HYBRID SANDWICH COMPOSITES WITH POROUS ALUMINUM CORE AND THERMOPLASTIC FIBER-REINFORCED COMPOSITE TOP LAYERS

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Introduction

Increasing environmental and economic demands in mechanical engineering require specific material combinations and adjusted manufacturing processes. Due to the achievable synergy effects, especially in automotive lightweight design, multi-material assemblies are increasingly applied [1]. Therefore, carbon fiber reinforced plastics (CFRP) arranged with new isotropic aluminum foam (AF) structures to a Hybrid Sandwich Composite (HSC) form the basis for novel weight-optimized as well as cost-effective applications.

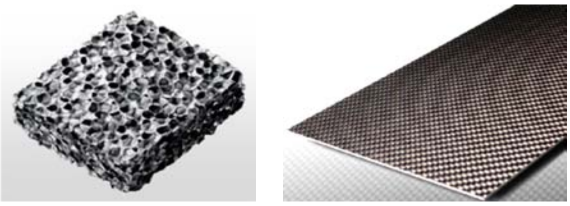

Fig.1: Closed-pore aluminum foam structure (left), Carbon fiber reinforced plastics (right)

This leads to high bending stiffness and high strength structures combined with excellent damping properties at high damage tolerances as requested in automotive applications.

Structure of the Hybrid Sandwich Composites (HSC)

Due to the investigations of the HSC, a symmetrical layer structure was elected. Thereby, a core made of closed-pore porous aluminum was reinforced with unidirectional thermoplastic CFRP top layers (PA6 CF60) as well as a buffer interface consisting of thermoplastic glass fiber prepregs (PA6 GF60) and additional PA6 matrix foils (Fig.2).

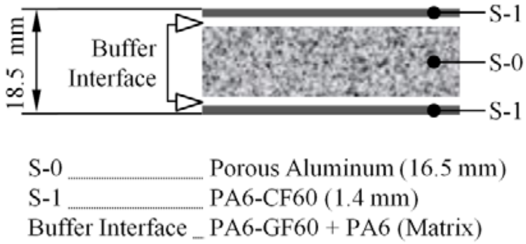

Fig.2: Structure of the Hybrid Sandwich Composites

In view of testing the sandwich structures by 4-point bending according to DIN 53293 a specimen geometry of 128.5 mm x 63.5 mm was defined for preliminary investigations.

Manufacturing process

The manufacturing process for the HSC-specimen is a hybrid technology by thermal pressing. Due to a possible delamination in the interface between the core and the top layers in downstreamed process steps (e.g. cutting) [2], a special tool has been designed, which realized the subsequent specimen geometry (Fig.3).

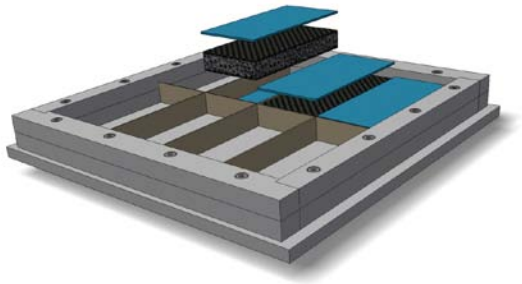

Fig.3: Thermal pressing tool (concept, prototype)

The main requirement to realize HSC-structures with the achievement of high stiffness values and strength properties is an optimized interface design with a perfect adhesion between top layers and core material [2]. To achieve this condition for the specimens Interface of the preliminary investigations different pre-treatment procedures were applied:

- Corundum Blasting and Flame Spraying
- Anodization
- Electrochemical Mechanizing [3]
- Abrade pre-treatment

Examination of the specimen

The resulting specimen have been tested with a 3-point bending (in referring to DIN EN 2377/2563) to determine possible failure types (Fig.4).

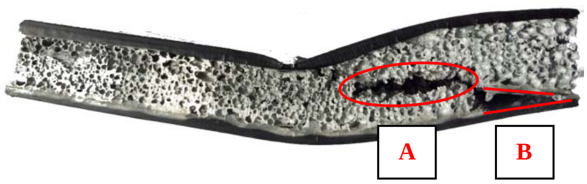

Fig.4: Failure mode A – Core failure
Failure mode B – Delaminating interface

Examination of the first specimen in the 3-point bending test shows a regular incidence of 2 specific failure modes [Fig.4]. The classic failure of the core in the region of the neutral line (A) and a failure in the interface (B) indicate a direct dependence towards quality and functionality of the interface.

