CHEMISTRY THAT MATTERS™

EXTEM™ RESIN PROCESSING GUIDE

DECEMBER 2022

CONTENTS

1. INTRODUCTION

1.1 INTRODUCTION AND PRODUCT SELECTION

SABIC's EXTEM™ thermoplastic polyimide (TPI) resins bridge the gap between extreme part performance and improved productivity facing current high-heat thermoplastics and thermoset materials.

This amorphous engineering resin provides the manufacturing productivity of melt processing by injection molding, extrusion, and others without requiring any post-cure or crystallization steps to yield maximum performance.

- True thermoplastic melt processability with ultra-high performance as molded
- No additional processing steps such as post-curing or similar needed to reach final product properties
- Glass transition temperatures up to 277°C
- Strong dimensional stability
- High strength, stiffness and creep resistance at elevated temperatures
- Inherent flame retardancy
- Outstanding flame, smoke and toxicity
- High limiting oxygen index

EXTEM resin's combination of high-end performance and easy processability changes the rules of the game for thermoplastic polyimides, opening new opportunities for these high performance resins in mainstream applications.

1.2 CHECK POINTS FOR SUCCESSFUL MOLDING

EXTEM™ resin is shear-dependent.

Treat it gently regarding

- Part design
- Tool design
- Molding machine (e.g. screw design)
- Processing conditions (e.g. screw speed, injection rate, etc.)

Drying

- EXTEM resins are hygroscopic
- Moisture content MUST be Below 0.02%
- Dew point controlled dryer or high temperature dehumidifying dryer capable of at least 175°C are recommended

Feeding

- Hopper dryer recommended to minimize exposure of dried resin to moisture which could lead to the resin's moisture content increasing

Screw design

- Use low shear screw: L/D = 20-25, CR = 2.0-2.3

Gates

- Use low shear gates whenever possible
- High shear gates (e.g. pin-gate) can potentially cause shear degradation
- If shear rates cannot be kept low, set injection speed needs to be as low as possible to minimize shear stress

1.2 CHECK POINTS FOR SUCCESSFUL MOLDING

Residence time:

- Compare actual shot volume (metering screw position) of trial mold with machine max shot volume (max metering screw position) to calculate total residence time.
- Best case scenario would be usage of 50-70% of barrel capacity per cycle to reduce residence time.
- SABIC generally recommends using a sloped cylinder temperature profile to reduce residence time < 4 minutes.
- If melt temperatures at the upper limit of the suggested temperature window are chosen, short residence time becomes even more critical to reduce overall thermal stress during processing.

Cylinder temperature:

- Check max cylinder temperature capability.
- Machine should be capable of reaching at least 420°C. Ceramic heater bands are suggested.

Mold temperature:

- Check tool temperature controller type (e.g. oil, water, electrical heater) and max temperature.
- Mold temperatures of 220°C will help minimize mold-in stress and post shrinkage.

Stops / Shutdown:

- For intermediate stops longer than 20 minutes, lower the barrel temperature to 200°C (392°F).
- When shutting down the machine, follow the procedures described in Section 5.

2. TOOLING

2.1 TOOL STEEL SELECTION

Tool Material Selection

The typical melt temperature of EXTEM™ resin is between 380 - 415°C.

The typical mold temperature is between 170 - 220°C.

The mold steel should have the below properties:

- High level of resistance to thermal shock and thermal fatigue
- Good strength at high temperature
- Excellent toughness and ductility
- Good machinability and ability to polish
- Excellent through hardening properties
- Good dimensional stability during hardening

Typical material selections are P21, A2, D2 or H13 (AISI) depending on total number of parts needed to be produced.

For a superior surface, 420, 440C or 630 stainless should be selected.

2.2 SPRUE DESIGN

Sprue Draft Angle and Locking

- The recommended draft taper angle is 3 ~ 5° (Fig. 2-1).
- Minimize sprue length as the diameter will otherwise become large at the bottom, increasing the overall cooling time and material waste.
- Locking design: Avoid designs requiring forceful ejection such as groove or undercut locking to avoid the occurrence of micro powder in optical applications.

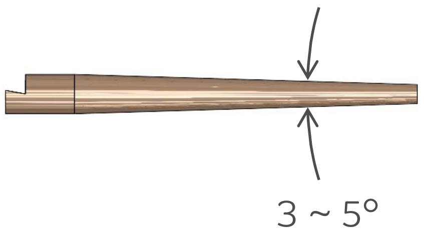


Fig. 2-1: Sprue draft angle

Sprue Polishing

- Fine polishing finish may be required for releasing from the bush.
- Sprue should be polished in draw direction (fine inside roughness results in good releasability otherwise the sprue can get stuck).

Sprue Diameter and SR

- Sprue minimum diameter and sprue bush R must be matched with molding machine.
- See Fig. 2-2

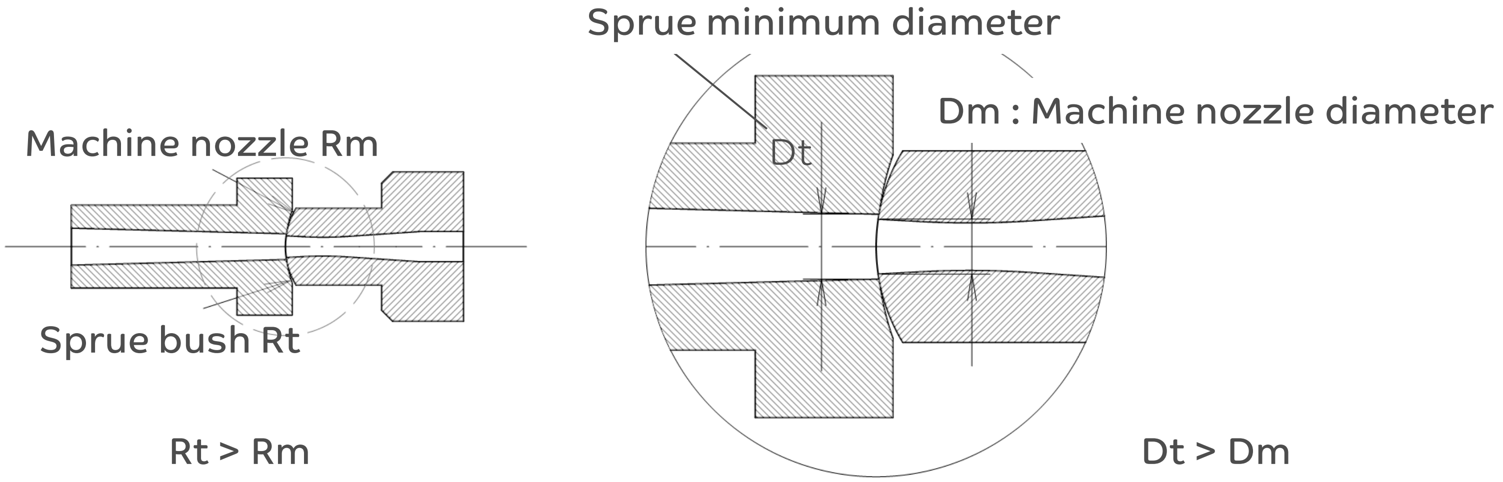


Fig. 2-2: Sprue diameter and R

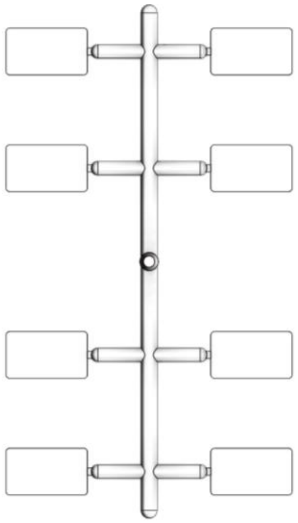
2.3 RUNNER FLOW BALANCING AND SLUG WELL

Equivalent Flow

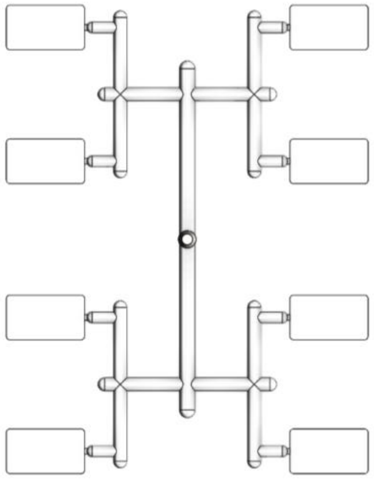
- When using multi-cavity molds, please make sure all runner diameters and flow lengths are equal.
- Fig. 2-3 is an example of multi-cavity molds.

Cold Slug Well

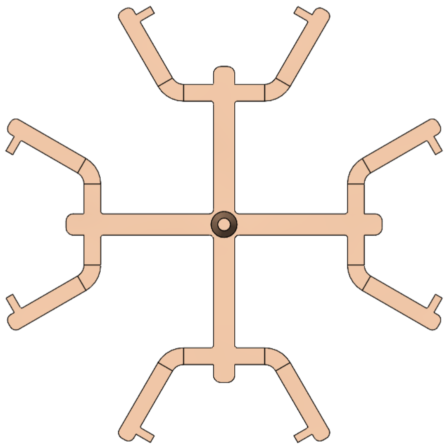
- To prevent the risk of gate splay or blush marks, a cold slug well must be set included (Fig. 2-4 and 2-5).



Not good



Good



Good

Fig 2-3: Equivalent flow runner layout

Fig. 2-4 : Not good

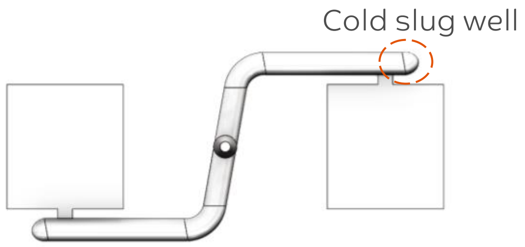


Fig. 2-5: Good

2.4 RUNNER DESIGN

Runner Cross-Section

- The inscribed circle indicates the area with better flow efficiency.
- The highest percentage of “(inscribed circle area) per (runner section area)” is the most favorable design.
- Figure 2-6 shows examples of runner cross sections:
  - The best is “full round” (a) although there could be a risk of mis-alignment as shown in (d)
  - The most practical runner cross-section is called modified trapezoid as shown in (b) and (c)
  - This has an ejection draft of 12 to 15° per side
  - Avoid using cross sections shown in (e) and (f)

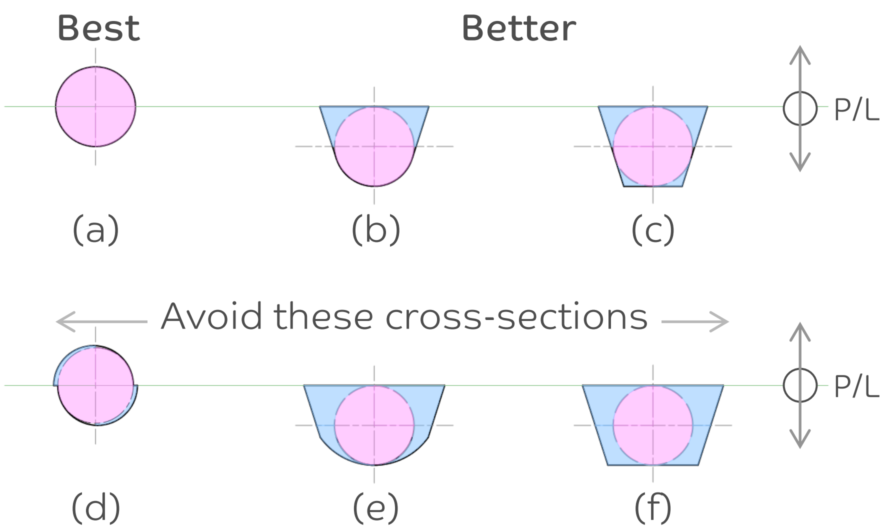


Fig. 2-6: Runner section

Runner Diameter

- Recommended minimum runner diameters are shown in Table 2-1.
- Note that the runner diameter D is also influenced by the part size (e.g. volume and wall thickness) and the resin viscosity.

