E-LFT process - a new mass-production process for structural lightweight parts

A new mass production process combining unidirectional endless and long fibre thermoplastic (E-LFT) has been developed. This one-shot production process is a combination of the well-established LFT process and a new process for unidirectional continuous fibers, which enables low cost mass production of complex structural lightweight parts.




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Parts made from long-fiber reinforced thermoplastics (LFT) are nowadays the first choice for large semi-structural components for automotive applications. Technical reasons are the persuasive characteristics of the components, particularly with regard to weight, functional integration and energy-absorption. Very efficient production processes like LFT-D-ILC (direct impregnation) [1] or highly concentrated pellets [2] are the economic reasons. The compression molding process allows to fabricate large parts in short cycle time and with very little fiber damage. To enhance the performance of such parts local reinforcements are widely discussed at the moment [3], [5], [6]. The reinforcements thereof consist of metal-inlays [4] or endless fiber reinforced thermoplastics, like tapes (continuous filaments) or woven-fabrics[3], [5]. Such reinforcement can improve the mechanical part performance enormously. On behalf of Albert Weber GmbH, ESORO AG has developed the proprietary E-LFT process from the original idea through concept trials to a fully-automated pilot line. Serial production starts end of 2006.

E-LFT process

The new developed E-LFT process stands for Endlessfiber reinforced Long Fiber Thermoplastic. It is based on the well established LFT compression molding process and combines the local reinforcements with unidirectional endless fiber tapes (EF). Figure 1 shows the two base materials: EF on the left side and LFT on the right. The E-LFT part in the middle is a 2/3 rear seat back and shows the local EF reinforcements in black.

Fig.1: E-LFT base materials - left: EF sticks, middle: E-LFT part 2/3 rear seat back, right: LFT rod granulates.

The LFT molding compound has relatively modest mechanical values but features excellent design freedom and allows efficient production of large-area parts. The unidirectional continuous filament tapes (EF) feature excellent mechanical properties and can be inserted three-dimensionally in line with the force characteristics and the component geometry. LFT components can thus be reinforced specifically to solve local stress problems. But E-LFT can also be used for much more challenging applications, since it is the only process to build real framework structures in targeted manner with EF tapes to substitute metal structures. The 2/3 rear seat back with integrated belt force transmission in figure 1 shows a complex EF tapes configuration and is an example for a metal substitution.

	Glass content	Spec. density
LFT (PPGF30)	30% by weight	1,12 g/cm³
EF (PPGF60)	60% by weight	1,48 g/cm³

EF and LFT mainly consist of the same materials, generally polypropylene and glass fibers. However, it is also possible to process other fibers (carbon or aramide) and matrices (PET, PBT, PA and ABS) [3]. LFT consists usually of 30% of weight glass fibers (PPGF30) and EF has typically a higher content of 60% of weight (PPGF60). glass content spec. densitiy LFT (PPGF30) 30% by weight 1.12 g/cm³ EF (PPGF60) 60% by weight 1.48 g/cm³ Figure 2: Fiberglass content of used materials. The system engineering of the E-LFT process is designed for fully automatic production. The principal components are EF processing, LFT processing, handling (robot) and press, see figure 3. The LFT extrudate can be provided either directly (LFT-D) [1] or with

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conventional rod pellet processing (LFT-G). The EF processing and the handling system for this process are completely new developments from ESORO. As is the case with LFT processing, a frame press with parallel mechanism is also used in the E-LFT process.

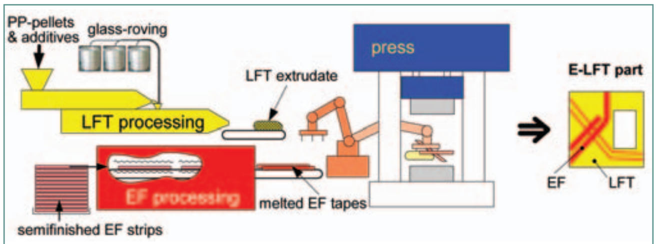

Fig.3: schematic E-LFT plant layout.

