

Processing Durethan® by extrusion blow molding

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1 Preparation of the material, drying

In the automotive sector and other areas, blow molded parts produced with the engineering plastics polyamide 6 and polyamide 66 are increasingly being used. These grades are mostly glass-fiber reinforced, but unreinforced grades can be used also. When polyamides are processed by extrusion blow molding, it is particularly important that the material be very well pre-dried. The moisture content of the material affects both, the stability of the parison and the surface quality of the blow molded parts.

With well pre-dried materials the melt viscosity is increased, allowing larger blow molding to be obtained. Fig. 1 compares the length of continuously extruded parisons with the length they would have if the parison was unable to lengthen under its own weight (here PA 66 GF25, Durethan AKV 325 H2.0 is shown as an example). The plot clearly shows that even small amounts of moisture can have a significant effect on the melt stiffness significantly.

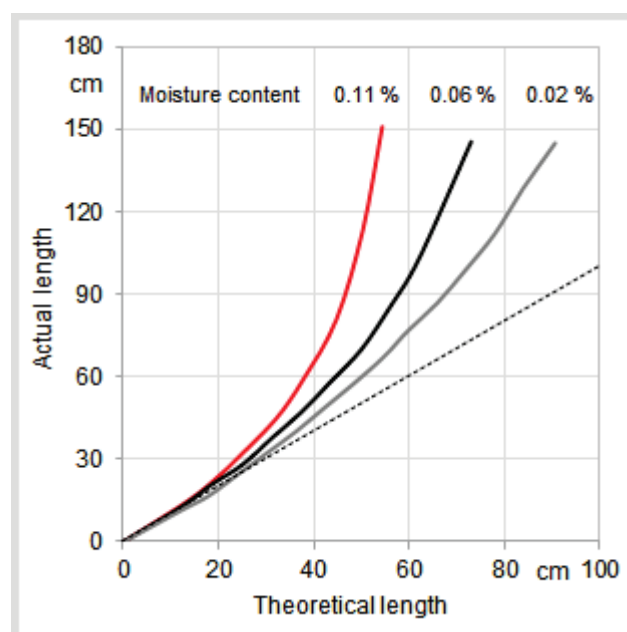


Fig. 1 Influence of moisture on melt stability

2 Surface quality

The amount of moisture in the plastic pellets has a crucial influence on the surface quality: the more

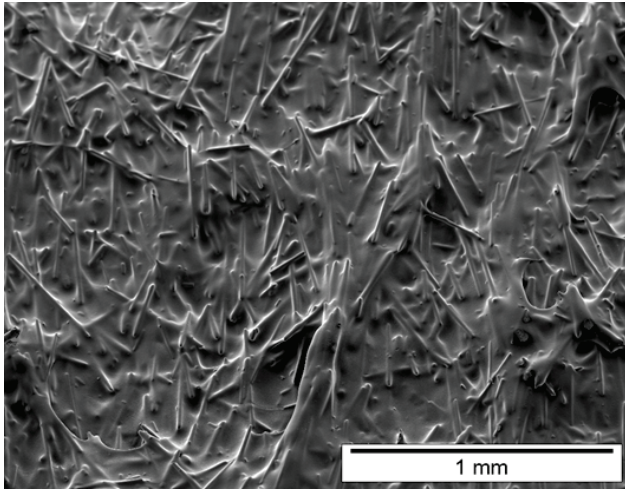
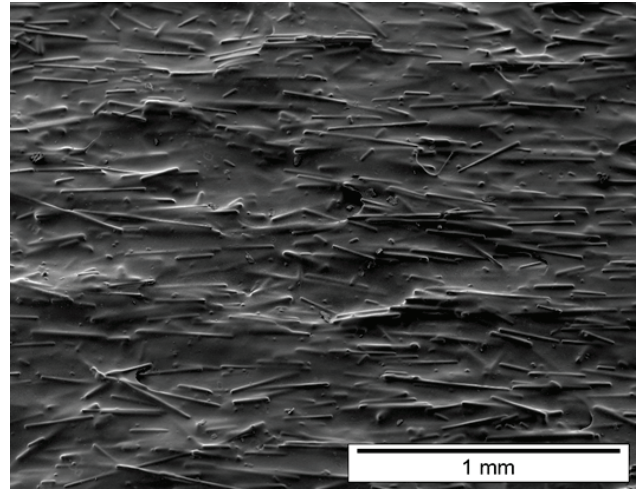


Fig. 2 Residual moisture 0.1 %

This applies to both the outer and the inner surface of a blow molded part. Stringent requirements are placed on the inner surface of media ducts in particular. When moisture content is too high, so-called "beards" can form through deposits of glass fiber

effective the pre-drying process, the fewer flaws on the part surface (Fig. 2).



Residual moisture 0.02%

reinforced polyamide building up on the edge of the mandrel. These become detached from time to time and stick to the inside of the hollow part. Fig. 3 shows defects of this type on the inside of a hollow part.



