APPLICATION INFORMATION

IMPROVED PHYSICAL PROPERTIES IN POLYAMIDE APPLICATIONS USING BYK-MAX CT 4275

TP A-9

A member of ALTANA

Contents

The challenge

Polyamide is used in many industries due to its excellent physical properties, ease of processing, relatively low density, and reasonable cost. There is continuous pressure to improve these benefits further to continue efforts in metal replacement and offer an alternative to higher cost engineering polymers. Additionally, PA6.6 must be used in a variety of applications due to its heat resistance compared to PA6. However, PA6 is less costly and many times more available than PA6.6.

Automotive and other applications require improved physical properties in polyamide compounds as well as improvement of HDT (heat deflection temperature) in neat PA6 to replace PA6.6.

Note

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Our solution

BYK has developed BYK-MAX CT 4275 specifically to increase the physical properties of polyamides while not having a significant effect on density. BYK-MAX CT 4275 is highly miscible in polyamides, especially PA6, requiring no special processing considerations.

Key benefits

- Increased HDT, especially in neat PA6
- Improved tensile strength and tensile modulus
- Reduction in density compared to other mineral fillers

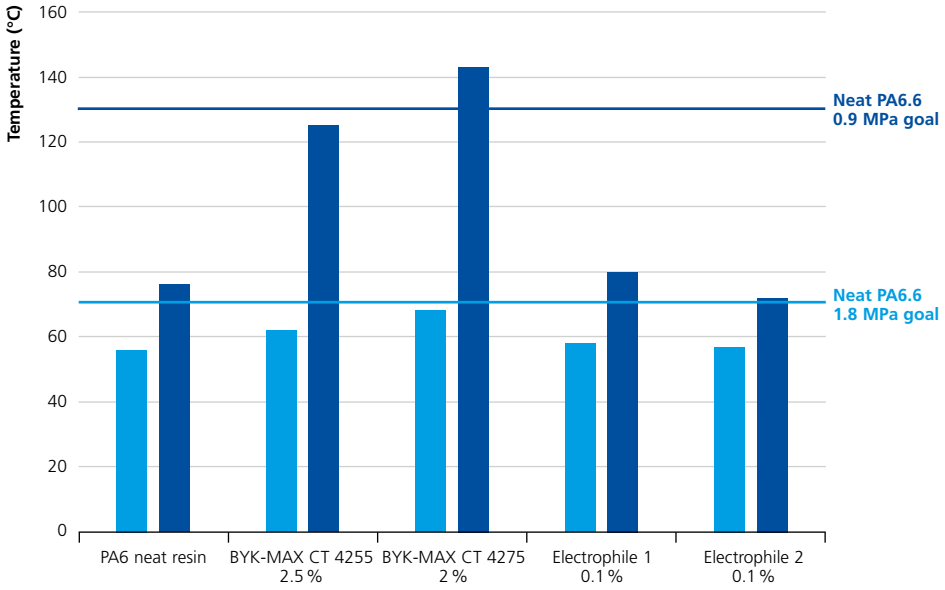
Increased heat deflection temperature

PA6.6 is used in many applications due to its higher HDT compared to PA6. There are multiple approaches to increase HDT properties, especially in neat PA6. Either reactive chemistry or compatibilized clay offer the possibility of success. However, clay products have proven more effective than other alternatives (G. 01).

This data demonstrates that adding either one of two organoclay types (BYK-MAX CT 4255 or BYK-MAX CT 4275) has a much larger effect on HDT than electrophile hardening technologies when dosed at recommended levels. While BYK-MAX CT 4255 has a positive impact on physical properties as well, it was originally developed to improve barrier properties. In contrast, BYK-MAX CT 4275 has been specifically developed to improve physical properties of engineering thermoplastics, especially polyamides. BYK-MAX CT 4275 in PA6 was able to match the HDT performance of PA6.6 with a loading of approximately 2.0 % to 2.5 %. In addition, this additive dosage will have only a very marginal effect on density.

