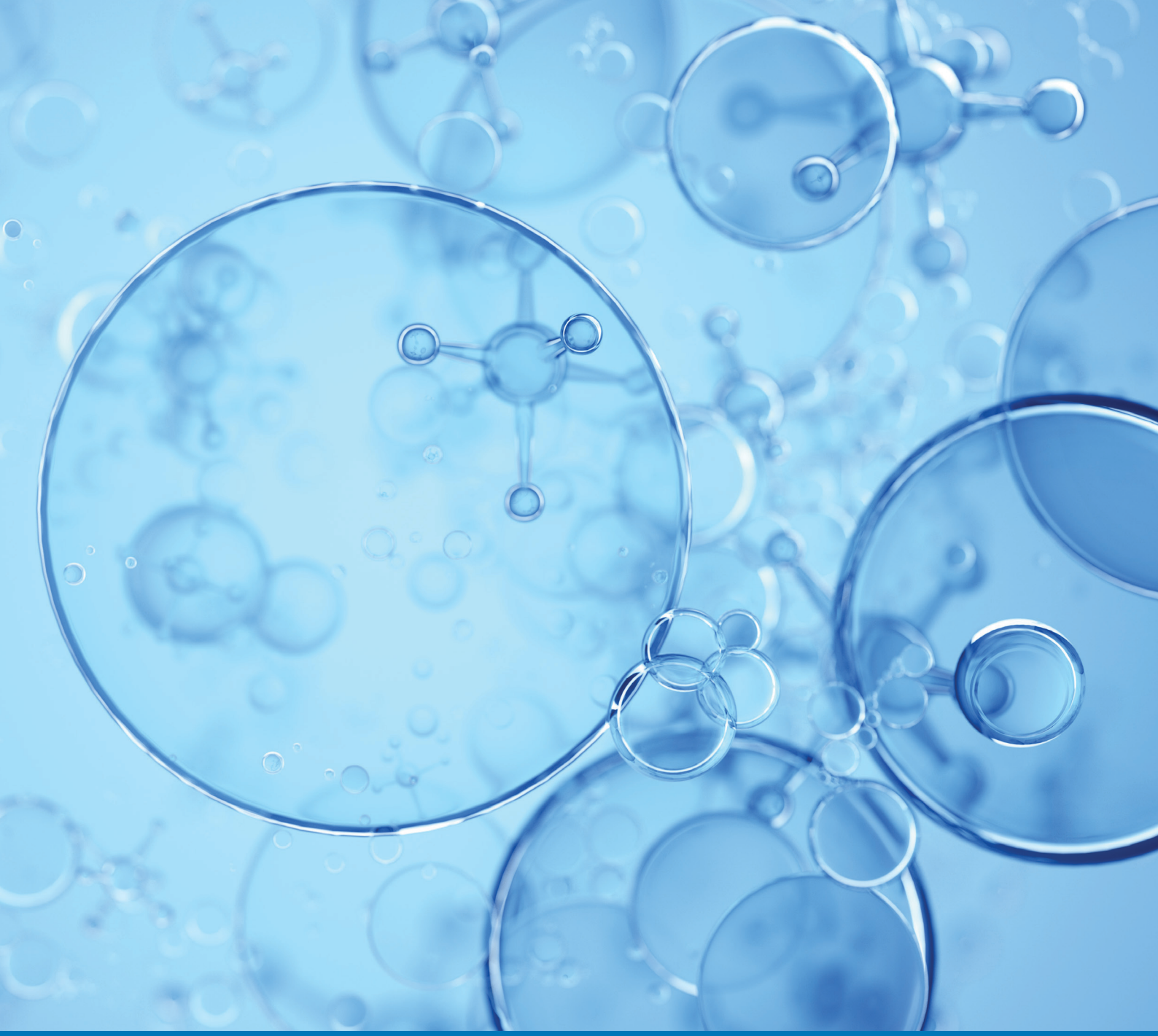


Troubleshooting Guide *for*

Avoiding Bubbles in Your Film or Sheet

nordsonpolymerprocessing.com | info@nordsonpolymerprocessing.com

Nordson

Bubbles in Extrudate

Bubbles in extrusion products are bad for everyone. They reduce the extrudate quality significantly, often making products impossible to sell. Operators are faced with extruder downtime and a lot of additional work to find the source of the problem and get everything going again. Consequently, the throughput and the efficiency of the operation drop. Preventing bubbles from appearing in the first place ensures smoother operation and better end-product quality.

