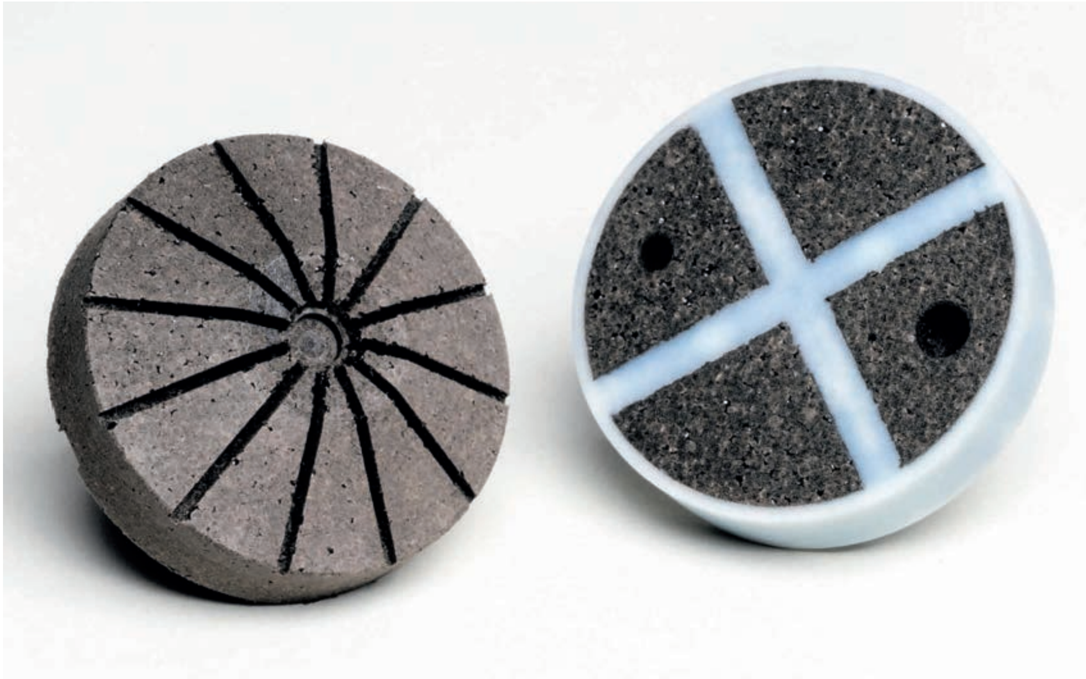
EPA Expands the Design Options

Overmolding PA Foam with PA

Polyamide particle foam (EPA) has a higher stiffness, strength and density than conventional polymer foams. Components made from EPA can also be overmolded with PA. This opens up interesting design possibilities for foam components.



The relatively large-volume EPA core (left) can be overmolded. This extends the design freedom and enables large-volume but comparatively lightweight components (right). © BASF

Polyamide particle foam (EPA) is a relatively new material compared to conventional foams based on polystyrene (EPS) or polypropylene (EPP), for example. Compared to conventional PP foam, EPA provides significantly higher stiffness while also offering an increased operating temperature (see **Table** p. 49). EPA can be directly connected with screws without pre-drilling. Injection-molded additional components can be easily joined to the foamed component using standard plastic welding processes. Bonding is also possible without any problems using the bonding systems known for polyamide (**Fig. 1**).

For suitability tests and quick prototypes, the foam can be milled into appropriate geometries. Tensile tests, compression tests and bending tests in accordance with current standards allow the material behavior to be modeled using the familiar material models for foams. This allows the behavior to be predicted virtually. BASF's CAE tool Ultrasim has non-linear and strain rate-dependent material models that also allow, for example, the prediction of crash behavior (energy absorption). Customers can also access corresponding material cards for their own simulations (**Fig. 2**).

The high temperature resistance combined with high compressive rigidity and strength allows the PA foam to be overmolded with conventional plastic injection molding compounds. This was first demonstrated at BASF by inserting relatively large-volume EPA cores milled from sheets into an injection mold (**Title figure left**). The overmolding succeeded »

Advances at a Glance: Ultramid Expand (EPA)

- High heat deflection temperature
- High temperature resistance
- Excellent mechanical properties at temperatures >120 °C
- Chemical resistance against automotive liquids
- Laser markable
- Drop-in solution in EPP tooling (steam chest molding)
- Recyclability
- Simulation models available
- Processable via e-coating

straight away: the EPA core inserted into the injection mold is melted on the surface by the injection molding compound, as the compound temperature is far above the EPA melting temperature. The result is a practically inseparable, intimate hybrid composite made of pure polyamide, which also offers advantages in terms of recycling.

Overmolding EPA with PA Provides More Design Freedom

The overmolding of EPA cores not only allows cavities to be filled easily, but also extends the design freedom in component design through the intelligent design of the EPA core: every recess in the EPA core represents an effective extension of the injection molding cavity. For example, if the EPA core contains grooves, these become ribs in the injection-molded component. Holes and openings in the EPA core form flow channels that can be treated as a kind of internal injection molding skeleton in an otherwise hollow component (**Title figure right**). In this way, large-volume but comparatively lightweight components can be designed.

