Firestone

NYLON 6 RESINS

CORRECTING MOLDING PROBLEMS

A TROUBLE SHOOTING GUIDE

A. TROUBLESHOOTING GUIDE FOR INJECTION MOLDERS.

I. INTRODUCTION

The source of problems in injection molding of nylon resins can depend upon such diverse factors as the particular resin used, the mold design, processing variables, polymer related deficiencies or problems, and the processing equipment used. Obviously many of these factors can interact, sometimes in complex manners. The purpose of the guide is to relate more common problems experienced with the injection molding of nylon to their probable causes, and to suggest corrective action to be taken by the molder.

The processor is ultimately responsible for the proper molding of any part, and must use his own individual skills and knowledge in achieving satisfactory molded parts and injection molding performance. However, the expertise of a Firestone specialist and the required laboratory back-up support are always available to the purchaser of Firestone nylon resins.

II. PRODUCT SELECTION

Firestone offers a family of nylon 6 molding resins, each with unique properties for different applications. Experience has shown each resin to be of excellent quality, exhibiting superior injection molding processability when handled correctly and used in appropriate applications.

Firestone assistance is available in the selection of most appropriate Firestone nylon 6 resin for a particular application. When screening of various types of molding resins is required, sample quantities are readily available.

III. PROCESSING

Good results in the injection molding of nylon parts are not achieved by accident. The equipment, the processing conditions and the behaviors of the nylon 6 polymer are all critical. The most significant factors are:

A. TEMPERATURE

The importance that temperature plays in the injection molding of satisfactory parts is well known.

Firestone nylon 6 resins have a melting point of approximately 420 degrees F/216 degrees C. Melt temperatures of 480-520 degrees F/249-271 degrees C are generally recommended, with the reinforced grades usually requiring higher melt temperatures than the unfilled grades for good flow properties. A general rule-of-thumb is to use the lowest melt temperature consistent with good processing, part appearance and part performance.

The viscosity of the melt, plasticizing rate and the melt temperature are all dependent on the cylinder temperature. Since the optimum cylinder temperature depends upon the machine, the mold configuration and the type of resin being used, it must be determined experimentally for each application. Temperature indicators are not always precise and reliable and should be calibrated at regular intervals Correlations between cylinder temperatures and melt temperatures are often use and can save the processor a considerable amount of time whenever a mold or resin change is required.

Crystallinity is an important factor in the properties of parts molded from Firestone nylon 6 and mold temperature is the key to control of part properties such as hardness, toughness, shrinkage, warpage, etc. Normally mold temperatures of 120-180 degrees F/48-82 degrees C are recommended for the injection molding of Firestone nylon 6 in order to prevent premature freezing of the melt. As with the cylinder temperature, some experimentation is required to establish the optimum mold temperature for a given application. Some gain in toughness, and clarity, as well as reductions in shrinkage, mold warpage and flashing can be achieved at the lower end of the recommended range. The appearance of flow lines, surface imperfections and short shots can indicate the need to operate at the higher end of the recommended mold temperature range.

B. REGRING CONTENT

Economics dictate some use of regrind by the processor; however the " more is better syndrome" should be avoided.

The allowable regrind level is dependent upon the resin used and the application. The general rule-of-thumb is 25-30% regrind.

Regrind and virgin resin should be thoroughly blended to avoid melt flow inconsistencies and dimensional variations. Immediate processing of regrind is recommended to avoid excessive moisture.

C. MOISTURE CONTENT

Firestone nylon 6 resins are supplied with a moisture content sufficiently low for good injection molding performance and good part appearance. Normal practice is to utilize hopper dryers at the press to eliminate the possibility of excessive moisture regain in the hopper and to provide some drying of the regrind.

D. CYCLE TIME

With Firestone nylon 6 resins, it is generally recommended that the injection time be just short of cushioning and that enough hold time be allowed to achieve complete gate freeze-off. The cooling time should be sufficient to give part ejection with no deformation.

E. INJECTION SPEED

Fast injection speeds are desirable due to economics. Since Firestone nylon 6 resins have a relatively sharp melting point, fast injection speeds are also recommended to reduce the potential for premature freezing of the melt.

