

# NEW DEVELOPMENTS IN PUR COMPOSITE SPRAY MOLDING PUR-CSM TECHNOLOGY FOR MULTIPLE PROCESSES

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## Abstract

Hennecke, with its **PUR-CSM Technology**, developed a flexible and efficient production system that has already proven successful in numerous applications. There are now six (6) **PUR-CSM** variants of the system which address various transportation parts' manufacturing needs (Fig.1):

**Multitech** – multi layered composite construction,

**Baydur** – thin walled, high strength, glass reinforced,

**Baypreg NF** – high strength, reinforced with natural fibers,

**Baypreg**– high strength/low weight, sandwich structure, with added fiberglass partial reinforcement capability,

**Baytec** – polyurethane spray skin technology,

**Bayflex** – filled, flexible polyurethane with enhanced properties, especially acoustical.

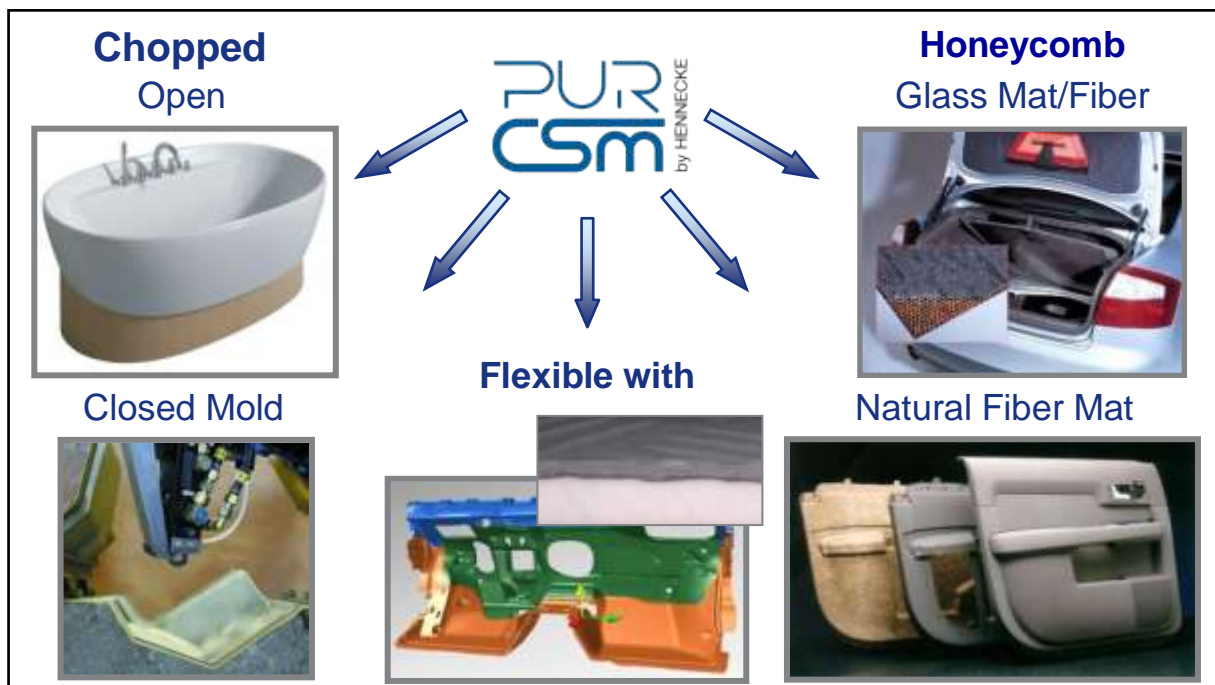


Figure 1: PUR-CSM Technology

## PUR-CSM Technology

The two newer composite variants are **PUR-CSM Multitech** and **PUR-CSM Baypreg**:

**Multitech** System – Multi layered PU process that offers the ability to build a part's thickness with various blown and un-blown, reinforced and non-reinforced layers. In addition, this process offers parts without using a conventional mold or mold clamp. The process utilizes only one half of a relatively inexpensive mold and cures without compression or pressure. This technology uses polyurethane to compete with FRP technologies with advantages including low emissions, faster curing times, higher productivity, and increased processing flexibility.