The injection molding compound can be arranged in standard wall thicknesses in the load paths and thus use the EPA foam to mechanically stabilize, guide the melt in a targeted manner and, last but not least, avoid mass accumulation. This enables complex geometries and simplifies the tools.

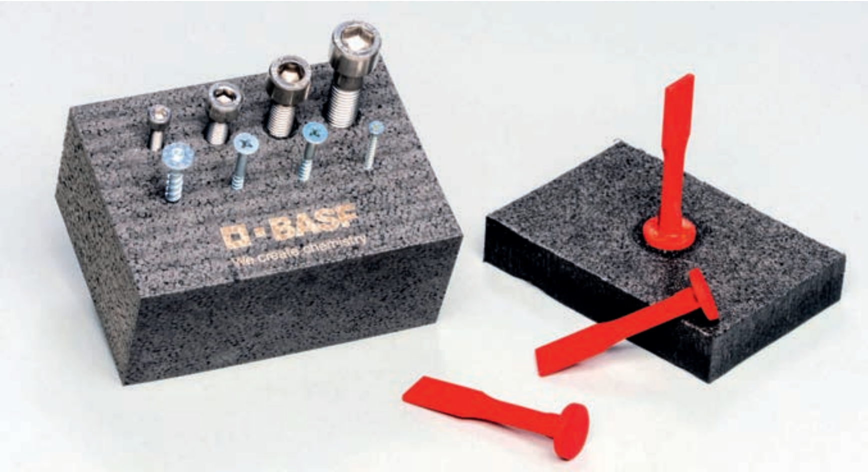


Fig. 1. EPA is suitable for screw connections with and without preparation (left) and for welding with injection-molded additional components (right). © BASF

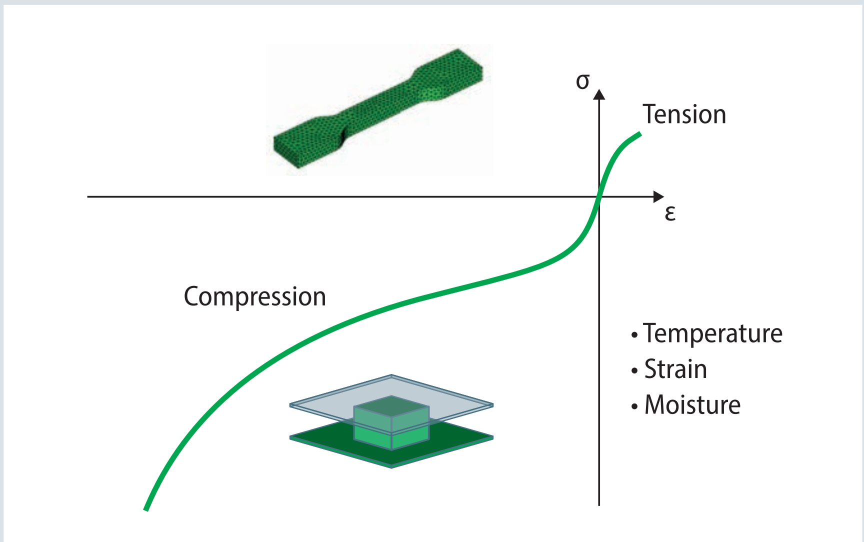


Fig. 2. BASF's CAE tool Ultrasim has non-linear and strain-rate-dependent material models that also allow the prediction of crash behavior (energy absorption). Source: BASF; graphic: © Hanser

Thermoplastic injection molding always means high filling pressures. Every surface in the mold that is in contact with the melt experiences this time-varying pressure as a mechanical load during the manufacturing process. In the case of an EPA core with a very low rigidity compared to metal, there is therefore an increased risk of unintentional deformation of the core (core displacement).

Can the Foam Withstand the Filling Pressure?

In order to test whether the EPA can withstand high filling pressures and whether core displacement occurs, a foamed and ribbed container made of EPA was manufactured at BASF (**Fig. 3**). By changing the inserts, the foaming tool for this component allows both a complete filling of the outer geometry and ribbed patterns with 5 mm and 3 mm wall thickness. The relatively small wall thickness of 3 mm for a foamed component is not a problem for the EPA foam, as there is also a version with 1 mm particles in addition to the standard commercial particle sizes of 2.5 mm diameter.

The numerical simulation (CAE) provides an estimate: a filling simulation software first carries out a standard filling analysis and writes out the determined pressure acting on the EPA core as a function of time and location as a high-resolution result. This scalar field (pressure) is then transferred to a mechanical FE computer model of the

Info

Text

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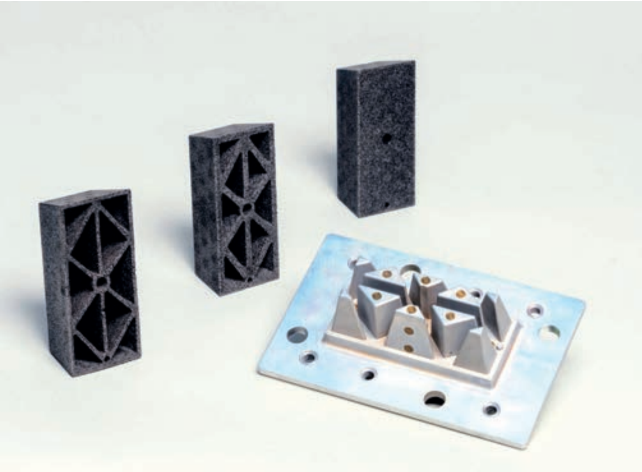