The effect of adding BYK-MAX CT 4275 in PA6 was investigated with respect to HDT and density in more detail (G. 02). By using BYK-MAX CT 4275 it is possible to match the HDT of PA6.6 by using PA6. The required amount to be added is between 1.5 % to 2.5 %, depending on specific goals. Using this amount of additive, the resulting density increase in PA6 would only be between 0.5 % to 1.1 %.

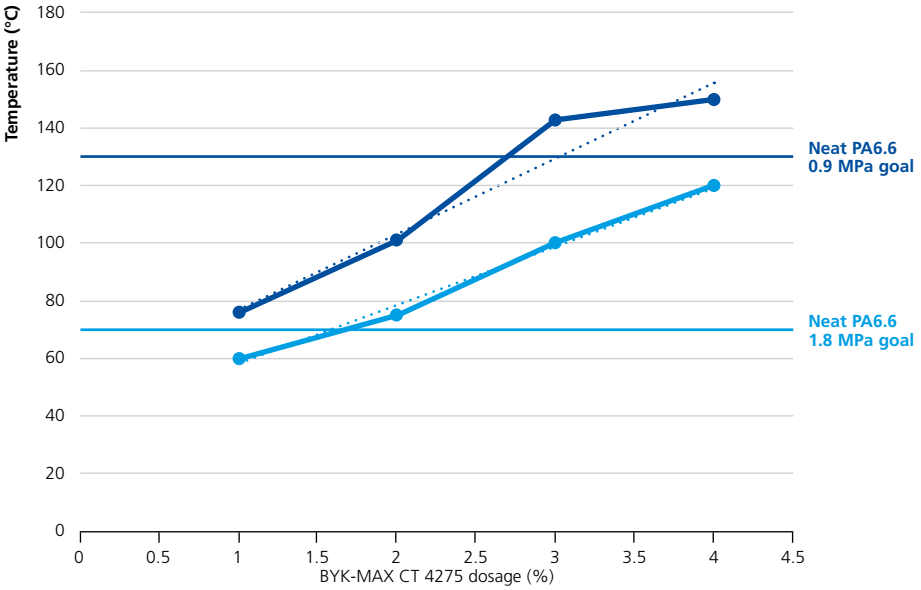
Options to increase PA6 heat deflection temperature