**Baypreg** System – PU technology utilizing a honeycomb core covered with fiberglass mat to produce lightweight, ultra high strength parts. The process also offers the ability to add partial reinforcement to mechanically enhance and strengthen specific areas of the part for attachment of hardware pieces or to stiffen areas with severe loading requirements without negatively affecting the ultra high strength/ low weight concept of the process.

Based on its modular construction concept the Hennecke **PUR-CSM** system offers a broad range of PUR processing technologies and provides tailor-made solutions for various applications. With this in mind, the molder is given the opportunity to process different parts utilizing one machine or production process, resulting in the ultimate in flexibility and the minimum in cost.

### **PUR-CSM: Polyurethane Composite Spray Molding**

In past years there has always been the desire to provide lightweight, serviceable parts with high strength for many industries. The aircraft industry was in the forefront with industries such as the automotive, trucking, recreational, and others soon to follow. Many of the parts required complex processing steps with relatively small volumes that limited the development of automated processing techniques and machinery innovation.

Although there are many materials used for making composites polyesters seemed to lead the way with inexpensive chemical prices, simple tooling, relatively inexpensive metering and dispensing equipment, and various techniques for application. Polyester lends itself to larger size parts production, lower volume requirements, and material properties that satisfied the need for high strength and low weight, among others. Polyesters have been successful for more than 50 years and will continue to be a viable material to certain producers for years to come.

However, requirements are changing for many polyester parts producers that are leading them to look for alternatives. Some of the products that were traditionally small volume parts are now becoming high volume parts and the initial problems with the use of polyesters are now becoming more troublesome. There was little concern for emissions from a plant that produced a few thousand parts per year. Many went relatively unnoticed. Now some of those plants are being asked to produce several thousand parts per week and are under close scrutiny from government agencies. Many manufacturers are being pushed towards adding more costly emissions equipment.

Polyesters have been purposely rather slow in reacting to allow longer processing windows to accommodate smaller dispensing equipment producing large parts and labor-intensive processing procedures. These longer processing windows come with a cost of longer cure times. These longer cure times ultimately dictate the amount of parts that can be produced on a given amount of tooling.

With the need to produce more parts while maintaining or lowering the emissions from a plant, manufacturers looked for other suitable chemicals to eliminate the problem. They needed a chemical system that would provide the structural properties required to achieve high strength with low weight, a chemical system that could be used with processes that were less labor intensive, and a faster cure time to minimize the number of tools required to produce the larger number of parts that were becoming required. Many tried to achieve their goals using polyurethane.

Polyurethane entered the composites market much later than polyesters. Manufacturers were trying Polyurethane for various parts in the 1970s with limited success. Polyurethane could give them the structural properties they desired with relatively fast cure times using less labor. However, on the downside, polyurethane was more expensive, required more sophisticated and expensive mixing and dispensing equipment, worked at higher pressures which necessitated more expensive molds and clamping equipment with much higher tonnages than traditional polyester users were accustomed. In many cases the cost for a polyurethane process was weighed against a polyester operation and the polyurethane, despite processing advantages, was dropped due to cost restraints.

Many people felt that polyurethane would never be able to compete unless there were large numbers of identical parts all processed with the same chemical system. This would allow a large number of parts to be produced with one metering unit and also minimize tooling costs. The problem was these types of projects rarely, if ever, existed.

The problems with polyurethane stemmed from the fact the material was dispensed by pouring. This causes certain restraints in many parts that are difficult if not impossible to overcome. The answer may lie with the new polyurethane spray systems. Systems such as the CSM-PUR systems may offer the key to producing large composite parts in smaller quantities. Equipment that is versatile enough to spray different chemical systems for different parts or spray different chemical systems to allow multiple processing steps on the same part.

