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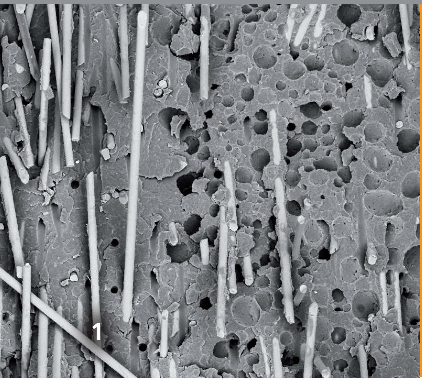
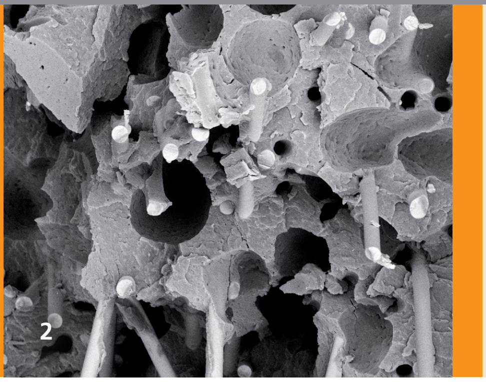
FRAUNHOFER INSTITUTE FOR CHEMICAL TECHNOLOGY ICT





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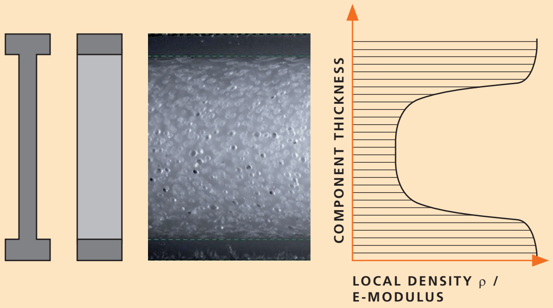

1 + 2 REM images of a microcellular integral foam (PP/LGF30).
3 Density and E-modulus distribution (right) over the cross-section of a typical integral foam (middle); simplified representation as a sandwich structure or double-T-beam (left).

LONG FIBER REINFORCED, THERMOPLASTIC FOAM (LFT-FOAM)

Long-fiber-reinforced thermoplastics (LFTs) have a broad application range, and a high productivity due to their good price-performance ratio. Compared to short-fiber-reinforced compounds, LFTs offer improved energy absorption and better thermal and/or long-term stability.

LFT components are generally applied in engineering and machine construction, in particular in the automotive sector. They are produced either from semi-finished products such as long-fiber-reinforced granulates (LFT-G) or by direct processing (LFT-D). The combination of these LFT processes with thermoplastic foam injection molding enables the production of long-fiber-reinforced thermoplastic foams (LFT foams) with a high lightweight potential.

At the Fraunhofer ICT a comprehensive range of process technology is available:

MuCell®

In the automated MuCell® process, polymer foams can be produced using physical blowing agents (N_2, CO_2). The MuCell® injection unit at the Fraunhofer ICT enables the processing of long-fiber-reinforced granulates (LFT-G), and is equipped with an optimized LGF screw (4).

Technical details

Screw diameter	mm	80
L/D		25
Max. dosing volume	ccm	1,402
Max. injection pressure	bar	1,401
Max. injection speed	ccm/s	442
Max. cylinder temperature	°C	450
Clamping force	kN	7,000
Blowing agent		N_2, CO_2

