INJECTION MOLDING PROCESS USER GUIDE

G-PAEK polymers and compounds are primarily processed in granular form. Most standard screw machines are suitable for this. The Injection barrel should be designed for process temperatures of up to 450 °C and MOC for screw and barrel should be bi metallic

SCREW AND BARREL

Standard screw (Four-zone screw) with L/D between 18 and 24 D are usually suitable. Zone breakdown: feed 55–60%, compression 20–25%, metering 20–25%. Flight depth ratio 2.0–2.5:1 The Injection barrel should be designed so that the required metered volumes lie between 30% and 70% of the maximum possible shot volume. This will produce a homogenous melt quality.

NOZZLE

The nozzle is in contact with the sprue-bushing for a high percentage of the total cycle time during normal operations, with the sprue-bushing having a considerably lower temperature than the melt and nozzle. Gharda G-PAEK polymers have a sharp crystallization point i.e. 335°C and will solidify quickly if the melt temperature falls below crystallization point Therefore, it is important to ensure that an adequately large heater covering the majority of the nozzle is fitted to prevent solidify off. Extended nozzles are not generally recommended for use with Gharda G-PAEK polymers because of the increased risk of solidification and / or degradation in the nozzle. At the recommended process temperatures, the viscosity of Gharda G-PAEK polymers is generally high enough to allow an open nozzle system. Shut-off nozzles are not recommended because they frequently contain melt dead spots and restrict injection pressure.

INJECTION UNIT

Screws made of corrosion-protected and wear-protected high-alloy steels are usually used to process Gharda G-PAEK polymer within the injection barrel. We recommend a bimetallic design for the injection barrel. Gharda G-PAEK polymer has a strong tendency to adhere to metallic surfaces; it is possible for cracks to form in the nitrided layer of nitrided screw surfaces during cooling. The nitride layer is not recommended on the barrel surface. Metallic areas that come into direct contact with the melt should be highly polished to prevent deposits that could cause thermal decomposition due to the increased residential time of the polymer. In order to obtain good conveying action by the screw, the friction between the granules and the barrel wall must be greater than that between the granules and the screw surface.

DRYING

Gharda G-PAEK polymer having moisture of less than 0.25 wt.%. We however recommend additional drying in order to obtain qualitatively high-grade final products.

Drying temperature	150–160 °C
Drying time	2–3 hours in the dry-air dryer or vacuum furnace
Hopper	Heated or thermally insulated
Max. residual moisture:	< 0.02%

MACHINE SETTINGS:

- **Temperature Profile:**

a) Injection Barrel Temperature Profile for Unfilled Material:

Feed Zone	Zone 1	Zone 2	Zone 3	Zone 4	Nozzel
360°C	380°C	385°C	390°C	395°C	400°C

b) Injection Barrel Temperature Profile for Filled Material:

Feed Zone	Zone 1	Zone 2	Zone 3	Zone 4	Nozzel
360°C	405°C	410°C	415°C	420°C	425°C

- ✓ The hopper temperature should maintain low to avoid clogging of the granules at through of the barrel.
- ✓ After the feed zone, heat is required to allow granules to melt before reaching the compression zone.
- ✓ Higher viscosity compounds of these polymers require increased barrel temperatures (typically between 10°C).

- **Back Pressure**

  To homogeneously melt Gharda G-PAEK polymers a back pressure of 10bar - 30bar is suitable. Fiber reinforced compounds should be processed at lower back pressures to reduce fiber length/breakage.

- **Injection Pressure**

  Depending on design of the product/molding, melt temperature, injection speed and mold temperature, pressures 700 bar to 2,000 bar may be encountered; in some cases these can be managed by increasing temperatures, reducing injection speed and/or increasing the flow path cross section (sprue, runner, gate).

- **Holding Pressure**

  Holding pressures are typically lower than injection pressures and must be maintained throughout the gate solid-off time to avoid sink marks and voids.

CLEANING

Remove other polymers completely from the extruder barrel before processing Gharda PEK polymer. This can be accomplished either by cleaning the cylinder and screw mechanically or by using suitable cleaning materials. These are materials that are thermally stable up to approximately 380 °C. Suitable materials include PES, PEI and, with limitations, high-viscosity HDPE. Since HDPE decomposes at these temperatures, effective ventilation is important.

