Case Study

Highly reinforced polyamide 6 as an alternative to steel, aluminum and GMT

OEM: Audi

Grade: Durethan® DP BKV 60 H2.0 EF

Manufacturer: voestalpine Plastics, Netherlands

Fig. 1 Injection-molded spare wheel well also provides reinforcement to the body structure

The outstanding stiffness and strength of highly reinforced polyamide 6 opens the door to new applications in automotive engineering as an alternative to steel, aluminum and glass-mat-reinforced thermoplastics (GMT). One current example is the spare wheel recess with integrated reinforcing channels in the new Audi A8. The recess is made of Durethan® DP BKV 60 H2.0 EF, a highly filled polyamide 6 from LANXESS with 60 % glass fibers. This polyamide 6 is the material of choice because it enables precise injection molding of the part's complex geometry. It would be very difficult to make the component from sheet metal due to the limited space available and the high draw ratios required. This plastic also enables direct integration of numerous functions, which would have required a large number of separate production and assembly steps in a metal design, with all the associated costs. One of the reasons for deciding against a GMT design was the huge amount of reworking the finely structured component would have required. The spare wheel recess is made by the Dutch company voestalpine Plastics.

With dimensions of 100 x 85 x 32 cm (3.25 x 2.75 x 1 ft), the spare wheel recess is unusually large for an injection-molded part. The plastic alone weighs approximately nine kilograms (20 pounds). The component is bonded and bolted to the body framework, and fulfils the additional function of reinforcing the aft structure of the car. This is achieved by integrating two reinforcing channels, each around two meters (6.5 ft) long, using gas injection technology (GIT).

Figure 2 reverse side of spare wheel well with integrated reinforcing channels

The plastic makes a major contribution to the high overall stiffness of the aft structure. Its tensile modulus of approximately 19,000 MPa at room temperature (conditioned: 13,000 MPa) is twice as high as that of a standard polyamide 6 filled with 30 % glass fibers. It also retains its stiffness at high temperatures – as required by Audi for components located close to the exhaust system, for example. This outstanding stiffness and strength are also important because the recess supports numerous fittings and attachments weighing a total of around 70 kg (155 lbs). These include the spare wheel, air spring compressor, vehicle jack, tools, battery and various control units. The battery is attached to an aluminum sheet that is integrated into the component. This prevents the battery from becoming detached in the event of a rear-end collision.

The spare wheel well is made in a single-stage injection-molding process. Particular challenges include the size and 3D complexity of the molded part, the high shot weight of around 12 kg (26 lbs), precise reverse-injection of the aluminum sheet for the battery and integration of the GIT process for the reinforcing channels. Precise metering is achieved using a 2,700 metric ton injection molding machine with a screw that has a relatively large diameter of 150 mm.

To produce the part the polyamide 6 is first injected into the mold. The highly reinforced thermoplastic's excellent flowability – similar to that of a standard polyamide 6 with 30 % glass fibers – means that only two gates are required. The GIT process is then used to produce the reinforcing channels, the excess melt being forced into overflow cavities. Durethan® BKV 60 H2.0 EF makes thin walls possible. In addition, the expelled melt can be returned to the process as recyclate at a ratio of 30 %. Another key benefit of the this material is the fact that its impressive flowability results in mold wear comparable to that observed when using a standard polyamide 6 with 30 % glass fibers.

LANXESS provided a comprehensive range of services during the development of the spare wheel well. This includes using mold filling analyses to optimize wall thicknesses and minimize warpage. LANXESS also provided assistance during mold construction, tool try-outs and initial production trials. Moreover, the material's recyclability was tested and integrative simulation was used to calculate the vibration characteristics of the finished part.

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Note:
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