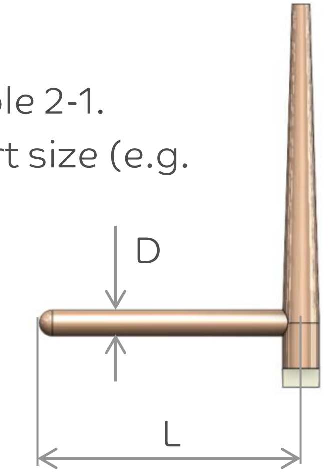


Table 2-1: Minimum runner diameter

For Runner Length	minimum D
less than 35 mm	4.0 mm
35 ~ 80 mm	6.0 mm
80 ~ 250 mm	7.5 mm
250 or more mm	9.0 mm

2.5 VENTING

Venting

- In order to degas, venting must be applied to runners and part cavities.
- The land length at cavity vents should be 3 ~ 8 mm.
- The depth should typically be 30 - 40 µm.
- The channel must be routed outside the tool with a depth of 0.2 - 0.5 mm.
- For small part molding, shallow vent depth are required in order to avoid flashing (Fig. 2-8 shows the example).
- Gas venting at ejector pins is effective as well.
- To avoid gas marks on the part surface, degassing is the most important countermeasure.
- Venting should be considered carefully.

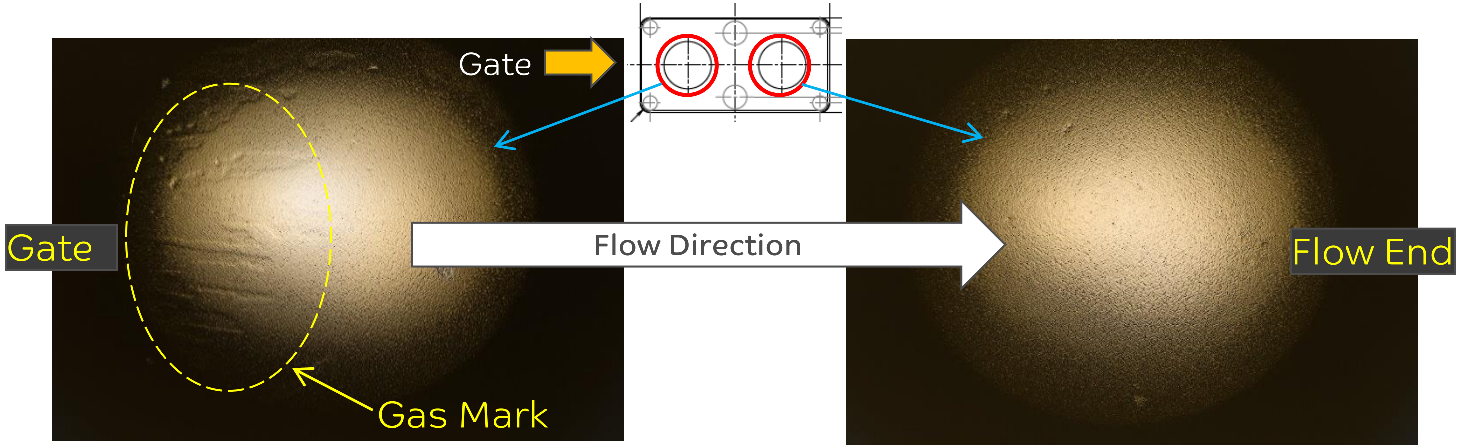


Fig. 2-7: Example of gas mark on part surface close to the gate

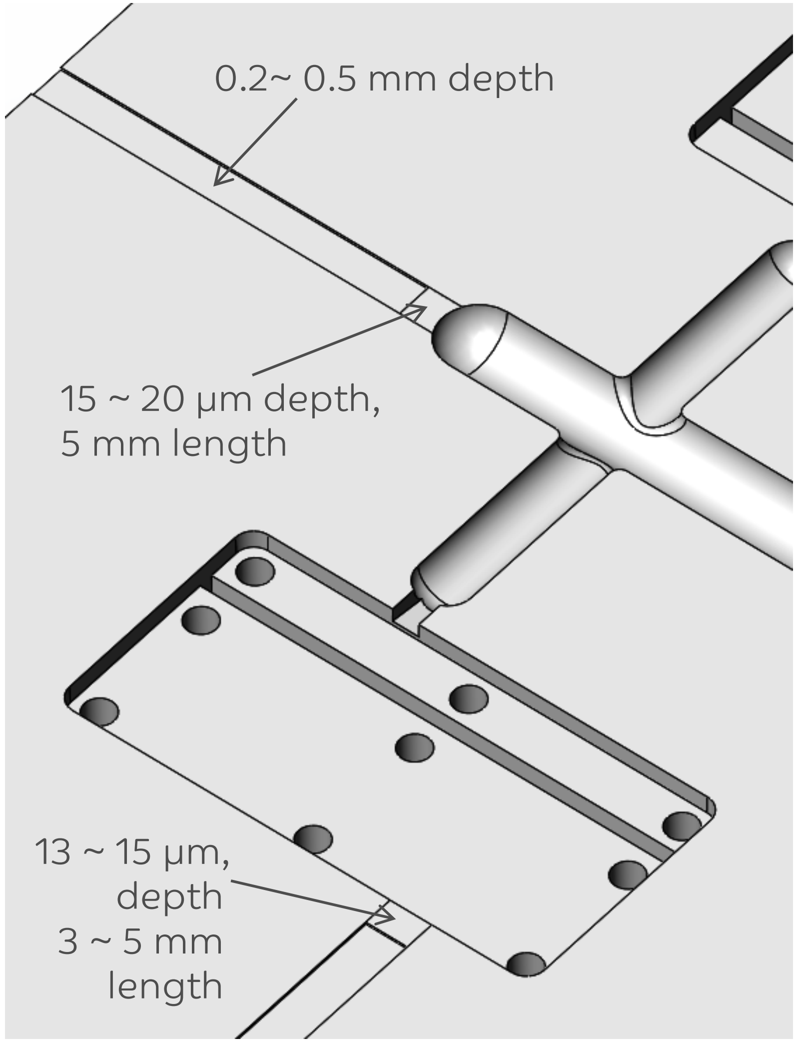


Fig. 2-8: Example of small part venting

2.6 EJECTING

Ejector Pin Layout

- A larger ejection area is recommended.
- Utilize as many ejector pins as the design allows.
- For deep ribs or bosses, blade or sleeve ejection is a good solutions.
- When standard ejection pins are used, they must be located symmetrically about the projection.
- Ejection balance must be considered to reduce deflection risk.

Ejector Pin Movement

- Required tool temperature for EXTEM™ resin molding is very high.
- Conical ejector pins should be avoided as these might cause sticking based on high processing temperatures.
- Maximize diameter where possible to avoid damage.
- Parallel motion of moving parts is also critical.
- Using bearing type guide bushings for ejector plates can help prevent issues.
- Please make sure you only use parts that can withstand the suggested processing temperatures.

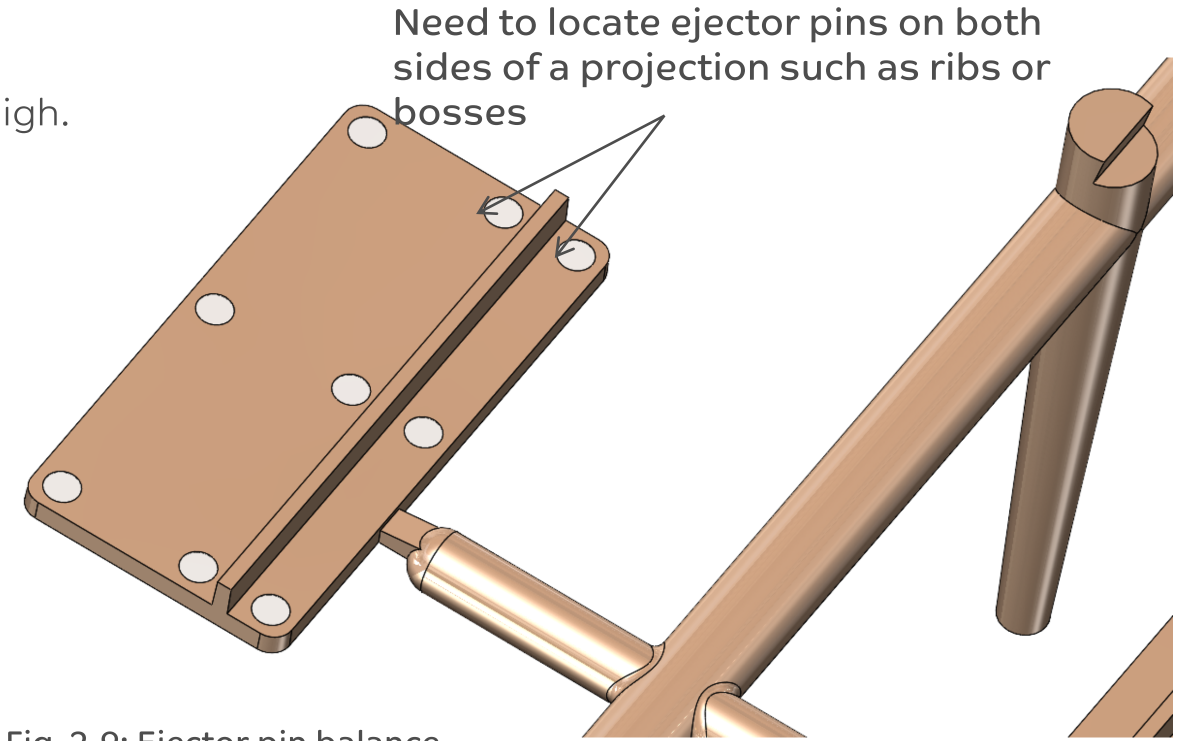


Fig. 2-9: Ejector pin balance

2.7 TOOL TEMPERATURE CONTROL (HEATING)

Heating

- The tool temperature must be maintained around 200°C.
- In most cases, built-in cartridge heaters are used for heating.
- The approximate heater wattage required can be estimated using the formula below:

$$Required\ Total\ Heater\ Wattage\ (kW) = \frac{W \times C \times (T_1 - T_2)}{H \times \eta \times 3600000}$$

Example: When W=60 kg, C= 460 J/kg-K, T1: 200°C, T2: 23°C, H= 1.0 hour, η=0.3

(60 x 460 x (200-23)) / (1 x 0.3 x 3600000) = 4.523 (kW)

Therefore, when 8 heaters will be used, 565 W needs for each.

where :

W : Target weight (kg)
C : Specific Heat of the target material (J/kg-K)
T_1 : Goal Temperature (°C)
T_2 : Start Temperature (°C)
H : Heating Time Period (hour)
η : Efficiency

- The clearance between heater and installation hole should as small as possible to improve heat transfer .
- The target clearance is less than 0.05 mm (one side).
- Larger clearances will lead to higher energy cost and reduced heater life.
- Thermocouples should be located close to heater hole and adjust the setting temperature by measuring the actual temperature.

If a liquid medium or steam is being used for the tool temperature control, be aware that high mold temperature can create high pressure in the system which can be a safety issue if the system is not perfectly sealed.

