 4.3-3 Changes in molding shrinkage ratio

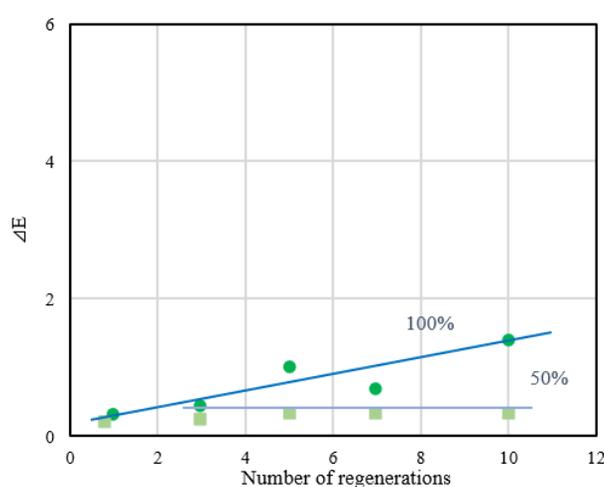


Figure 4.3-4 Color change

4.4 Mold deposit

Mold deposit (MD) refers to a contaminant adhering to a mold in forming. When a polyacetal (POM) resin is used, adhesion of a MD can take place. In this case, a phenomenon occurs in which dimensional accuracy cannot be obtained, mold release is poor, and surface-appearance is also poor.

4.4.1 MD generation factors

- (1) Bleed-out of an additive material in the POM adheres to the mold
- (2) Formaldehyde [HCHO] gases re-polymerize on the mold surface, Generates paraformaldehyde [HO(CH₂O)_nH].

4.4.2 Forming conditions and the tendency of MD to form

The formation and molding conditions of MD tend to be as follows, and the condition setting based on these is desirable.

(1) Resin temperature

Lower forms = less MD.

Table-4.1-1 Effects of Molding Conditions (Mold for MD Determination): F20-03

	Solids content	Gas content	Total
Molding conditions. 1	10	90	100
Molding conditions. 2	4	36	40

Molding conditions. Of the sum of 1 Relative value, which was set as 100 (Molding machine IS90B)

	Cylinder temperature	Injection speed
Molding conditions. 1	230°C	85%
Molding conditions. 2	195°C	50%

(2) Injection speed

Do not excessively increase.

※If the injection speed is excessively high, the air in the cavity is not vented in time, this promotes the formation of MD.

(3) Residence of resin in the cylinder

Shorter residence time= less MD is formed. Molding machine capacity avoids is too large for product weight. Avoid material retention in the resin cylinders.

(4) Mold temperature

Higher mold temperature = less MD is formed.

Table-4.1-2 Effects of mold temperature

	MD generation SHOT count
Mold temperature 25°C	Over 400
Mold temperature 90°C	1400 OK

- F20-03
- Undried
- Cylinder temperature: 230°C
- Injection speed: 85%

(4) Drying the resin

Drying should be done thoroughly because water promotes the formation of MD.

Table-4.4-3 Effects of pre-drying: F20-03
 ※Relative MD generation caused by forming

Resin drying conditions	Relative MD evolution
No drying (<i>water content about 0.4%</i>)	118
With drying (<i>water content about 0.0%</i>)	100

(relative value with total with drying set as 100)

4.4.3 Precautions for removing MD and storing molds

(1) Clean the mold frequently.

If MD is slightly stuck, it can be removed by wiping with a cloth.

(2) Do not store the mold before cleaning MD.

Especially during the period of high temperature and high humidity from the rainy season as rust generation is possible.

(3) If MD adheres

Scrub the mold with a non-damaging material such as bamboo vera, copper, or brass.

Metal polish is also effective.

Use of MD removers

(4) About MD removers

MD remover is sprayed onto the mold at the beginning of MD attachment to suppress the sticking.

5.1 Flow properties of Dupital and other resins

Fluidity of each grade of Dupital and other thermoplastics is shown in Figure 5.1-1.

