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Cryogenic Deflashing *for High Performance Materials*

Used to remove parting-line flash in newly molded plastic parts, cryogenic deflashing can remove internal and external flash while maintaining efficiency and productivity.

By Joe Tittermary, Air Products

Manufacturing high performance materials for growing markets such as automotive and electronic components certainly has its challenges. Molded or machined parts must meet strict tolerances and intricate finishes. When elastomer parts are manufactured by way of injection, transfer or compression molding, a thin membrane of material, called flash, remains along the mold-parting line. Flash is excess, unwanted material that must be removed from finished parts.

Several techniques can be used to remove flash:

- Manual cutting with scissors or knives.
- Manual tear trimming at the mold.
- Die punching.
- Cryogenic deflashing.

Manual tear trimming or manual cutting is the process of manually removing tear trim beads from around the parting line of the finished part. While the capital cost is low for this technique, the process is labor intensive. In addition, manual tear trimming has relatively high variability in quality and production rate due to geometry of the part.

Die punching to remove flash consists of placing the molded product into a die, shaped like the finished part, and simultaneously punching the parts out of the flash mat (similar to using a cookie cutter). While this method provides somewhat consistent quality with a low capital cost, the process is labor intensive, resulting in lower production output.

Cryogenic deflashing is a process that uses the extremely low temperature of a cryogen such as liquid nitrogen (LIN) to remove flash. It accomplishes this by embrittling the rubber or plastic parts and subjecting the material to mechanical stress through tumbling and simultaneous media blasting. Media blasting is the process of blasting an item with small particles of various abrasive substances at an extremely high velocity to make changes to the surface. When combined with media blasting, tumbling enables uniform impingement of the blast media over the entire surface of all parts, removing both internal and external flash.

As industries continue to push the envelope towards more sophisticated and intricate molded parts, and manufacturers strive to safely comply with increasingly rigorous quality standards, cryogenic deflashing is a viable solution that balances both needs while maintaining efficiency and productivity in the manufacturing process.

By simply changing the process parameters and media size, cryogenic deflashing is amenable to many molded products, including O-rings, grommets and gaskets. With a low to moderate capital cost, cryogenic deflashing enables a consistent deflash quality and high production rate. A well-designed and operated system can result in lower overall labor and operating costs.

Cryogenic Deflashing Using Liquid Nitrogen

No deflashing process can make up for poor mold design or mold wear that leads to a poor or nonexistent parting line. The types of materials that may benefit from cryogenic deflashing can be seen in table 1, and the types of molded parts that may benefit from cryogenic deflashing can be seen in table 2.

Cryogenic deflashing is ideal when flash is thin with a good base or transition point where the flash can break away from the molded part in a precise manner. This transition in part thickness is known as the parting line and is a key factor in overall deflashing quality. Cryogenic deflashing is not ideal for thin cross-sectional parts such as diaphragms; parts with thin, sharp edges; and certain medical-related products due to contamination and cleanroom regulations.

Safety is paramount in any manufacturing process, and cryogenic deflashing using liquid nitrogen is no exception. When handled properly, liquid nitrogen is a safe and effective addition to many types of processes. Because liquid nitrogen can reach temperatures of -320°F (-195°C), transfer equipment and piping must be insulated and proper personal protective equipment (PPE) must be worn to avoid cryogenic burns.

Additionally, when liquid nitrogen vaporizes into a gas, there is a volume expansion of almost 700:1. Therefore, piping and equipment must be designed for adequate ventilation to avoid overpressurization and rupture. Although nitrogen is nontoxic and largely inert, it can act as a simple asphyxiate by displacing the oxygen in air. For this reason, work areas must be ventilated properly. Oxygen analyzers also should be used to monitor oxygen levels in the work area. Be sure to review the proper safety information and consult an industry professional for appropriate guidance.

To accurately project liquid nitrogen consumption, deflashing trials should be conducted.

To optimize operating costs, part quality and production output, it is important to properly manage liquid nitrogen consumption. Many factors — such as equipment, type of part, piping and geometry — can impact liquid nitrogen consumption rates during the cryogenic deflashing process.

Equipment for Cryogenic Deflashing

When selecting equipment, keep in mind:

- Type, size and capacity.
- Age, condition and maintenance history.
- Controls.

Type, Size and Capacity. Tumbler, shot blast and load capacity affect overall operating efficiency.

Age, Condition and Maintenance History. Older equipment tends to be less efficient due to equipment design, deterioration of the insulation surrounding the deflashing chamber, lack of precise temperature control and poorly maintained LIN injection piping.

Controls. Accurate temperature control of the deflashing chamber is achieved through proper placement of the LIN injection orifices and thermocouple probe to optimize deflashing quality and LIN consumption. Accurate control of basket-, belt- or impeller-wheel speed is required to further optimize finish quality and system efficiency.

Factors of importance regarding molded parts include:

- Durometer (hardness of the compound).
- Parting-line flash thickness.
- Part geometry, configuration and cross-section thickness.
- Molded part loading.