2.8 TOOL TEMPERATURE CONTROL (AIR GAP, COOLING)

Thermal Insulation

- An air gap between insert die and base mold is considered thermal insulation.
- When placing an air gap on the bottom of an insert, avoid projection into the cavity / runner area.
- Thermal management of the tool is a key factor and thermal insulation should be used as needed to control the temperature.
- The insulation material needs to have a high compression modulus and accurate parallelism.
- An insulation plate can be used. Confirm suitability for the application:
  - Compressive strength
  - Temperature resistance
  - Parallelism of the front and back surfaces

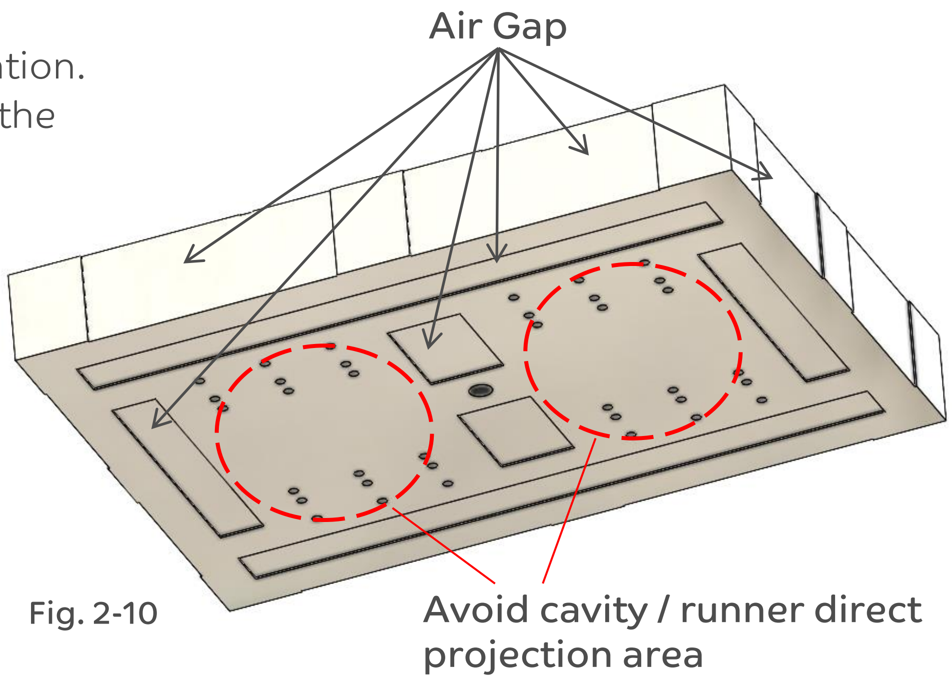


Fig. 2-10

Cooling

- In most cases, there is no need to consider a cooling structure because the mold temperature when molding EXTEM^{TM} resin is very high.
- For parts with thicker wall thickness, consider channel cooling with cold air.
- For usage of conventional liquid cooling, please ensure temperature capability of the cooling liquid.

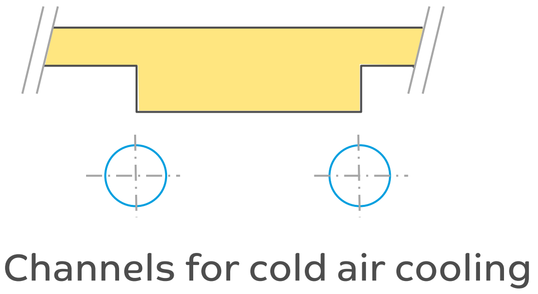


Fig. 2-11

2.9 MOLD SHRINKAGE

Mold Shrinkage

- In general usage, the mold shrinkage values vary from 1.0 to 1.2%, measured on 3.2 mm thickness test coupon.
- These values are affected by internal cavity pressure, tool & melt temperature, etc.
- Thinner wall thickness will require high injection pressure.
- Keep flow length as short as possible as shorter flow length will help to reduce part shrinkage.
- Fig. 2-12 and Fig. 2-13 show the effect of melt temperature on mold shrinkage values measured on samples with the following dimensions: 25 x 25 mm, wall thickness 0.5 mm and 1.0 mm.

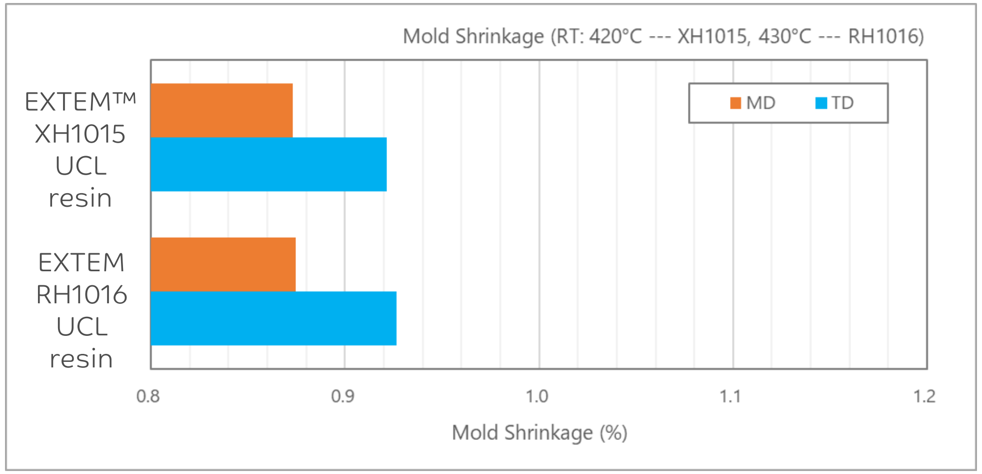


Fig. 2-12: Example of measured mold shrinkage values (t=0.5 mm, Resin Temp.: 420°C (XH1015UCL), 430°C (RH1016UCL) ; Mold Temp.: 200°C, Holding Pressure : 90 MPa)

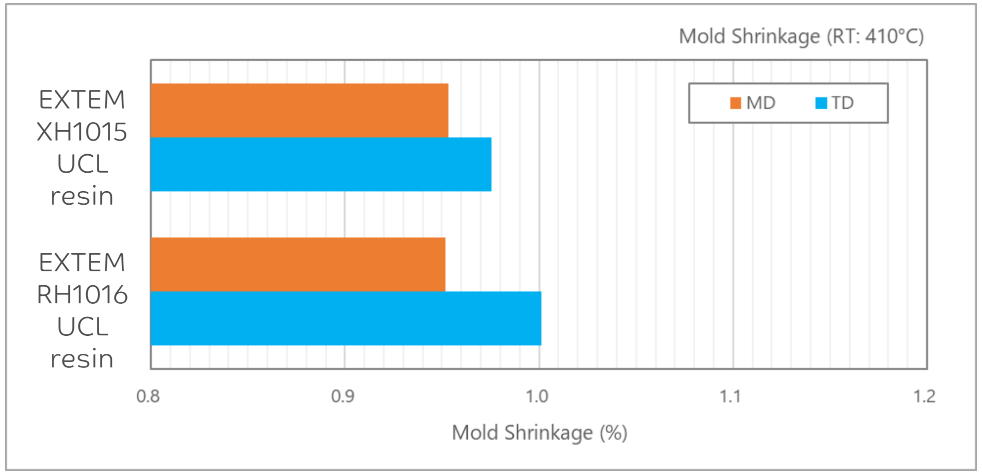
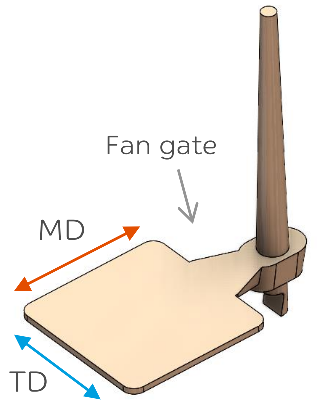


Fig. 2-13: Example of measured mold shrinkage values (t=1.0 mm, Resin Temp.: 410°C ; Mold Temp.: 200°C, Holding Pressure : 90 MPa)



Part shape (25 x 25 mm)

3. INJECTION MOLDING EQUIPMENT

3.1 Clamping force, injection pressure
3.2 Heater for cylinder, barrel capacity
3.3 Screw diameter
3.4 Screw design
3.5 Dryer

3.1 CLAMPING FORCE, INJECTION PRESSURE

Clamping Force

- High clamping forces are required to avoid flashing.
- Thinner wall thickness will require higher clamping force due to increased injection pressure.
- The below guideline can be used as an initial estimate:

Table 3-1 : Required clamping force

Wall Thickness	Required Clamping Force (m-tons)
$t \leqq 0.8$	1.1~2.4 x Projection Area (cm^2)
$0.8 < t \leqq 1.2$	0.8~1.1 x Projection Area (cm^2)
$1.2 < t \leqq 2.0$	0.6~0.8 x Projection Area (cm^2)

Injection Pressure

- Required injection pressure will depend on flow length and wall thickness.
- The below guideline can be used as an initial estimate:

Table 3-2 : Required injection pressure

Wall Thickness	Required Max. Injection Pressure (MPa)
$t \leqq 1.0$	240
$1.0 < t \leqq 1.5$	220
$1.5 < t$	180

3.2 HEATER FOR CYLINDER, BARREL CAPACITY

Cylinder Heaters

- The resin melt temperature for EXTEM™ resin molding will be 400°C or higher.
- Therefore, heaters must have the capability to achieve and control temperatures at this level.
- Ceramic band heaters are recommended.

Barrel Capacity

- Barrel size should be minimized to reduce residence time of melted resin.
- With short residence time, heaters need to have enough power to ensure full melting of EXTEM resin during processing.
- Shot volume should be 40 -70% of full barrel capacity.
- SABIC generally recommends residence time < 4 minutes, when possible.
- A baseline residence time can be calculated as follows:

$$\text{Residence Time (min.)} = \text{Barrel Capacity (cm}^3\text{)} \times 1.1 / 1 \text{ shot volume (cm}^3\text{)} \times \text{Cycle Time (s)} / 60$$

A more accurate calculation needs specific details about the screw design.

3.3 SCREW DIAMETER

Screw Diameter

- A smaller screw diameter will not only benefit the residence time but also improve shot weight accuracy and stroke control.
- A higher level of stroke control will be needed for micro molding applications.
- The below example shows the impact of screw diameter on stroke size and ultimately the controllability.
- Accuracy of the V/P switch over location, shot size and injection speed changing point are very critical for accurate molding.
- The most favorable screw diameter to mold EXTEM™ resin ranges from 1/2.5 to 1/1 of the shot stroke.

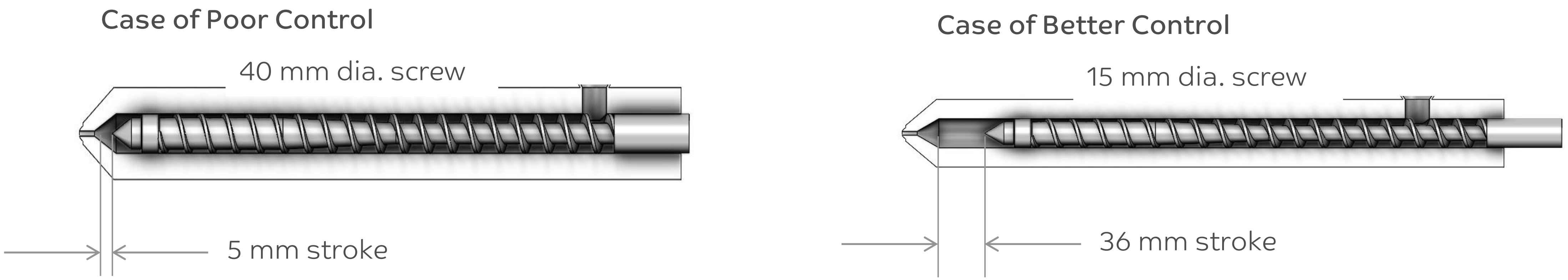


Fig. 3-1 : Effect of screw diameter on stroke control

3.4 SCREW DESIGN

Screw Design

- A conventional 3-zone, full-flight screw can be used for EXTEM™ resin molding.
- A low-shear screw is recommended.
- High-shear screws such as double-flight or mixing type will significantly increase shear heating and are not favorable.
- A short feeding zone as well as a long compression zone with a gradual constant taper leading to a short metering zone are preferred.
- If a specific screw selection is not possible, general-purpose screws (e.g., 0.25L metering, 0.25L compression, 0.5L feeding) with 20 to 25 as L/D can be used.

- The preferable compression ratio is between 2.0 and 2.3 : 1.

- P (Flight Pitch) / D (Screw Diameter) ratio:
  - 1.0 is suitable for standard molding.
  - P/D of 0.7 is suitable for high accuracy molding.