F. PRESSURE

Improper pressures can cause a multitude of problems including flashing, short shots, improper injection rates and excessive packing.

Pressure requirements for the injection molding of Firestone nylon 6 depend on many factors, including the molding machine, mold design, condition of the mold, melt temperature and mold temperature. Some experimentation is usually required to achieve the optimum pressures for each application. Firestone nylon 6 generally requires relatively low pressure due to its excellent flow characteristics.

IV. MOLD DESIGN

Mold design is critical for the injection molding of any plastic material, and improper design can cause problems too numerous to mention in this publication. It may be possible to mold an acceptable part from Firestone nylon 6 with an incorrect mold design, but it will be extremely difficult and highly uneconomical.

V. TROUBLESHOOTING

This guide is presented as an aid to the processors of Firestone nylon 6. While Firestone technical personnel are always ready to assist when problems arise, it is hoped that troubleshooting recommendations/suggestions presented in the following Tables I to XIX will aid the processor in solving specific problems " on-the-spot", without undue delay and expense, The problems covered are those which are most commonly encountered in injection molding.

TABLE 1
BURN MARKS

POSSIBLE CAUSE	SUGGESTED CORRECTIVE ACTION
A. High melt temperature	1. Reduce melt temperature
B. Injection rate too rapid	1. Reduce first stage pressure. 2. Reduce boost time.
C. Entrapped air in mold.	1. Vent mold cavity at final fill point. 2. Lower injection speed (first stage pressure and/or boost time) 3. Gate relocation,
D. High moisture content in resin	1. Use hopper/dryers. 2. Dry resin prior to molding. 3. Eliminate moisture pick-up by Improving material handling procedures. 4. Reduce lag-time between production and use of regrind material.

TABLE II
CRAZING/CRACKING

POSSIBLE CAUSE	SUGGESTED CORRECTIVE ACTION
A. Excessive packing resulting in highly stressed area at gate.	1. Lower packing pressure. 2. Reduce shot size.
B. Low mold temperature	1. Increase mold temperature.
C. Mold cooling non-uniform	1. Redesign mold cooling system for uniform cavity cooling.
D. Improperly designed knockout system	1. Redesign knockout system to provide balanced ejection forces.
E. Excessive undercut	1. Rework mold.
F. Draft angles inadequate	1. Rework mold.

TABLE III DIMENSIONAL
VARIATIONS

POSSIBLE CAUSE	SUGGESTED CORRECTIVE ACTION
A. Inconsistent molding conditions.	1. Duplicate previous molding conditions
B. Machine control malfunctions or inadequate controls, resulting in temperature variations.	1. Check and recalibrate control instrumentation. 2. Replace inadequate controllers. C.
Resin feed non-uniform	1. Adjust temperature profile to yield optimum feeding. 2. Adjust shot size for uniform, minimum cushion.
D. Non-Uniform cavity pressure due to unbalanced runner.	1. Provide maximum holding pressure. 2. Increase injection rate. 3. Progressively increase gate sizes from sprue to provide uniform filling.
E. Poor part design.	1. Redesign part.
F. Material variations.	1. Improve virgin/regrind blending. 2. Reduce regrind to virgin ratio. 3. Clean hopper thoroughly when switching materials.

TABLE IV
FLOW LINES/MARKS

POSSIBLE CAUSE	SUGGESTED CORRECTIVE ACTION
A. Low melt temperature.	1. Raise melt temperature. B.
Low mold temperature.	1. Raise mold temperature.
C. Injection rate too rapid.	1. Lower first stage pressure.
	2. Reduce boost tome.
D. Jetting due to improper gate size	1. Increase gate size.
	2. Lower injection rate.
	3. Raise melt temperature.

TABLE V LAMINATION AT
THE GATE

POSSIBLE CAUSE	SUGGESTED CORRECTIVE ACTION
A. Low melt temperature.	1. Raise melt temperature. B.
Cold mold	1. Raise mold temperature. C.
Slow injection rate	1. Raise first stage pressure.
	2. Increase boost time.
D. Low holding pressure.	1. Raise holding pressure.
E. Small gate size.	1. Increase gate size.