Inside the family of 6 PUR-CSM processes there are two technologies that offer the possibility to compete with polyester. They are the PUR-CSM Baypreg and the PUR-CSM Multitec variants.



*Figure 2: MN-10 Mixhead*

## Typical Processing Equipment

The processing equipment required for all PUR-CSM technologies consists of:

**Mixhead and Nozzle:** delivers chemical spray to the part

**Metering System:** supplies chemical to the mixhead

**Robot:** used to move and position the mixhead for spraying

**Mold Carrier or Clamp:** used to hold two mold halves together – needed for 2 PUR-CSM variants

The mixhead MN-10 (Fig.2) used for all PUR-CSM technologies comes in either a 2 component version or a 4 component version. Each of the mixheads can be supplied with a fiberglass chopping system mounted to the mixhead and fully integrated into the metering units control system. The glass chopper's output can be controlled with the output of the spray head or be controlled independently (Fig. 3).

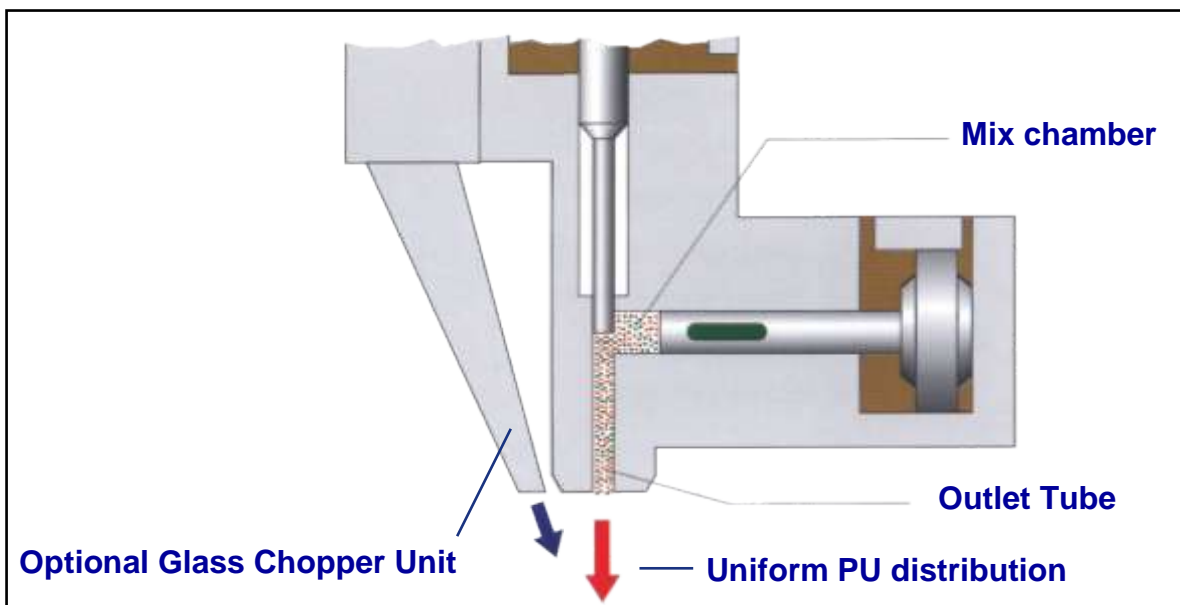


Figure 3: Basic modules of the MN-10 spray mixhead with glass fiber injector unit.

Both versions of the MN-10 mixhead are self-cleaning and require no solvent baths or flushes. This is an important production issue since it avoids downtime in the part cycle and eliminates the problems with handling solvents.

The 2-stream mixhead can dispense one polyol and 1 isocyanate while the 4-stream mixhead can dispense any combination of polyols and isocyanates totaling 4. The mixheads also come in a hardened version should the need arise to dispense a chemical with abrasive fillers.

If CO<sub>2</sub> or other additives are needed they can be batched or supplied directly at the mixhead. Supplying additives of this type at the mixhead versus batching adds to the versatility of the system.