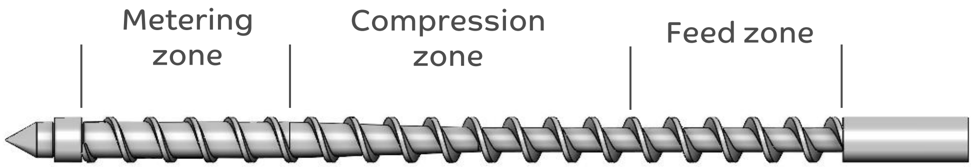


Fig. 3-2 : Screw design

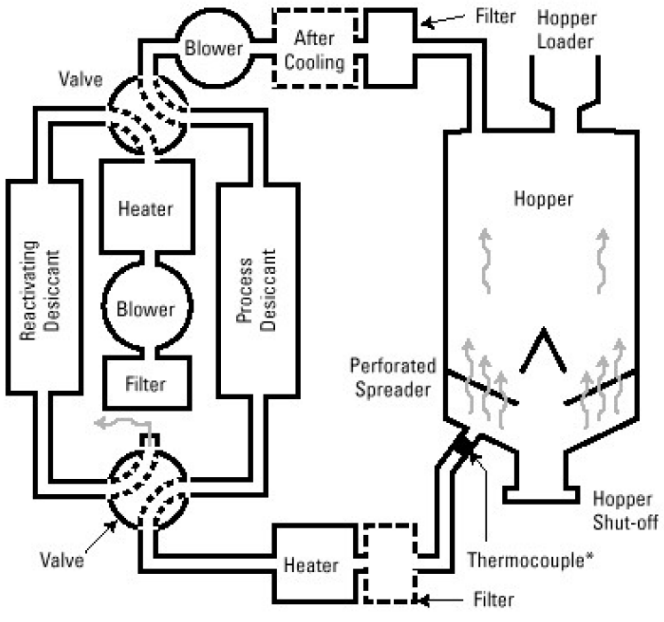
			Europe typical GP Screw
Screw Length (L/D)	Suggested 20		
Screw Configuration	Feed Zone	20 ~ 25%	~ 50%
	Compression Zone	50 ~ 55%	~ 25%
	metering Zone	20 ~ 25%	~ 25%
Flight Depth Feed	7.2 ~ 7.8 mm		
Flight Depth Meter	3.4 ~ 3.6 mm		
Compression Ratio	2.0 ~ 2.3 : 1		
No Flow Back Valve angle of Back Ring		45°	

✓ Do not use a ball check valve
✓ Nitrided materials are not recommended for screw or barrel

3.5 DRYER

A variety of drying technologies are available commercially that are suitable for EXTEM^{TM} resin drying.
The selection of the right dryer for EXTEM resin will be dependent on the situation, application, and production volume.

- A closed loop system with dehumidifying, recirculating hot air hopper dryer including an after-cooler is suggested.
- The dew point of the air at the input of the hopper should be -29°C (– 20°F) or lower.
- Drying temperatures of 175°C or higher are recommended and the equipment needs to be capable of reaching and maintaining this level.
- The hopper design should provide a steady flow of dried pellets to the intake of the molding machine.
- It is recommended to use a temperature-controlled hopper mounted dryer in addition to the main dryer to avoid re-absorption of moisture while material sits in the hopper.
- It is suggested to re-feed a portion of the pellets from the bottom of the main dryer back into the loader before production start to avoid using wet material that has been stored below the heated section of the dryer.
- Old desiccant bead dryers tend to provide instable air and are not suitable.
- It is suggested to use a hopper having capacity for a 6~12 hour-long production to avoid prolonged heat exposure.



*Monitors air temperature, dew point, and air flow at this location.

Fig. 3-3 : Schematic of a typical desiccant dryer

4. MOLDING CONDITIONS

4.1 VISCOSITY

Figure 4.1: EXTEM™ resins capillary rheology at melt temperature of 400˚C

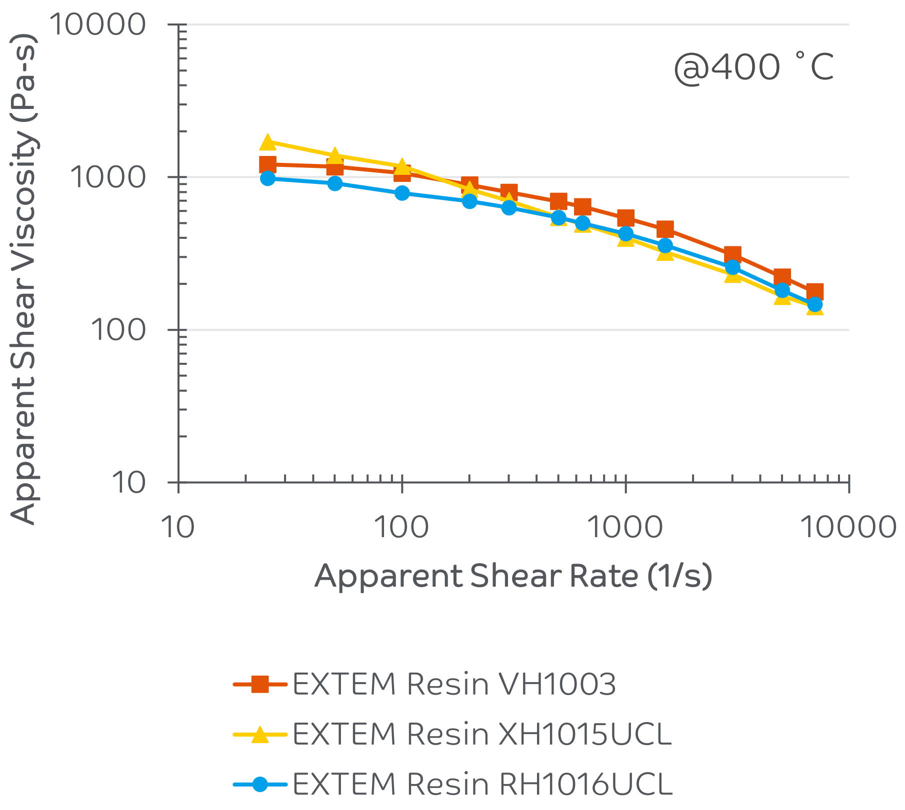
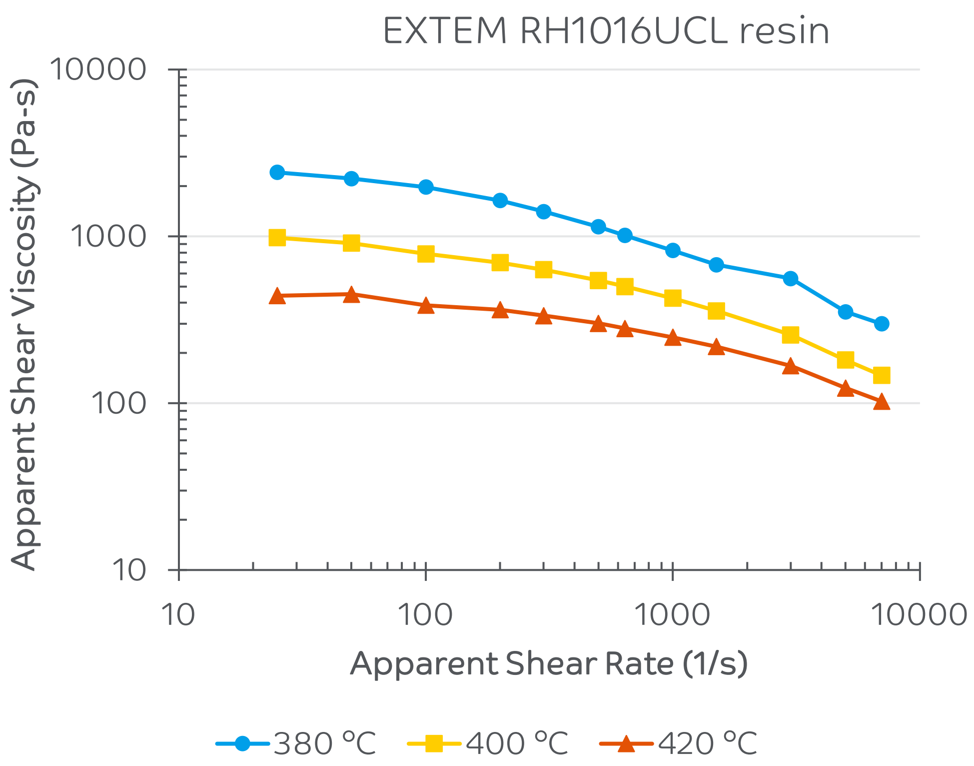


Figure 4.2: Apparent viscosity of EXTEM™ RH1016UCL resin at multiple temperatures



4.2 P (PRESSURE) – V (VOLUME) – T (TEMPERATURE) DIAGRAM

Figure 4-3: P-V-T diagram of EXTEM™ XH1015UCL resin

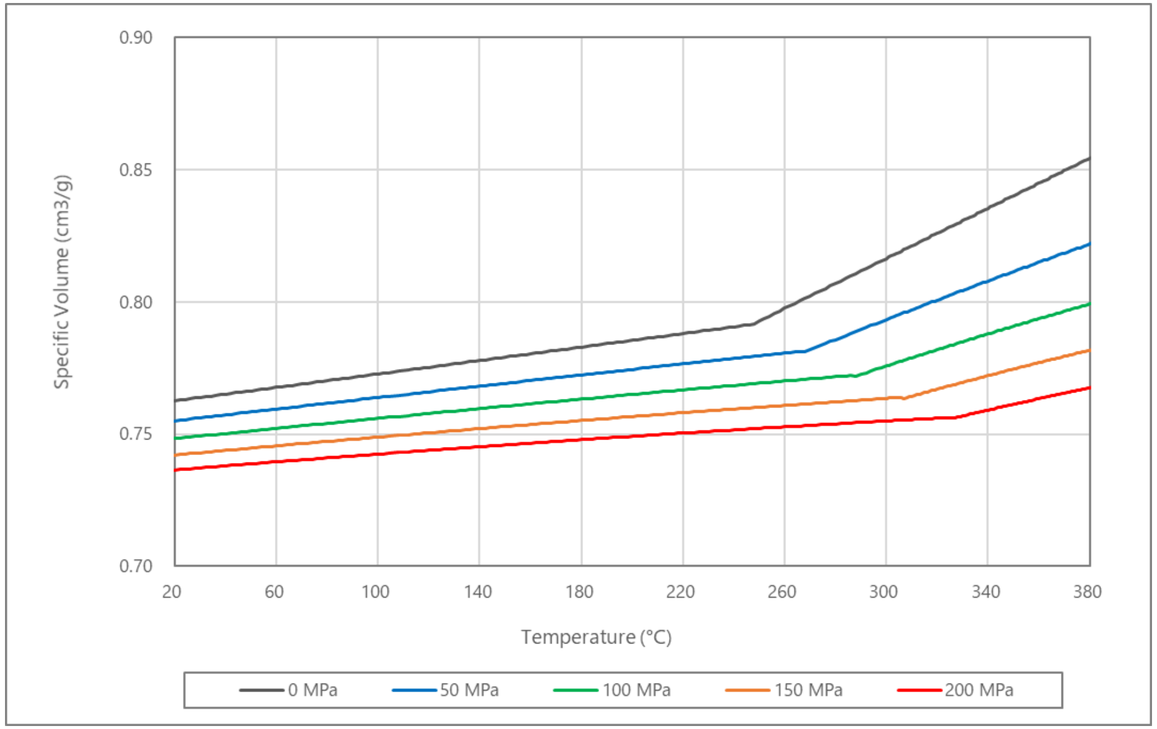
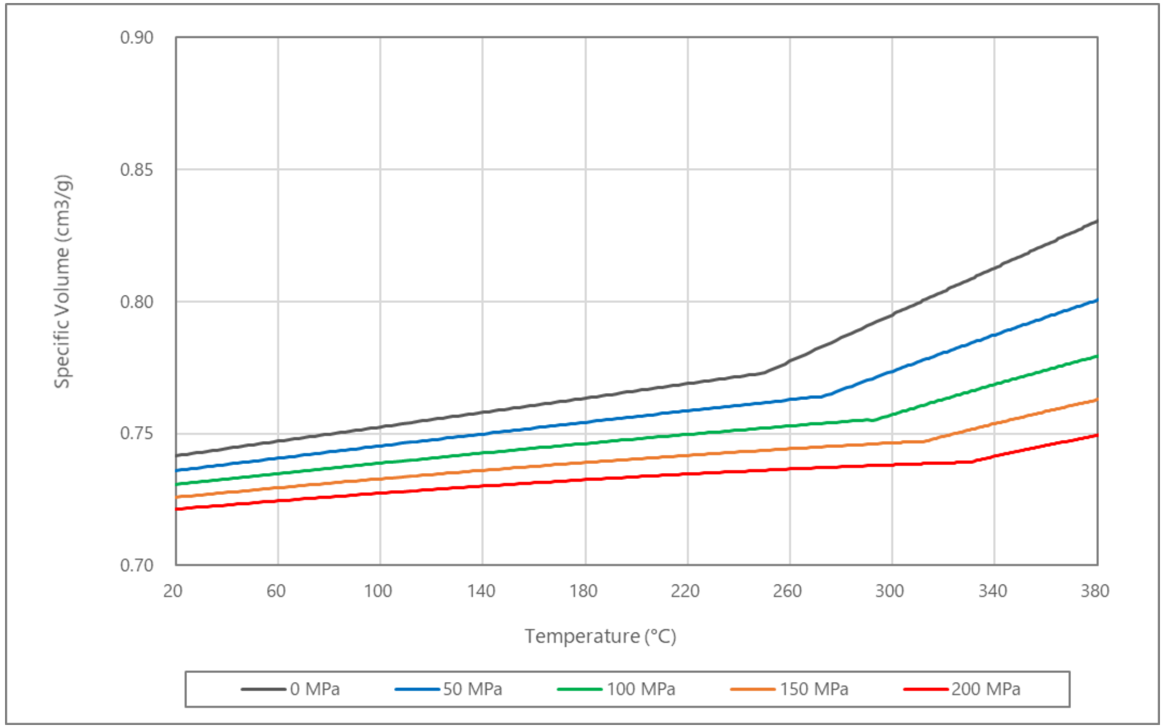


