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PROCESS OPTIMIZATION FOR ULTRA-LIGHTWEIGHT POLYURETHANE/PET RESIN TRANSFER MOLDING (RTM) SANDWICH COMPONENTS

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1. INTRODUCTION

With their high stiffness-to-weight ratio, sandwich structures are ideal lightweight design components. Countless materials are available as core and face sheets – the appropriate combination for a given application might therefore be difficult. Material compatibility in terms of processing and application is however crucial for adequate properties. The combination of glass fiber reinforced polyurethane for the face sheets and low-density PET foams as core material are an ideal choice for structural components in all kind of transportation applications. An efficient processing route for the manufacture of such structures is the Resin Transfer Molding (RTM) process, where the dry preform, including face sheets and core, is placed in a cavity and resin is injected under pressure. Elevated temperature and pressure enable a fast curing, thus demolding of the finished part is possible within minutes. Within the EUREKA project PRISCA (Polyurethane Reaction Injection for Structural Composite Applications), materials and processes for the manufacture of PUR-RTM sandwich components have been established and characterized [1].

2. MATERIAL SELECTION

Glass fiber reinforcements are widely used in composite applications, either for monolithic structures or sandwich components. They combine excellent strength, good stiffness, low weight and relatively low material costs. For demanding structural application, the matrix system commonly used today is epoxy. Polyurethane is an interesting alternative to epoxy, as it offers similar mechanical properties but might come with additional advantages: a very broad bandwidth of tunable properties, better impact toughness and lower costs. For sandwich components, the processing is typically faster and the very low viscosity of polyurethane resin reduces the pressure required for the injection thus enables the use of very light foam cores.

In combination with a PET foam core, an ultra-lightweight, high performance yet very cost efficient sandwich is feasible. In fact, the combination of PET and PU enables new applications within the transport industry, where the price-performance ratio is crucial. PET foam cores are easy to thermoform (T=160°C) and do not show any spring back effects [2].

3. PROCESS DEVELOPMENT

Efficient production of sandwich parts may be done using different process routes:

- Hot pressing of dry preforms (thermoplastic face sheets)
- Wet press molding of dry preforms (thermoset resins)
- Resin injection of dry preforms (thermoset resins)

Within the context of this project, the latter method is used. Compared to the other processing routes, there are some advantages using the RTM process (Fig. 1):

- High performance parts are feasible (excellent impregnation and consolidation, high fiber volume content, low voids, excellent adhesion)
- Comparably low processing times thanks to fast resin injection (low viscosity) and fast curing (snap cure)
- Core limits prevent risk to equipment

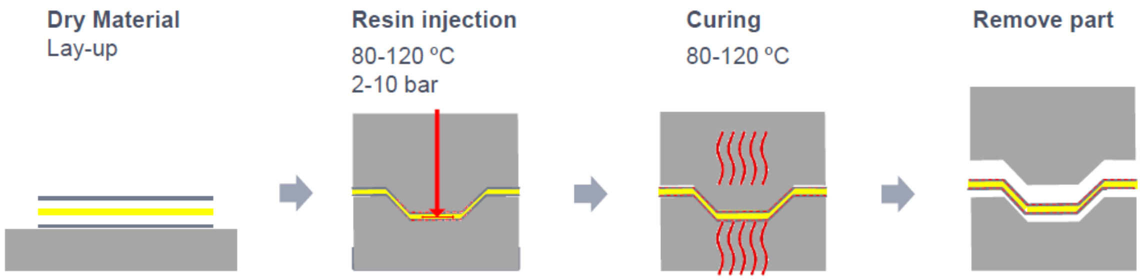

Fig. 1: RTM process to manufacture structural sandwich components [1].

However, the implementation of robust RTM processes is challenging, as effects such as fiber washing or race tracking might influence the fill pattern and turn a part unusable. The successful production of PUR-RTM sandwich components therefore depends on several process parameters. The objective is to manufacture (even larger) sandwich parts in the shortest possible time, without damaging the PET core due to the cavity pressure created by the resin injection. Thus, process parameters have to be adjusted in an appropriate range to enable such manufacturing cycles. This has been done by using a coupon tool to produce a sandwich specimen with dimensions 220 x 110 x 20mm (Fig. 2). By adapting resin system, core architecture and process parameters, an optimal combination for a robust production could eventually be identified.

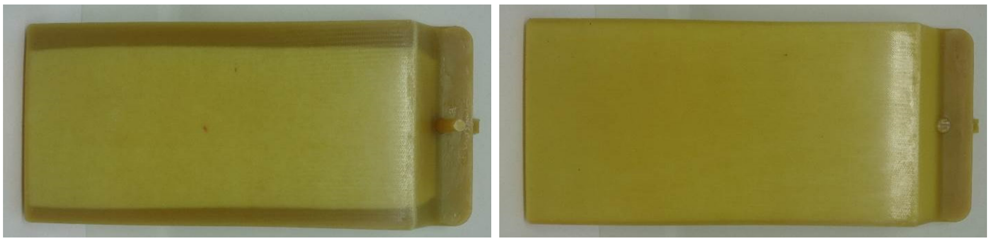

Fig. 2: Sandwich specimen (left: collapsed core; right: optimized processing).

In this context, based on a PET foam core and a low-viscosity PU resin system, the process parameters as illustrated in Table 1 have been optimized.

Table 1: process parameters for the manufacture of PET/PU sandwich structures.

Resin	Core	Fibers	Temperatures	Max. cavity pressure	Flow rate	Inj. time	Cycle time
Rühl Puropreg	AIREX TX.170	Glass fibers	Tool: 120°C Resin: 60°C	8bar	4g/s	20s	<5min

4. RESULTS

The main objective of this work was to develop appropriate processing technologies for the fast and robust manufacture of structural PUR-RTM sandwich parts. In terms of evaluation of the manufactured specimens, the flow front propagation inside the tool has been monitored using indicator marks, to be able to identify race tracking and potential dry spot formation. Fig. 3 shows a typical flow path, where it can clearly be seen that race tracking occurs along the vertical edges in direction of the pressure drop.

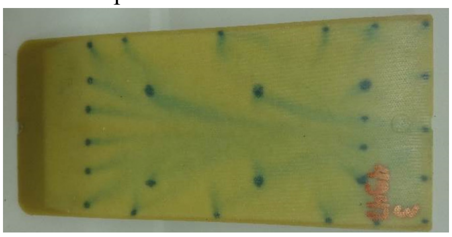

Fig. 3: Typical flow path marked by indicators with race tracking along the edges and back-flow towards the vent.

As with monolithic RTM parts, race tracking cannot be completely avoided and is a result of a gap between preform and mold. It is however possible to minimize the influence by adjusting process parameters (foam core cutting, processing temperatures, injection pressure) and thus obtain a reproducible part quality.

Further work will focus on the process optimization for curved sandwich components. As a robust and reproducible process has been reached on coupon-level, the next logical step is to transfer the technology to real-life geometries.

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