Thermoplastic Composite Hybrids for Serial Application

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***Abstract* — This publication focuses on the manufacturing concept for the production of a composite hybrid component using the example of a car roof crossrail. The emphasis is on the continuously fiber-reinforced DExWin® thermoplastic profiles for load path-appropriate reinforcement of the component, which were produced by ProfileComp GmbH using pultrusion technology.**

***Keywords* —Thermoplastic Composite Hybrids, Continuous Reinforced Thermoplasts, DExWin® Thermoplastic Profiles, Pultrusion, Hot Melt Impregnation, UD Tapes & Profiles**

I. Introduction

Currently, there is a growing demand for high-strength CFRP components (CFRP stands for carbon fiber-reinforced plastics) across all industries. In the automotive sector, BMW's i-series in particular is ensuring a carbon fiber-reinforced plastics boom. For the first time, the production of a vehicle whose body is largely made of CFRP in an average series size of 10,000 p. a. was successfully completed. Up to now, the use of fiber-reinforced composite components in the automotive sector has been limited to selected sports and racing cars with traditionally low unit numbers. In contrast to the aerospace or wind energy sector, the technical necessity of the use of composite materials in the automotive industry does not exist to such an extent as to accept the corresponding additional costs for weight savings. For this reason, further reductions in component costs are required in order to be able to place high-strength fiber-plastic composites in high-volume applications. Cost reductions result, among other things, from process improvements or smart design approaches (e. g. composite hybrids). [1] [2] [3]

II. Composite Hybrid

A. Component Concept

The research project "MAI Skelett" takes up these two approaches. All activities in the project where based on the requirement to produce low-cost CFRP high-performance components in large quantities. The implementation was realized using the specific example of a roof crossrail through the cooperation of several project partners from different industries:

- BMW (Project Management, Product Design and Thermoforming)
- CirComp / ProfileComp GmbH (Production of continuous fiber-reinforced thermoplastic profiles (DExWin® profiles)
- Eckerle GmbH (Injection Moulding & Tool Manufacture)
- P+Z Engineering GmbH (Component Dimensioning, Simulation und Optimization)
- SGL-ACF (Production of Injection Moulding Compound & Carbon Fibres)

All three classic lightweight construction potentials - material, structural and system lightweight construction - were exploited in the component design. The result is a composite hybrid of carbon fibre-reinforced thermoplastic in skeleton design (see Fig. 1).

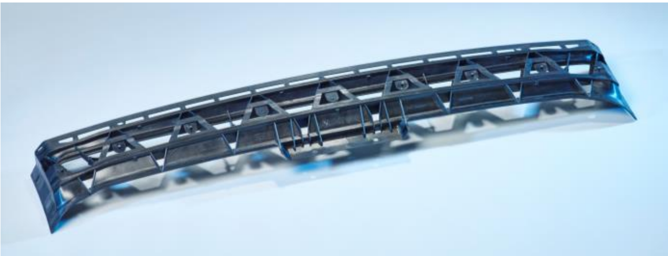

Fig. 1: Composite hybrid made of carbon-fibre-reinforced PA6

Continuous fibre-reinforced DExWin® thermoplastic profiles from ProfileComp GmbH are used along the structural load paths. Due to the unidirectional orientation of the carbon fibres, the maximum performance of the material can be used. Fig. 2 illustrates that the profiles are also formed at the end of the component to exactly cover the load path. The profiles are surrounded by injection-moulded compound, which, thanks to the same base material, enables an ideal bonding of the reinforcing profiles to the ribbed structure. The injection moulding material was compounded on the basis of recycled carbon fibres.

Fig. 2: Continuous fibre-reinforced DExWin® profiles made by ProfileComp GmbH covering the component load paths (red arrows)

B. *Manufacturing Concept*

In addition to the advantage of short cycle times when processing thermoplastics, the reduction to just a few process steps is a decisive factor for the economical production of the roof crossrail made of CFRP. The core processes for the production of the roof crossrail are limited to the manufacture of the endless fibre-reinforced thermoplastic profiles in a single-stage production process, the forming of these and the subsequent back-injection moulding to the finished component. Both, the continuous production of the continuous fiber-reinforced thermoplastic profile as well as the forming process and the injection moulding process including the handling of the formed profiles are automated.

III. PRODUCTION OF UD PROFILES

The continuous fibre-reinforced thermoplastic profiles are produced by ProfileComp using a continuous pultrusion process (DExWin® process, see Fig. 3) where the rovings are impregnated with plasticized polymer and then shaped and consolidated in a calibration tool.

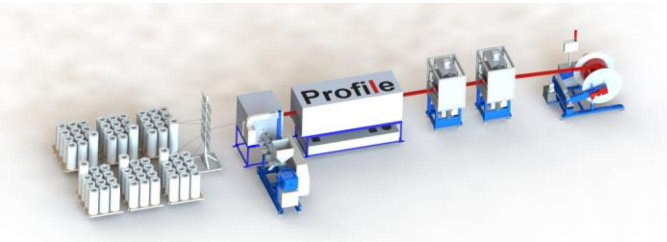

Fig. 3: DExWin® Process

Using the melt impregnation technology enables processing a multitude of thermoplastic matrices. Table I illustrates the material combinations already used, which are specially adapted to customer requirements.

TABLE I: DEXWIN PRODUCT PORTFOLIO

Reinforcement	Continuous Fibres	Carbon, Glass
	Farbics (0°/90°)	
Thermoplastic Matrices	PP, PE, ABS, PA (PA6, PA6.6), PBT, PET, TPU, PVDF, PPS	

DExWin® process enables the production of so-called tapes and profiles with large cross-sections (in this application 10mm x 10mm) in a single-stage process. Due to the cost structure of the "MAI Skelett" project, so-called Heavy Tows made of carbon were used to produce the profiles. Due to the large number of single filaments and the high packing density, Heavy Tows are very difficult to impregnate with the thermoplastic material. In order to guarantee a processing of the 50k fiber - consisting of 50,000 filaments - ProfileComp has developed an additional module for processing the rovings. The aim of this module is to achieve the widest possible spreading of the roving so that the filaments can be completely impregnated. In addition, a concept revision of the melt impregnation tools was carried out to optimize the matrix flow.

IV. CONCLUSION

Cross-company cooperation enabled the production of a low-cost roof crossrail made of thermoplastic CFRP materials within the "MAI Skelett" research project. The positioning of the CFRP UD profiles according to the load path enables high component strength and maximum material efficiency. The lean manufacturing process and the use of thermoplastic material lead to a significant reduction in cycle times and process costs. In addition, a significant reduction of waste in the production process can be achieved.

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