To determine a first range of mechanical properties in view of testing by 4-point bending according to DIN 53293 the correlation between force and distance is shown in Fig.5.

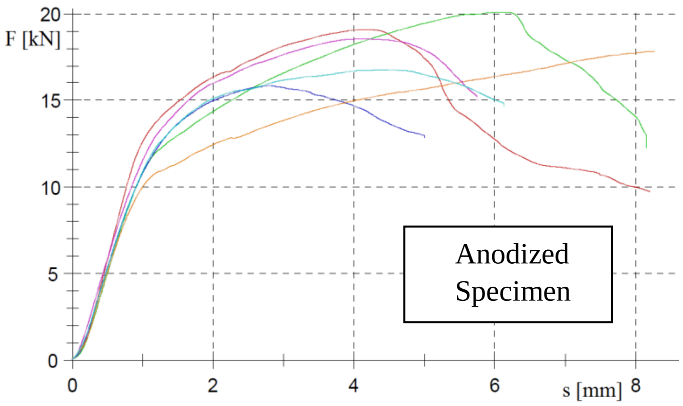

Fig.5: Force-distance diagram

To identify the property of HSC in comparison to single porous aluminum structure the flexural bending modulus as well as the specific modulus is opposed in Fig.6.

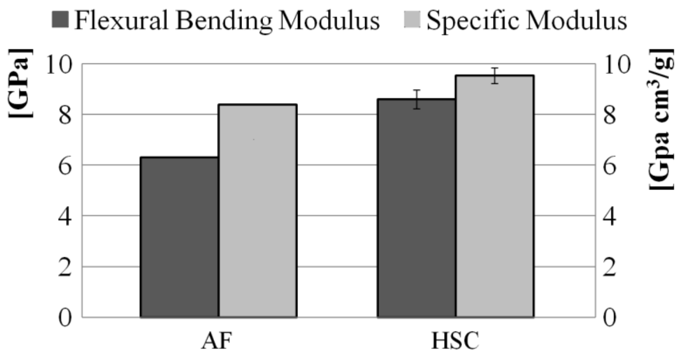

Fig.6: Comparison of Aluminum Foam (AF) and Hybrid Sandwich Composite (HSC)

Potential for application in passenger vehicles

With a generic technology demonstrator, which is represented by an automotive lightweight rim for passenger cars - the “Wheel Center Sandwich Rim Concept” - a potential application for the use of Hybrid Sandwich Composites (HSC) was realized. Regarding this the construction concept was also realized as an exchangeable assembly for series application, which is modular scalable for different series.

Motivated by the homogeneous properties of aluminum foam structures, the sandwich construction offers the main advantages of a continuous semi finished parts. Due to the reference to the characteristics of a shear wall support, the main burden of tensile and compressive forces in the bending load case are assigned the outer layers and the shear load transfer to the core structure. Thus, the joining members can be specifically designed to meet the demands in an integrated design.

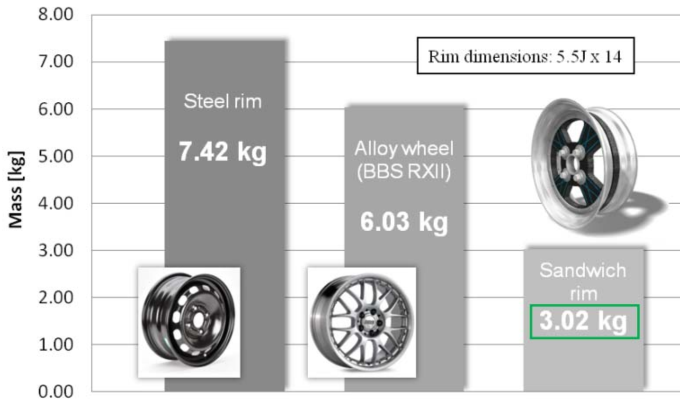

Fig.7: Comparison of rims-weights

The achievable weight reduction compared with a usual steel rim as well as an alloy rim with similar dimensions and permitted payload is shown in Fig.7. Due to the principle of sandwich construction it is possible to reduce the mass about 59%.

With a dedicated manufacturing process regarding to the subsequent part geometry the outstanding characteristics of Hybrid Sandwich Composites can be fully exploited by the influence of the interface design.

Acknowledgement

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