Nordson PPS provides components for polymer processing from the pump to the extrusion die. We have systems in the field to process all kinds of polymers in various line configurations. In this article, we'd like to share our experience and provide you with guidelines for smooth and bubble-free extruded products.

There are three primary sources of bubble formation: air, moisture, and polymer degradation (volatiles).

Air

Air can get into the system at various points within a polymer processing line, starting at the very beginning. It can already become trapped in the feeding system of the screw, caused by smaller feed- or irregular scrap particles. If the source material is uneven in shape and size, it usually has a low bulk density, and the air is likely to be pulled in during the feeding process. Especially when the screw has no venting feature, the air entrapped here remains in the melt until it reaches the discharge unit and is manifested in the end product. A solution can be letting the screw rotate slower, so less air gets pulled into the process. But lowering the rotational speed of the screw usually comes with the price of less throughput per hour and can harm the melt homogeneity.

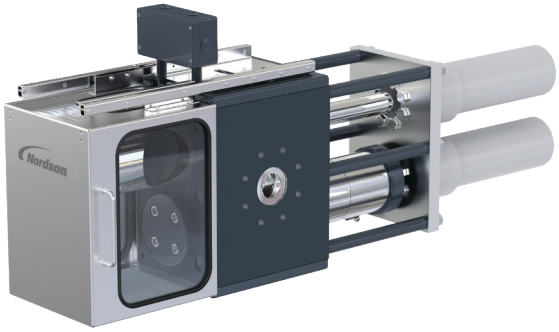
In some cases, the compression ratio of the extruder screw is too low and the air is not squeezed out properly during the melting process. If this is the case, a new screw with a different geometry might be required to ensure that the melt is in the proper condition before being processed further.

Layers of recycled material in film and other extrusion products are becoming more common by the day. Countries worldwide increase the pressure on manufacturers to increase sustainability by incorporating more recycled material into their products. In these cases, extrusion lines often have a piston-type melt filter with a screen that removes contamination from the processed material.

A sensitive step in this filtration process is the screen change. The piston is exposed to the outer atmosphere, and air enters the cavity. Air entrapments in the polymer melt can appear in the final product and reduce its quality significantly.

Our BKG® continuous filters have an elaborate venting system, ensuring that air escapes completely before filtration continues.

During the venting process, the air is displaced by the melt flooding into the cavity once the piston moves back into the housing. The air escapes through special



BKG® NorCon™ K-SWE Screen Changer

venting grooves in the piston. Timing and precision are key here. We need the air out and the piston back in the filtration position as quickly as possible. But if the cavity fills up too fast, pressure fluctuations can be the consequence. These can be a major problem in film and sheet lines, causing breakages, thins spots, and fisheyes. In Nordson's BKG® piston-type melt filters, the piston design allows a controlled melt inflow ensuring that the cavity fills slowly and no pressure drops occur.

With the melt pressure controlled venting start, our customers can take control of the melt inflow to another level. They determine a maximum allowed pressure drop considering the processed material and the end product requirements. The piston then moves in stepwise, and the cavity fills up slowly. The pressure is monitored closely. If the cavity fills too fast and the pressure drops beneath the allowed value, the piston moves back, and instantly, less melt flows into the cavity. The piston then moves forward in smaller steps to ensure the melt is withdrawn from the production flow sensitively.

Moisture

Residual moisture can cause various problems in polymer processing lines. When the polymer heats up, the water evaporates, and the polymer melt becomes spiked with bubbles. It is crucial to store the source material in a dry location and ensure that it is not exposed to significant temperature differences that can cause condensation.

Some polymers absorb moisture more than others and require pre-drying, a vented extruder, or both. As a rule of thumb, moisture levels need to be below 0.1% to avoid problems that are noticeable in the product. Polymers with high moisture absorption include: TPU, TPE, PET, PC, PA, PMMA, ABS, and SAN. A hopper dryer is often also incorporated into the line when processing these materials, which further dries the material before plasticizing.

Degradation

Polymer bonds can break if the polymer is processed at elevated temperatures, and free radicals can react. The result of these reactions is thermal degradation. Ethylene-based materials tend to cross-link and form gels, while propylene-based materials suffer chain scission and can release gases causing voids.

A straight-forward way to avoid thermal degradation is to reduce the processing temperatures. We recommend, when possible, to lower the temperature setpoints at the extruder barrel zones. In many cases, this can quickly solve the problem.