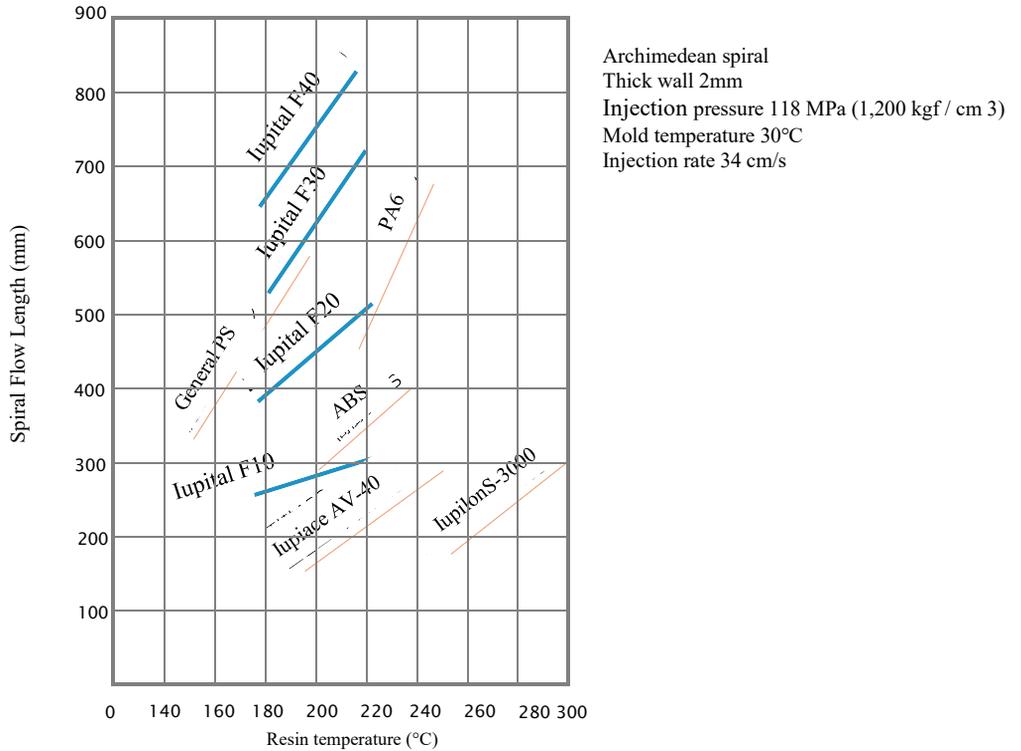


Figure 5.1-1 Liquidity of Dupital and other resin

5.2 Molded part wall thickness and flow length

Figure 5.2-1 shows the tendency of the flow length to change depending on the wall thickness of the molded article.

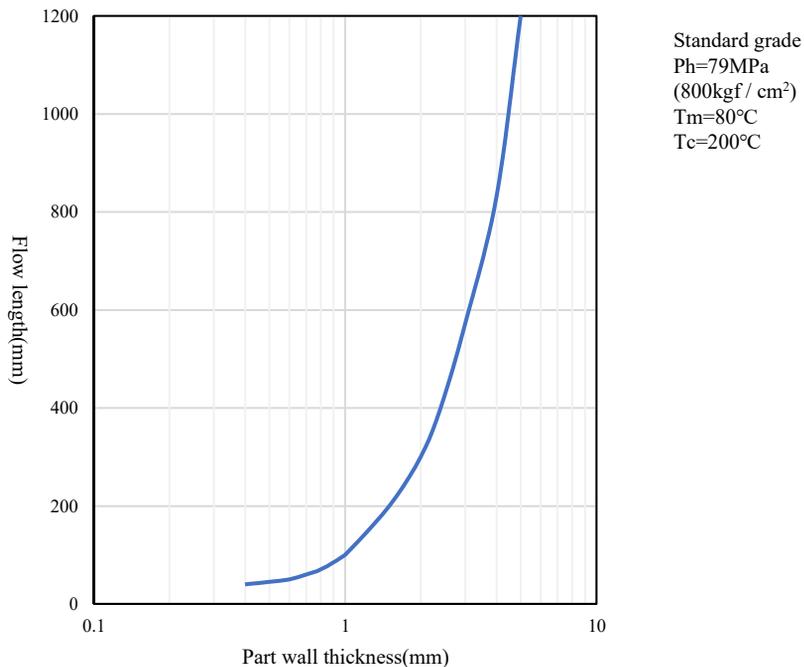


Fig. 5.2-1 Molded part wall thickness and flow length

5.3 Molding conditions and specific flow length

Flow length shows various trends depending on molding processing conditions. Below the relationship between the molding conditions and the flow length is shown as a specific flow length. Conditions for determining the specific flow length were based on the following.

Grades: F20-03

Injection pressure: 79Mpa(800kgf/cm²) Mold temperature: 80°C

Resin-temperature: 200°C Injection rate: 68cc/sec

Using the flow length under these conditions as a L0, the specific flow length L/L0 was obtained using the flow length L under various conditions.

As can be seen from the following results, the specific flow length shows a linear relationship with the injection pressure and resin temperature, and a curve relationship with the mold temperature.

5.3.1 Injection pressure

Figure 5.3-1 shows the relationship between injection pressure and specific flow length.