Figure 4-4: P-V-T diagram of EXTEM™ RH1016UCL resin



EXTEM RH1016UCL resin shows higher Tg and lower specific volume values compared to EXTEM XH1015UCL resin

4.3 PRE-DRYING

Recommended Conditions

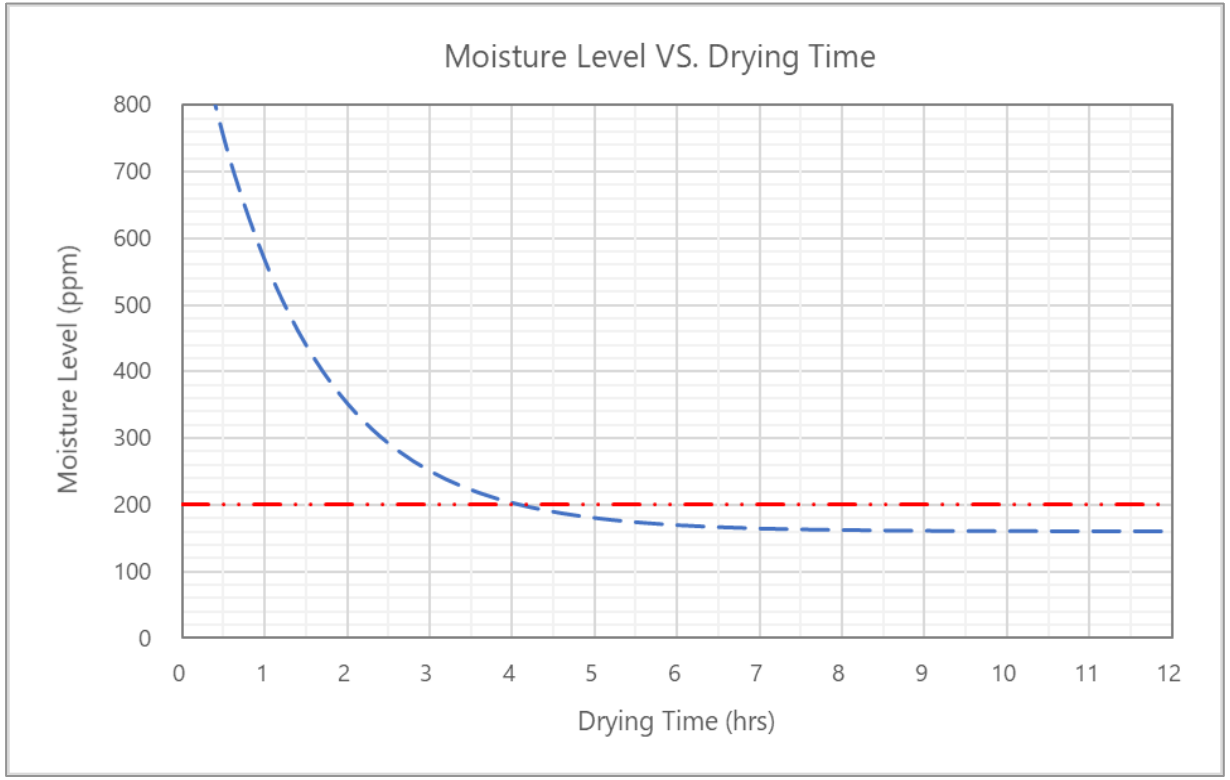
- The moisture content should be less than 0.02% (200 ppm).
- Dew point controlled dryer or dehumidifying dryer are recommended.

Table 4-1: Pre-Drying recommendation (Dew point controlled dryer)

Grades		VH1003	XH1015	XH2315	RH1016
Drying Temp.	°C (°F)	150 (302)	175 (347)	175 (347)	175 (347)
Drying Time*	Hrs.	4~6	4~6	4~6	4~6

* Times suggested are "mean times" and may be longer for some colors and grades.

- Avoid drying times exceeding 10 hours.
- When using a normal box-type drying oven, raise the drying temperature to 190 ~ 200°C.
- In this case, drying time should be 6~7 hours.
- Minimize resin in feed hopper.



Drying Temperature : 175°C

Fig. 4-5: Example of "Drying time vs. Moisture level" (EXTEM™ RH1016 resin)

4.4 MOISTURE MEASUREMENT

- Before EXTEM™ resin molding starts, it is recommended to measure the actual moisture content to ensure appropriate drying.
- Among moisture measurement methods, sensor-based measurement instruments are recommended because they only detect moisture among other evaporated volatiles.
- In the case of using mass-based instruments such as a thermo gravimetric method, set the heating temperature over 180°C and heating time not less than 3 minutes so that all the moisture inside the EXTEM resin pellets is extracted.
- Fig. 4-6 shows the detected moisture contents comparison of sensor based and mass-based method.

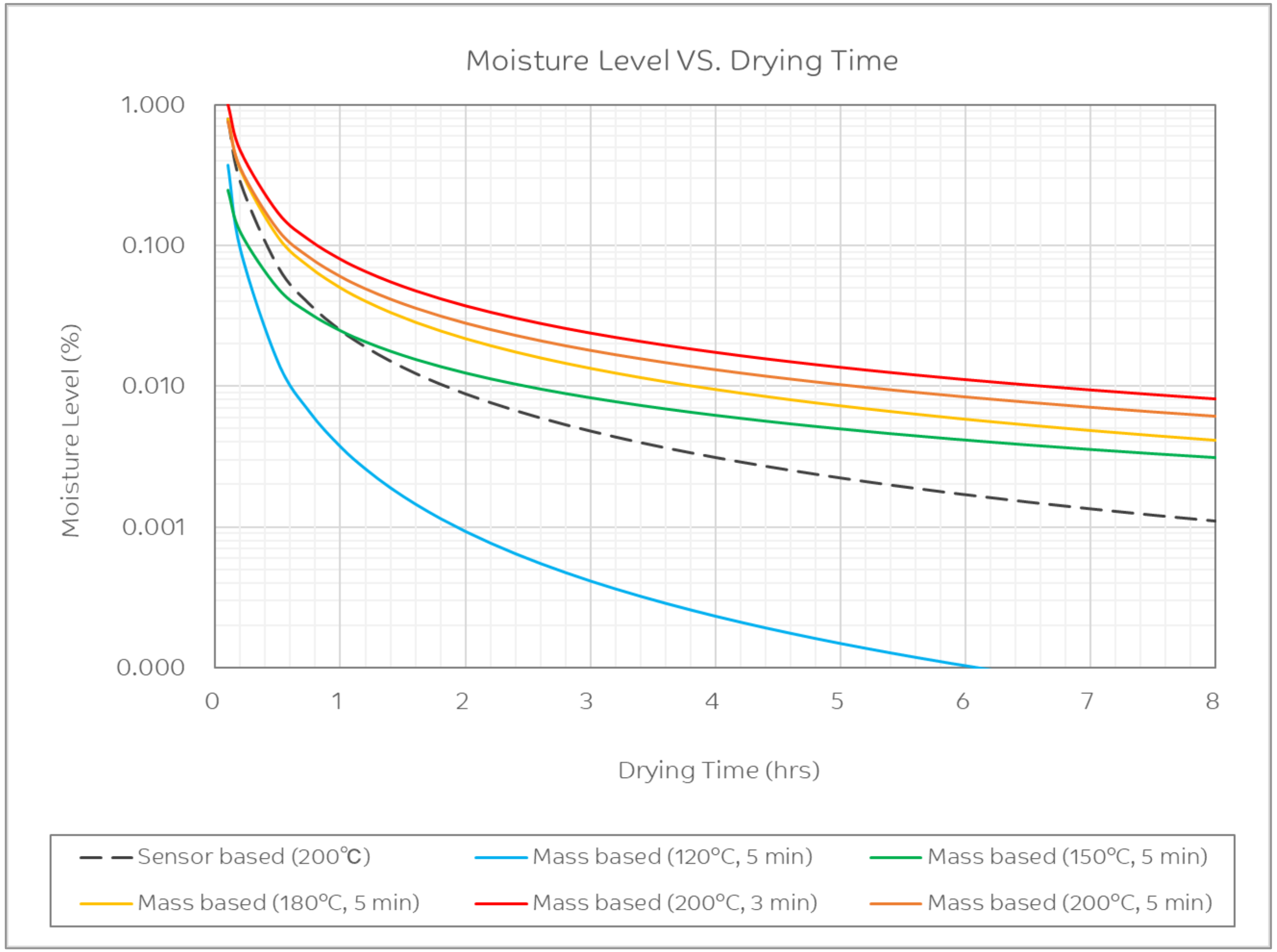


Fig. 4-6: Detected moisture content as function of heating [temperature and time from mass-base analyzer]

4.5 TEMPERATURE SETTING

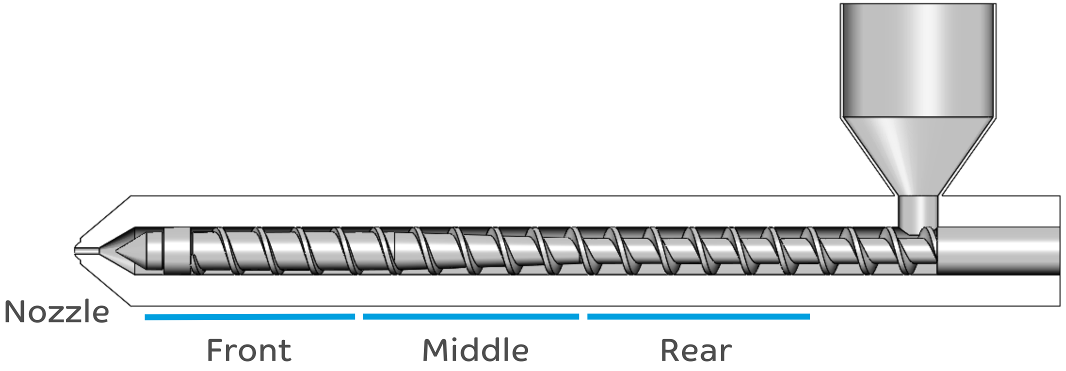
- Higher melt temperature is one of the most effective ways to achieve higher flow, and thus, ensure full filling of the cavity.
- However, please be aware that the higher melt temperatures may result in a color shift.
- If recommended melt temperatures are exceeded, resin degradation may appear.
- A ramping temperature profile from feeding zone to nozzle is suggested. This will minimize any risk of heat degradation of the resin if a higher melt temperature or residence time cannot be avoided.
- An intake temperature control is recommended to sustain stable operations.