Fig. 3 Defects due to "beard" formation

When polyamides are processed in a blow molding process, they require considerably lower moisture content than for an injection molding process, for example. Therefore both virgin material and regrind should be dried to a moisture content of less than 0.06% (or preferably less than 0.03%) in order to satisfy the stringent quality requirements of the automotive industry.

The best driers to use are desiccant driers with a dew point of approximately $-30\text{ }^{\circ}\text{C}$. Since the PA products referred to here are mostly colored black in color as well as heat-stabilized for use in the engine compartment, they can be dried at higher temperatures than natural-colored polyamide 6 and polyamide 66 grades or those with lighter colors.

For such light-colored grades, the drying temperatures may not exceed 80 °C in order to prevent yellowing due to oxidation.

The drying conditions shown in table 1 are suitable for heat-stabilized PA 6 and PA 66 blow molding grades in practice.

Drying conditions

| Material | | Dry air dryer | |
|-------------------------------------|--|---------------|-------------|
| Product class | Durethan | Temperature | Drying time |
| PA 6 unreinforced | BC 550 Z DUSXBL BC 700 HTS DUSXBL | 80 – 100 °C | 6 – 12 h |
| PA 6 GF15 PA 6 GF20 PA 6 GF25 | BKV 315 Z H2.0 BKV 320 Z H2.0 BKV 325 Z H2.0 | 80 – 100 °C | 6 – 12 h |
| PA 66 GF20 PA 66 GF25 | AKV 320 Z H2.0 AKV 325 H2.0 | 100 – 110 °C | 6 – 12 h |

Recommended moisture content < 0.06% (preferably < 0.03%)

* Dew point approx. -30 °C

Table 1 Drying recommendations for black colored (900116) blow molding grades

Experience has shown that these conditions are sufficient for virgin material in the "as delivered" state and also for regrind that is re-used directly without lengthy intermediate storage.

For material with a higher moisture content, i.e. material from open or damaged containers or regrind that has been stored in unsealed containers for a prolonged period of time, a considerably longer drying time may be necessary.

3 The plasticizing unit

Processing glass-fiber reinforced polyamides requires a wear-resistant extruder barrel and screw.

Extruders with a smooth feed section are generally used, guaranteeing a plasticizing capacity which is sufficiently high and uniform.

It is acceptable to use conventional three-section screws with medium-level compression (compression ratio approximately 1 : 2.5 to 1 : 3) and a length of 20 to 25 D. When processing glass-fiber-reinforced polyamides, it is essential to avoid shearing sections with a narrow shear gap so as not to grind the glass fibers and unnecessarily reduce the mean glass fiber length, which is critical for good mechanical properties.

The glass fibers used for these engineering polyamides are generally 0.2 to 0.4 mm in length and have a diameter of approximately 10 µm. Therefore it is strongly recommended not to use fine-meshed melt

filters between the extruder and the die head, since such filters can rapidly become clogged by the glass fibers.

A large number of extrusion blow molding machines are equipped with grooved feeding zone extruders which are standard for high-molecular polyolefins. These can also be used, with certain reservations, for the PA products described here. However, it may happen that the feed capacity of the grooved feeding zone exceeds the melting capacity of the screw. Depending on the screw geometry, this can then lead to unacceptably high drive torque or to an uneven feed, or even to a total breakdown in the feed. Parts of the material that did not melt can block the flow channel in the compression zone and metering zone. It is possible to alleviate the force-feed effect of the grooved feeding zone by employing higher temperatures, which will also promote proper melting. Therefore, when processing PA 66 grades, in particular, it is advisable to make provision for an oil heating unit to heat the grooved feeding zone. Grooved feeding zone temperatures of 130 to 170 °C have proven successful in achieving less damaging feed characteristics.

4 Barrel temperatures

It has been seen on different extruders that a so-called "inverse temperature profile" gives good plasticizing results with respect to both throughput and melt quality. Fig. 4 shows appropriate temperature

range settings for processing the PA 6 and PA 66 products. It is also permissible to raise the temperature setting to a level considerably higher than the proposed ranges if the feed is not sufficiently uniform, the screw torque is too high or the melt quality is not sufficient. Heat-stabilized Durethan grades are relatively insensitive to short-term peak temperature

loads. Therefore, in the case of Durethan® AKV 325 H2.0, the temperature setting for the first heating zone can be in the range of 320 to 330 °C, with the downstream temperatures falling to the lower level at a correspondingly later stage. Specific throughputs of 1.2 to 1.4 (kg/h)/(1/min) were achieved with these settings on different 60 mm extruders.