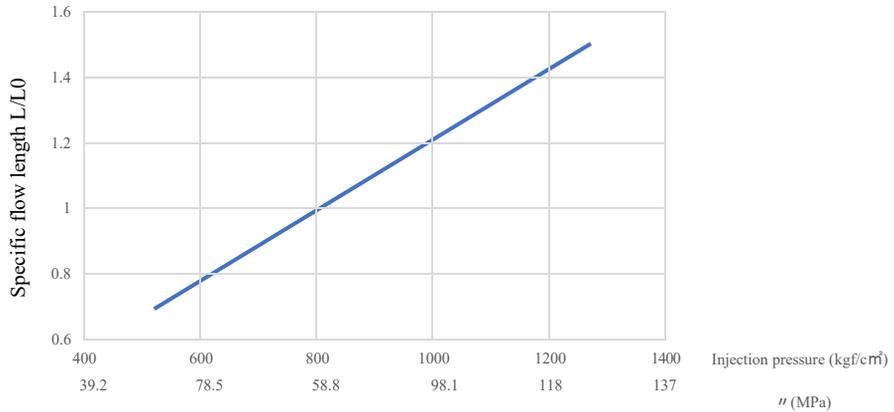


Fig. 5.3-1 Injection pressure and specific flow length

5.3.2 Mold temperature

Figure 5.3-2 shows the relationship between mold temperature and specific flow length.

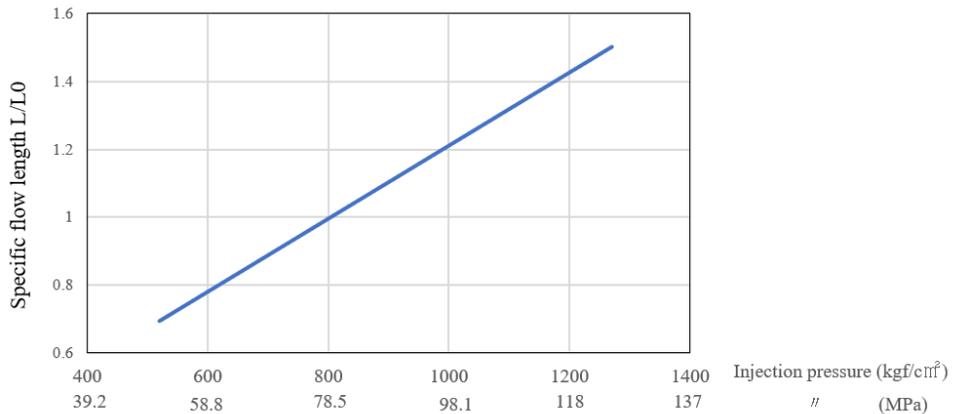


Fig. 5.3-2 Mold temperature and specific flow length

5.3.3 Resin temperature

The relationship between resin temperature and specific flow length is shown in Figure 5.3-3.

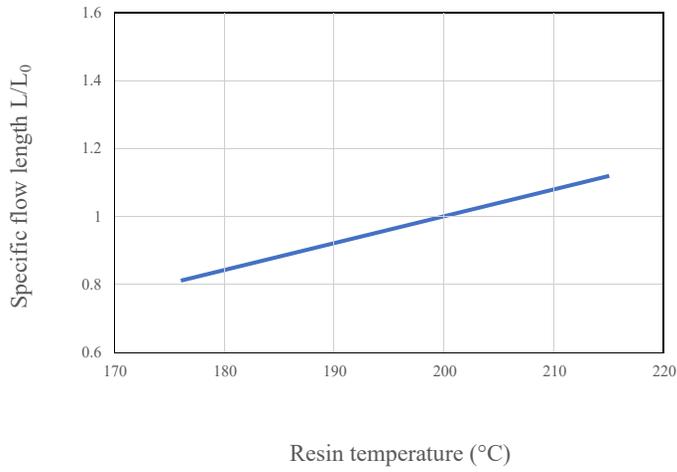


Figure 5.3-3 Resin temperature and specific flow length

6.1 Molding shrinkage

As a factors causing molding shrinkage, expansion and shrinkage due to heat, compression elastic recovery, change in specific volume due to change in crystallinity, orientation of molecules, can all be considered. Refer to Figure 6.1-1 for the relationship between specific volume and temperature of the Iupital standard grade. Since the molding shrinkage of Iupital, which is a crystalline resin, can greatly change in various factors as described above, it is important to account for shrinkage in mold design.

Molding shrinkage is affected by the shape (*wall thickness*), molding conditions (*injection pressure, injection time, mold temperature, resin temperature*), and mold structure (*sprue/runner size and gate shape*).

