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## Introducing a novel manufacturing process for automotive structural/semi structural composite components

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### Abstract

Potential uses of composite materials are currently being investigated by the automotive industry to reduce vehicle weight and CO<sub>2</sub> emissions. Existing composite production processes are however, low volume and high cost. The aim of the present study was to develop a novel end-to-end production process to produce a light weight, cost effective polymer composite with reduced TAKT time and potential for structural applications. Components were produced from discontinuous random fibres mixed with an epoxy resin system. Static and dynamic mechanical testing as well as durability tests are in progress to evaluate the performance of these materials. Initial results were compared to Sheet Moulding Compound (SMC) as the benchmark composite material.

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### 1. Introduction

In order to meet strict emission reduction targets and to enable electro mobility, it is essential to reduce the structural weight of future automobiles [1]. Fiber reinforced polymer composites are of more interest to the automotive industry due to their lightweight, reduced tooling cost, resistance to corrosion and their higher specific energy absorption in comparison to their metal alternatives [2]. One of the important obstacles in using polymer matrix composites as automotive body parts is their potential loss of mechanical integrity when exposed to elevated temperatures of the e-coat process. During this process, paint particles are suspended within a liquid medium with a charge upon them. Under a high voltage DC current, the paint particles migrate to the part being painted and are deposited onto the surface, forming an even continuous

film. This process continues until the desired thickness is reached, at which point the film insulates the part and the process is complete, leaving a corrosion resistant and durable paint film [3]. The typical temperature for e-coating of metal components is 200°C. While different approaches, such as assembling the composite parts to the BIW after the aggressive e-coat process or lowering the temperature of the e-coat process, have been suggested and used to eliminate this issue [4], none of these approaches are suitable for a high volume production process.

The High Volume Lightweight Technologies for Vehicle Structures (HiLiTe) project was established to develop a novel production process for manufacturing high-volume composite parts for the automotive industry. The project's aim was to achieve a 30% weight reduction on the structural steel case study component while meeting all performance and safety

specifications of the steel benchmark. Cost reduction of 40% was to be achieved from traditional composite materials and processing considering SMC material as the benchmark. An important requirement for this project was the ability of the composite components to withstand the high temperature paint line production step of approximately 200°C, considering that the matrix may exhibit a loss of mechanical integrity at this elevated temperature. Additionally, the project aimed to reduce TAKT time in manufacturing this light-weight, cost-effective polymer composite structure.

## 2. Method and Materials

First stage of the project was to select an automotive component as the demonstrator part. A component decision matrix was defined with bulkhead, panel reinforcement and bonnet inner as targeted application candidates. All candidates were inner components which do not require high quality finish, to ensure a reduced process time. These components were each scored based on the identified desirable attributes such as weight, crash safety, repeatability, tolerance sensitivity and potential adverse life time effects and bonnet inner was selected as the appropriate component to focus on during the term of the project.

An important parameter in selecting the composite matrix material was its ability to withstand the elevated temperature of the e-coat line. This parameter was identified as one of the processing boundaries and the research performed on various

polymers showed epoxy resin as a suitable material with the potential of withstanding the e-coat line temperature.

To reduce production cost of the component, discontinuous random carbon fiber was considered as reinforcement and a continuous mixing process was used to mix the fiber-epoxy system before its deposition on to the press. The component was molded into a net-shape. Net-shape molding of the material reduces the de-flashing operations to a minimum if not totally removing it, and therefore assists with eliminating the need for post processing as well as reducing material waste.

To aid with reducing the process TAKT time and eliminate stand still periods during molding, tool skins were introduced and used in molding of the component. The use of tool-skins allows for easy transfer of the material in the manufacturing cell and simultaneous operation of the press and the material mixing and charging robots, to ensure that each step of manufacturing is kept under 2 minutes. This is in addition to the fact that the material itself allows for cure cycles between 90 and 120 seconds. A schematic of the manufacturing cell simulation is shown in Figure 1. The composite charge is deposited onto the tool skin while the next charge is being prepared and the charges in front are going through the maturing oven and pressing. In such a way, in a mass production line, the through-put of the production cell is improved without the need for several complete tools. The overall cell utilization is also improved as the robots can be working while the part is being pressed, instead of standing idle when a single tool is being used.

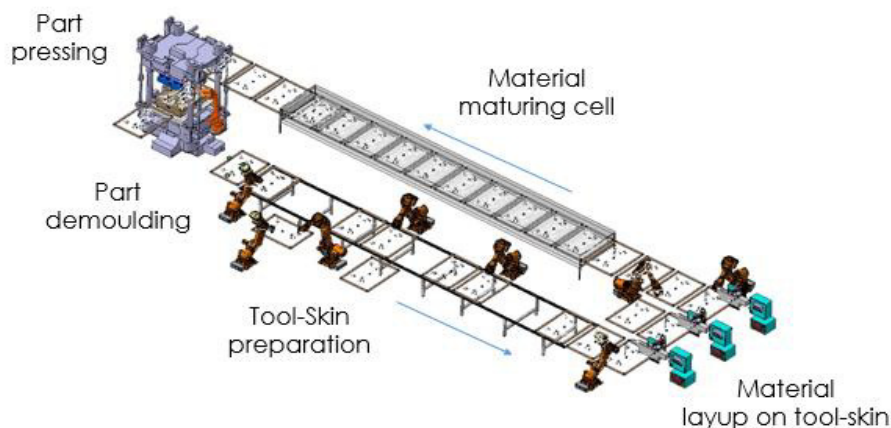


Fig. 1. Schematic of the HiLiTe manufacturing cell

Tool skins were produced through an Incremental Sheet Forming (ISF) [5] technique, which uses a round tipped tool attached to a computer numerical control (CNC) robot to incrementally indent a metallic sheet. The advantage of such a technique is that no press die is required, as in traditional sheet metal forming, thus lowering costs. Figure 2 shows a demonstrator tool skin and the component molded from HiLiTe material.



Fig. 2. Incremental Sheet Forming tool skin and molded component from HiLiTe material

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