Akulon®

Akulon® Fuel Lock

PA6 and PA6-I

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GRADE CODING
Akulon® PA6 and PA6-I blow molding grades.

Akulon® Fuel Lock is a generation of polyamides (nylon polymers), which exhibit very effective barrier properties. Akulon® Fuel Lock is used in applications that require low permeation and extreme impact requirements at low temperature, like sORE (small off-road engine) fuel tanks or liners in Type IV light weight composite tanks for CNG (Compressed Natural Gas).

Blow molding requires specific knowledge regarding balancing the process window, product properties and the equipment capabilities. This practical guide aims at explaining how to successfully use Fuel Lock in the blow molding process and how this differentiates from processing HDPE.

Akulon® Fuel Lock is mostly used in continuous extrusion blow molding processes or intermittent processes like reciprocating or accumulator extrusion blow molding. Reciprocating screw, intermittent extrusion blow molding technology, is the preferred choice for high-volume production of lightweight containers at the lowest cost per container. This process provides fast parison delivery and control that are typical requirements of dairy, juice and water industry. Accumulator head technology is the best choice for the production of large and heavy parts in mono layer. It covers the widest range of applications: from industrial packaging to fuel tanks, from toys to household and gardening items.

MATERIAL HANDLING

Pre-drying conditions
While processing polymers that absorb moisture, such as nylons, care must be taken to assure that the moisture content of Fuel Lock resin, as well its regrind, is maintained at a maximum level of 0.10% or lower. Processing at moisture level higher than the recommended level may lead to a decrease in mechanical and physical properties. A modern, closed loop, desiccant bed dryer sized for proper throughput should be utilized. It is also advisable to regularly check the moisture content of the molding resin plus regrind using a commercially available moisture analyzer.

Drying conditions:

Drying time	Temperature	Remarks
4 – 8 hours	80°C (175°F)	Maximum moisture content will be 0.10%

Regrind
Since the blow molding process generates scrap at up to a 50% by weight level, the reuse of this material is required due to process economics. Evaluations of the use of Fuel Lock regrind has shown that levels up to 100% have been successful in maintaining the physical and mechanical properties of the virgin material. The successful use of Fuel Lock regrind in the blow molding process requires good initial care of the molded material, like proper initial drying.

Recommendations for blow molding

Akulon® Fuel Lock

PROCESSING

Melt temperature

The melt temperature mainly affects processing behavior via the viscosity and the color. A too high processing temperature results in a decreased melt strength and can result in discoloration (yellowness). Recycle of material that was processed at a too high temperature is not recommended.

Mold temperature

No/limited impact of the mold temperature can be expected on the pinch line or the part surface when processing Akulon® Fuel Lock. The mold temperature can be optimized to tune the result in surface quality and/or should be taken into account considering the design. It is recommended to use a mold temperature within the upper range of the recommended mold temperature regime for high article complexity.

Extrusion Zones			Resin	Mold
Feed	Compression	Metering	Melt	Temperature
260 – 280°C	250 – 260°C	245 – 255°C	250 – 260°C	20 – 80°C
(500 – 536°F)	*(482 – 500°F)*	*(473 – 491°F)*	*(482 – 500°F)*	*(68 – 176°F)*

The intake of material can be restricted by limitations of the equipment, like the power of the motor, which can be overcome by increasing the feed zone temperature. The preferred melt temperature at the die head is around 255°C (491°C). The die head temperature can be increased if surface roughness (sharkskin) is experienced.

Screw design

It is recommended to use a gradual compression screw with a L/D (length/diameter) ratio of ~25 and a compression ratio of ~3.0 (depth feed zone/depth metering zone). A shorter screw may result in inhomogeneous mixing, while an improper compression ration may result in air entrapment or overheating of the melt.