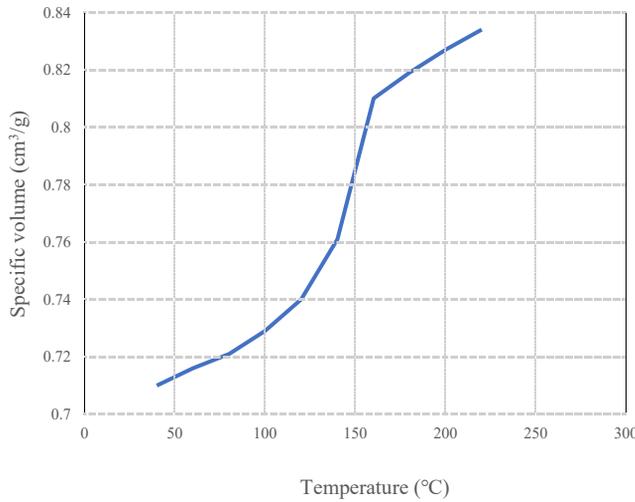


Fig. 6.1-1 Relationship between specific volume and temperature

6.1.1 Wall thickness and molding shrinkage

Molding shrinkage is highly thickness-dependent, with minimum shrinkage occurring between 2-3mm (Figure 6.1-2)

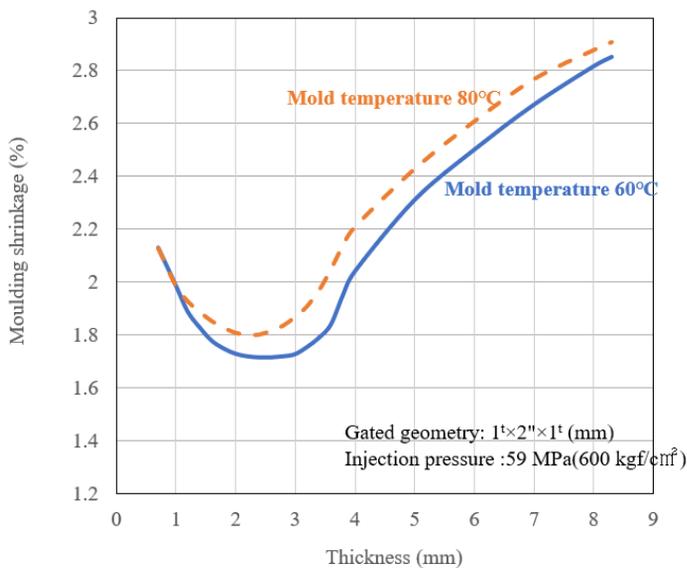
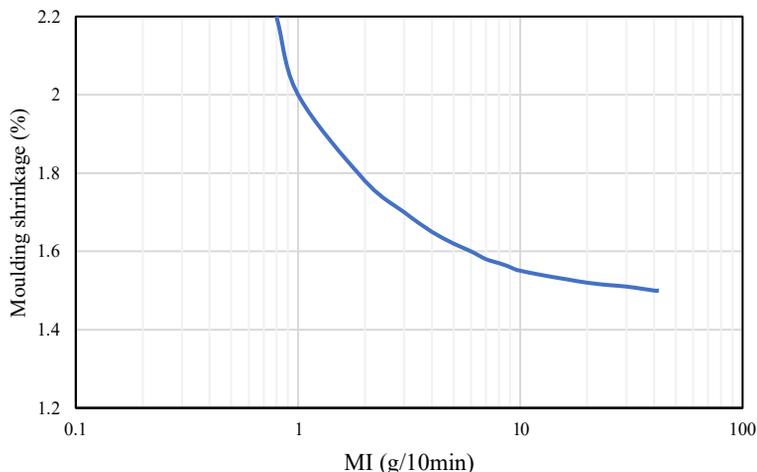


Figure 6.1-2 Molded article thickness and molding shrinkage ratio

6.1.2 Melt Index (MI) and shaping shrinkage

The relation between the change in MI and the shrinkage rate of the Iupital standard-grade is shown in Fig. 6.1-3.



Ph=78.5 (MPa)
Tm=80°C
Tc=200°C

Relation between-6.1-3 MI and the forming shrinkage rate

6.1.3 Anisotropy of molding shrinkage

The difference between the flow direction of molding shrinkage and the direction perpendicular to molding shrinkage is called the anisotropy of molding shrinkage. Anisotropy varies significantly by grade and requires careful consideration. Refer to Table 6.1-1 for Iupital grade-specific anisotropy values.