A conical nozzle is utilized which provides a symmetrical conical spray pattern on the part (Fig. 4). The nozzle allows a wider range of spray outputs and is capable of better handling processing variants with more consistency resulting in a higher quality part.



*Figure 4: CSM Module Glass Chopper Unit: Wetting on the Fly*

The metering system consists of 2 to 4 dispensing modules depending upon the number of chemical streams needed. A pumping module is utilized to supply all unfilled chemicals. A special cylinder-dispensing unit is used when abrasive filler is loaded into one of the chemical components. This cylinder module is unique (Fig.5) in that it consists of two cylinders that can move together or independently. This results in a unit capable of handling abrasive fillers with continuous operation without creating any pressure spikes that could compromise the mixing or deliver off ratio chemicals to the part.



*Figure 5: HT Cylinder Metering Module*



*Figure 6: Six-Axis Robot*

The robot required for the PUR-CSM technologies can be any one of several commercially available 6-axis robots (Fig. 6). In the case of multiple parts production on one system or large parts requiring rotation and tilting the robot may need to control as many as 10 axes. The minimum weight carrying capacity should be approximately 125 Kg.

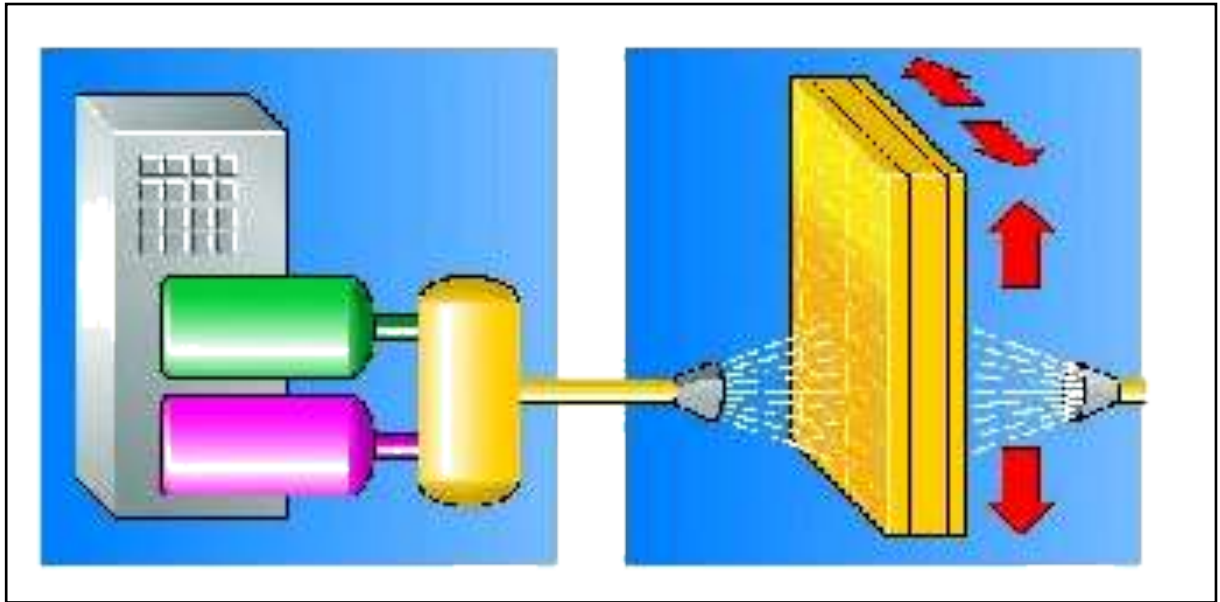
The mold carrier or clamp is needed for two technologies, PUR-CSM Baypreg and Baydur. All other variants require only one mold half and no clamp or press.

### **PUR-CSM Baypreg**

The Baypreg process consists of two variants, Baypreg NF and Baypreg. The first variant utilizes natural fiber mats in lieu of the standard Baypreg process that utilizes Fiberglass mats. Since the standard Baypreg process is the most prevalent it will be used throughout the remainder of this paper.