TABLE VI MATERIAL
DISCOLORATION

POSSIBLE CAUSE	SUGGESTED CORRECTIVE ACTION
A. Overheating in cylinder.	1. Lower melt temperature.
	2. Reduce overall cycle.
	3. Reduce screw speed.
	4. Lower back pressure.
	5. Use smaller capacity machine to reduce cylinder residence time.
B. Material hanging up in cylinder or nozzle.	1. Purge cylinder thoroughly.
	2. Reduce injection rate.
	3. Check cylinder for cracks.
	4. Remove nozzle and clean.
	5. Remove valve and check for ring wear.
C. Oxidation/ degradation due to excessive drying temperature.	1. Reduce drying temperatures. Recommended range is 170-180degF 77-82degC for hot air dryers. If drying under vacuum, temperature of 200F/93C may be used.
D. Contamination	1. Improve handling of virgin and regrind.
	2. Purge cylinder thoroughly.
	3. Keep hopper covered.
	4. Clean hopper thoroughly when switching materials.
E. Flow over sharp projections	1. Check for nicks in nozzle.
	2. Check for sharp projections or defects in mold.

TABLE VII
NOZZLE DROOL

POSSIBLE CAUSE	SUGGESTED CORRECTIVE ACTION
A. Nozzle temperature too high	1. Lower nozzle temperature
B. High melt temperature	1. Lower cylinder temperatures. 2. Decrease screw speed (screw machine) 3. Lower back pressure (screw machine)
C. Excessive moisture in resin	1. Utilize hopper/dryer 2. Dry material prior to molding 3. Eliminate moisture pick-up by improving material handling procedure.
D. Nozzle orifice too large	1. Use nozzle with smaller orifices.
E. Excessive cycle time.	1. Decrease overall cycle time.
F. Lack of lubrication	1. Use lubricated resin.
G. Improper type nozzle	1. Use positive-seal nozzle 2. Use reverse taper nozzle.

TABLE VIII PART
BRITTLENESS

POSSIBLE CAUSE	SUGGESTED CORRECTIVE ACTION
A. Low melt temperature	1. Raise melt temperature.
B. Polymer degradation due to overheating.	1. Lower melt temperature. 2. Cylinder residence time excessive, use smaller capacity machine.
C. Excessive moisture in resin	1. Utilize hopper/dryers. 2. Dry material prior to handling. 3. Eliminate moisture pick-up by improving material handling procedures. 4. Reduce lag-time between production and use of regrind material.
D. Contamination or excessive pigment.	1. Resin inspection for contamination. 2. Review handling and use of regrind material. 3. Reduce pigment loading. 4. Keep hopper and other possible exposure points covered. 5. Thoroughly purge injection cylinder. 6. Clean hopper thoroughly when switching materials.
E. Excessive regrind.	1. Reduce amount of regrind. (Do not exceed 25-30% regrind as a general rule).
F. Slow injection rate	1. Increase inject/first stage pressure. 2. Increase boost time.
G. Improper location of gate	1. Relocate gate. Keep gate away from potential stress area.
H. Gate size too small	1. Enlarge gate size.

TABLE IX
NOZZLE FREEZE OFF

POSSIBLE CAUSE	SUGGESTED CORRECTIVE ACTION
A. Nozzle temperature to high.	1. Decrease nozzle temperature.
B. Pressure too low.	1. Increase injection pressure.
C. Low mold temperature	1. Raise mold temperature.
D. Nozzle orifice to small.	1. Use nozzle with larger orifice.

TABLE X PART
FLASHING

POSSIBLE CAUSE	SUGGESTED CORRECTIVE ACTION
A. Excessive pressure.	1. Lower injection pressure. 2. Reduce boost time. 3. Reduce injection forward time.
B. Temperature excessively high.	1. Lower melt temperature. 2. Lower mold temperature.
C. Overpacking.	1. Lower packing pressure. 2. Reduce shot size.
D. Injection force greater than available clamping forces.	1. User larger tonnage machine. 2. Reduce number of cavities.
E. Clamping pressure too low.	1. Increase clamping pressure.
F. Mold deficiencies.	1. Progressively increase gate size from sprue to obtain uniform filling. 2. Balance cavity layout for maintenance of uniform pressure in cavity.
G. Insufficient venting.	1. Increase cavity venting.
H. Foreign matter left in mold.	1. Inspect and clean mold thoroughly.
I. Improper mating of mold surfaces	1. Insure mold properly installed. 2. Inspect and repair parting lines. 3. Inspect and repair cavities and cores not having positive seal and surface mating.

