Troubleshooting the PLA Sheet Extrusion Process

Problem	Probable cause	Suggested course of action
Machine direction lines in sheet (die lines)	Contamination in or at the lip	Clean the surface of the lips
		Clean the gap between lips with brass shim stock
		Take off die clean and examine for damage or corrosion
	Contamination particles inside the die (before lips)	Remove and clean die
	Plate-out buildup (at the die lip)	Insure all foreign polymer is purged from system
		Check temperatures for cold spots on the die
		Obtain sample for quantitative analysis
	Damage or contamination on or in die lips	
	Improper pinning of the web to casting / polishing roll	Increase roll temperature to get better contact with roll
		Install electrostatic pinning to force material against roll
	Polishing nip roll floating	Increase nip roll air pressure to force material against the roll
	Non-rotating idler roll scratching surface of the sheet	Free-up stuck roll, / lubricate roll
	Surface scratches on chill roll	Clean and optically examine chill rolls. Resurface if necessary
Erratic gauge control in TD	Die is out of adjustment	Proper die gap set across the width of the die
	Non optimal die pressure	Adjust process so the die pressure is between 1000 & 3000 psi
		Verify the restricter bar is not controlling die pressure
	Die temperature not uniform across the die	Independently verify the die temperature
		a) check accuracy of controllers and thermocouples
		b) Insulate die with fiberglass baffles
	Erratic flow on the bank in the nip of the chill roll	Adjust process to minimally perceptible bank
Erratic gauge control in MD	Surging in the extruder	See " Surging in extruder" below
	Poor tension control on the sheet line	Install a regeneration drive on the pull roll to isolate winder tension
		Adjust/ install a clutch on the 3rd cooling rolls
	Erratic flow on the bank in the nip of the chill roll	Adjust process to minimally perceptible bank
	If periodic on line with single chain drive, Uneven tension of the roller driving chain	Adjust chain tension, install new drive chain

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Problem	Probable cause	Suggested course of action
Surging in extruder	Uneven melt conditions in extruder (solid bed break up)	Raise heat in first zones of extruder Modify screw design
	Erratic polymer feed	Check feed throat for bridging, reduce feed throat temp If no cooling on feed throat, install Make certain hopper level is constant Check uniformity of feed resin, quality of pellets and regrind
	Material sticking on the screw causing erratic feeding	Remove material that is adhered to the screw. Use screw cooling if available (mandatory for amorphous feeds)
	Contamination of foreign plastic	Fully purge our feed systems and hoppers
Die pressure fluctuation	Clogged screen or disk pack	Replace screen with clean screen pack
	Melt pump surging	Verify drive is functioning properly Adjust parameters on pressure control loop
	Surging in the extruder	Refer to "Surging in extruder" section
Orange peel surface	Surface viscosity in die too high	Raise die temperature Raise heat in last zones of extruder
	Plate out on chill rolls	see "Plate out on chill rolls"
Dark specks and streaks	Polymer degrading	Reduce melt temperature Check for hot spots in adapter piping Open restrictor valve after screw barrel (reduction of back pressure)
	Defective thermocouple / control	Repair or correct affected zone
	Contaminants in melt	Examine virgin polymer pellets for black spec contamination Examine venting opening for degraded material or contamination Clean material handling system from box/silo to extruder Clean hopper and securely cover If using regrind, examine regrind for contamination and check granulator Clean die lips Check die design and streamline if necessary
	Polymer hang-up between die lip and body	Check mating surfaces for mis-alignment, damaged areas Check die design and streamline if necessary
	Metal corrosion or galling of shank bearing	Pull screw and examine for pitted chrome Pull screw and examine screw shank for oily or carbonaceous buildup