CLEANING EASY SIX STEPS:

1) Remove the polymer material from the hopper.
2) Run the screw empty.
3) Feed in the cleaning material mention above and continue extruding until there is no longer any visible trace of the PEK polymer.

4) Reduce the cylinder temperatures to a lower value that is still acceptable for PEK (370 °C) and, if necessary, reduce further to the temperatures of the cleaning agent.
5) Continue to purge with the purging material until the typical temperatures of the cleaning material have been attained.
6) If required purge with another material that can be easily removed from the metal before mechanical cleaning.

INJECTION MOLDING TROUBLE SHOOTING GUIDE

The purpose of this guide is to identify a broad range of molding problems that can arise in injection molded parts during Gharda G-PAEK Polymers. This is intended as a guide only and may not be the optimum solution for every application.
When troubleshooting, it is important to remember that the first step is to identify the "true" issue. When making processing changes, make one change at a time and allow two cycles, at a minimum, before moving on. If the change made does not fix the problem, then you should put that setting back to its original setting before making the next change.

Black Specks	
Possible cause	Remedy
1. Contamination in material	✓ Replace with new material
2. Heater Band malfunction	✓ Check for over run/over heating
3. Contamination from previous run	a) Clean screw and barrel b) Check for hang up areas in screw and check valve areas
4. Degraded Polymer	a) Lower melt temperature b) Lower back pressure c) Lower screw RPM

Blisters/Bubbles	
Possible cause	**Remedy**
1. Moisture in material	✓ Check moisture levels of material and dry if needed
2. Air Entrapment	a) Check vents and clean if needed b) Reduce clamp pressure to minimum amount needed c) Increase back pressure
3. Degraded polymer	a) Lower melt temperature b) Lower back pressure c) Lower Screw RPM

Black Specks	
Possible cause	**Remedy**
1. Contamination in material	✓ Replace with new material

2. Heater Band malfunction	✓ Check for over run/over heating
3. Contamination from previous run	a) Clean screw and barrel b) Check for hang up areas in screw and check valve areas
4. Degraded Polymer	a) Lower melt temperature b) Lower back pressure c) Lower screw RPM

Brittleness	
Possible cause	**Remedy**
1. Moisture in material	✓ Check moisture level of material and dry if needed
2. Excessive melt temperature	a) Lower melt temperature b) Lower nozzle temperature c) Decrease back pressure d) Check for long residence times in the barrel and lower temperatures if needed
3. Melt temperature to low	a) Increase melt temperature
4. Contamination	b) Inspect resin for contamination (replace if contaminated)
5. Excessive amounts of regrind	✓ Purge machine thoroughly ✓ Reduce regrind % (general rule- 25-30%)
6. Improper gate size/location	a) Increase gate size to obtain optimum filling b) Relocate gate away from potential stress areas

Burns in gate area	
Possible cause	**Remedy**
1. Burrs or sharp corners at the gate	a) Polish gate area to eliminate rough areas and sharp edges b) Decrease gate land length
2. Gate size to small	✓ Gate size should be 50-80% of the nominal wall thickness
3. Color concentrate shear sensitive	✓ Remove color concentrate and run natural to verify

Burns at the end of fill	
Possible cause	**Remedy**
1. Plugged vents	✓ Clean vents
2. Over clamping	✓ Reduce clamp pressure to minimum needed
3. Inadequate vents	✓ Add vents
4. Melt temperature to high	✓ Reduce melt temperature
5. Injection rate to fast	✓ Decrease injection rate

Cracking/Crazing	
Possible cause	**Remedy**
1. Contamination	a) Change to different lot of material b) Eliminate regrind as contamination source c) Remove colorant
2. Part removal	a) Redesign knockout system for balanced ejection force b) Rework mold and provide adequate draft angles and eliminate excessive undercuts
3. Packing excessive material into the mold	a) Decrease pack pressure b) Decrease shot size c) Increase transfer point to lower peak injection pressure d) Decrease injection time
4. Non-uniform or too cold of a mold temperature	a) Increase mold temperature b) Supply uniform cooling to cavity
5. Chemical contamination	a) Do not over use mold release b) Clean mold