TABLE-6.1-1 Anisotropy (%) of shrinkage for each grade of Iupital

Grade	Flow direction //	Right angle direction	Anisotropy/ /
F10	1.8	1.8	0.0
F20	1.6	1.6	0.0
F30	1.5	1.5	0.0
F40	1.5	1.5	0.0
FV-30	1.5	1.5	0.0
FG2025	0.5	0.8	-0.3
MF3020	1.5	1.0	0.5
FB2025	1.3	1.3	0.0
FC2020D	0.2	0.6	-0.4
FC2020H	0.3	0.6	-0.3
FT2010	1.4	1.4	0.0
FT2020	0.8	0.8	0.0
LO-21A	1.6	1.6	0.0
FX-11	1.6	1.6	0.0
FL2010	1.6	1.6	0.0
FL2020	1.6	1.6	0.0
FU2025	1.3	1.3	0.0
FU2050	0.8	0.8	0.0
ET-20	1.1	1.1	0.0
TC3015	1.2	1.2	0.0
TC3030	0.9	0.9	0.0

Ph:78.5Mpa
(800kgf/cm²)
Tm:80°C
4in disk, 3mmt

6.1.4 Molding conditions and molding shrinkage

The molding shrinkage of the Iupital is also affected by the molding conditions. Below are the molding conditions that have a large effect on the molding shrinkage of Iupital.

① Injection pressure (holding pressure)

Relationship between molding shrinkage ratio and injection pressure (holding pressure) of Iupital shows the relationship as shown in Figure 6.1-4.

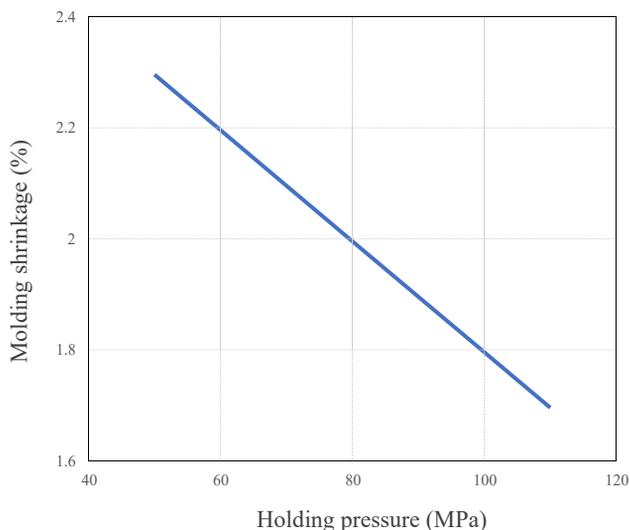


Figure 6.1-4 Relationship between molding shrinkage and holding pressure (standard grade)

② Injection time

As shown in Figure 6.1-5, the relationship between the molding shrinkage rate and the injection time of Iupital shows a near-proportional relationship until the gate solidifies, but after the gate solidifies, the molding shrinkage rate shows a nearly constant value.

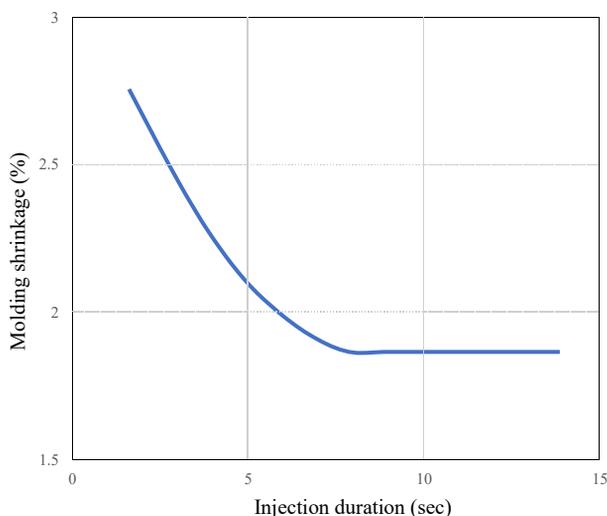


Figure 6.1-5 Relationship between molding shrinkage and injection time (standard grade)

③ Mold temperature

The relationship between the molding shrinkage ratio and the mold temperature of Iupital shows a proportional relationship as shown in Figure 6.1-6.

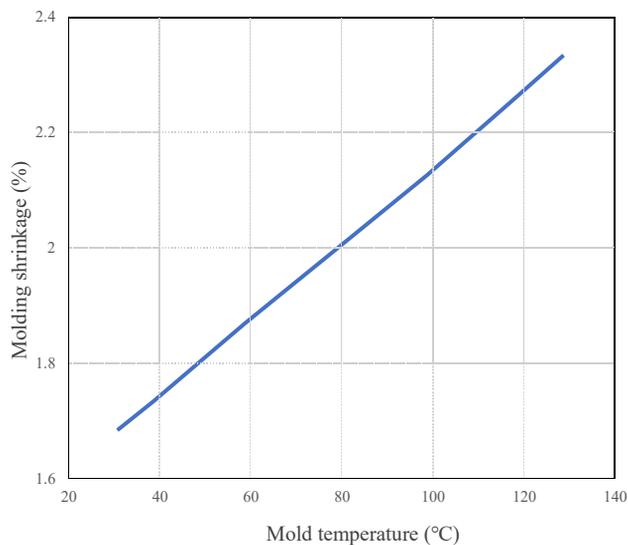


Fig. 6.1-6 Relationship between molding shrinkage ratio and mold temperature (standard grade)

④ Resin temperature

The relationship between the molding shrinkage ratio and the resin temperature of Iupital is shown in Fig. 6.1-7, but the effect is small compared with the mold temperature.