As figure 3 shows, LFT and EF are processed parallel and placed together into the mold by a handling-system. The semifinished EF sticks are heated in an infrared field while the LFT is processed with an extruder. The two elements EF and LFT have to be compression-molded in the molten state, else no good bonding between the materials will result. Therefore an efficient handling, which places the materials in one shot as well as the EF strips at the exact position, is necessary. When the press closes and fills the cavities of the mold the bonding between EF and LFT is realized. Standard compression molds can be used and because of the vertical flash faces and the exact dimensions and placement of the EF strips no edge trim is necessary. Compared to standard LFT processing only slightly longer handling time for EF placement is necessary, thus cycle time is very short, rendering the process suitable for large-volume series. All sequences and systems are monitored and controlled by an overriding control system. This is extremely important for fast and secure processing under fully-automated conditions. In addition, a specific simulation tool has been developed for EF processing. This further increases process security. For process development and material-data determination a pilot-plant was set up. Parallel to this, the necessary fundamentals for component construction were developed. Having all process and design specialists in-house, enables very efficient component engineering.

Fig.4: E-LFT pilot-plant at Esoro.

Figure 4 shows the fully automated pilot-plant at Esoro in Fällanden (ZH) with 1000t press, extruder for rod-granulates, robot, and the EF-system, which was specifically developed and constructed for this process.

Characteristics of E-LFT components

Combining LFT and EF allows the component properties to be enhanced in targeted manner. Enhancement of several hundred percent in the mechanical characteristics are possible by comparison with pure LFT components, see figure 5. The strength and rigidity values of the EF tapes are exceedingly higher than those of LFT.

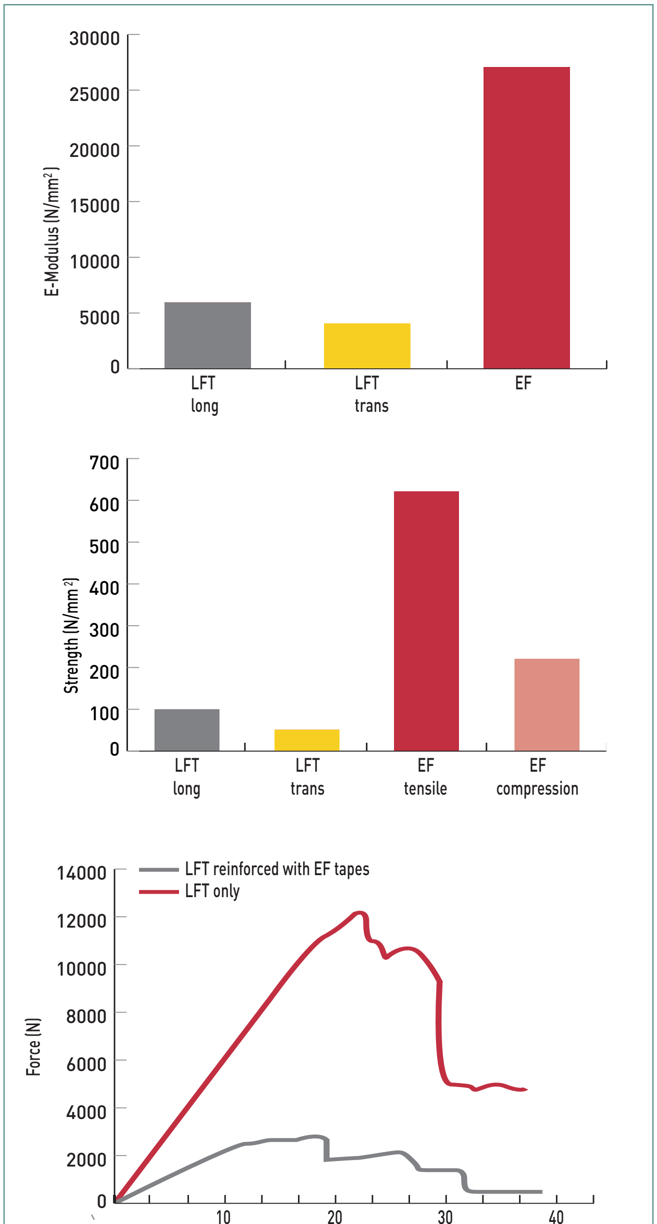

Fig.5: mechanical properties of base-materials and of an E-LFT part compared to LFT.