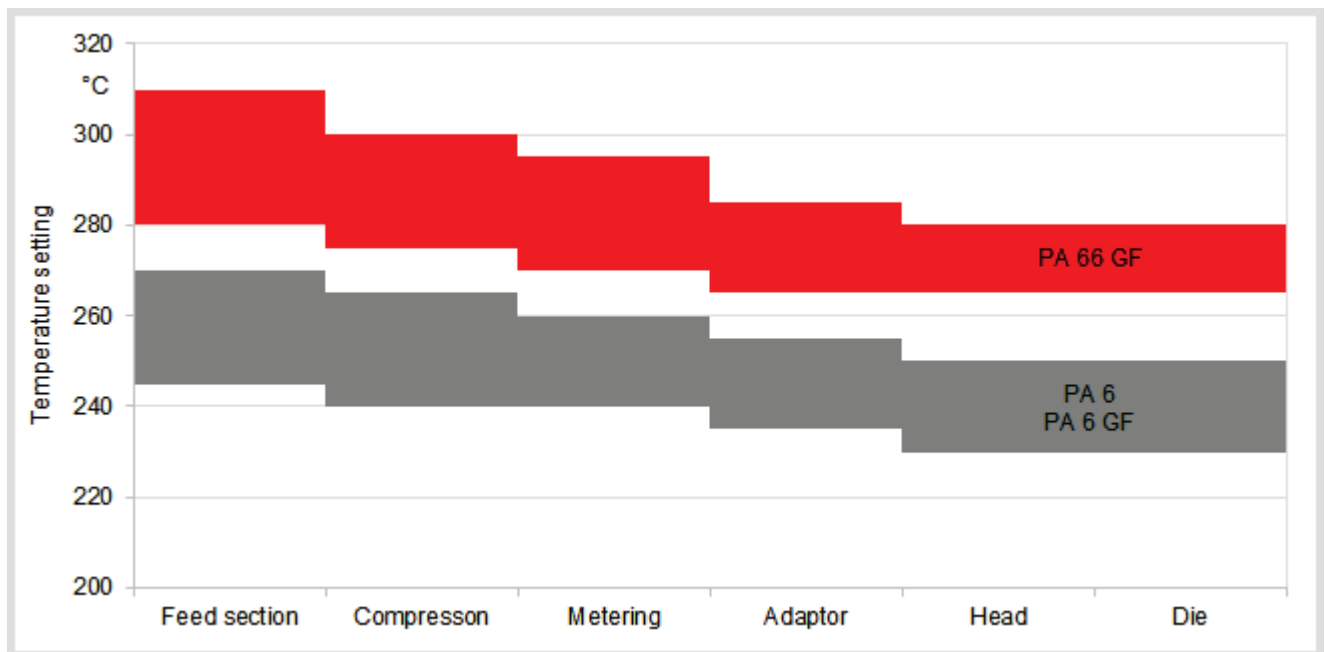


Fig. 4 Setting ranges for barrel temperatures

5 Mold temperature

Generally, the mold should be at a temperature of 60 to 90 °C. As with a large number of other materials, the reproduction of detail on the polyamide surface improves with higher mold temperatures. The comparatively high solidification rate of these polyamides means that the high mold temperature does not automatically lead to longer cooling times and therefore longer cycle times. In the case of suction blow molding with Durethan® BKV 315 Z H2.0 and AKV 325 H2.0 resins, mold temperatures of 120 to 140 °C showed considerably better article surfaces than a mold temperature of 80 °C.

6 Processing regrind

Experience has shown that the regrind from scrap that occurs in conventional production of engineering blow molded parts can be fed back into the process on a continuous basis. The continuous re-use of production scrap is also economically advantageous.

It is not possible to specify a maximum limit for the permitted regrind content. While the polyamide itself

displays only minor signs of degradation after reprocessing, it should be noted that the length of the glass fibers is reduced with each processing cycle, leading to a reduction in the mechanical properties of the material. How much property reduction is acceptable for a specific part will need to be established in each individual case. It is therefore recommended that sample parts which have been manufactured under the expected production conditions, including maximum regrind percentage, be submitted for final qualification testing.

Please keep in mind that the geometry of the re-ground pellets differs from that of the virgin material. This can lead to a change in the flow properties and feed behavior of the material. It may therefore be necessary to adjust the machine settings to compensate, particularly the screw speed.

As has already been stated in Section 1, "Preparation of the material/drying", efficient re-drying is essential when processing regrind, as well.

7 Swelling behavior

It is difficult to give precise details of the materials' swelling behavior, since swelling is not only conditioned by the material used but also by other parameters, such as:

- Output rate/extrusion rate
- Melt temperature
- Die geometry (inside cone/outside cone)
- Die gap width.

The values given in Table 2 are an approximate guide for selecting the die diameter. These are values that have been established in practical tests. The exact die diameter must then be determined in tests under the applicable process conditions with the specific mold that is to be used.

Swelling behavior

| Product class | Durethan | Die swell: Ø Die : Ø Parison |
|---------------------|-------------------|---------------------------------|
| PA 6 non-reinforced | BC 550 Z DUSXBL | 1 : 1,8 |
| | BC 700 HTS DUSXBL | 1 : 1,6 |
| PA 6 GF15 | BKV 315 Z H2.0 | 1 : 1,4 |
| PA 6 GF20 | BKV 320 Z H2.0 | 1 : 1,2 |
| PA 6 GF25 | BKV 325 Z H2.0 | 1 : 1,1 |
| PA 66 GF20 | AKV 320 Z H2.0 | 1 : 1,2 |
| PA 66 GF25 | AKV 325 H2.0 | 1 : 1,4 |

Table 2 Empirical values for swelling behavior in the blow molding of Durethan

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