Fig. 3. Changing the inserts in the foaming mold allows for different wall thicknesses in the foamed and ribbed container. © BASF

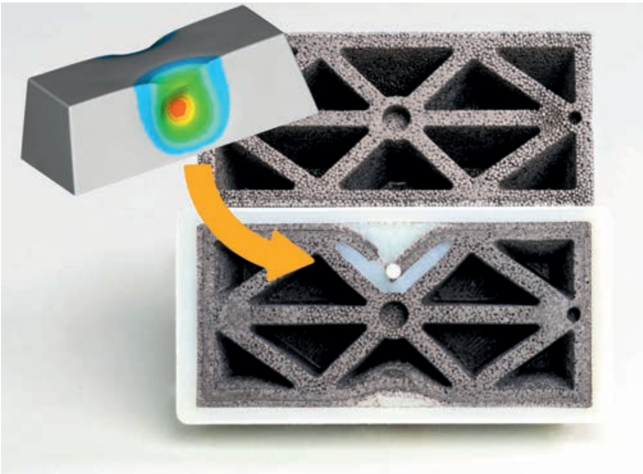

Fig. 4. The numerical core displacement analysis at top left predicted the collapse of the middle side walls, which was confirmed in the real test at bottom right. © BASF

component using BASF's Ultrasim CAE tool. In the Ultrasim approach, it is possible to use a mechanical FE software that is decoupled from the filling simulation, which also allows the consideration of contacts and non-linear material behavior of the EPA core. **Figure 4** on the left shows the results of the numerical core displacement analysis. In the filling phase, quite small deformations can be seen, while in the holding pressure phase a significant collapse in the middle of the longer outer walls is predicted.

The Reality Check: From Simulation to Production

First, the cores filled with foam were overmolded. Ultramid B3EG6, a PA-GF30, was used as the overmolding material. After setting the standard machine parameters, the parts were of good quality after just a few shots. The use of foam cores with the 5 mm thick ribs then confirmed the collapse of the middle side walls predicted in the core displacement simulation (**Figure 4 right)**. Subsequently, it was shown that even a reduction of the holding pressure avoids this effect.

There is another way to produce overmolded components with even higher holding pressure values: by specifically supporting the corresponding walls in the foam component against collapse. Based on the simulation carried out in advance, metal supports were milled in preparation for this and inserted into the foam core at the vulnerable points. **Figure 5** shows the comparison of the components with the same injection molding parameters on the left without and on the right with the supports. The effectiveness of the support measure is obvious.

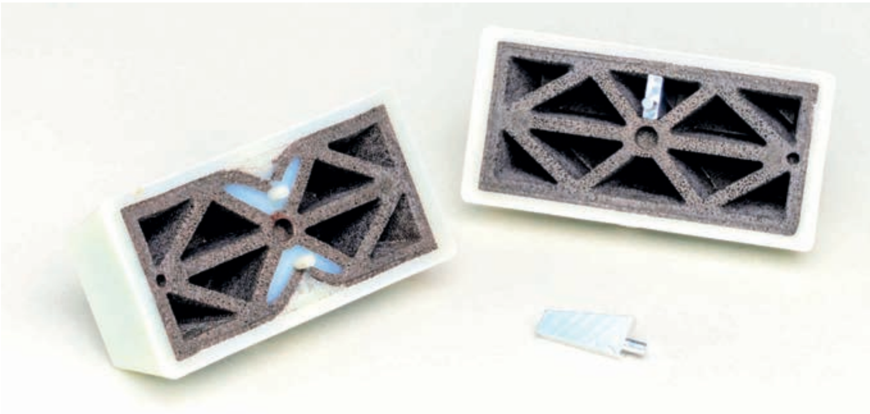

Fig. 5. Based on the simulation, metal supports were inserted into the foam core at the endangered areas, which prevented the collapse of the side walls. © BASF

Property	Particle size 1 mm	Particle size 2.5 mm
Density	400 g/l	340 g/l
Maximum application temperature	150 °C; heat stable up to 190 °C for a few hours	150 °C; heat stable up to 190 °C for a few hours
Melting temperature, DSC	216 °C	216 °C
Compression stress at 10 % (cond.)	6 MPa	3 MPa
E-modulus at room temperature (cond.)	223 MPa	139 MPa

Table. Data of the EPA foam Ultramid Expand. Source: BASF

Conclusion

With its technological properties, the EPA foam Ultramid Expand opens up new areas of application for particle foams. The possibility of overmolding the material considerably increases the design freedom for injection-molded components. The tests show that even thin-walled EPA cores can be overmolded despite high injection pressures. Core displacement simulation with Ultrasim provides important information in advance about the expected behavior during production and enables precise design of overmolded components. ■