The impact behaviour of automotive components is of particular importance. LFT parts have already good impact resistance and again EF can improve this property enormously, see figure 6. Even at very low temperature of –30°C the properties can be maintained.

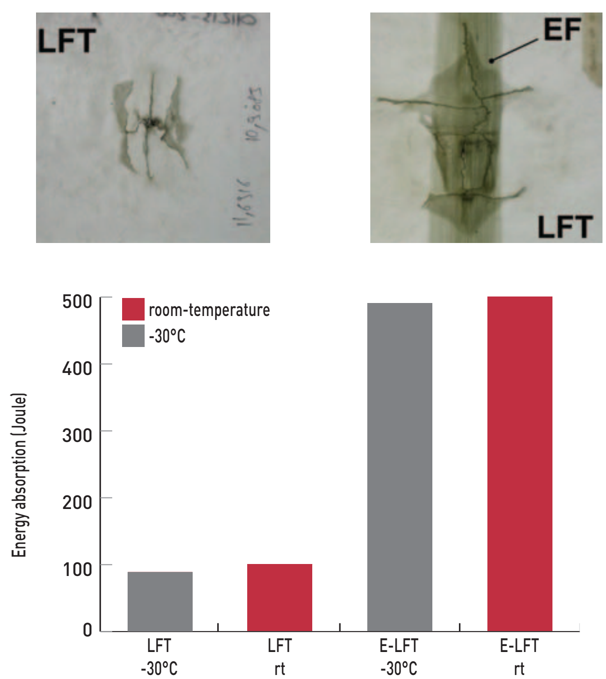

Fig.6: impact properties of LFT and E-LFT parts at room-temperature and –30°C.

Because of the very effective reinforcement of the EF tapes it is possible two work even with lower LFT properties. So it is possible to use recyclate with slightly lower properties as well as LFT of shorter fiber length. The LFT with shorter fibers have therefore the big advantage of better flowability. This makes it possible to produce thinner and larger parts, which have more complexities, see figure 7.

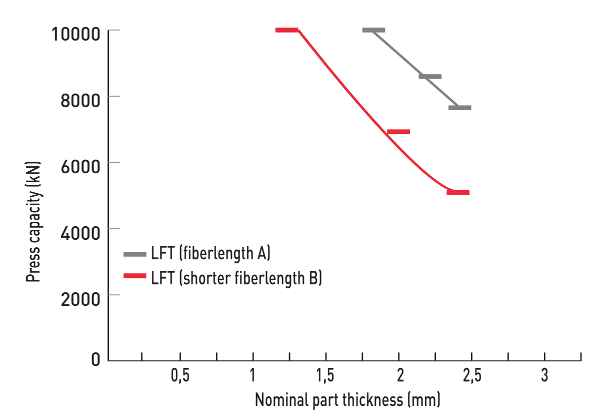

Fig.7: flowability of LFT of different fiber lenght .

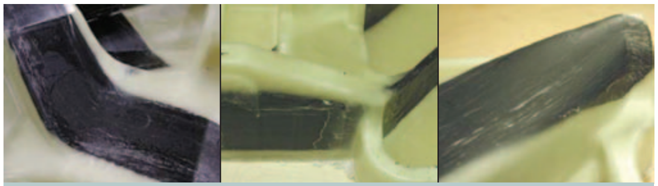

Fig.8: different 3D-shaped EF tape geometries.

One of the very big advantages of the E-LFT process is the design-freedom. The EF tapes can be placed in almost any shape according to the load paths and the component geometry. The tapes can be placed plane or as rip-geometries. Figure 8 shows some examples of 3D-shaped EF tapes.

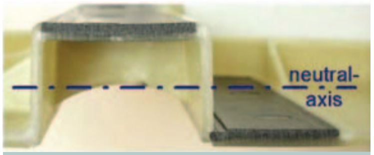

Fig.9: cross-section with EF.