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Problem	Probable cause	Suggested course of action
Curved lines in cross-machine direction	Melt bank too large	Reduce melt bank to minimally perceptible bank
	Melt folding	Check extruder output, & determine if surging - if so, see "Surging in extruder"
		Gap of bottom roll too close, adjust nip gap to eliminate folding at bottom gap
	Rolls too hot causing sticking	Reduce roll temp slightly to relieve sticking
Curved lines in cross machine direction (during coextrusion - either multi-manifold die or combining block)	Melt flow instabilities	Adjust viscosity by changing melt temperature
		Change thickness of individual layers
Gels in sheet	Contamination with other polymers	Clean material handling system from boxes to hopper
		Completely purge extruder, adapter pipes, screen pack, static mixer, melt pump and die
	Contamination introduced with regrind	Clean regrind system and purge with PLA flake
		Examine sheet fed into regrind system for foreign contamination like dust and dirt
	Gels in feed polymer	Verify feed polymer has no gels by pressing plaque or extruding retain of smaller lab extruder
Dull spots on sheet surface	Sheet picking plate-out off chill roll	See "Plate out on chill roll"
Plate out on upper (polishing) chill roll	Top chill roll temperature too cold	Raise chill roll temperature in small increments, clean roll and monitor. Repeat if necessary
	Chill roll not contacting sheet uniformly	Raise nip pressure to a minimum of 600 pli (pounds / linear inch of wetted surface)
		Adjust flow from die to minimize thick areas in web
	Web viscosity too high to allow polishing with available nip pressure	Raise melt temperature
	Non uniform cooling in chill roll	Clean flow channels in chill roll
Plate out on casting chill roll	Sheet not pinned to roll	Raise roll temperature in small increments
		Increase pinning force on web
		Raise melt temperature
		Use alternate pinning mechanism such as air knife or electrostatic pinner

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Problem	Probable cause	Suggested course of action
Brittle sheet	Sheet too cold	Raise temperature of last chill roll. Sheet temperature should be between 75 and 115 F (25 - 45 C)
	Loss of molecular weight during extrusion	Insure feed polymer moisture content is < 250 ppm Reduce polymer melt temperature Reduce residence time of polymer melt
Hazy sheet	Contamination with other polymers	Clean material handling system from boxes to Completely purge extruder, adapter pipes, screen pack, static mixer, melt pump and die Clean regrind system and purge with PLA flake
	Incorrect additive package	Stop addition of additive package and see if sheet clears
	Polymer crystallizing	Reduce primary chill roll temperature
	Microscopic bubbles inside sheet	Decomposition of additive, remove additives and observe
Internal holes in sheet	Moisture	Dry polymer Dry regrind Seal hopper or use inert gas layer
	Air	Decrease heat in first zone of extruder If using venting, insure vent is clear of polymer Increase suction pressure on melt pump Reduce regrind concentration Change screw design to screw with higher compression ratio (> 2.0)
	Degrading polymer	Reduce polymer melt temperature by reducing Change screw design to less intense screw
	Decomposing additives	Stop addition of additive package and see if sheet clears
Melt freeze off	Melt temperature too low	Increase die temperature Increase heat in last zone of extruder Check for burned-out heater bands
	Screen too cold	Preheat screens before changing, check temperature control of screen changer

Troubleshooting the PLA Sheet Extrusion Process

Problem	Probable cause	Suggested course of action
Surface roughness in sheet	Die temperature too low Contamination with other polymers	Increase die temperature Clean material handling system from boxes to hopper Completely purge extruder, adapter pipes, screen pack, static mixer, melt pump and die Clean regrind system and purge with PLA flake
Trapped air marks under sheet	Excessive melt sag between die and nip point Uneven bank, marks occurring at high spot	Lower melt temperature to increase viscosity by reducing head pressure, decreasing screw speed or reducing temperatures Move extruder die closer to chill roll Move nip point lower than die centerline Angle die to achieve web contact with nip point just before nip point Reduce melt bank to minimally perceptible bank, uniform across the nip Use alternate pinning mechanism such as air knife or electrostatic pinner
Sagging of web at die exit	Low melt strength	Insure polymer is dried to less than 250 ppm moisture Lower melt temperature to increase viscosity by reducing head pressure, decreasing screw speed or reducing temperatures Use alternate pinning mechanism such as air knife or electrostatic pinner
Unpolished spots on web	Poor distribution of polymer and / or pinning of sheet Insufficient roll stack polish	Adjust flow from die to minimize thick areas in web Increase pinning force on web Increase roll stack temperature Decrease roll gap
Uneven color distribution	Bad pigment distribution	Check with MB supplier quality of masterbatch Increase back pressure (close restrictor valve, higher mesh screen) Check screw design for mixing zone Install static mixer
Polymer flow from vent	Conveying capacity of primary stage of screw greater than the secondary stage	Reduce pressure at head of screw Increase or reduce temperature of feed section of extruder Increase percentage of regrind
Edge waving in MD	Surging in extruder Uneven melt condition in die	See "Surging in extruder" Adjust die gap and restrictor bar Open deckling of die
Cracking at trimmed edges	Uneven or dull cutter blade	Adjust / replace knives