Residence time

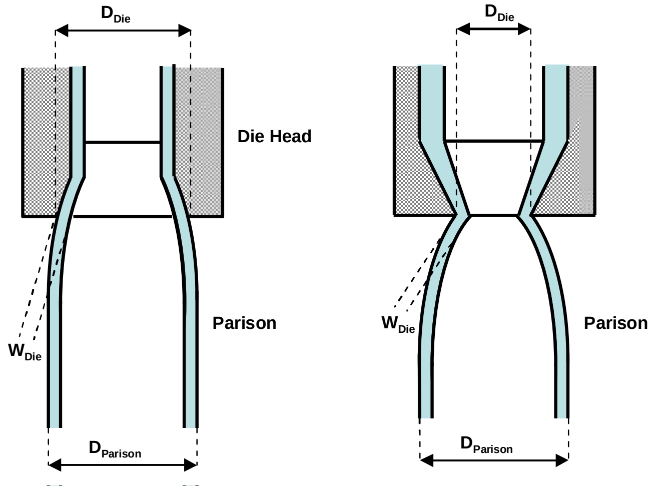
Downtime of the equipment or production stops may result in a relatively long residence time of the material at high temperature. Expect a reduction of the melt strength during extrusion when restarting. The impact on melt strength is higher for polyamides compared to HDPE. Akulon® Fuel Lock is designed to withstand process interruptions of ~1 hour without concessions to the quality of the performance.

Akulon® Fuel Lock

MACHINERY

Swell and blow-up rate

Die swell can be defined as the ratio between the outer parison diameter and the outer diameter of the die. The die swell of Fuel Lock is less than for HDPE. Typically, a die is used for Fuel Lock that is about twice the size than when processing HDPE. Besides the material, flow rate, viscosity, melt strength and die width, the die swell depends on the design of the die.



Diverging and converging die heads result in different die swell

A die swell of around 10% can be expected with Akulon® Fuel Lock. In general, Fuel Lock has a lower die swell than HDPE. Blow-up ratios of 1:3 to 1:5 can be achieved, depending on the part complexity.

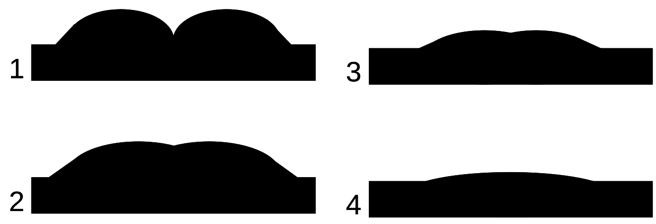
The blow-up pressure and speed have impact on the polymer distribution in the shape (wall thickness, etc.) and the final color (in case oxygen is used as blow-up medium). Preferably, the blow-up speed is optimized with a profile.

Closing speed

The closing speed of the mold has an impact on the pinch line (depending on the design of the mold). The closing speed has an optimum, which means in practice that closure of the final few mm should be done at reduced pace to allow material to flow into the pinch.

Mold design

The mold design should be considered to improve the pinch of the application. Below an overview of pinch profiles that could be encountered:

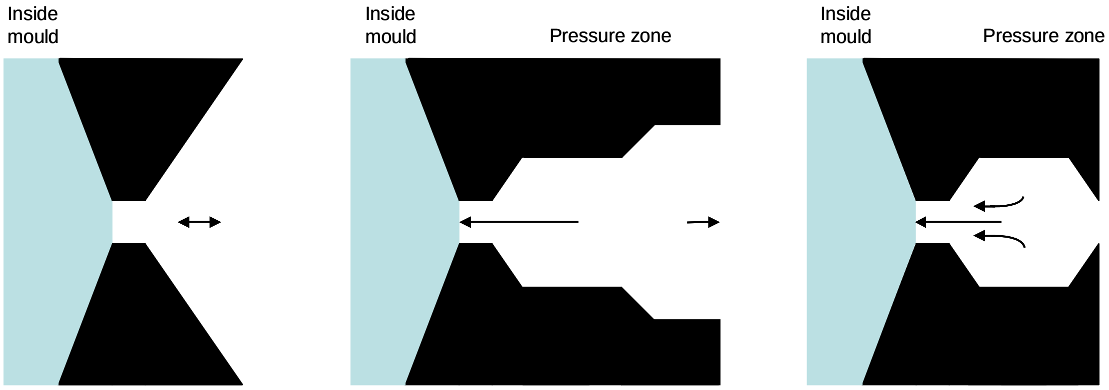


Pinch lines

Akulon® Fuel Lock

Typically, category 1 pinches should be avoided by using the correct mold design in combination with a proper processing window (temperature, pre-drying, recycle, heat stabilization, air/nitrogen, closing speed, etc.) and closing speed profile.

A pressure zone is recommended in the mold design to process Fuel Lock. Below three examples of how a mold designs could look like:



Regular mold type 1 *Pressure zone mold type 2* *Pressure zone mold type 3*

SAFETY

For the safety properties of the material, we refer to our SDS which can be ordered at our sales offices. During practical operation we advise to wear personal safety protections for hand/eye/body.

STARTUP/SHUT DOWN/CLEANING

Production has to be started and stopped with a clean machine. Cleaning can be done with preferably a high viscous natural PA6 (GF), applicable cleaning agents or HDPE. It is recommended to start-up with natural Akulon® Fuel Lock to visually check on contaminations.

CONCLUSION

Akulon® Fuel Lock is a polyamide, which can be processed via blow molding in a broad operating window with similar equipment as used for HDPE. Akulon® Fuel Lock is an intrinsic robust solution for reduced permeation of hydrocarbons through tank walls.

Recommendations for blow molding

Akulon® Fuel Lock

TROUBLESHOOTING

Parison	Q: Parison strength too little. Sagging observed.
	A: The melt temperature is too high, due to a too high barrel temperature. Reduce the barrel temperature or reduce the extrusion speed.
	A: The melt temperature is too high due to friction of the screw or in the die head. Increase the barrel temperature or increase the die temperature.
	A: The residence time is too long, resulting in degradation.
	A: Too much moisture in virgin material or regrind.
	A: Use high-flow material
Inner surface	Q: The inner surface is rough / sharkskin.
	A: Reduce the extrusion speed (though balance the speed to avoid sagging).
	Q: The inner surface (natural tank) shows discoloration (yellowish/brownish).
	A: The wall thickness is too high, resulting in storage of intrinsic heat (low cooling speed) and therefore oxidative degradation. Optimize die position or optimize extrusion volume profile.
	A: Viscous dissipation at the extrusion die, resulting in too high surface temperature of the parison. Reduce extrusion speed or reduce melt viscosity (barrel temperature increase).
Power	Q: The power of the machine reaches the maximum power.
	A: Increase overall barrel temperature or shift from an increasing barrel temperature profile to a decreasing temperature profile (when having a grooved intake zone) by increasing the temperature at the intake/feed zone(s) → inverse temperature profile.
Pinchline	Q: The pinchline strength is too little.
	A: Contamination with HDPE could form an inner layer of HDPE that heavily affects the pinchline strength.
	A: The parison is too cold, resulting in limited flowability of the melt and therefore a reduced contact area and too little melt mixing.
	A: Mold design is not tailor made for polyamides, resulting in too little backflow of material into the pinch.
	A: Oxidation of the inner layer
	Q: Black lines or spots are observed on the surface.
Contamination	A: Possibly HDPE contamination, which will negatively influence the pinchline and the impact performance. More cleaning required. Mostly, contamination originates from the accumulator (low self-cleaning capability).
Defects	Q: The wall has a 'popcorn' like structure.
	A: Too much moisture in the material.
	Q: Loud noise/bang from the die.
	A: Too much moisture in the material.

Contact DSM in case more information is required from the aspect of material or processing.