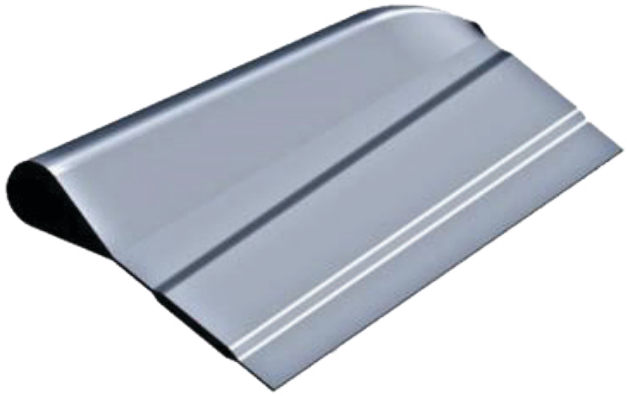
However, since a lot of the heat comes from screw rotation and shearing, it might be necessary to reduce the rotational speed of the screw, which often results in a decrease in output. A new screw with a geometry that reduces the shearing might be the best path forward.

If bubbles only appear in a specific area of the product, it is possible that only a single temperature zone is too hot. In this case, you should check that the thermocouples are installed, calibrated and functioning correctly.

Degradation is also caused by the long polymer residence time. If the material remains at the flow surfaces of the line components for too long, degradation can occur. The stagnant material can sometimes increase in molecular weight, which results in gels. Decreasing of the molecular weight is also possible, which can cause the release of gaseous reactive by-products that appear as bubbles in the extrudate.

The rheologically optimized EDI® Multiflow™ I-R flow distribution manifold for extrusion dies is designed to master this challenge. The material quickly and smoothly travels through this well-streamlined die. The result is low polymer inventory time in the die, and the material does not degrade.

We have described too much shearing as one of the reasons for material degradation. The truth is that insufficient shearing can be equally harmful. Low shear stress negatively impacts the melting and mixing process of the polymer. Material exposed to too little shear stress tends to stick to the walls and does not scrub itself away. Some material will always build up on the surfaces, but this layer needs to be renewed constantly to produce bubble and streak-free products. And here, the shear stress comes in – this is the scrubbing force on the flow channel walls. The channels need to be sized and shaped appropriately so that this build-up on the flow surfaces gets scrubbed away continuously, and the material has no time to degrade and cause problems. The EDI® Multiflow™ I-R die flow distribution channel has a primary manifold cross section with a "rounded back." This design increases velocity and shear stress, especially in the manifold corners, to help improve purging and promote complete surface renewal.



EDI® Multiflow™ I-R Die Flow Channel

Bubbles in the product are bad for everyone. The good thing is that measures are available to avoid them all along the processing line. From material storage to the feeding process and finding the right balance of process parameters, operators have a lot of possibilities to improve the process. In extrusion, many components have to work together smoothly to ensure a high-quality end product. It is crucial that operators know the customer's requirements and understand how to use the given technology for the best results.

Extrusion & Fluid Coating Dies

USA
1450 Lakeland Drive
Chippewa Falls, WI 54729
Phone +1 715 726 1201

Europe, Middle East, & Africa
Hessenweg 3-5
48157 Muenster
Germany
Phone +49 251 265010

China
11 Building, 212 East Jiangtian Road
Songjiang
Shanghai 201613
Phone +86 21 57850918

Japan
Toshin Building 8F
1-5-21, Katsushima,
Shinagawa-ku
Tokyo 140-0012
Phone + 81 3 5762 2770

Melt Pumps, Melt Filters, and Valves

USA
1291 19th St Ln NW
Hickory, NC 28601
Phone + 1 828 326 9888

Europe, Middle East, & Africa
Hessenweg 3-5
48157 Muenster
Germany
Phone +49 251 265010

China
11 Building, 212 East Jiangtian Road
Songjiang
Shanghai 201613
Phone +86 21 57850918

Japan
Toshin Building 8F
1-5-21, Katsushima,
Shinagawa-ku
Tokyo 140-0012
Phone + 81 3 5762 2770

Pelletizing Systems

USA
1291 19th St Ln NW
Hickory, NC 28601
Phone + 1 828 326 9888

Europe, Middle East, & Africa
Hessenweg 3-5
48157 Muenster
Germany
Phone +49 251 265010

China
11 Building, 212 East Jiangtian Road
Songjiang
Shanghai 201613
Phone +86 21 57850918

Japan
Toshin Building 8F
1-5-21, Katsushima,
Shinagawa-ku
Tokyo 140-0012
Phone + 81 3 5762 2770

> www.nordsonpolymerprocessing.com
info@nordsonpolymerprocessing.com

Nordson