The Baypreg process consists of a honeycomb core wrapped with a chopped strand glass mat. The core can be anywhere from 2-3mm to more than 100mm thick with the most predominant range 6mm-25mm. The honeycomb structure can be manufactured from paper, plastic, metal, or wood. The most prevalent material used is treated paper.

The glass mat is typically supplied in a roll the same width as one dimension of the part. The mat is cut to length so that it will cover both sides of the part. The glass mat can also be supplied precut to the correct width and length should the customer so desire.

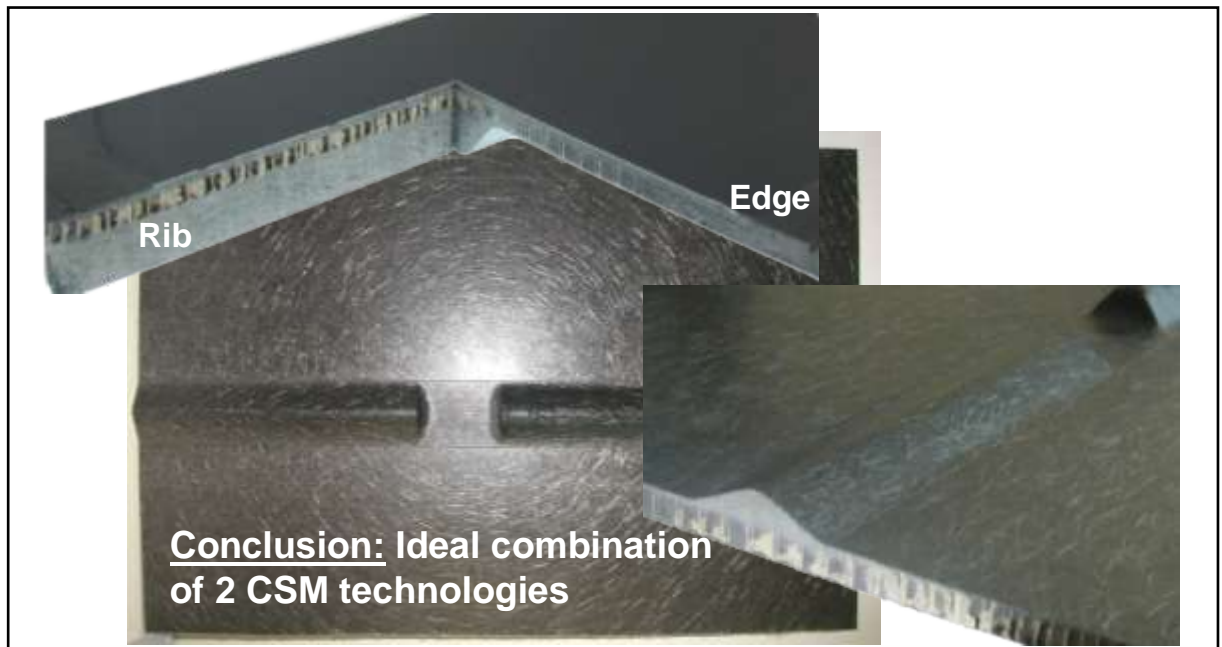


*Figure 7: Fixed mixhead for Baypreg Spraying.*

This packet or sandwich is then picked up with a gripper system by the robot and moved to the spray area. The spray area can be arranged in two different ways; fixed mixhead or moveable mixhead. The first arrangement would consist of a fixed MN-10 spray mixhead positioned in a booth. The robot would bring the sandwich to the booth and precisely move the sandwich back and forth in front of the mixhead saturating the glass mat with the Baypreg chemical (Fig.7). Upon completion the robot would turn the sandwich and do the same to the opposite side. Once both sides of the sandwich were saturated with the Baypreg chemical, the sandwich would be taken to a clamp and compressed and heated. The compression assures the chemical bonding between the layers and provides final forming to the part shape. The heat is supplied to start and speed the chemical reaction.