Table 4-2: EXTEM™ resin melt temperature suggestions

	Unit	VH1003	XH2315	XH1015UCL	RH1016UCL
Melt temperature	°C (°F)	380~405 (716~761)	380~405 (716~761)	380~410 (716~770)	385~415 (725~779)
Nozzle temperature	°C (°F)	375~400 (707~752)	375~400 (707~752)	375~405 (707~761)	385~415 (725~779)
Front - Zone 3 temperature	°C (°F)	380~405 (716~761)	380~405 (716~761)	380~410 (716~770)	385~415 (725~779)
Middle - Zone 2 temperature	°C (°F)	370~395 (698~743)	370~395 (698~743)	370~400 (698~752)	385~410 (725~770)
Rear - Zone 1 temperature	°C (°F)	360~380 (680~716)	360~380 (680~716)	360~385 (680~725)	385~395 (725~743)
Intake (throat) temperature	°C (°F)	70~100 (158~212)	70~100 (158~212)	70~100 (158~212)	90~110 (194~230)
Mold temperature	°C (°F)	140~180 (284~356)	160~200 (320~392)	160~200 (320~392)	175~220 (347~428)

4.6 CYLINDER TEMPERATURE

Recommended cylinder temperatures shown below:



Front Section (Metering Area)

- Temperature should be set between 385 to 415°C, which is the same as the required melt temperature.

Middle Section (Compression Area)

- Temperature should be set 5 ~ 10°C below front section.
- This should help avoid shear heating in the compression zone.

Rear Section (Feed Area)

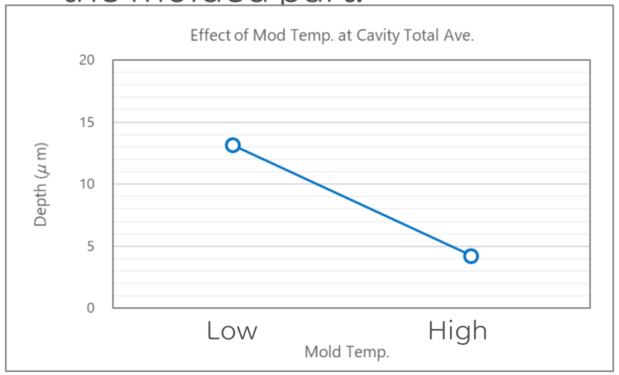
- Temperature should be set 10 ~ 20°C below the front section.
- In this area, pellets are carried toward the compression area.
- The temperature should be set just high enough to ensure proper feeding.
- A temperature below 385°C should not be used.

Nozzle

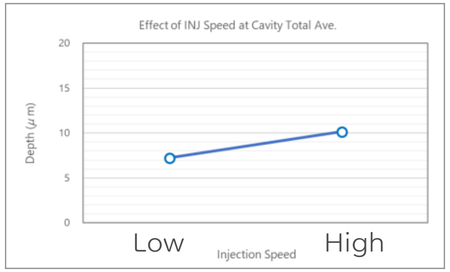
- Nozzle temperature should be set the same as the front section.
- It can be adjusted by observing the molding stability and part defects.

4.7 MOLD TOOL TEMPERATURE

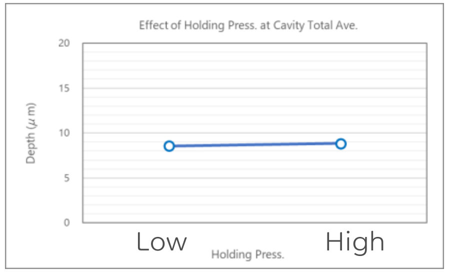
- The suggested mold tool temperature is between 175 and 220°C (in the case of EXTEM™ RH1016UCL resin).
- If high transferability is required, it can be set higher.
- The below graphs show the effect of molding parameters on a potential sink depth at opposite locations of the convex lens shape.
- In this study, the tool temperature showed the largest effect.
- The effect of holding pressure was less significant due to a pressure loss caused by the thin base wall thickness of the molded part.



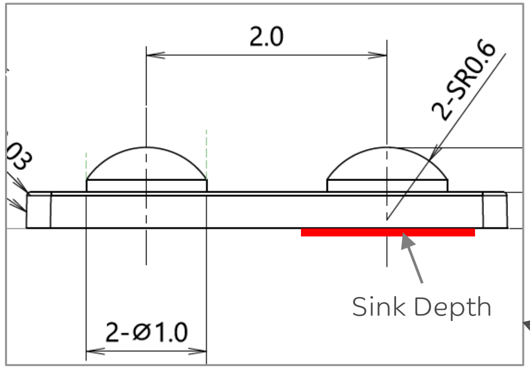
Effect of tool temperature



Effect of INJ speed



Effect of holding pressure



Measured location

Part Shape

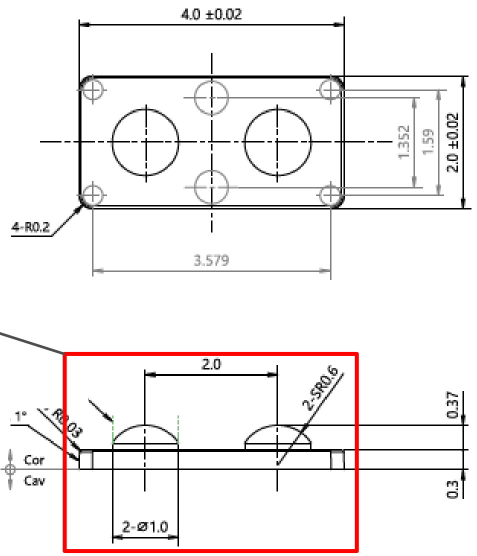


Fig. 4-7: Effect of molding conditions on sink depth (Material: EXTEM RH1016UCL resin)

4.8 INJECTION SPEED AND INJECTION VOLUME SPEED

- The highest injection speed is recommended to avoid solidification of the resin which will result in high filling pressure, especially when parts have thin walls.
- This approach may lead to challenges such as outgassing of the resin melt, or a temperature rise in the mold based on high air compression.
- Also, aesthetic issues such as jetting or splay marks within the gating area may require lower injection speed to avoid. Finding the right compromise will be the key for success.
- Note that the "injection speed" (screw boosting speed, unit = mm/s) means the machine setting in general.
- It is the linear speed of the screw.
- The actual filling speed could be indicated by "volume speed" (unit = cm^3/s or mm^3/s).
- The injection "volume speed" will vary based on different screw diameters at the same injection speeds.

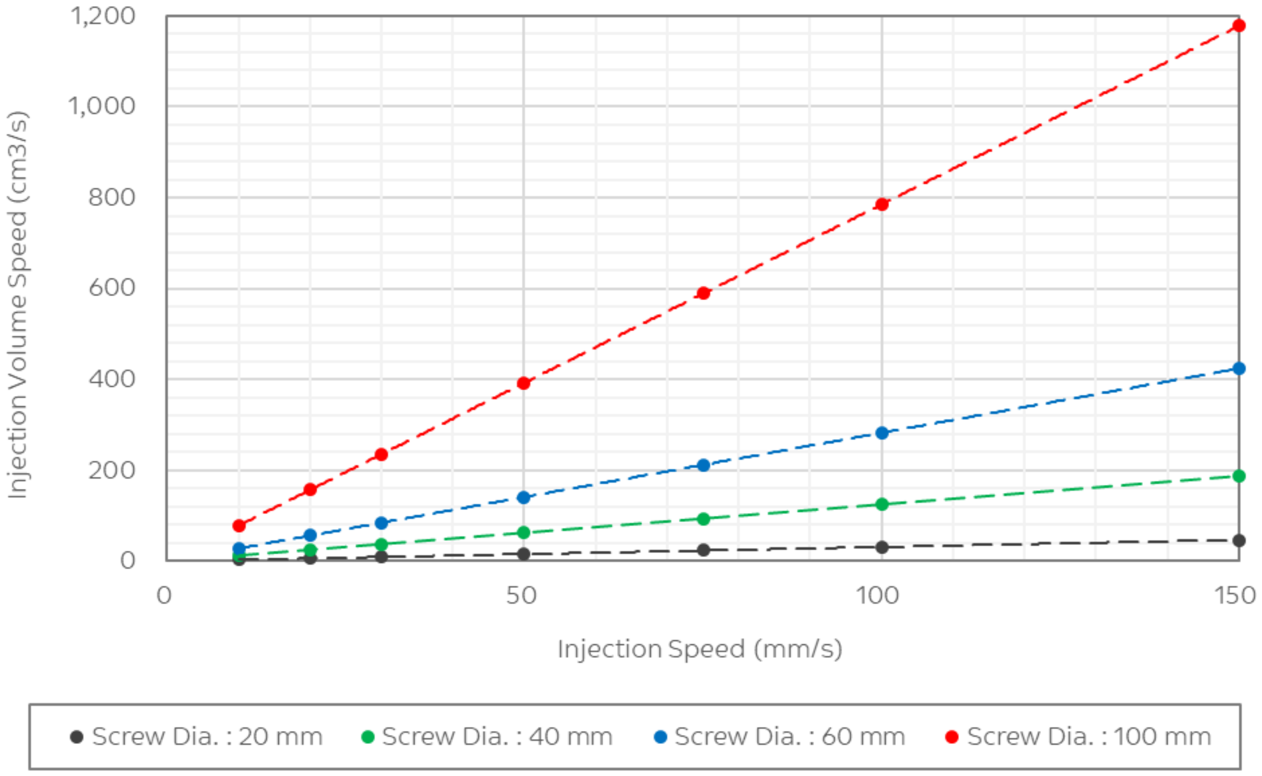


Fig. 4-8: Injection (screw) speed vs. Injection volume speed

4.9 INJECTION SPEED AND SHEAR RATE AT NOZZLE

- The following graph showcases calculations of injection "volume speed" and apparent shear rate at the nozzle from "injection (screw) speed" at several screw size diameters.

- As an example, if a shear rate of 1. E+04 sec^{-1} at the nozzle is desired , the injection speed shall be within the range of 45 ~ 85 mm/s.

- Starting with an injection speed of 45 ~ 85 mm/s is therefore recommended when molding EXTEM™ resin or a new tool for the first time.

- Remember that the values are theoretical and not directly indicating the actual behavior of the injected resin into the cavity.

- Remember to observe the actual screw movement carefully.