1.8 MPa 0.9 MPa

G. 01

Heat deflection temperature change depending on BYK-MAX CT 4275 addition



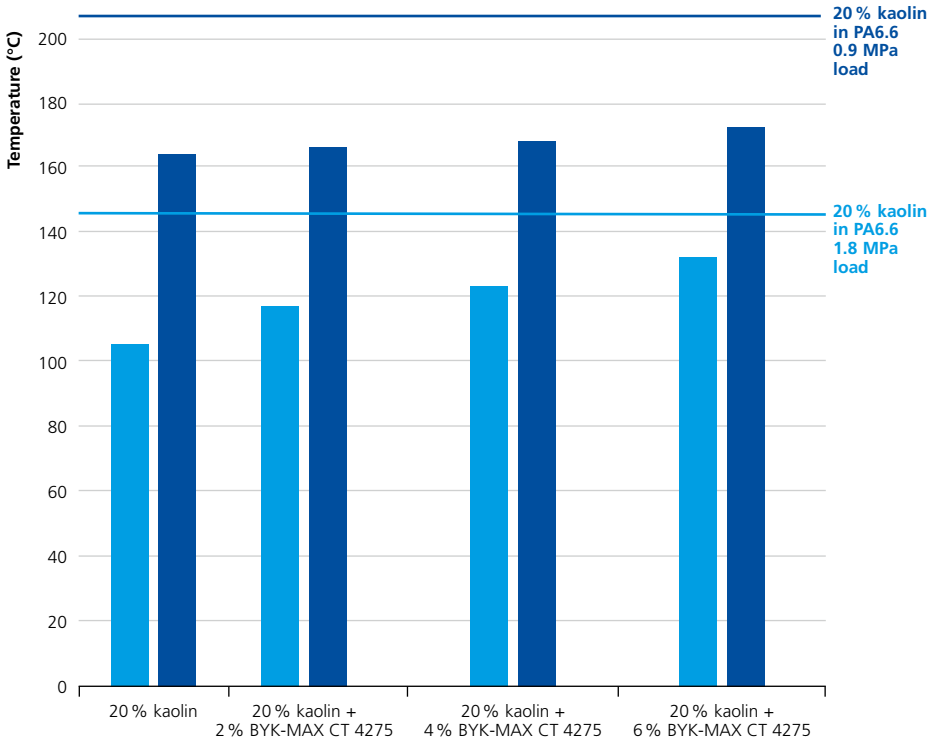
1.8 MPa 0.9 MPa

G. 02

It is very popular to use kaolin as a mineral filler in polyamides for reinforcement. Using kaolin is cost effective and does increase the stiffness and surface quality of PA6 and P6.6. It was tested whether the HDT of 20 % kaolin-filled PA6.6 can be achieved by adding BYK-MAX CT 4275 to 20 % kaolin-filled PA6. The effect at 0.9 MPa is very marginal, while the effect at 1.8 MPa is more significant (G. 03). But neither achieves the goal up to an addition level of 6 %. Nevertheless, it can be expected that an addition of 8–10 % BYK-MAX CT 4275 in 20 % kaolin-filled PA6 could match the 1.8 MPa HDT of 20 % kaolin-filled PA6.6.

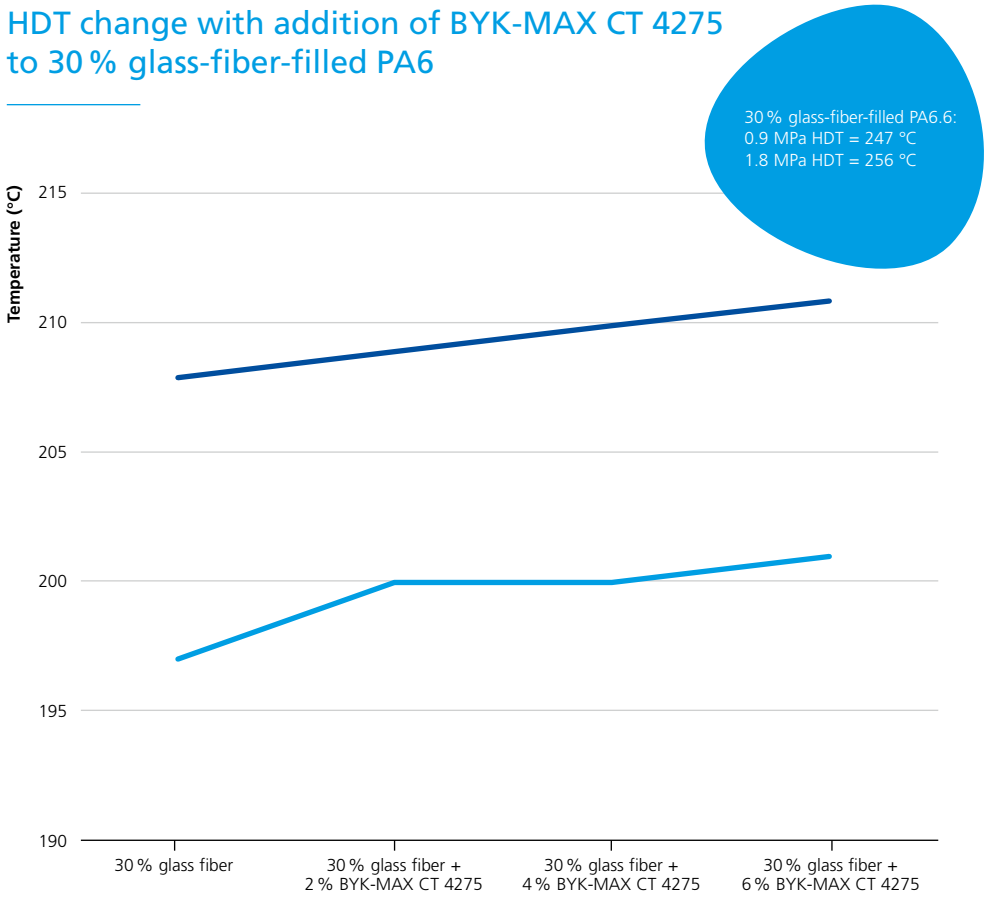
Fiberglass is also a popular reinforcement for polyamides. As expected, addition of BYK-MAX CT 4275 provides only marginal increase in HDT as the fiberglass plays the dominant role of reinforcement. The levels achieved do not approach those of similar PA6.6.