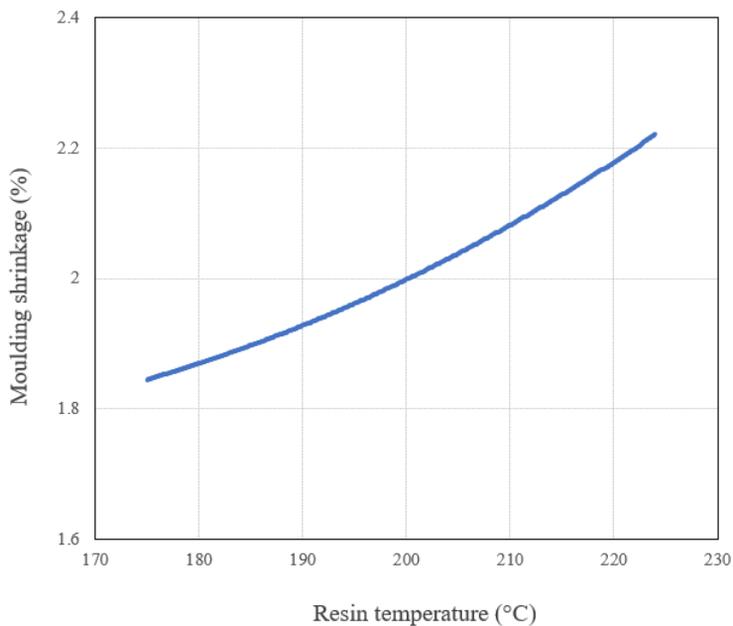


Figure 6.1-7 Relationship between molding shrinkage and resin temperature (standard grade)

6.2 Dimensional change by annealing

Crystalline resins like Iupital experience dimensional shrinkage due to recrystallization when heated (*annealing*). This shrinkage is highly sensitive to molding conditions, mold temperature, and heating time. Figures 6.2-1 to 6.2-6 detail heat shrinkage for Iupital standard-grade samples (70mmLx20mmWx t mm) under varying conditions (mold: 50-80°C, heat: 60-150°C, time: 30-120min).