Durometer. Durometer can influence embrittlement temperature and LIN consumption. Higher durometer (harder) compounds embrittle at warmer temperature settings and require less LIN to cool. Lower durometer (softer) compounds embrittle at colder temperature settings and require more LIN to cool.

Parting-Line Flash Thickness. Parting-line flash thickness will determine the ability of the system to finish the molded part in conjunction with cycle time and LIN consumption. Thicker flash is more difficult to remove and requires longer deflash cycle time, resulting in higher LIN consumption. Optimum parting-line flash thickness is 0.001 to 0.005”. Mold design and condition are key to optimum finish quality and LIN consumption.

Part Geometry, Configuration and Cross-Section Thickness. The geometry of the molded parts also

Types of Materials That May Benefit from Cryogenic Deflashing

Neoprene Rubber
Nitrile Rubber
Butyl Rubber
Styrene-Butadiene (SBR) Rubber
Ethylene Propylene Diene Monomer (EPDM) Rubber
Silicone Rubber
Liquid Crystal Polymers (LCPs)
Thermoset and Thermoplastic Plastics

TABLE 1. Some materials are better suited for cryogenic deflashing than others.

Molded Parts That May Benefit from Cryogenic Deflashing

O-Rings and Gaskets
Medical Implants, Catheters
Electronic Connectors, Insulators
Valve Stems, Washers, Fittings
Face Masks, Goggles
Grommets
Seals
Mountings
Bushings

TABLE 2. Cryogenic deflashing is ideal when flash is thin with a good base or transition point where the flash can break away from the molded part in a pr ecise manner.

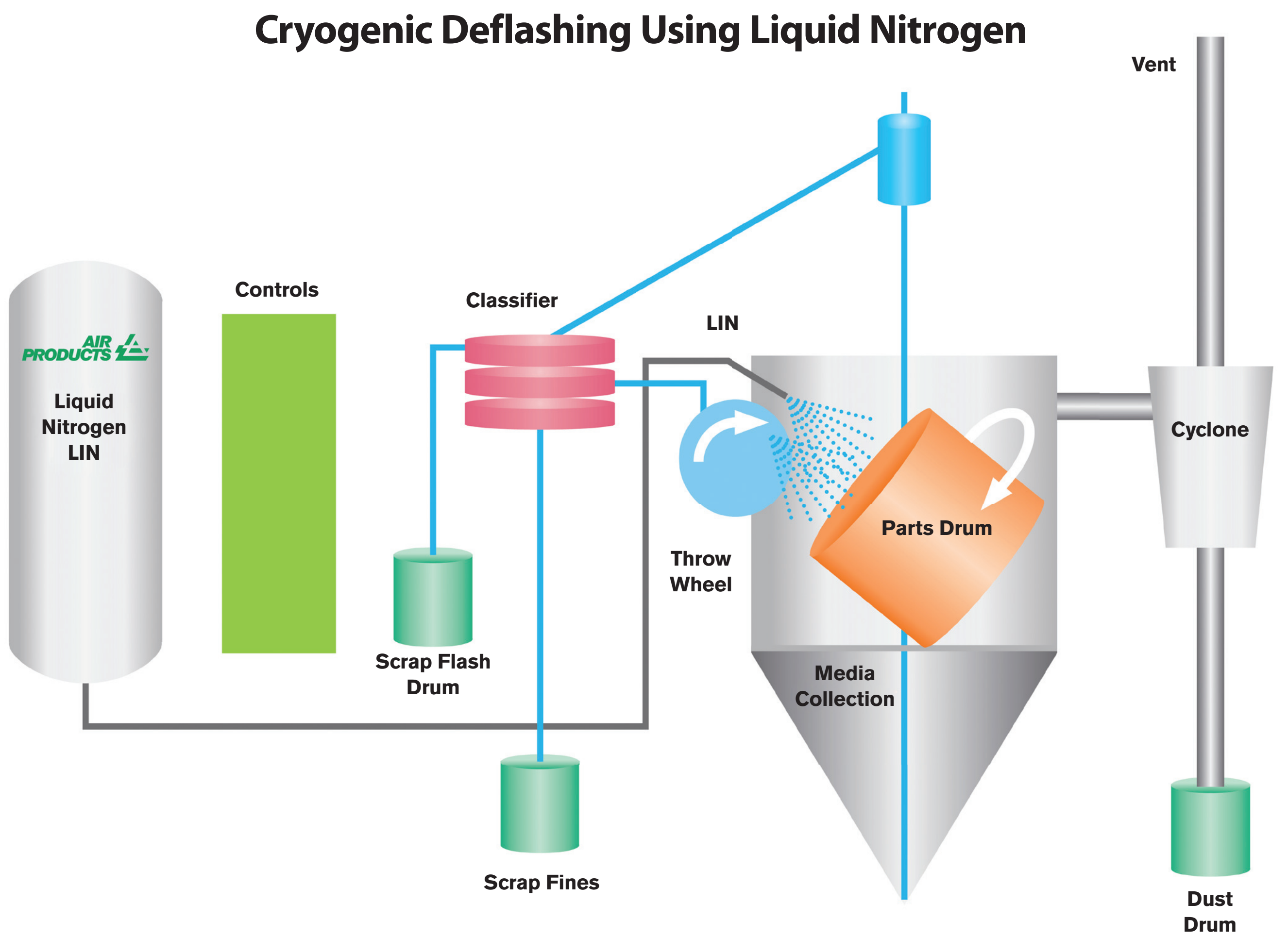
will have an impact on blast wheel speeds, belt or basket speeds and the length of the deflashing cycle. Parts with thin cross-sections and sharp, delicate edges may require longer deflashing cycle time and will result in increased LIN consumption.