Effect of adding BYK-MAX CT 4275 to 20 % kaolin-filled PA6 on HDT



G. 03

HDT change with addition of BYK-MAX CT 4275 to 30 % glass-fiber-filled PA6

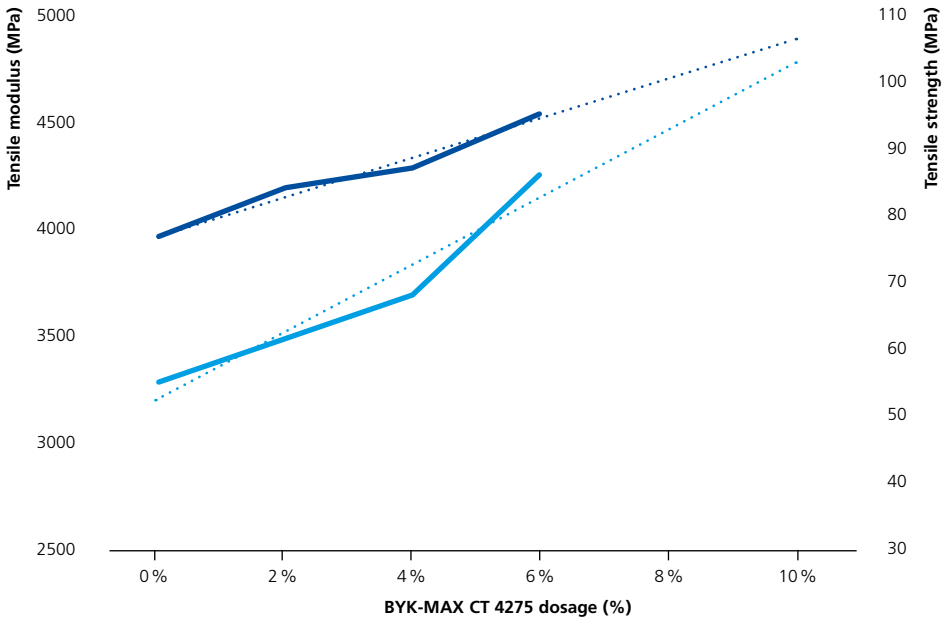


G. 04

Improved tensile strength and modulus

Similar to the positive effect of BYK-MAX CT 4275 on HDT, it can be used to boost other physical properties of PA6, such as tensile strength and tensile modulus, without a significant increase in density. An increase in tensile strength of 23 % and in tensile modulus of 29 % is possible when adding 6 % of BYK-MAX CT 4275. This addition increases the density by only 1.8 %. Further increases out to at least 10 % addition levels are expected and predicted below (G. 05).

Increase in physical properties by addition of BYK-MAX CT 4275



● Tensile modulus ● Tensile strength

G. 05

Reduction in density compared to other mineral fillers

Another interesting study is replacing kaolin used in mixed-reinforcement systems. One common combination is using kaolin with glass fiber. Starting with a baseline formulation of 17 % glass fiber and 21 % kaolin in PA6, the kaolin was removed and replaced with varying amounts of BYK-MAX CT 4275 and fiberglass to match similar properties. (The difference in amounts between kaolin and BYK-MAX CT 4275 was accommodated by adding PA6.) The test matrix is shown in T. 01.

The use of BYK-MAX CT 4275 initially results in an increase of both tensile modulus and strength (Formula PA6 #2). This provides significant improvements in modulus and strength but does not quite reach the level of PA6.6 (G. 06). Further testing was completed by adding in a small amount of glass fiber, with further increases in modulus and strength (PA6 #3 and PA6 #4 below). Similar results can be seen in PA6.6 formulations.