©Effect of heating temperature and time on the shrinkage ratio

Mold temperature 50°C

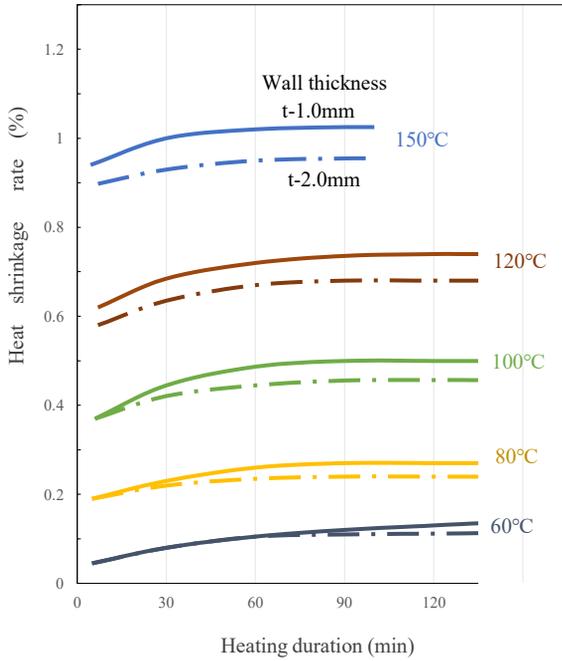


Figure 6.2-1

Mold temperature 80°C

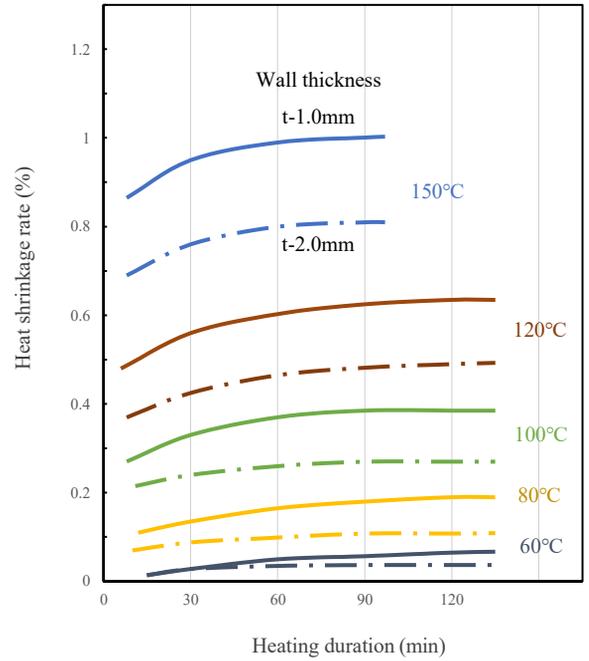


Figure 6.2-2

©Effect of Molded Wall Thickness of Heating Shrinkage Rate

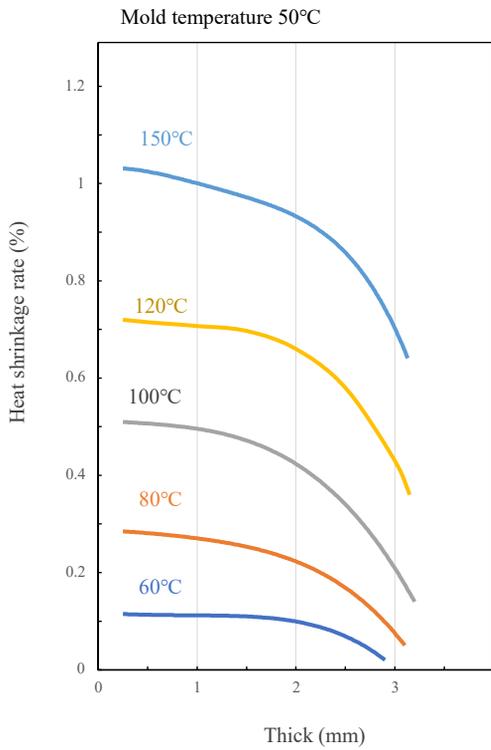


Figure 6.2-3

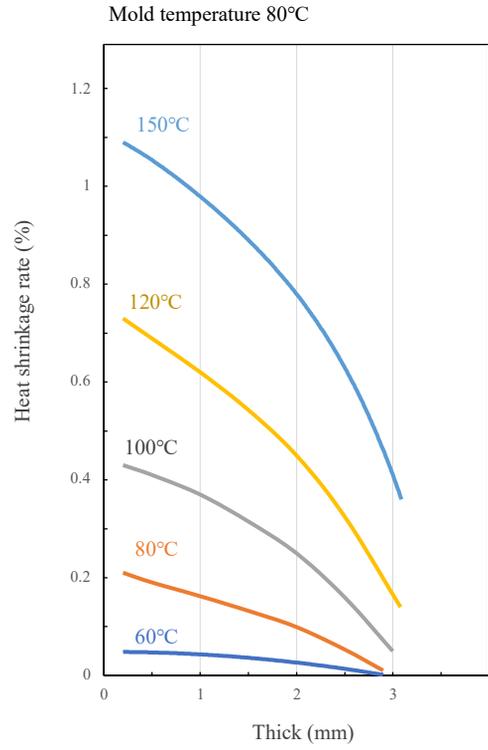


Figure 6.2-4

©Effect of heating temperature on the heat shrinkage ratio.