Molded Part Loading. Optimum LIN consumption is achieved when the equipment is loaded to its rated capacity and when part load density is high. The weight of the additional parts offsets the fixed heat load of the system, resulting in lower LIN consumption ratios in terms of pounds of LIN per pounds of parts deflashed.

LIN Transfer Piping and Usage Variables

The type, size, length, configuration and usage pattern of the cryogenic liquid transfer piping system will determine the amount of heat leak losses incurred in the piping system. A poorly designed piping system will cause excessive two-phase flow, resulting in erratic process control, longer operating cycle time and increased LIN consumption. The estimated LIN consumption and part loading density for various part compounds can be seen in table 3.

To accurately project LIN consumption, deflashing trials should be conducted. Trials should utilize the appropriate deflashing equipment with optimum parts



This schematic depicts a cryogenic deflashing process using liquid nitrogen. Using the very low temperature of cryogens like liquid nitrogen, cryogenic deflashing temporarily embrittles residual material for removal when subjected to stress applied though tumbling and media blasting.

loading for the given equipment size. Consideration also must be made for deflashing quality relating to flash thickness, part geometry and mold condition. The following parameters are also important for conducting cryogenic deflashing trials:

- Media selection.
- Temperature.
- Throw wheel speed.
- Process/blast time.

Media Selection. Proper selection of media type is based on the geometry of the part/product.

Temperature. If the flash is still present on the part and is flexible after tumbling, the part was under-embrittled and temperature should be lowered. If the part is damaged or broken, it likely was over-embrittled, and the temperature should be raised.

Throw Wheel Speed. The throw wheel is the impeller wheel that accelerates the blast media. If the geometry of the part is thin, a lower wheel speed should be used. On the contrary, if the geometry of the part is thick, use a higher wheel speed. The presence of sharp, delicate edges dictates using a lower wheel speed.

Process/Blast Time. Recommended process/blast time is two to three minutes, but additional time and cycle may be needed on the same batch. It is best to evaluate the initial results and then adjust the next new cycle accordingly.

Ongoing Process Management and Optimization

Changes will occur over time. It is a part of every operation. It is important to re-evaluate your approach when new parts are introduced or when your process begins to experience unexpected issues from known or unknown changes. Optimization of the cryogenic deflashing process may include:

- Changes to the liquid nitrogen inlet

Estimated LIN Consumption and Part Loading Density for Various Part Compounds

Compound	Load Density (lb/ft^3)	Deflashing Temperature (°F)	Liquid Nitrogen Ratio (lb of LIN/lb of parts)
Neoprene	High	-100	0.75 to 1.0
Neoprene	Low	-100	1.0 to 1.5
Nitrile	High	-100	0.75 to 1.0
Nitrile	Low	-120	1.0 to 1.5
Butyl	High	-140	1.0 to 1.5
Butyl	Low	-150	1.5 to 2.0
SBR	High	-150	1.0 to 1.75
SBR	Low	-160	1.75 to 2.5
EPDM	High	-150	1.0 to 1.75
EPDM	Low	-160	1.75 to 2.5
Silicone	High	-175 to -225	1.75 to 3.0
Silicone	Low	-180 to -250	2.0 to 5.0

Load density: High ≥ 30lb/ft^3 Low ≤ 5 lb/ft^3

TABLE 3. A poorly designed piping system will cause excessive two-phase flow, resulting in erratic process control, longer operating cycle time and increased LIN consumption. The estimated LIN consumption and part loading density for various part compounds are shown.

nozzle to adjust spray pattern and flow rate.

- Thermocouple maintenance to ensure that the temperature and liquid nitrogen flow are controlled correctly.
- Mechanical checks to make sure that the throw wheel and material control cages are oriented correctly and continue to operate properly.
- Deflashing recipe re-evaluation to optimize the duration and liquid nitrogen usage for each different part material and geometry.
- Liquid nitrogen supply piping checks to avoid the unnecessary loss of liquid nitrogen to venting or piping that has lost its insulation value over time.

Cryogenic deflashing of molded or machined parts has become an increasingly important option for meeting the strict tolerances and intricate finishes of high performance materials used in today's growing markets such automotive and electronic components. Using the very low temperature of cryogens like liquid nitrogen, cryogenic deflashing temporarily embrittles residual material for removal when subjected to stress applied though tumbling and media blasting. By employing this method, manufacturers can benefit from consistently high production rates and product finish quality, resulting in lower labor and operating costs. A cryogenic gases application specialist can help identify the type of equipment best suited for a deflashing operation as well as test a variety of process parameters to help optimize productivity. **PC**

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