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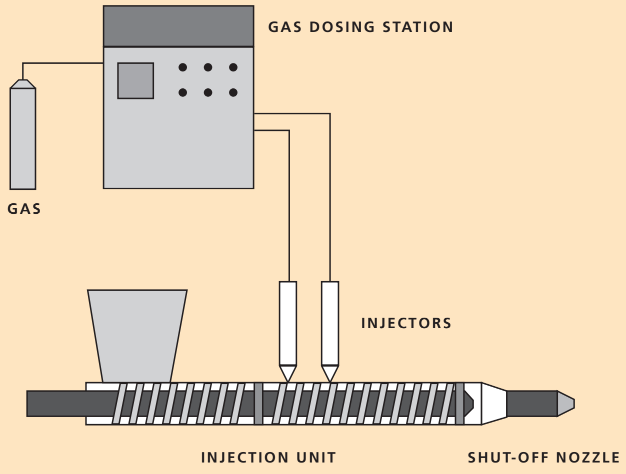
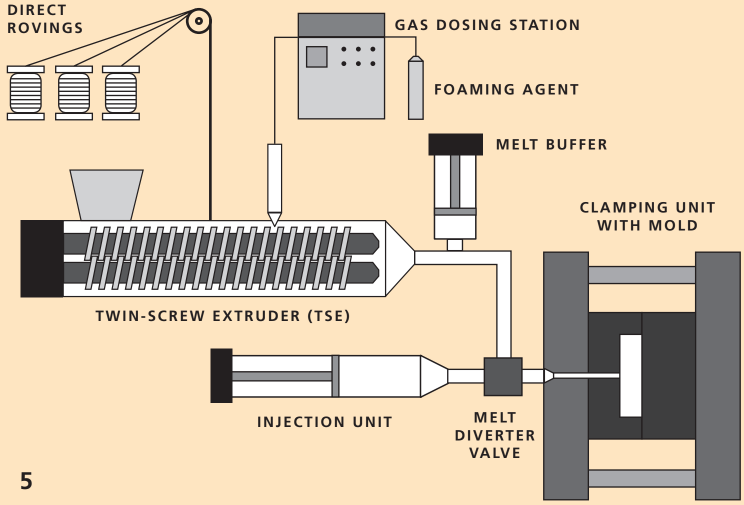


4 *Diagram of MuCell® process.*



5 *Diagram of LFT-D foam process.*

LFT-D foam

In the LFT-D foaming process, continuous fibers (D-rovings) and the necessary blowing agent are fed into the thermoplastic melt via the twin-screw extruder (TSE) of an injection molding compounder (IMC) (5).

The excellent mixing effect and continuous processing of the twin-screw extruder, combined with the gravimetric dosing of the blowing agent, lead to a highly-dispersed (single phase) polymer-gas solution and to components with exceptionally fine cell structures and significant weight-specific mechanical properties. The LFT-D process also offers advantages in terms of fiber length: longer fibers can be achieved in the component compared to processes based on semi-finished products. In addition the process does not require a mechanical non-return valve.

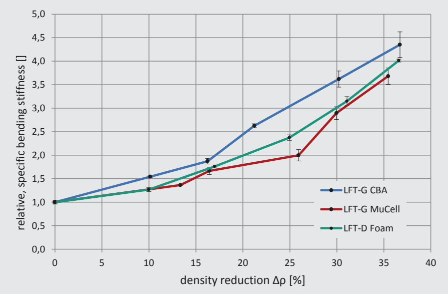
Technical details

Screw diameter TSE	mm	40
L/D TSE		48
Diameter of injection screw	mm	105
Max. dosing volume	ccm	4,160
Max. injection pressure	bar	1,650
Max. injection speed	ccm/s	945
Max cylinder temperature	°C	450
Clamping force	kN	7,000
Blowing agent	N_2, CO_2, CBA	

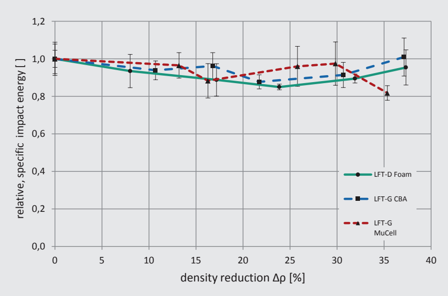
Lightweight potential

The typical integral foam structure resulting from thermoplastic injection molding, which can basically be considered as a sandwich structure, allows material savings in the neutral axis, while separating the surface layers (3). Unlike in conventional production processes, the sandwich is not produced ex-situ by joining a surface layer to a core: rather, it is produced automatically in-situ in the injection mold.

Integral foam structures, with a constant weight per unit area but greater wall thickness, have a significantly higher bending stiffness than compact components. The second moment of area I is increased with the third power of the wall thickness. This means that a relatively small reduction in density leads to a significant increase in stiffness (S=E*I), which is illustrated below using the example of a PP-LGF30 foam sandwich. Stiffness can be optimized by increasing wall thickness H respectively density reduction Δρ at constant weight per unit area. For example, a density reduction of 37 % in this case leads to a stiffness four times higher than that of components with a compact structure:



While non-reinforced components show significant embrittlement during foaming, the energy absorption capacity (impact strength) of LFT foam components remains almost constant:



Our offer

In this research area we offer the following services:

- Feasibility studies
- Material development
- Benchmark testing
- Process development
- Consultancy services concerning process and component design
- Production of prototypes

V04.0