

LFI-PUR® – THE PROCESS FOR HIGH-QUALITY, LONG-GLASS-FIBER-REINFORCED POLYURETHANE PARTS

Josef Renkl and Wolfgang Söchtig

Krauss-Maffei

Abstract

Krauss-Maffei's LFI-PUR® technology can be used to reinforce both light-weight and solid PU parts with long-glass-fibers. In a LFI-PUR® system, glass fiber from a roving is chopped into filaments which are wetted with the PU reaction system. The mix is discharged into the open mold, the mold is closed and the part is formed under pressure, causing the glass filaments and the PU matrix to bond into a high-strength composite.

The unique process technology benefits of LFI-PUR® can boost a company's competitive advantage in the production of glass-reinforced PU components. The process can be used to produce foamed or solid parts with high-quality surfaces. Additional benefits are high stiffness and low thermal expansion.

Exactng a Competitive Advantage

In a cost comparison, LFI-PUR® outperforms competing processes. It is a more cost-effective alternative to SRIM and its products can be successfully substituted for SMC, GFP and metal components.

Sources of cost-savings include the lower cost of glass-fiber rovings compared with glass mat. In addition, process steps are eliminated. There are no glass mats to be shaped then inserted in the mold and the edge trimming step is also eliminated so there are no trimmings of which to dispose.

Parts produced with this process satisfy the most exacting quality requirements. The chopped fibers are uniformly wetted and their distribution in the mold is isotropic, resulting in high strength parts with low thermal expansion. The process can be used successfully for parts with very thin walls. By increasing and decreasing fiber concentrations and fiber lengths during processing, it is possible to produce zones capable of withstanding higher loads. Furthermore, increased amounts of blowing agent can be used to alter the density of the material over a wide area since foaming certain areas saves material and reduces the weight of the finished part.

At the Heart of the Process: the LFI Process Unit

The LFI process unit consists basically of a cutter unit and a mixing head (see *Figure 1*). The cutter unit draws in the roving, chops it into filaments of the pre-set length and shoots the filaments into the mixing head. The mixing head combines the reaction components and discharges the PU resin into the mold simultaneously along with the fibers.

The roving is drawn between two rollers: one is rubber-covered and acts as the anvil; the other is a metal roll with the cutter blades attached (see *Figure 2*). As the rolls rotate, the cutter blades push into the elastic surface of the rubber. The roving is brittle and snaps under the pressure.



Figure 1: At the heart of the process – the LFI process mixing head.

Fiber length is determined by the number of blades, with 8 blades being the maximum. A cutter roll with a circumference of 100 mm can be configured to produce fiber lengths from 12.5 to 100 mm.

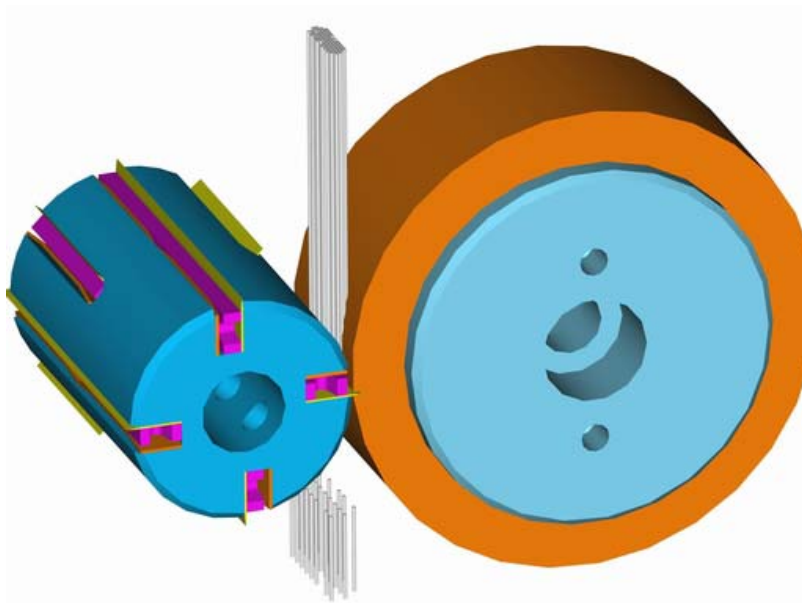


Figure 2: As the cutter unit rolls rotate, the cutter blades push into the elastic surface of the rubber roll, snapping the roving into filaments.

The cutter roll is split into two zones, making it possible to switch between two fiber lengths during a shot. Each zone can be fitted with different numbers of blades. Shifting the cutter roll axially alters its position relative to the anvil roll, thus changing fiber length.

The cutter unit has to be opened to replace rolls. Since no tools are required to open the unit, this has proven to be a very service-friendly operation. The cutter roll is replaced as a complete unit. This quick change system keeps system downtime to a minimum.

The PU components are injected into the mixing chamber of the mixing head at high velocity and mixed via a high-pressure impingement process. The reaction mix is propelled through a ring-shaped slit, emerging in a continuous hose shape. Compressed air forces the chopped glass fibers through the central bore of the mixing head cleaning piston into the center of this PU hose. As the mixture of PU, compressed air and glass fibers exits the piston, the air expands and atomizes the liquid PU mix. This ensures that the fibers are uniformly wetted as the mix is discharged in the form of a spray jet into the open mold. Oscillating compressed air regulates the spray jet pattern to enable the coverage of a large area within the mold on each pass of the mixing head.