TABLE XI
VOIDS/BUBBLES

POSSIBLE CAUSE	SUGGESTED CORRECTIVE ACTION
A. Excessive moisture in resin	1. Utilize hopper/dryer. 2. Dry material prior to molding. 3. Eliminate moisture pick-up by improving material handling procedure. 4. Reduce lag-time between production and use of regrind material.
B. High melt temperature.	1. Lower melt temperature. 2. Decrease overall cycle time.
C. High internal shrinkage due to insufficient material in cavity.	1. Raise holding temperature 2. Increase injection forward time. 3. Increase gate size. 4. Minimize thick sections in part design.

TABLE XII
PARTS STICKING IN MOLD

POSSIBLE CAUSE	SUGGESTED CORRECTIVE ACTION
A. Overpacking.	1. Lower first stage injection pressure. 2. Reduce boost time. 3. Reduce shot size. 4. Reduce injection forward time. 5. Lower holding pressure.
B. Parts too hot.	1. Increase mold cooling time. 2. Lower melt temperature. 3. Lower mold temperature,
C. Low nozzle temperature.	1. Raise nozzle temperature.
D. Insufficient knockout	1. Redesign for balanced ejection forces
E. Insufficient mold release	1. Apply mold release agent to cavity. 2. Add external mold release agent or change to lubricated resin.
F. Inadequate sprue puller	1. Redesign sprue puller.
G. Improper mold surface finish	1. Draw polish to proper finish.
H. Inadequate draft or cavities/sprue	1. Polish and provide maximum allowable draft.
I. Cavity misalignment/core shifting.	1. Realign cores and cavities.
J. Cavity pressure non-uniform (multi-cavity mold)	1. Redesign runner-gate system for balanced filling of cavaties.
K. Surface imperfections and undercuts in mold.	1. Repair and polish.

TABLE XIII
PART SURFACE IMPERFECTIONS

POSSIBLE CAUSE	SUGGESTED CORRECTIVE ACTION
A. Low melt temperature.	1. Raise melt temperature.
B. Cold mold	1. Raise mold temperature.
C. Slow injection rate.	1. Raise first stage injection pressure. 2. Increase boost time. 3. Increase injection speed.
D. Insufficient material in mold	1. Increase shot size/maintain constant cushion. 2. Raise second stage injection pressure.
E. Water or condensation on mold	1. Examine and repair any water leaks. 2. Raise mold temperature.
F. Excess lubrication on mold surface	1. Wipe mold thoroughly with solvent. 2. Reduce use of mold release agent.
G. Moisture in resin	1. Use hopper/dryers. 2. Dry material prior to molding. 3. Eliminate moisture pick-up by improving material handling procedures.
H. Mold surface defects.	1. Examine and remove any defects. Draw polish surface.

TABLE XIV
PART WARPAGE

POSSIBLE CAUSE	SUGGESTED CORRECTIVE ACTION
A. Low melt temperature	1. Raise melt temperature.
B. Parts ejected too hot	1. Lower melt temperature.
	2. Lower mold temperature.
	3. Increase mold cooling time.
C. Varying wall thickness	1. Provide additional cooling to thickness sections.
	2. Increase mold cooling time.
	3. Operate stationary and moving mold halves at different temperatures.
	4. Redesign part for more uniform cross-section.
	5. Use metal with high conductivity for the mold sections requiring greater heat dissipation.
D. Non-uniform filling	1. Increase injection rate.
	2. Raise packing pressure.
	3. Redesign to provide balanced gates and runners.
E. Improperly designed knockout system	1. Redesign for balanced ejection forces
F. Poor pressure distribution	1. Gate into heavy section.
G. Overpacking	1. Lower packing pressure.
H. Lost contact with cavity surface.	1. Increase injection rate.
	2. Increase first stage injection pressure
	3. Provide adequate venting.

