Complex Blow Moldings for the Engine Compartment*

Product Information

ATI 1137

Branched Polyamides Extend Range of Application

Conventional polyamides with a linear structure can only be used to a limited extent for blow molding and thermoforming processes. New branched grades of polyamide based on PA 6 and PA 66 with higher pseudo-plasticity have now been developed for these manufacturing processes.

In recent years, polyamides have been increasingly used to replace traditional metal parts in vehicle engine compartments. The main reasons for this development are the attainable reduction in the weight of the components – up to 50 % – and the significant cost advantages in manufacture. Other benefits include the greater design scope offered by plastics and the production process, smoother inner surfaces and the possibility of integrating additional component functions in the molding process.

The specifications for materials destined for the engine compartment are varied and, for most applications, can be satisfied by PA 6 and PA 66. The most important properties of materials used in this segment are a high long-term service temperature of 130° to 140 °C, corresponding dynamic load-bearing capacity, resistance to heat aging and good chemical resistance to oils, grease, battery acid, cooling fluids, road salt, etc. Due to the trend in the automotive industry to improve efficiency through higher combustion temperatures and further reduce noise emission by encapsulating the engine compartment, the thermal properties of competitive plastics are likely to gain further importance in the future.

Polyamides have already made their mark for the production of intake manifolds. Here, the parts (usually half-shells) are produced by injection molding and then welded together. For the manufacture of pipes with complex three-dimensional shapes, the industry tends to use the extrusion blow molding process or, for long pipelines, the new suction blow molding process. For this, however, the standard grades of PA 6 and PA 66, including the higher viscosity types used for film and profile extrusion, are unsuitable. The melt elasticity of these polyamides is inadequate for producing large parisons.

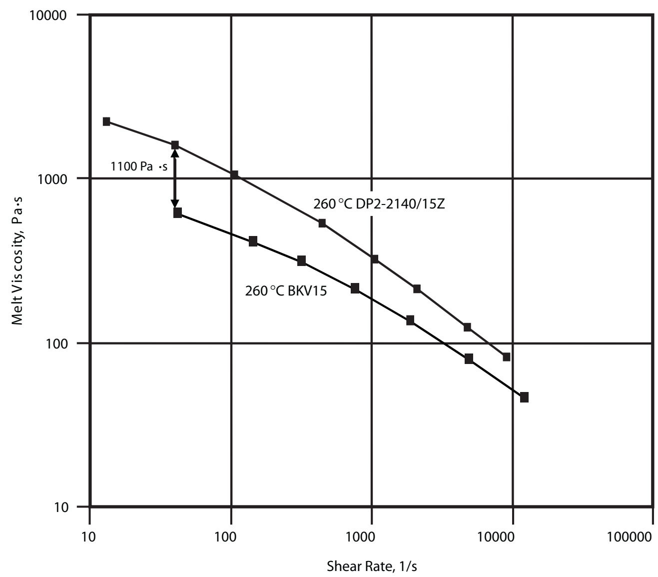

*Figure 1: The branched polyamide Durethan® DP2-2140/15Z polyamide shows a constant increase in melt viscosity over Durethan® BKV 15 polyamide even at low shear rates.***

One commonly used way to increase the viscosity of the melt involves compounding the polyamide with elastomer modifiers. Such modified polyamides can have a much higher melt viscosity than high-viscosity linear polyamides and are sometimes also suitable for the manufacture of large blow moldings. However, the relatively high content of non-polyamide components has a negative effect on the material properties. Particularly affected are the resistance to chemicals and to heat-aging as well as the heat distortion temperature. At the same time, the strength and elasticity modulus are reduced while the extensibility and impact strength are increased — which may be an advantage or a disadvantage, depending on the application.

** Technical paper by D. Joachimi, D.W. Pophusen, H. Schulte, and R. Kammerer, first published in Kunststoffe 12/2000.*

*** These items are provided as general information only. They are approximate values and are not part of the product specifications. Type and quantity of pigments or additives used to obtain opaque colors and special effects can affect material properties.*

Branched Polyamides for Extrusion Blow Molding
LANXESS has succeeded in developing new pseudo-plastic polyamides based on PA 6 and PA 66 using long-chain branched polyamide molecules. These new pseudo-plastic polyamides retain typical polyamide properties and are suitable for extrusion blow molding. The main innovations with these materials are their high viscosity at low shear rates and their normal polyamide viscosity at higher shear rates. Figure 1 shows the differences in melt viscosity between branched and linear polyamides as a function of the shear gradient.

Whereas the standard PA 6 GF 15 polyamide shows virtually no increase in viscosity at low shear rates, the pseudo-plastic grade (Durethan® DP2-2140/15Z polyamide) displays a constant marked rise in the melt viscosity. This means that the new material can satisfy the chief criteria for processing by blow molding.