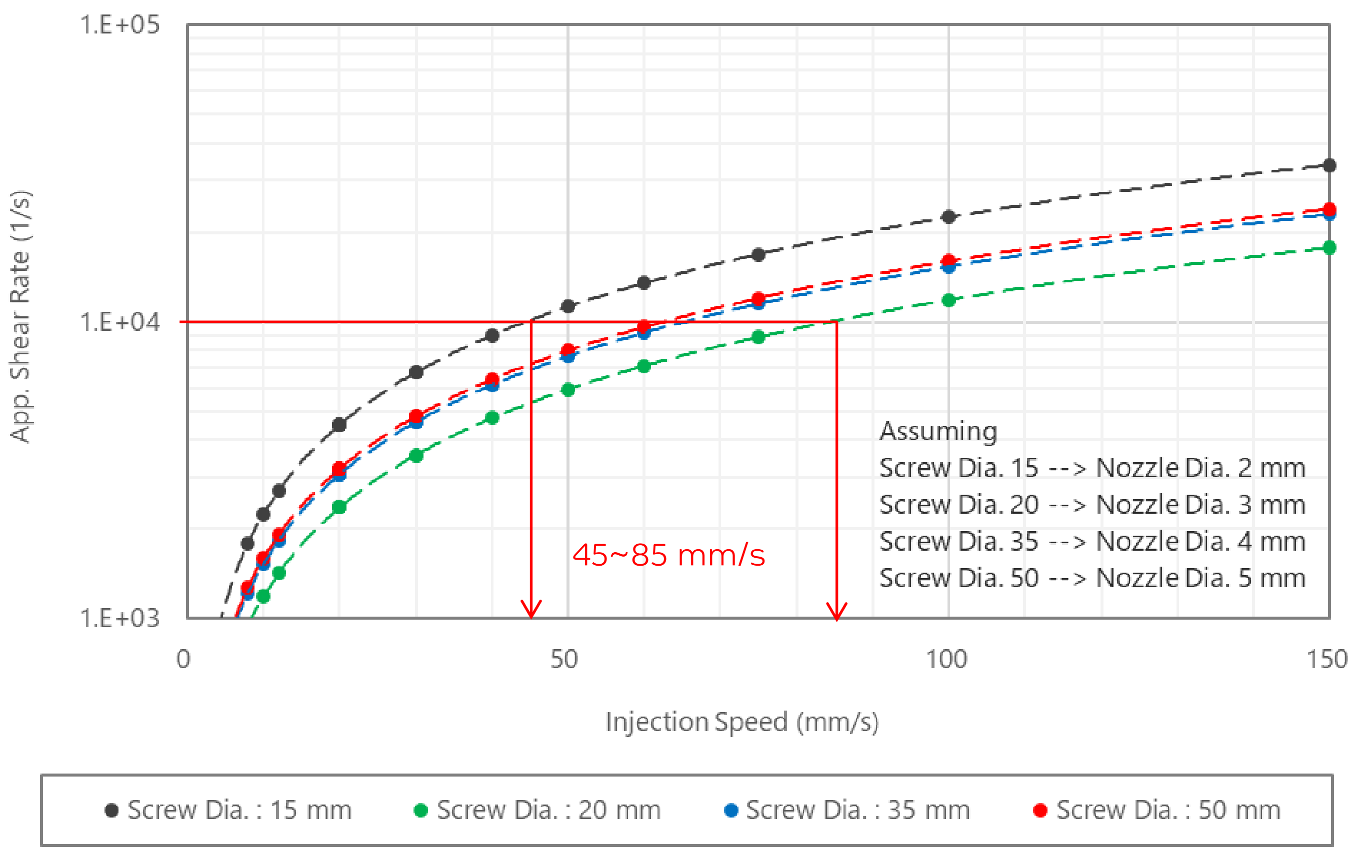
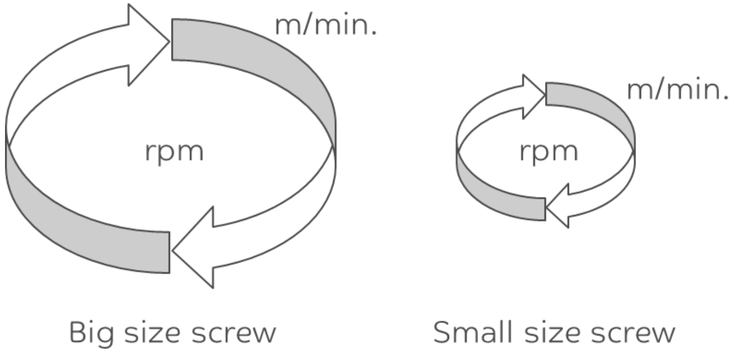


Fig. 4-9: Injection (screw) speed vs. Shear rate

4.10 SCREW ROTATION SPEED

- Use linear line speed at the outside diameter of the screw to understand the impact of the resin melt by shear heating.
- Note that if the screw diameter changes, the linear speed will be a different value even when the rotation speed remains the same.
- The recommended linear speed is below 5.0 m/min (screw diameter <15 mm) or ~ 10 m/min (50 mm screw dia.).
- Excessive rotation speed has a risk of not only surplus shear heating, but also lower thermal energy transference due to inadequate plasticization time, thus it might be a cause of uneven melting.
- The dosage time should be monitored to confirm the shot-to-shot consistency.



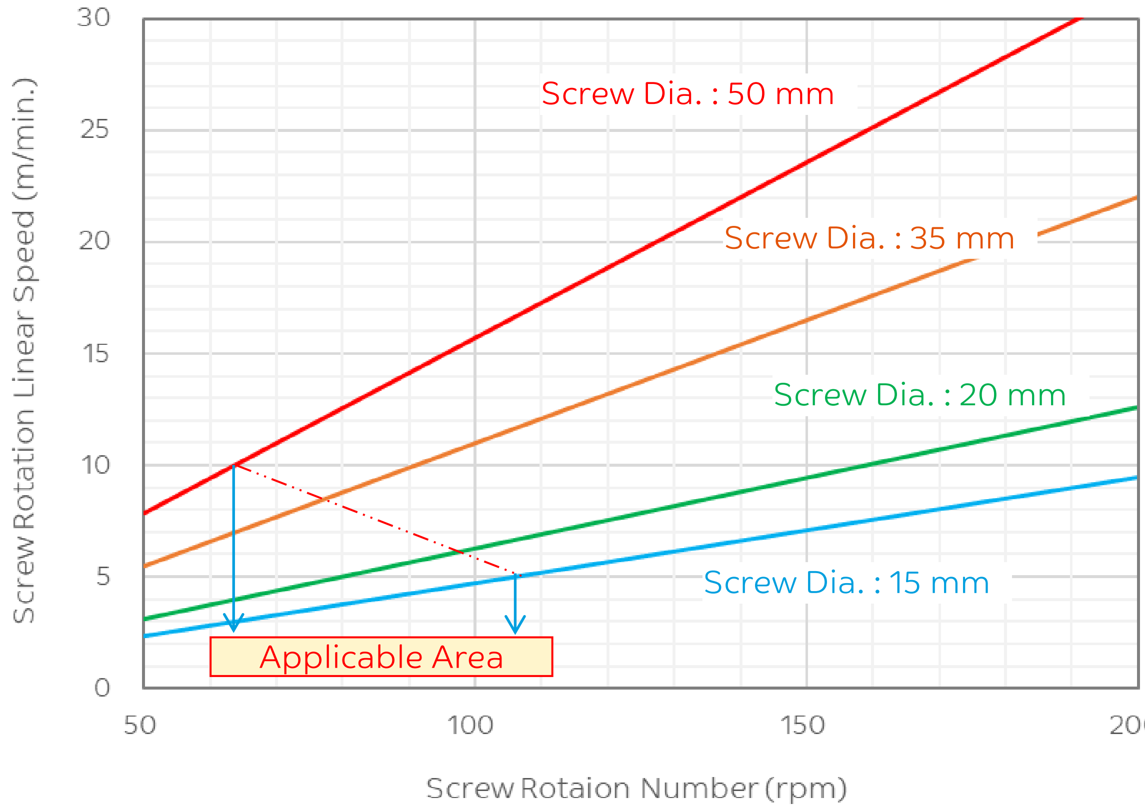


Fig. 4-10: Applicable Screw Linear Speed vs. Screw Diameter

4.11 INJECTION, HOLDING, AND BACK PRESSURE

Injection Pressure

- The required injection pressure is related to the melt viscosity of the material.
- The injection molding machine automatically increases the injection pressure within its given limits based on the flow resistance caused by the viscosity of the resin in order to achieve the set injection speed.
- This is also affected by part and sprue/runner design.
- The injection pressure must be limited to protect the tool from damage resulting from excessive internal cavity pressure.
- It is wise to start with lower pressure levels and adjust as needed.

Holding Pressure

- The resin melt temperature does immediately decrease once injected into the mold.
- Adjusted packing pressure is needed to reduce shrinkage and ensure consistent shot to shot dimensions of the part.
- Excessive packing pressure can lead to flashing and high residual stress around the gate area.
- The desired value needs to be determined during a molding trial.

Back Pressure

- In general, back pressure is set between 5 to 10 Mpa.
- Please check the fill time consistency, if molded parts have defects and if there is material drooling from the nozzle.
- Select appropriate back pressure based on these observations.

4.12 HOLDING (PACKING) TIME

- Holding time should be varied in order to achieve the desired part weight consistency.
- As holding time increases, the part weight will increase.
- The weight curve has a saturation point. Holding time should be set around the saturation point.
- In the example on the right, a holding time of 6 to 7 seconds would be adequate.
- Note that the required holding time may depend on the gate size and tool temperature.
- Excessive holding (packing) pressure levels should be avoided.
- It may cause high residual stress in the part around the gate.

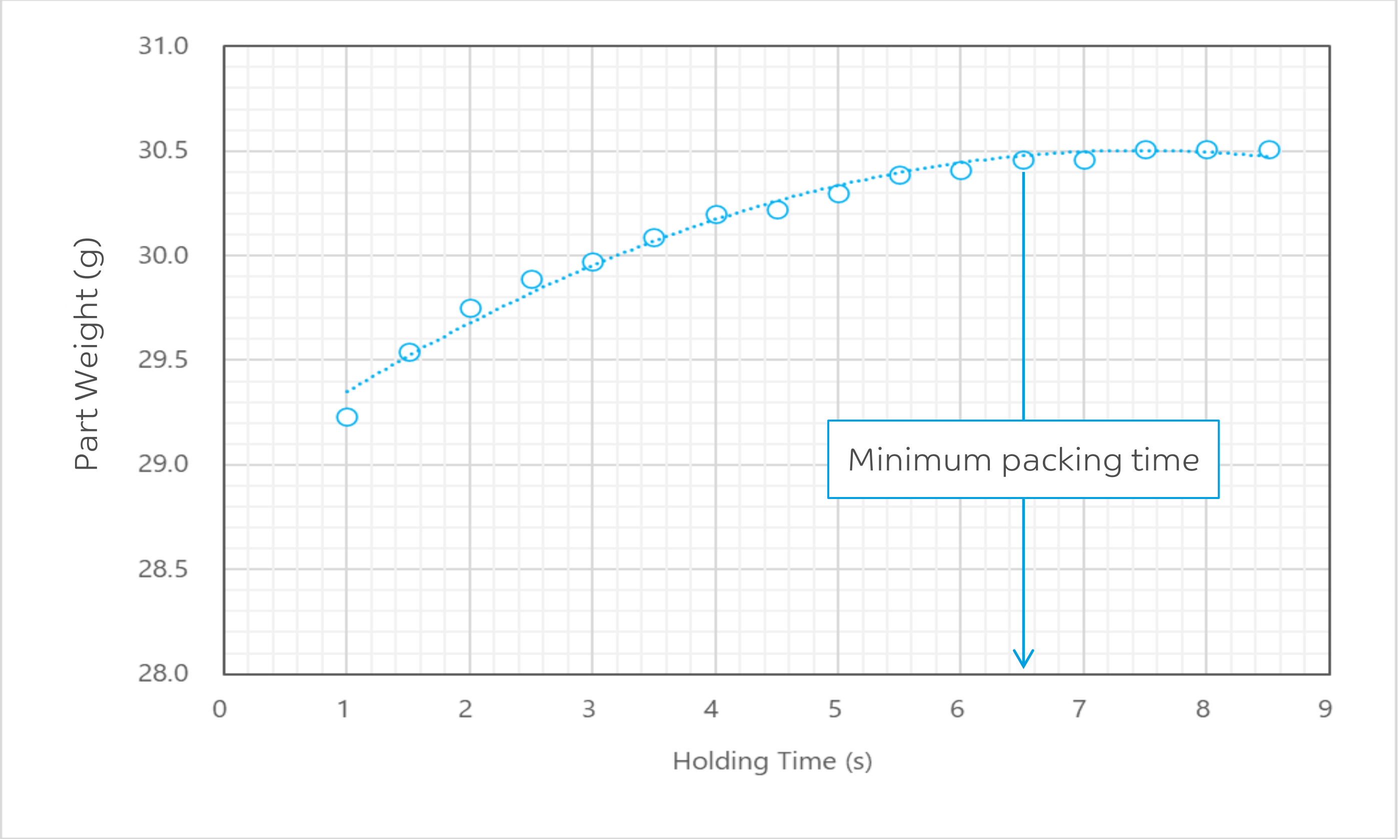


Fig. 4-11: Part Weight vs. Holding Time

4.13 PROCESSING EFFECTS ON OPTICAL PROPERTIES

IR Transmission

- Figure 4-12 shows IR transmittance of EXTEM™ XH1016UCL resin, measured on a 1 mm thick optical plaque.
- Residence time has the most significant influence on IR transmission among processing parameters.
- Shorter residence time is desirable for higher light transmission.
- Slow injection and lower holding pressure are also helpful for higher transmission; however, the influence is less pronounced than residence time.
- Melt temperature and tool temperature don’t affect IR transmission.