TABLE XV
POOR WELDS/WELD LINES

POSSIBLE CAUSE	SUGGESTED CORRECTIVE ACTION
A. Low melt temperature.	1. Raise melt temperature.
B. Cold mold	1. Increase mold temperature.
C. Insufficient pressure	1. Raise first stage pressure.
	2. Increase boost time.
	3. Increase injection forward time.
	4. Raise holding pressure.
D. Entrapped Air	1. Provide adequate vents.
	2. Reduce injection rate
E. Excessive lubricant/mold release plugging vents.	1. Clean mold surface thoroughly
F. Excessive distance from gate to weld lines	1. Relocate gates.
	2. Use multiple balanced gates.

TABLE XVI
SHORT SHOTS

POSSIBLE CAUSE	SUGGESTED CORRECTIVE ACTION
A. low melt temperature.	1. Raise melt temperature.
B. Cold mold.	1. Raise mold temperature.
C. Insufficient pressure on material in cavity	1. Raise first stage injection pressure. 2. Increase boost time.
D. Inadequate feeding of material	1. Increase shot size (maintain constant cushion)
E. Entrapped air/resistance to fill	1. Vent properly 2. Increase number/size of vents.
F. Flow to cavity restricted	1. Increase size of nozzle-sprue runner gate system.
G. Unbalanced flow (in multicavity mold)	1. Increase gate size. 2. Redesign runner system for balanced flow.
H. Poor part design.	1. Redesign part.

TABLE XVII
SINK MARKS

POSSIBLE CAUSE	SUGGESTED CORRECTIVE ACTION
A. Insufficient pressure on parts.	1. Raise first stage injection pressure 2. Raise holding pressure.
B. Insufficient material packed into cavity.	1. Increase shot/size maintain constant cushion. 2. Increase boost time. 3. Increase injection forward time.
C. High melt temperature.	1. Lower melt temperature
D. Premature freezing of gate.	1. Increase injection rate. 2. Raise melt temperature. 3. Increase gate size.
E. Parts ejected too hot.	1. Lower melt temperature. 2. Lower mold temperature. 3. Increase mold cooling time. 4. Provide improved mold cooling.
F. Heavy sections adjacent	1. Redesign part with more uniform wall thickness. 2. Improve/increase mold cooling at thick sections. 3. Move gate to heavy section. 4. Include design over sink mark to hide it from view (when elimination through part redesign cannot be achieved).

TABLE XVIII SPLAY/SILVER
STREAKING

POSSIBLE CAUSE	SUGGESTED CORRECTIVE ACTION
A. Excessive moisture in resin	1. Utilize hopper/dryers 2. Dry material prior to molding. 3. Eliminate moisture pick-up by improving materials handling procedures.
B. High melt temperature.	1. Lower melt temperatures.
C. Condensation on mold surface	2. Raise mold temperature.
D. Excessive mold release agent on mold surface	1. Wipe mold surface thoroughly with solvent. 2. Use external mold release sparingly
E. Moisture condensing on unmelted resin in feed sections.	1. Reduce throat cooling. 2. Raise rear zone temperature.
F. Melt fracture	1. Increase gate size, 2. Localized gate heating.

TABLE XIX
SPRUE STICKING

POSSIBLE CAUSE	SUGGESTED CORRECTIVE ACTION
A. Improperly fitted sprue nozzle interface.	1. Sprue bushing orifice should be larger than the nozzle.
B. Sprue bushing taper insufficient	1. Increase taper.
C. Pitted surfaces	1. Eliminate pits and draw polish surface.
D. Inadequate pull back	1. Increase undercut and redesign puller.
E. Overpacking in sprue.	1. Lower holding pressure 2. Reduce injection forward time. 3. Reduce shot size.
F. Sprue diameter excessive	1. Redesign sprue with smaller diameter.
G. Low nozzle temperature	1. Increase nozzle temperature to provide clean break.

Firestone Textiles Company
1200 Dundas Street East
Woodstock, Ontario, Canada
N4S 7Y9

Ph: 1-800-999-6231
1-519-421-5648
Fax: 1-519-537-6235
Mark.Morissette@firestone-textiles.com
www.firestone-textiles.com