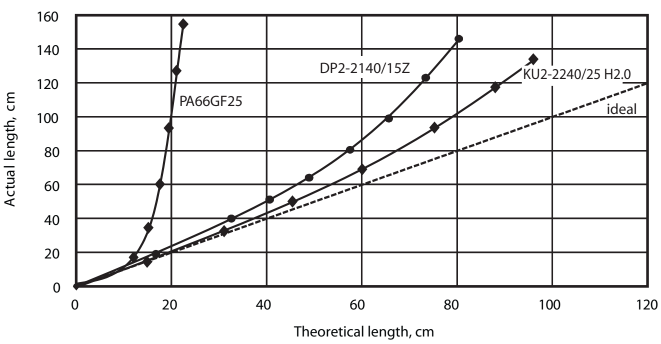

*Figure 2: Comparison between the melt viscosity of a linear standard PA 66 GF 25, branched PA 66 GF 25 (Durethan® KU2-2240/25 polyamide), and branched PA 6 GF 15 (Durethan® DP2-2140/15Z polyamide).**

On the other hand, it is not possible to reliably assess the suitability of a material for extrusion blow molding exclusively on the basis of its viscosity data. More reliable for development and optimization purposes are practical extrusion trials that reveal the behaviour of the melt as a parison, together with the sagging characteristics of the material under its own weight, plotted against the discharge time. From the ratio between actual length and theoretical length of the extruded parison, we get a curve that, from a certain parison length, only begins to deviate from the ideal profile with longer actual parison length.

A linear standard PA 66 GF 25, as used for injection molding, deviates very quickly from the ideal curve. Branched PA 66 GF 25 (Durethan® KU2-2240/25 polyamide) and PA 6 GF 15 (Durethan® DP2-2140/15Z polyamide) do not deviate from the ideal curve until a length of 60 to 80 cm is reached (Figure 2).

In principle, longer pipes or larger blow moldings with more uniform wall thickness distribution could be produced from a material that only fluctuates from the ideal when a longer parison length is reached. These results were determined in a continuous extrusion process, but in practice, molding lengths of about twice that size can be produced if a melt accumulator is used for the blow molding process. With the melt elasticity shown in Figure 2, parisons well over 1 m in length with a gross weight of up to approx. 8 kg can be blow-molded.

A process for the large-scale production of pseudo-plastic polyamides via controlled branching has been developed and a product range with different glass fiber contents established. Most of the mechanical properties, the resistance to chemicals and the resistance to heat-aging of these high-viscosity branched grades are the same as those of their standard-viscosity counterparts.

Pipes and Blow Molded Parts in the Cooling Circuit
Components used in a cooling circuit are subject to particularly stringent demands with regard to thermal aging and resistance to glycol/water. An indicator of possible material damage is the Izod impact strength, which drops significantly the longer the plastic is immersed in a cooling fluid. The requirements are satisfied more readily by a glass fiber-reinforced PA 66 than by PA 6 GF. With PA 66 GF, too, there are grades on the market for extrusion blow molding that attain the necessary melt viscosity with the aid of elastomer modifiers. However, the higher temperatures and high content of other materials place higher demands on the compounding of modified glass fiber-reinforced PA 66 GF and PA 6 GF.

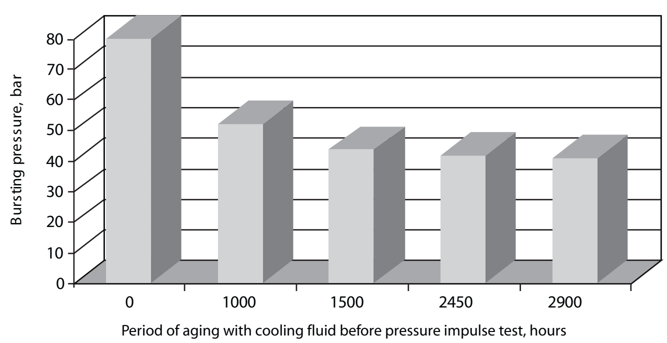

Figure 3: Bursting pressure results for cooling water pipes of Durethan® KU2-2240/25 polyamide, after heat aging (filled with coolant, 130° C, circulating air oven) and alternating pressure test (ethylene glycol, 130° C, 2.4 bar pressure pulses, 250,000 cycles). Pipe dimensions: Length >1,000 mm, Diameter 23 mm, Wall Thickness 2-3 mm.*

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For the new product, PA 66 GF 25 (Durethan® KU2-2240/25 H2.0 polyamide), the company's long experience in the development of hydrolysis-resistant injection molding compounds based on PA 66 GF was combined with its expertise and know-how in the production of branched polyamides. The result is a branched, high-viscosity polyamide 66 with optimum glycol/water resistance, a high melt elasticity and a slow solidification rate. The major requirements with regard to the resistance properties and processing by extrusion blow molding are thus satisfied.

Through the optimized solidification rate, good surface characteristics and pinch-off weld qualities are also attained. Since a pinch-off weld can basically be a weak point, cooling water pipes of PA 66 GF 25 produced by blow molding should, wherever possible, be made in a 3D-process without any pinch-off welds in areas of high stress.