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	Using a knife or fixed-blade cutter on thick or cool sheet	Replace knife or fixed-blade cutter with rotary sheer cutter
Problem	**Probable cause**	**Suggested course of action**
Shrinkage in MD is to high	Web tension to high Incorporation of stresses into a rather cold sheet, due to a second calandering process Melt bank too large	Reduce speed of pulling roll Open second roller nip Adjust process to minimally bank
Dome of sheet in TD concave (edges bend to bottom) for a vertical down-stack	Uneven cooling	Reduce bottom roll temperature and possibly increase chill roll temperature
Dome of sheet in TD convex (edges bend to bottom) for a vertical down-stack	Uneven cooling	Increase bottom roll temperature and possibly decrease chill roll temperature
Bowing of sheet in MD	Web too warm when winding Uneven web tension	Reduce temperature of final cooling roll Adjust thickness distribution of the sheet Adjust pull roll gap and evenness of contact pressure Adjust roller gap Adjust cutting device, sharpen cutter

Safety and Handling Considerations

Material Safety Data (MSD) sheets for PLA polymers are available from NatureWorks LLC. MSD sheets are provided to help customers satisfy their own handling, safety, and disposal needs, and those that may be required by locally applicable health and safety regulations, such as OSHA (U.S.A.), MAK (Germany), or WHMIS (Canada). MSD sheets are updated regularly; therefore, please request and review the most current MSD sheets before handling or using any product.

The following comments apply only to PLA polymers; additives and processing aids used in fabrication and other materials used in finishing steps have their own safe-use profile and must be investigated separately.

Hazards and Handling Precautions

PLA polymers have a very low degree of toxicity and, under normal conditions of use, should pose no unusual problems from incidental ingestion, or eye and skin contact. However, caution is advised when handling, storing, using, or disposing of these resins, and good housekeeping and controlling of dusts are necessary for safe handling of product. Workers should be protected from the possibility of contact with molten resin during fabrication. Handling and fabrication of resins can result in the generation of vapors and dusts that may cause irritation to eyes and the upper respiratory tract. In dusty atmospheres, use an approved dust respirator. Pellets or beads may present a slipping hazard. Good general ventilation of the polymer processing area is recommended. At temperatures exceeding the polymer melt temperature (typically 170ºC), polymer can release fumes, which may contain fragments of the polymer, creating a potential to irritate eyes and mucous membranes. Good general ventilation should be sufficient for most conditions. Local exhaust ventilation is recom-mended for melt operations. Use safety glasses if there is a potential for exposure to particles which could cause mechanical injury to the eye. If vapor exposure causes eye discomfort, use a full-face respirator. No other precautions other than clean, body-covering clothing should be needed for handling PLA polymers. Use gloves with insulation for thermal protection when exposure to the melt is localized.

Combustibility

PLA polymers will burn. Clear to white smoke is produced when product burns. Toxic fumes are released under conditions of incomplete combustion. Do not permit dust to accumulate. Dust layers can be ignited by spontaneous combustion or other ignition sources. When suspended in air, dust can pose an explosion hazard. Firefighters should wear positive-pressure, self-contained breathing apparatuses and full protective equipment. Water or water fog is the preferred extinguishing medium. Foam, alcohol-resistant foam, carbon dioxide or dry chemicals may also be used. Soak thoroughly with water to cool and prevent re-ignition.

Disposal

Troubleshooting the PLA Sheet Extrusion Process

DO NOT DUMP INTO ANY SEWERS, ON THE GROUND, OR INTO ANY BODY OF WATER. For unused or uncontaminated material, the preferred options include recycling into the process or sending to an industrial composting facility, if available; otherwise, send to an incinerator or other thermal destruction device. For used or contaminated material, the disposal options remain the same, although additional evaluation is required. (For example, in the U.S.A., see 40 CFR, Part 261, “Identification and Listing of Hazardous Waste.”) All disposal methods must be in compliance with Federal, State/Provincial, and local laws and regulations.

Environmental Concerns

Generally speaking, lost pellets are not a problem in the environment except under unusual circumstances when they enter the marine environment. They are benign in terms of their physical environmental impact, but if ingested by waterfowl or aquatic life, they may mechanically cause adverse effects. Spills should be minimized, and they should be cleaned up when they happen. Plastics should not be discarded into the ocean or any other body of water.

Product Stewardship

NatureWorks LLC has a fundamental duty to all those that make and use our products, and for the environment in which we live. This duty is the basis for our Product Stewardship philosophy, by which we assess the health and environmental information on our products and their intended use, then take appropriate steps to protect the environment and the health of our employees and the public.

Customer Notice

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