The EF tapes can be put at the specific positions, for example with maximum distance from the neutral-axis, figure 9. The EF system makes it also possible to process EF tapes of different cross-sections. Therefore thicker tapes can be used in places where higher stresses occur. So with a minimal amount of reinforcement a maximum effect can be realised, which results in a immense light-weight potential.

With the E-LFT process real framework structure can be built. In figure 10 is shown how complex the EF's can be arranged – four EF tapes cross each other, two of them as EF rips. The LFT is used for shaping and functional integration, as well as for the

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Fig.10: EF crossing.

Fig.11: critical and subcritical crack-propagation by dynamic loads.

embedding of the EF strips. If the process parameters are maintained properly the E-LFT parts have very good resistance against dynamic loads.

The left picture in figure 11 shows a failure in the interface by insufficient process parameters and on the right subcritical crack propagation at good process parameters. A further advantage of the E-LFT process is the good reproducibility.

This is a result of the exact and reproducible and the optimal process control.

Application field

The E-LFT process is designed for high volume production of large components, which have high structural loads, high integration potential and where light-weight and cost efficiency are important requests. Therefore automotive components are the main application sector. Some target parts are shown in figure 13. It's seen that E-LFT parts can be applied where GMT or LFT components come to their limits. Furthermore E-LFT components can replace parts, which are up to date the domain of metallic solutions.

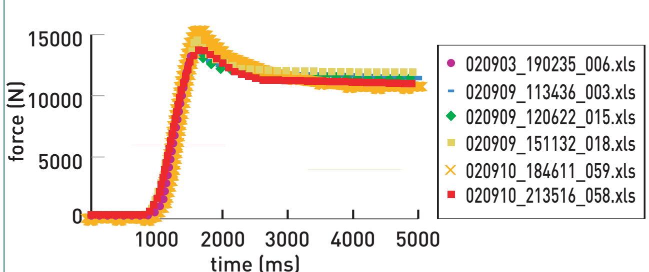

Fig.12: reproducibility tests of entire component.

The E-LFT process gives the possibility to produce components with local reinforcements (EF) for large-volume application in a cost efficient way. The EF tapes can be inserted three-dimensionally following exactly the paths of load and the component's geometry. To reinforce components at the exact places, where it's needed, enables an immense light-weight potential. ■

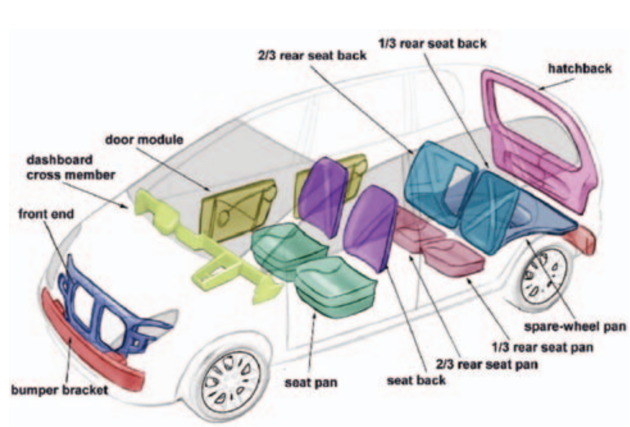

Fig.13: automotive target-application field.

Focus...

Local reinforced parts for structural lightweight applications are widely discussed at the moment especially in comparison with LFT (long-fiber-thermoplastic) and GMT (glass-mat-thermoplastic). Esoro has developed the new E-LFT process for Albert Weber GmbH. The process combines the two elements of unidirectional endless-fiber-thermoplastic (EF) and LFT in a one shot process for high volume applications. E-LFT stands for Endless-fiber-reinforced Long-Fiber-Thermoplastic. The LFT molding material has relatively modest mechanical properties, but does exhibit excellent design freedom and enables efficient production of parts with a large surface area. The unidirectional endless fibres (EF) provide excellent mechanical characteristics and can be inserted three-dimensionally, following exactly the paths of load and the component's geometry. This enables low-cost mass production of complex structural lightweight parts, which can substitute components previously manufactured as metal structures.

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