PA6 formulation tested for replacing kaolin in mixed-reinforcement systems

Formula	BYK-MAX CT 4275	Glass fiber	Kaolin	Total ash*
PA6 #1	0 %	17 %	21 %	38 %
PA6 #2	5 %	17 %	0 %	20.5 %
PA6 #3	3 %	22 %	0 %	24.1 %
PA6 #4	2 %	25 %	0 %	26.4 %

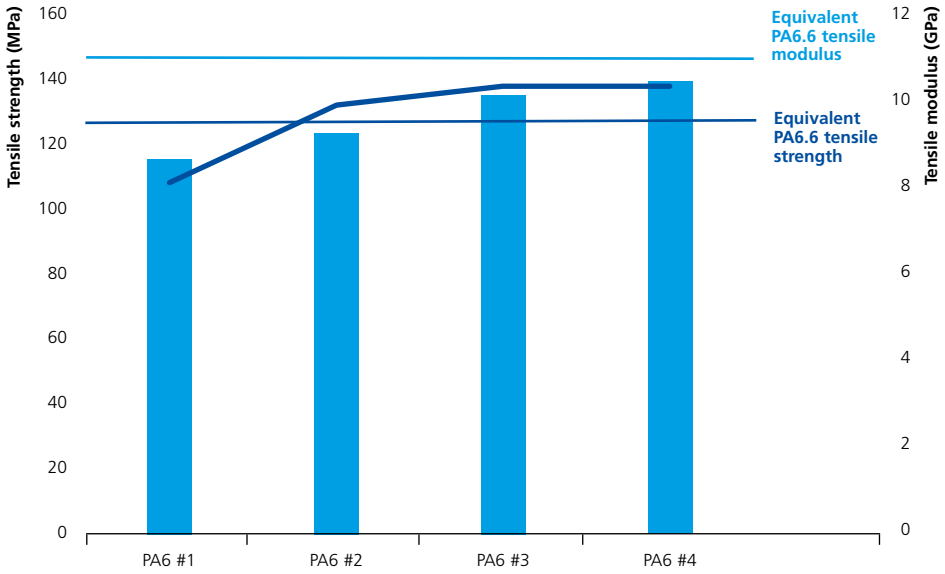
* Total ash is slightly less than the sum of glass fiber and BYK-MAX CT 4275 because BYK-MAX CT 4275 contains an organic coating that burns during the ash test.

T. 01

The use of BYK-MAX CT 4275 not only improves physical properties, but it also decreases density and improves melt flow rate (G. 07). If used in the same mold, a 10 % weight reduction can be realized. Due to the improved flow, it may be possible to mold thinner parts, thus improving weight reduction further.

The flow improvement is not limited to the single-point melt flow measurement but is also evident in the shear versus viscosity curves (G. 08).

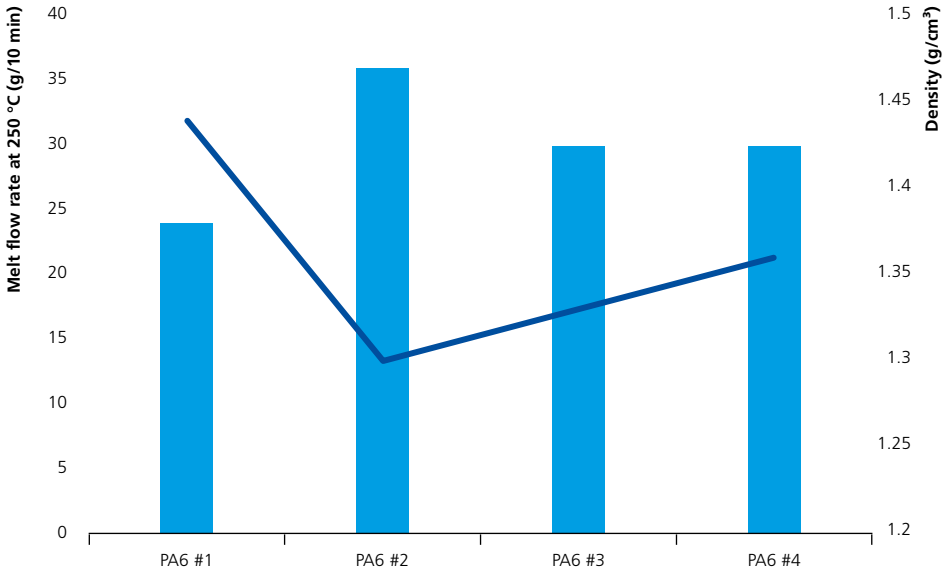
Kaolin replacement with BYK-MAX CT 4275 in PA6 MF grade