Burns in gate area	
Possible cause	**Remedy**
4. Burrs or sharp corners at the gate	a) Polish gate area to eliminate rough areas and sharp edges b) Decrease gate land length
5. Gate size to small	✓ Gate size should be 50-80% of the nominal wall thickness
6. Color concentrate shear sensitive	✓ Remove color concentrate and run natural to verify

Dimensional Inconsistency	
Possible cause	**Remedy**
1. Non-uniform feeding of material **2.** Insufficient packing of part **3.** Regrind levels inconsistent **4.** Melt pressure variations **5.** Unbalanced runner system	a) Adjust temperature for optimum filling b) Increase shot size to maintain proper cushion c) Replace check valve if cushion cannot be maintained ✓ Increase injection forward time and pressure to ensure gate freeze off a) Review regrind blending procedures b) Decrease level of regrind ✓ Increase fill pressure to maintain the selected velocity of most runs

	a) Increase holding pressure to maximum b) Increase injection rate c) Balance runner and gate sizes to provide balanced filling

Discoloration	
Possible cause	**Remedy**
1. Material Overheating	a) Decrease screw RPM b) Decrease back pressure c) Decrease residence time d) Check barrel and nozzle heater bands and thermocouples
2. Contamination by foreign material	a) Review material handling procedures b) Purge injection cylinder

Flashing	
Possible cause	**Remedy**
1. Excessive melt/mold temperature	✓ Reduce melt and mold temperatures
2. Excessive packing of material	✓ Decrease packing pressure
3. Injection pressure to high	a) Decrease injection pressure b) Decrease boost time c) Decrease injection rate d) Increase transfer position
4. Projected area to large for available tonnage	✓ Switch to larger tonnage machine
5. Uneven or poor parting line and mating surface	a) Remove mold and carefully inspect and repair parting lines b) Repair cavities and cores that do not have a positive shut-off
6. Mold clamping pressure not properly adjusted	a) Increase clamping pressure b) Check parting line for obstruction c) Check press platens for parallelism
7. Non- uniform cavity pressure due to unbalanced filling	a) Balance/increase runner and gate sizes to obtain uniform filling P b) Properly balance cavity layout for maintaining uniform cavity pressure

Flow Lines	
Possible cause	**Remedy**
1. Melt temperature to low	✓ Increase melt temperature
2. Mold Temperature to low	✓ Increase melt temperature
3. Gate size to small	✓ Increase gate size
4. Non- uniform wall thickness	✓ Redesign part for more uniform wall thickness to provide for optimum filling

Nozzle Drooling	
Possible cause	**Remedy**
1. Nozzle temperature to hot	a) Decrease nozzle temperature b) Decrease melt temperature c) Reduce back pressure d) Increase screw decompression
2. Moisture in material	a) Review material handling procedures to eliminate moisture pick up b) Dry material according to manufactures recommendations

Parts sticking in mold	
Possible cause	**Remedy**
1. Over packing material in mold	a) Decrease first stage injection pressure b) Decrease boost time c) Decrease injection forward time d) Decrease packing pressure
2. Insufficient draft on cavities/sprue	✓ Increase transfer position
3. Part to hot for ejection	a) Redesign to allow maximum allowable draft b) Increase cooling time c) Decrease melt temperature d) Decrease mold temperature
4. Undercuts to big to allow part release	✓ Redesign or reduce undercut
5. Molded part sticking to stationary half of mold	a) Redesign sprue puller b) Increase nozzle temperature
6. Knockout system incorrectly designed	✓ Redesign for balanced ejection force

Short Shots	
Possible cause	**Remedy**
1. Melt temperature to low	✓ Raise melt temperature
2. Mold temperature to low	✓ Raise mold temperature
3. Insufficient material volume	a) Increase shot size to maintain a constant cushion b) Inspect non-return valve for wear
4. Air entrapment causing resistance to fill	a) Provide adequate venting b) Increase number and size of vents
5. Restricted flow of material to cavity	a) Increase gate size b) Increase runner size c) Use larger orifice nozzle