Thorough pressure impulse tests and bursting pressure tests were carried out under practical conditions and confirm the excellent resistance of the material to coolants. The tested components had a complex geometry, a wall thickness of 2 –3 mm and an outside diameter of 23 mm. Depending on the period of heat exposure, the average bursting pressures were between 40 and 50 bar (Figure 3). The components were pre-aged in a water/glycol mixture at 130 °C. This was followed by pressure impulse testing at an ambient temperature of 130 °C and a media temperature of 130 °C, using straight ethylene glycol. The peak impulse pressure was 2.4 bar, with a cycle time of 1 Hz and 150,000 cycles.

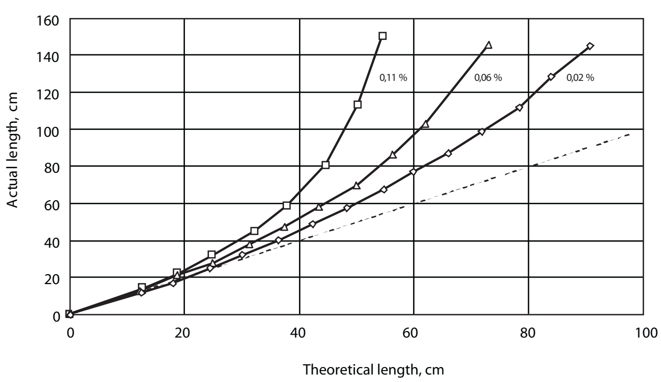
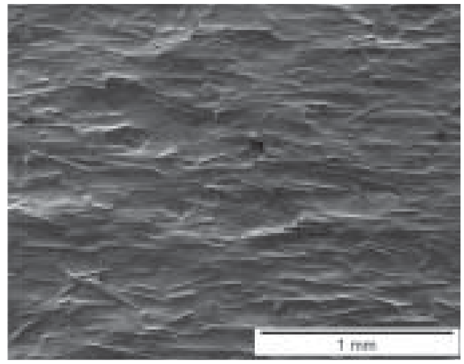


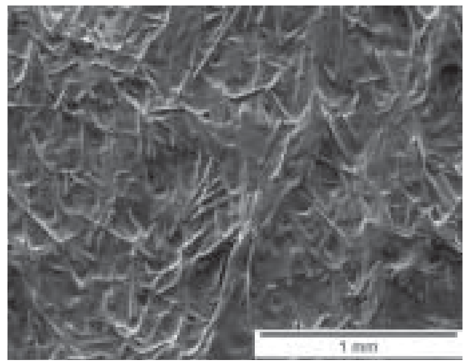
*Figure 4: Influence of residual moisture on the sagging characteristics in extrusion blow molding with PA 66 GF 25 (Durethan® KU2-2240/25 H2.0 polyamide).**

The moisture content of the material during processing has an important influence on the part quality. The better the material has been pre-dried, the greater is the parison length that can be produced without sagging (Figure 4). The moisture content of the granules also has a visible influence on the quality of the surface: the more effectively the pre-drying was carried out, the fewer defects there are on the surface (Figure 5).

Fig. 5



Processed with residual moisture content of 0.02 %



Processed with residual moisture content of 0.11 %

New Application Possibilities in Thermoforming

There is no reason why this new development could not also be used for other processing methods. Until now, PA 6 with a wall thickness greater than 0.5 mm, especially glass fiber reinforced grades, was regarded as unsuitable for thermoforming (often also referred to as deep drawing). Thermoforming involves stretching a heated, securely clamped, cut-to-size blank so that the original wall thickness declines. The thermoforming of film and sheets above a thickness of 0.5 mm is only possible above the crystalline melting point and necessitates a melt elasticity that has not so far been attainable with linear PA 6 grades.

Through the development of pseudo-plastic polyamides, it has now become possible for the first time to produce PA 6 grades that can be processed by thermoforming. Their high melt viscosity allows the semi-finished material to be heated to the necessary thermoforming temperature, which is above the crystalline melting point. Excessive sagging upon heating the sheet is avoided because of the melt viscosity. After the heating-up phase, the sheet can be pre-stretched by means of inflation air, which results in more uniform wall thickness distribution and better reproduction of the mold contours.

To assess the thermoforming characteristics, the new pseudo-plastic materials were tested on a thermoforming unit (Manufacturer: Illig) with a multi-stage mold (Figure 6). The pyramids produced in this way with a high level of wall thickness uniformity show that relatively high forming and stretching ratios can be achieved with the new material.

Possible applications lie in the production of oil sumps, engine encapsulation, underbody sub-assemblies and various structural components. As with any product, the use of Durethan polyamide resins must be tested (including but not limited to field testing) in advance by the user to determine suitability.

Figure 6: Step pyramid, stretching ratio 1:2.4

Conclusions

The development of new branched polyamides extends the possibilities in component production. Thanks to their high melt viscosity, it will also be possible in future to use molding processes such as extrusion blow molding and thermoforming for the processing of PA 6 and PA 66.

Developmental Products

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Note: The information contained in this publication is current as of May 2005. Please contact LANXESS Corporation to determine whether this publication has been revised.

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