● Tensile modulus ● Tensile strength

G. 06

Density and processability changes due to use of BYK-MAX CT 4275

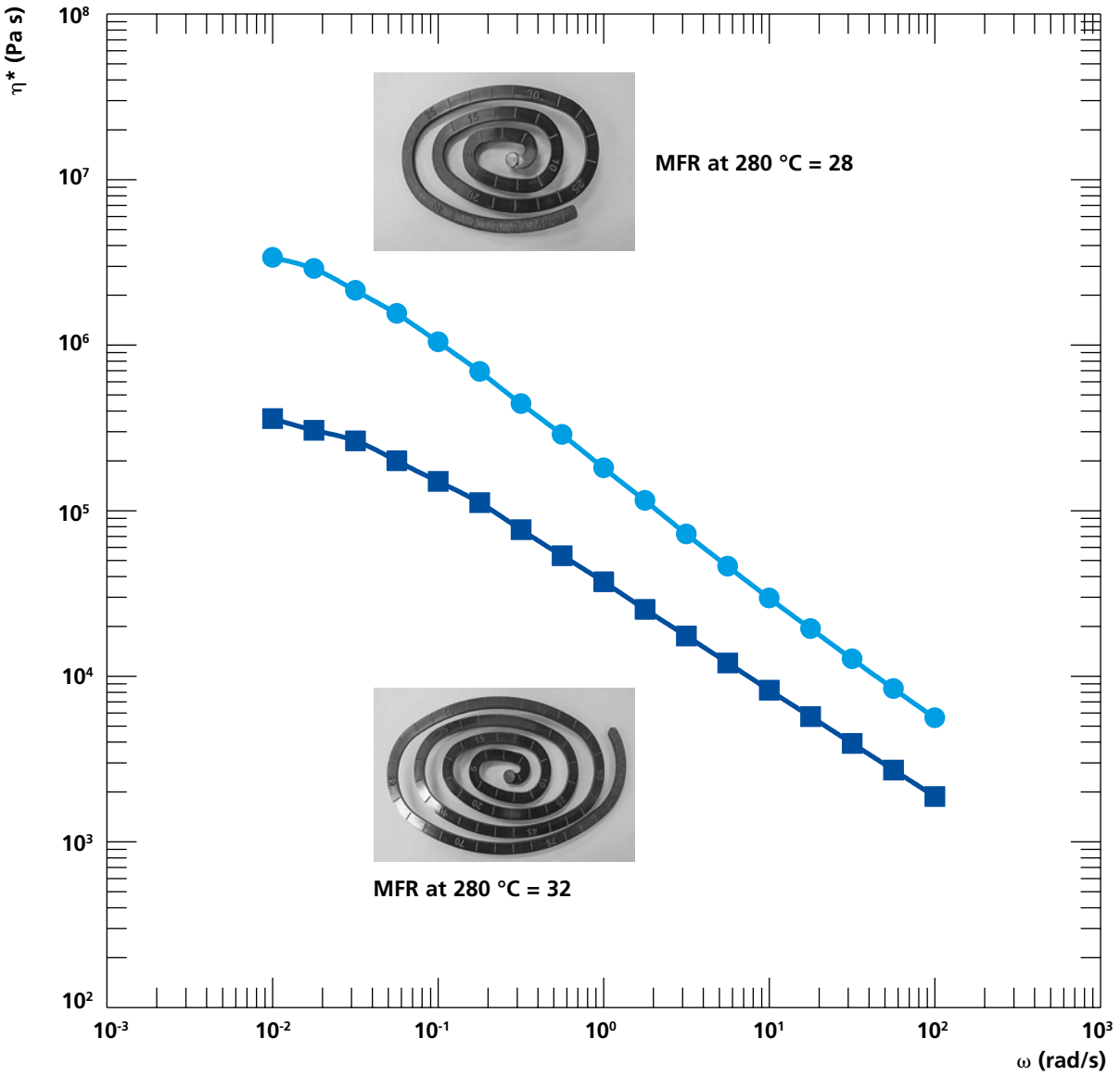


● MFR ● Density

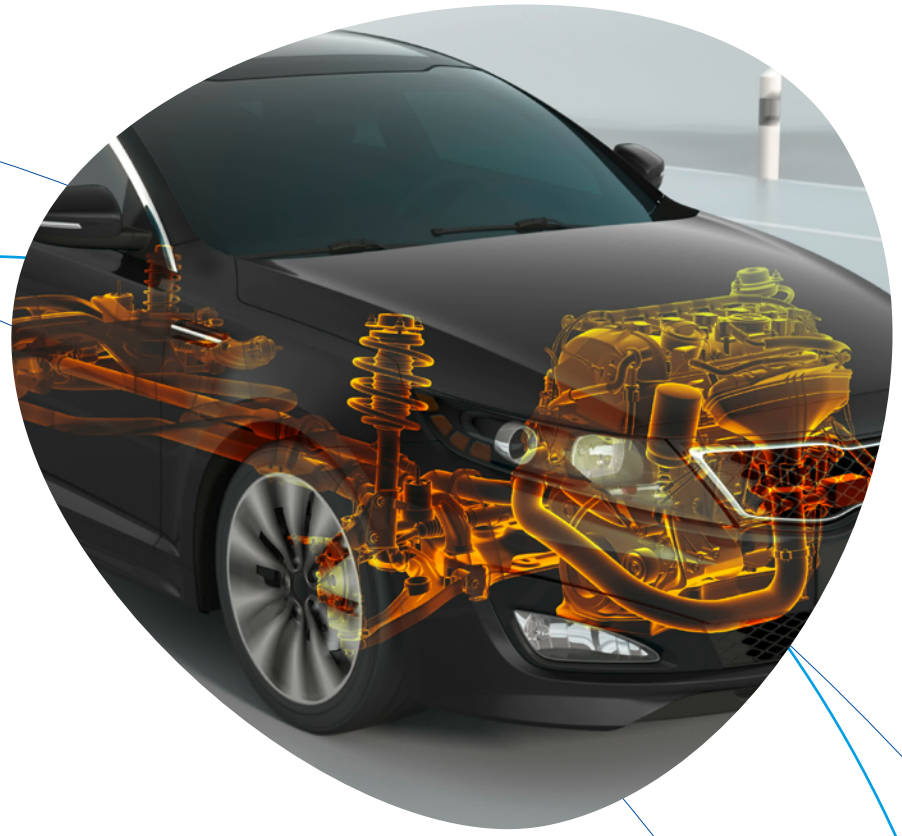
G. 07

Physical property optimization with processability improvement

Processing improvement example in mixed reinforcement system: shear versus viscosity and spiral flow improvements



Physical property equivalent systems with optimized density: ● PA6.6/17 % glass fiber/21 % mineral filler ● PA6.6/21 % glass fiber/2 % BYK-MAX CT 4275



Conclusion

Polyamide is used in many industries due to its excellent physical properties, ease of processing, relatively low density, and reasonable cost, but there is continuous pressure to improve these benefits further. BYK-MAX CT 4275 can provide improvements in physical properties and processability at a reasonable cost. In many instances, it can enable the use of PA6 in place of PA6.6. It also offers progress in the continuous struggle to reduce density and weight.

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