Splay (Silver Streaking)	
Possible cause	**Remedy**
1. Excessive moisture in material	a) Review material handling procedures to eliminate moisture pick up b) Dry material according to manufactures recommendations
2. Melt temperature to high	a) Decrease barrel temperatures b) Decrease nozzle temperatures
3. Excessive shear heat	a) Reduce screw RPM b) Increase gate and runner size c) Decrease injection rate d) Check nozzle for obstruction
4. Air entrapment	a) Reduce screw decompression b) Improve mold venting
5. Condensation or excessive lubricant on mold surface	a) Increase mold temperature b) Clean mold surface c) Minimize use of mold release
6. Moisture condensing in feed section of barrel	a) Decrease throat cooling b) Increase rear zone temperature

Sinks and Voids	
Possible cause	**Remedy**
1. Improper part design **2.** Insufficient pack and hold times **3.** Insufficient volume of material **4.** Gate freezes off prior to properly packing out part	✓ Core out thick wall sections ✓ Ensure pack and hold time is sufficient for gate freeze by performing a gate freeze analysis a) Increase shot size to maintain a constant cushion b) Inspect non-return valve for wear a) Increase size of gates and runners b) Increase size of the nozzle and sprue

Sprue Sticking	
Possible cause	**Remedy**
1. Nozzle orifice is larger then sprue orifice	✓ Use nozzle that has an orifice at least .010” smaller then the sprue orifice
2. Insufficient taper on sprue bushing	✓ Increase taper on sprue bushing (Minimum of 1.5° over the length of the sprue) E
3. Imperfections on inside of sprue	✓ Eliminate imperfections and polish surface in direction of draw
4. Over packing material in sprue	a) Reduce pack and hold time b) Decrease injection forward time c) Utilize machine sprue break
5. Nozzle temperature to low to provide clean break	a) Increase nozzle temperature

	b) Use reverse taper nozzle

Surface Imperfections (Glass/Carbon on surface, mineral bloom)	
Possible cause	**Remedy**
1. Melt temperature to low	✓ Increase melt temperature
2. Mold temperature to low	✓ Increase mold temperature
3. Insufficient packing of the part	✓ Increase pack pressure
4. Insufficient material in mold	a) Increase shot size and maintain constant cushion b) Decrease injection transfer position
5. Injection rate to slow	a) Increase first stage pressure b) Increase boost time c) Increase injection speed
6. Water on mold surface	a) Increase mold temperature b) Look for water leaks and repair if needed
7. Excessive build up of lubricant on mold	a) Clan mold surface b) Use mold release sparingly
8. Moisture in material	a) Review material handling procedures b) Dry material prior to molding
9. Inadequate venting	✓ Increase number of vents

Warpage	
Possible cause	**Remedy**
1. Part ejected while too hot	a) Decrease melt temperature b) Decrease mold temperature c) Increase cooling time d) Cool part in warm water after ejection e) Use secondary fixture to hold part dimensions
2. Shrinkage differential due to non-uniform shrinkage	a) Increase injection rate b) Increase pack pressure c) Balance runners and gates d) Increase runner and gate size e) Increase/decrease injection time
3. Melt temperature too low	✓ Increase melt temperature to provide better pack out of part
4. Shrinkage differential due to non-uniform wall thickness	a) Increase cooling time b) Redesign part with uniform wall thickness
5. Insufficient pack and hold times or pressures	✓ Add pack and hold time or pressure
6. Ejection system poorly designed	✓ Redesign ejection system for balanced ejection force
7. Differential mold cooling	

	✓ Balance mold temperature

Weak Weld Lines	
Possible cause	**Remedy**
1. Melt temperature too low	✓ Increase melt temperature
2. Mold temperature too low	✓ Increase mold temperature
3. Insufficient pressure at weld line	a) Increase first stage injection pressure b) Increase boost time c) Increase pack pressure d) Increase pack time e) Increase injection rate/speed
4. Air trapped in mold	a) Increase vents at weld area b) Decrease injection speed to allow air removal c) Decrease clamp pressure to minimum pressure
5. Injection rate to slow	a) Increase injection speed b) Increase boost time c) Increase first stage injection pressure
6. Flow distance from gate to weld line area excessive	a) Relocate gate or use multiple gating b) Utilize overflow tab in mold to increase strength in weld line area