*Figure 8. Turning Mechanism*



*Figure 9. Baypreg Partial Reinforcement*

The second spray scheme would include a turning mechanism that would spin the Baypreg sandwich about a horizontal axis (Fig.8). In this scenario the robot would be equipped with a spray mixhead and an end effector capable of picking up and releasing a gripper tool. The robot would move the gripper to the Baypreg preparation area and secure the Baypreg sandwich. The gripper tool with the Baypreg sandwich would be placed flat in the turning device and the MN-10 spray mixhead would spray the Baypreg chemical on one side only. Once one side was completed the turning mechanism would spin the sandwich 180 degrees so that the robot could spray the opposite side. One advantage to this scheme is it allows you to spray chopped glass in selected areas that need partial reinforcement (Fig. 9) for higher localized load carrying capacity without appreciably increasing part weight or reinforcement for attachment points such as hinges. This scheme can also be utilized when multiple PUR-CSM technologies are used on one part. Once the part is formed and cured in the clamp it is removed and ready for trimming and final part operations.



*Figure 10: Acrylic Bathtub Shell*

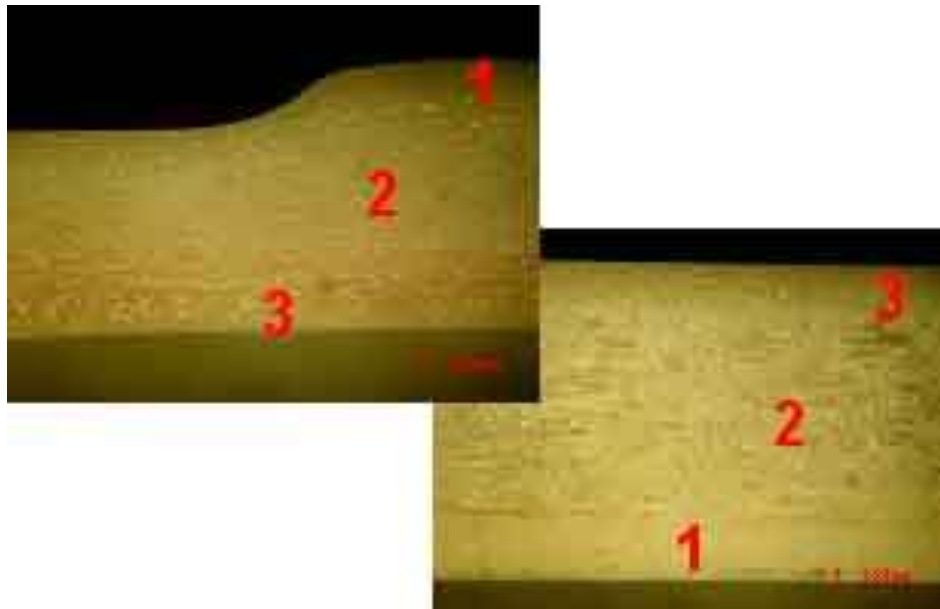
## PUR-CSM Multitec

The Multitec process is unique with polyurethane in that it is sprayed in layers with some layers containing blowing agent, some without, some layers with chopped glass reinforcement, others without (Fig.11). The technology also requires only one mold half and no mold clamping fixture.

This variant is typically used for reinforcement behind a thin walled show surface (Fig. 10) such as a light gauge metal (i.e., garage door), plastic shell (i.e., acrylic bathtub), thin thermoplastic films or foils (i.e., industrial transportation equipment or class A automotive surfaces), prototypes, or facing materials for the construction industry.

This variant is expected to compete with traditional fiber reinforced polyester (FRP) processes and does very well when small numbers of large parts are required and the cost of molds cannot be easily amortized over the number of parts needing to be produced. The layered spray up approach with this technology often allows processing of more than one part at any given time. While one part is going through an intermediate cure after a sprayed layer has been completed the robot and MN-10 spray mixhead move to a different part and spray another layer applicable to that parts requirements. The equipment can change chemical systems, additives, and chopped glass reinforcement delivery within 3-5 seconds.