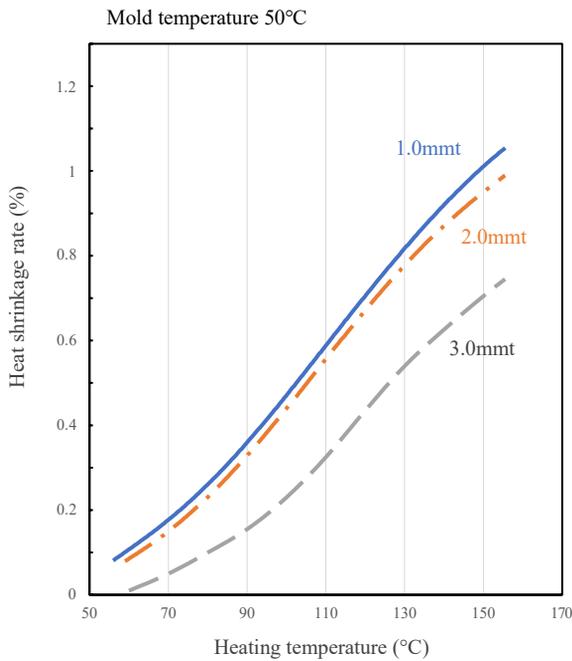


Figure 6.2-5

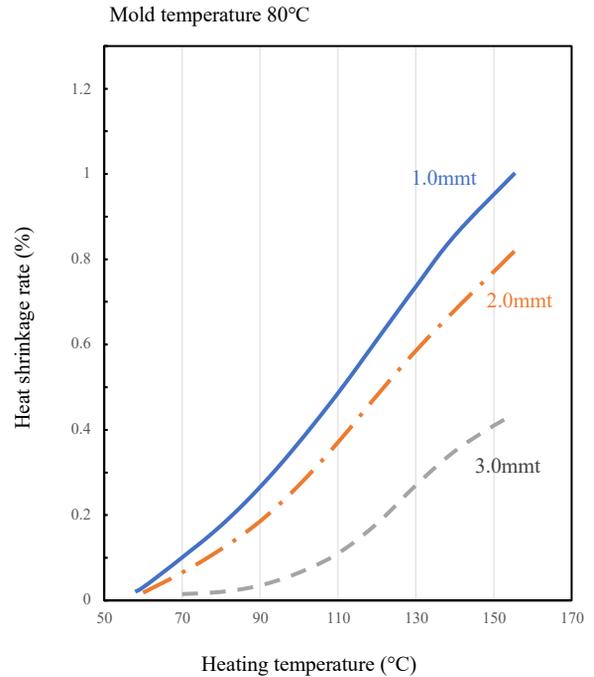


Figure 6.2-6

6.3 Time course of post-shrinkage molded product dimensions

Molded articles undergo dimensional shrinkage as crystallization progresses immediately after molding. Especially, when the mold temperature at the time of molding is low, dimensional change happens for a longer time. Figure 6.3-1 shows long-term dimensional change data for Iupital.

(Long-term shrinkage from immediately after molding by $\Phi 30$ disk)

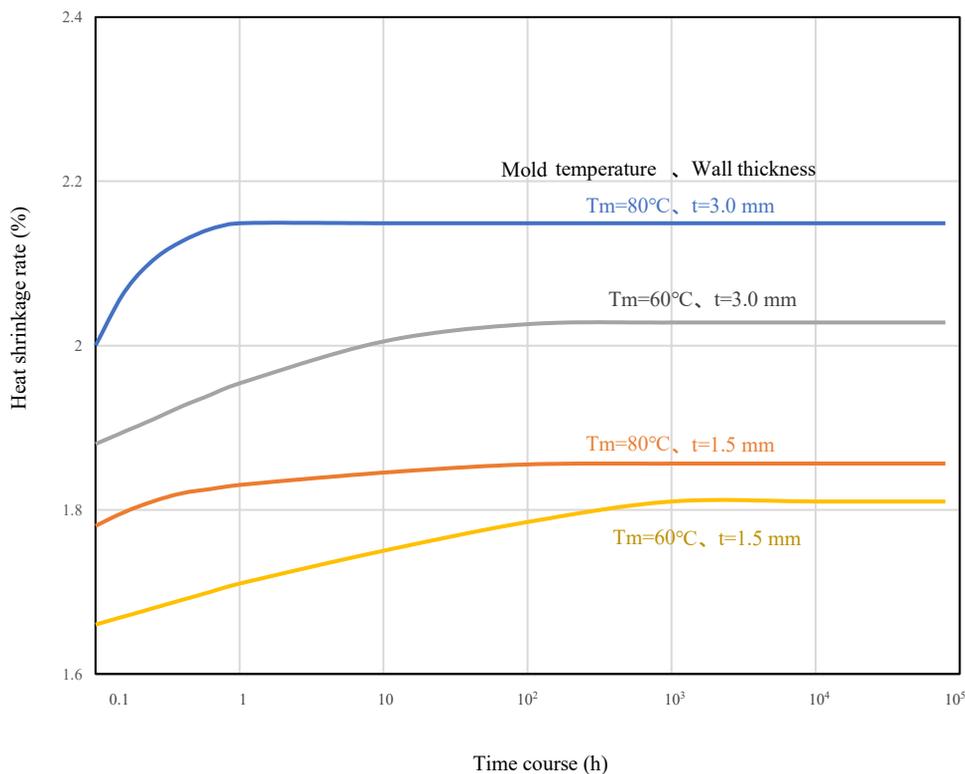


Fig. 6.3-1 Long-term dimensional change of Iupital (standard grade)

[Ref].

- Polyacetal Resin Handbook Nikkan Kogyo Shimbun, Inc.
- Basic plastic age for mold design
- Injection molding plastic age
- Nikkan Kogyo Shimbun, Mold for Injection Formation
- Introduction to Die Design Sigma Publication
- Plastic Mold Handbook Japan Synthetic Resin Technical Association