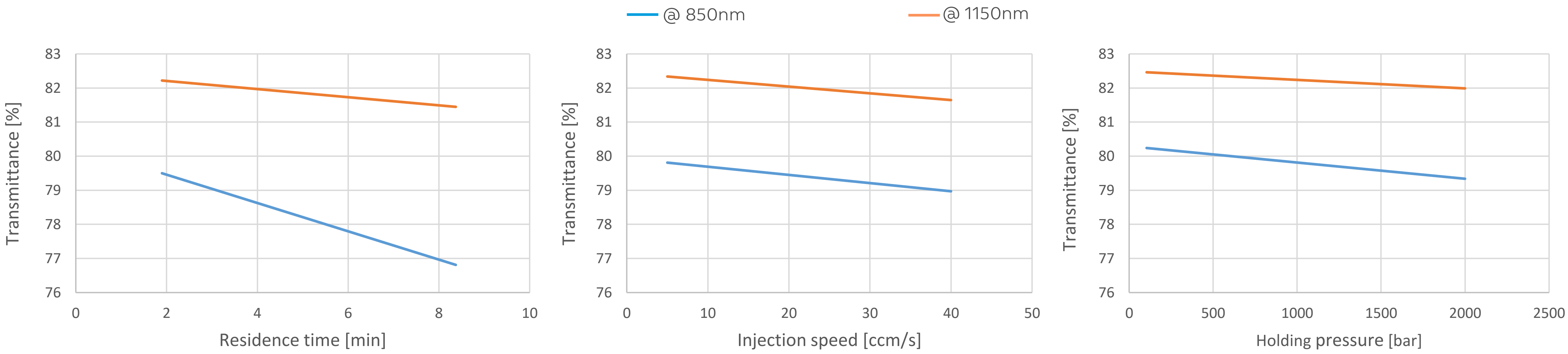


Fig. 4-12 : Effects of molding conditions on IR transmittance of EXTEM RH1016UCL resin, measured on 1mm thick optical plaque. (Molded at melt temperature 400°C, tool temperature 180°C)

5. PURGING

5.1 START-UP AND SHUT-DOWN

General Start-Up (When the resin remaining in the cylinder is PC or lower melt resin)

- When starting up the machine, set the barrel heat to 315°C (599°F).
- Allow the machine to reach and soak at those settings before rotating the screw.
- Then start to purge with dried PC (LEXAN™ 131 resin) while raising the temperatures to 375°C (707°F).
- Introduce dried PEI (ULTEM™ 1000 resin) while raising the barrel temperatures to 385°C (725°F).
- Set the barrel temperatures to the desired EXTEM™ resin set-points and introduce the EXTEM resin until completely purged and up to temperature.
- The initial shots should be checked for contaminants in the molded parts.

General Shut-down

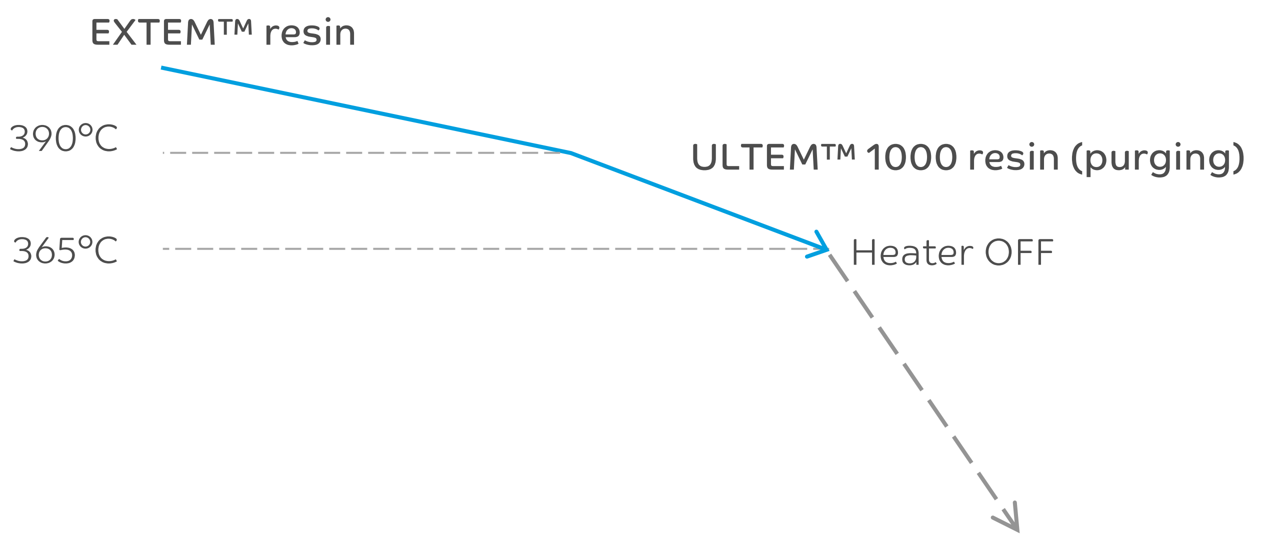
- When shutting down the machine, cool down EXTEM resin temperature to 390°C (734°F) first.
- Then introduce dried ULTEM 1000 resin and purge slowly until the barrel temperature reaches 365°C (689°F).
- Follow with PC (LEXAN 131 resin) until the barrel temperatures are below 310°C (590°F).
- The hopper should then be shut off at the throat and the machine run until all residual resin is purged out of the barrel.
- The screw should be sucked back 20 ~ 40mm to pull the check-ring away from the melt and into the barrel where there are larger heaters before turning the barrel heaters off.

- For intermediate stops, during which no purging is considered, the barrel temperatures should be reduced to about 15 -20°C above Tg of the EXTEM resin.
- When interrupting the process for longer than 20 minutes, the temperature shall be lowered to 200°C (392°F).

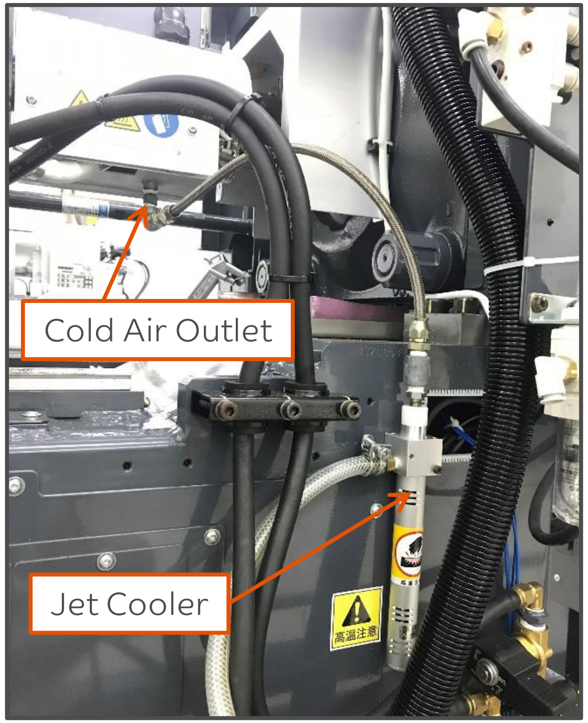
5.2 PURGING, SHUT DOWN, CASE 1

Case 1

These instructions can be followed if you are attempting to stop production of EXTEM™ resin for the day, but plan to re-start the next day.



Avoid residence time >8 mins at melting temperature

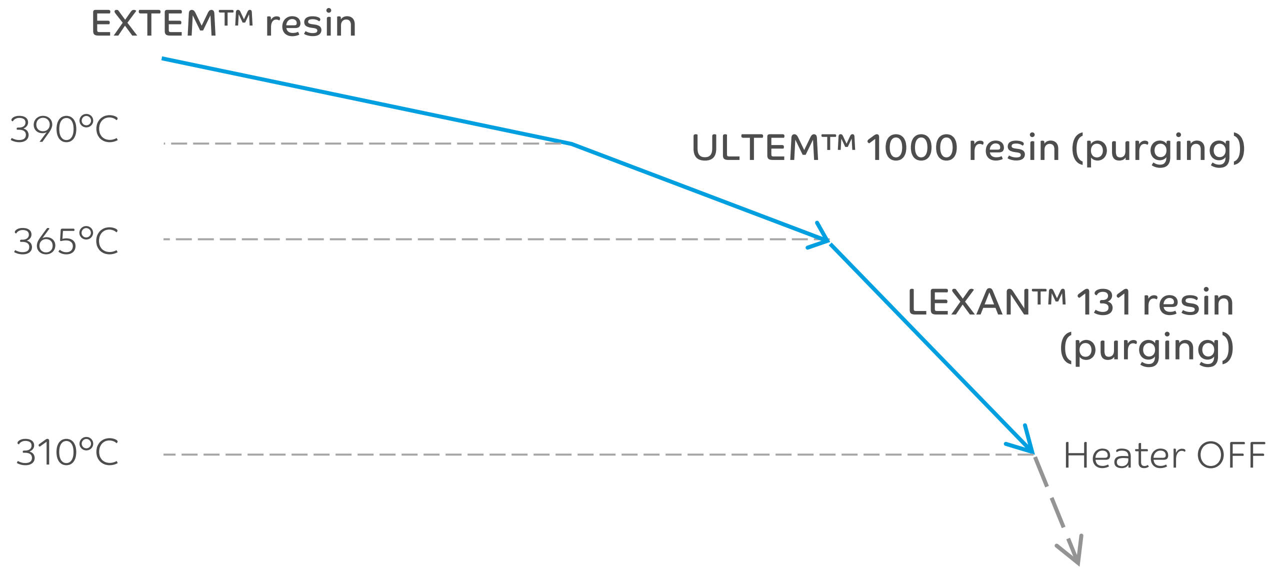


*Optionally, it is also recommended to install cooling vents on the cylinder unit to help achieve the quickest possible reduction of cylinder temperature after production stops.

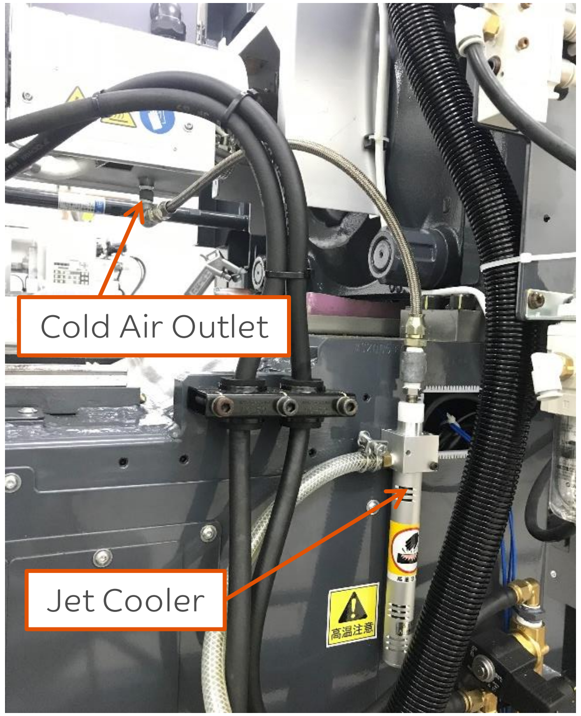
5.3 PURGING, SHUT DOWN, CASE 2

Case 2

These instructions can be followed if you are attempting to stop production and change to a lower temperature resin (e.g. LEXAN™ resin) the next day.



Avoid residence time >8 mins at melting temperature



*Optionally, it is also recommended to install cooling vents on the cylinder unit to help achieve the quickest possible reduction of cylinder temperature after production stops.

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