Emissions from this process are virtually non-existent and the only need for ventilation is for particulates. This process is fully automated and production ready.



*Figure 11: Processing of MultiTec*

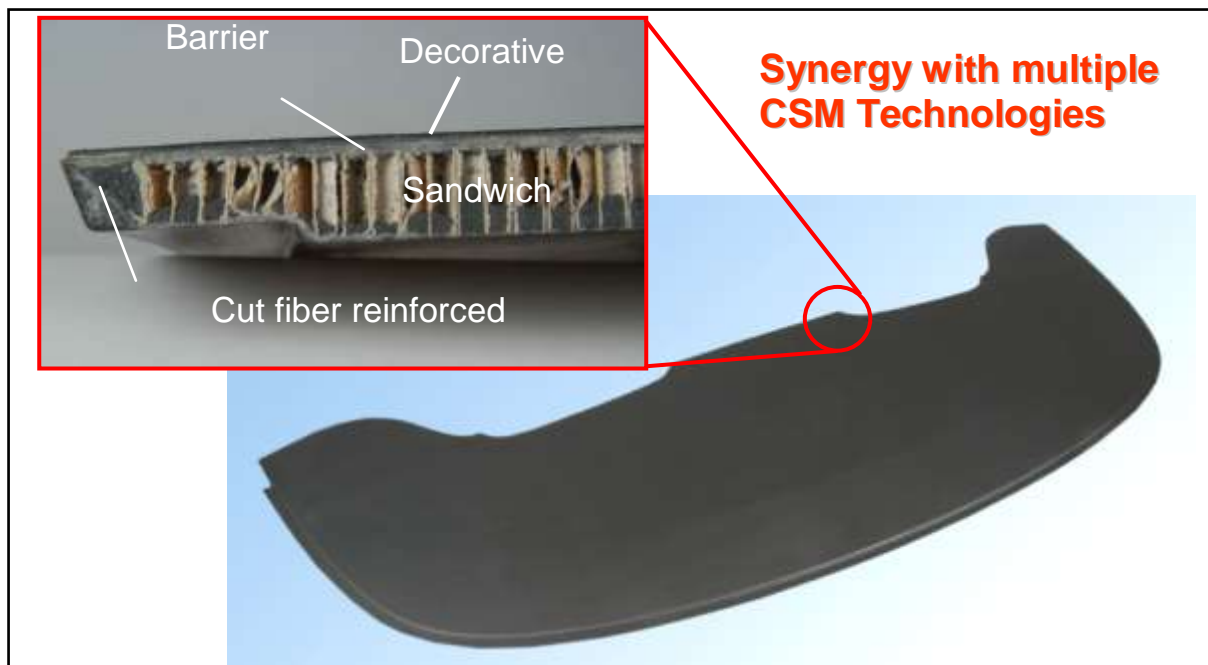


Figure 12: Convertible Boot

### Summary

PUR-CSM technologies bring many new capabilities to the marketplace (Fig. 12). The PUR-CSM variant Baypreg allows molders to produce ultra high strength, low weight parts utilizing honeycomb and glass mat technology for high performance applications. Additional benefits are realized by using the glass-chopping feature to add partial reinforcement in areas with much higher loading requirements without adding appreciable weight to the part.

The PUR-CSM Multitec variant is the technology which will allow molders to compete with traditional FRP molders on large parts with low to medium volume using polyurethanes. This technology will allow FRP molders to compete in their marketplace utilizing polyurethanes by adding existing, production ready automation to their process.

The PUR-CSM group of technologies can provide will allow molders to process different parts utilizing different chemicals with one metering and spray system. It will also allow one part, with multiple processing steps requiring different chemicals, to be processed with that same metering and spray equipment. The PUR-CSM technologies offer a unique flexible processing system previously not available in the PUR industry.