Continuous Operation with the Roving Guide System

Roving spools are delivered on pallets; the roving cabin of a LFI-PUR® system accommodates two pallets. The end of one roving is joined to the beginning of the next for continuous operation. The empty pallet is changed out for a full one while production goes on using the second pallet.

On its way from the roving to the cutter unit, the glass fiber strand runs through a guide system of tubing and around diverters. The tubing serves two functions. On the one hand, it contains the fines (later vacuum extracted) produced as the fiber runs around the diverters. On the other hand, it keeps contaminants such as release agents and moisture away from the roving.

If the mixing head is in operation while the cutter unit is idle, the tension on the roving is maintained by a system of brakes and the compensation carriage. For smaller runs or lab units, the mixing head can be fitted with a roving container.

Cleaning the Mixing Head

The movement of the control / cleaning piston sweeps residual resin and glass out of the mixing chamber and the discharge tube. Only the front end of the discharge tube and the spherical end of the cleaning piston will be coated with resin. For this reason, after each shot, these surfaces are cleaned with a high-pressure water spray in the mixing-head cleaning unit (see *Figure 3*). The wet surfaces are dried with compressed air. PU residues are filtered out of the washing water then re-used.

Application Examples

The LFI-PUR® process has become established in a number of application areas, particularly for components with large surface areas that need to withstand high mechanical loads. Also significant is the high-quality surface that can be produced by any one of several

different approaches, dependent upon the product. Another growing application area is honeycomb-core molding, which produces components with high strength and very low density.



Figure 3: The front end of the discharge tube and the spherical end of the cleaning piston are washed after every shot to remove material residues.

High-gloss Surfaces

LFI-PUR® is used in the production of automotive components requiring high-gloss (Class-A) surfaces. Perhaps the best-known example of this technology is the roof module for the Smart car (see *Figure 4*).



Figure 4: LFI-PUR® roof module with high-gloss surface.

The outer skin of the roof module, a co-extruded, pre-shaped sandwich film, is inserted into the lower mold half. This skin consists of an ASA/PC substrate with a colored coating topped with a clear coating (both PMMA). The mix of PU and glass fibers is discharged onto the skin and molded into shape under pressure. This process produces a composite part with a coefficient-of-expansion similar to steel or aluminum and capable of withstanding extreme temperatures.

Tractor engine covers are another example of this type of application (see *Figure 5*). Previously, they were produced in a GFP process and hand-laminated. Switching to a LFI-PUR® process improves cycle times dramatically. The high-quality surfaces are produced in a single process step, completely eliminating the subsequent painting step which is required by the conventional process.



Figure 5: Using the LFI-PUR® process to make tractor engine covers results in significant cycle time reductions. The subsequent painting step required by conventional processes is eliminated.

An alternative approach to achieving a high-quality surface on visible parts is to spray the high-gloss polished or structured surface of the mold with a gel coat. The PU mix is discharged onto this gel layer. The molding process creates a permanent bond between the gel coat, as decor, and the PU as substrate. This process is used, for example, in producing house and room doors for the construction industry (see *Figure 6*).



Figure 6: In making internal and external doors, the high-gloss or grained surface of the mold is first sprayed with a gel coat. The PU mix is discharged onto this gel layer.

Structured Surfaces

LFI-PUR® parts can also be produced with attractive, grained surfaces, depending upon the product specifications. An example of this type of surface is part of the tonneau cover for a convertible (see *Figure 7*). The first step is to mold the part in a LFI-PUR® process. Then the part is flooded with PU and molded to produce a grained skin.



Figure 7: To produce automotive components with a grained surface, the substrate is molded in a LFI-PUR® process then flooded with a PU skin.

Structural Automotive Components

For some structural automotive components, the requirements for surface quality are relatively low since the surface will not be visible once the parts are installed. If these structural parts are made of PU, they can be produced in a LFI-PUR® process with a high glass load to achieve a high modulus-of-elasticity (see *Figure 8*). Typically, these parts must withstand relatively high mechanical stress. Examples of structural automotive component applications include instrument panel supports, underbody protection parts and tail gates for pick-up trucks.



Figure 8: LFI-PUR® makes it possible to produce structural components for cars and trucks having a high elastic modulus and capable of withstanding high mechanical stress.

Honeycomb Core Molding

Honeycomb core components combine low weight with high stiffness. In this process, a LFI layer is first discharged into the mold. The light-weight, honeycomb-structure cardboard layer is placed on top of this layer and a second PU/glass layer is then discharged onto the honeycomb core.

An additional option is to add a laminated fabric decor layer on both sides of the part in the mold. This means that it is possible to make assembly-ready automotive components, such as rear package shelves and car trunk mats, in a one-step process (see *Figure 9*).



Figure 9: Combining LFI-PUR® with a honeycomb core produces components that combine high stiffness with low weight.

Summary

Krauss-Maffei's LFI-PUR® process has unique benefits in the production of glass-reinforced PU components. LFI-PUR® products have outstanding mechanical properties, including a higher elastic modulus and a lower coefficient-of-thermal expansion. By controlling foaming, it is possible to produce densities between 0.5 and 1.7 g/cm³. The LFI-PUR® process offers a number of variants, targeted at meeting demanding requirements for different high-quality surfaces.