VLIESCOMP - NONWOVEN INNOVATIONS FOR RESOURCE EFFICIENT AND COST-OPTIMIZED SEMI-STRUCTURAL COMPOSITE STRUCTURES

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Abstract

Currently the transition of lightweight solutions into the industrial use often fails due to high material and manufacturing costs. In addition, there are open questions regarding ecological aspects in the area of recycling and reuse. In this area of conflict, an innovative approach should be chosen to use hybrid nonwovens instead of classic reinforcement structures. The aim of VliesComp was not to look for the highest mechanical structural potential, but to generate ecological and cost efficient, multifunctional added value for dedicated industrial applications. Hybrid nonwovens offer a new possibility for material value creation with an improved ecological footprint (2nd use and recycling). A multifunctional added value is sought with regard to ecological and cost-related material value creation as well as for tailor-made property / application combinations.

The focus of the work in the field of textile technology development was, on the one hand, stiffening, vibration-damping elements and, on the other hand, high-strength fibre composites for housing parts of electrical machines.
In the development of vibration-damping elements for generator construction, an alternative to currently used glass fibre reinforced composites was sought. The use of both natural fibre reinforced composites and aramid fibre reinforced composites was investigated. Mixtures of the named reinforcing fibres with polyamide fibres (PA6) were also produced in order to investigate the damping effect of the PA6 fibres in the composite more closely. Classic epoxy resin systems were used as matrix components in these composites.
For the application in the field of housings for electrical machines, both aramid fibre-reinforced composites and composites based on recycled carbon fibres were included in the considerations. For this purpose, the nonwovens were first developed from the corresponding recycled materials and then further processed into prepregs.

The poster presents the results of the VliesComp project funded within the Transferprogramm Leichtbau (TTP). It is oriented towards the chosen solution path from the selection of possible applications to the development of textile semi-finished products to finished demonstrator components from the field of mobility, energy technology as well as mechanical engineering. Parallel to this, a digital twin was mapped using the data collected in the processes and an ecological evaluation in the form of an LCA was aimed for.

Introduction

Currently the transition of lightweight solutions into the industrial use often fails due to high material and manufacturing costs. In addition, there are open questions regarding ecological aspects in the area of recycling and reuse. In this area of conflict, an innovative approach should be chosen to use hybrid nonwovens instead of classic reinforcement structures. The aim of VliesComp was not to look for the highest mechanical structural potential, but to generate ecological and cost efficient, multifunctional added value for dedicated industrial applications.

To achieve this goal, a consortium was formed along the value chain. The Sächsisches Textilforschungsinstitut (STFI) e. V. from Chemnitz contributed its expertise in the recycling of fibrous materials, the development of nonwovens and the characterisation of textile semi-finished products. Tenowo GmbH, Hof, a nonwovens manufacturer from the field of technical textiles, was involved transferring the developed semi-finished products to industrial scales and contributing its know-how in the further processing of these materials into composites. The partners Siemens AG, Erlangen (coordinator) and Invent GmbH, Braunschweig contributed expertise in the development, testing and production of composite components. Both are active in different application sectors, so that a broad market could be covered.

Experimental

During the project, several priorities were set and successfully addressed. These included, among others:

- Definition of requirements for materials, processes and components
- Technology development in the area of materials and process technology of hybrid nonwovens
- Technology development in the field of digital value creation and ecology of hybrid nonwovens
- Demonstration of technology usability via component realisation and evaluation

The poster focuses exclusively on two selected fields of application (see figures 1a and 1b), as the entire range of the project work cannot be presented in such a compact way. As examples, the development steps in the application fields of

- Innovative e-machine designs for the energy transition → damping winding head support elements for generators
- Innovative e-machine designs for e-mobility → lightweight bearing shield for e-motors

illustrated.

Fig. 1a: Symbolic image generator

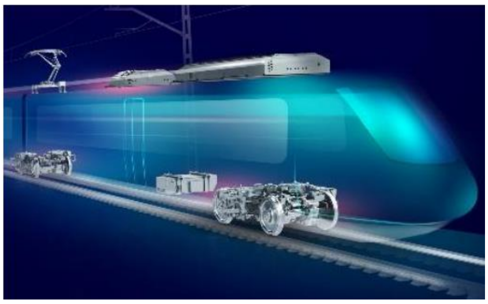

Fig. 1b: Symbolic image bearing shield

For both application fields the partners developed hybrid nonwovens or nonwovens based on 100 % recycled fibers.

The currently used elements based on glass fibre reinforced plastics (GFRP) served as a reference for the damping winding head support elements. The aim was to achieve improved damping behaviour by realisation of the same stiffness. Therefore, in addition to natural fibres and aramid fibres, PA6 fibres as well as blends of these fibre types were included in the investigations. The needle-punched nonwovens developed using carding and cross-lapping process were subsequently embedded in an epoxy resin matrix using RTM process.

The development approach for the lightweight bearing shield was to use 100 % recycled carbon fibres in the form of nonwovens, which were further processed into prepregs by using a bio resin system and then consolidated into components. The current state of the art of the bearing shield in steel construction served as a reference. With the help of a structural component analysis, the requirements for a further developed cone design in composite construction were recorded and implemented.

Results

After several optimisation loops, it was possible to develop winding head support elements based on hybrid nonwovens with improved damping properties and comparable stiffness to the reference. Figure 2 shows a comparison of the damping properties of acually used winding head support elements based on GFRP with a variant developed in the project based on a hybrid nonwoven made of recycled aramid fibres blended with PA6 fibres in an epoxy resin matrix.

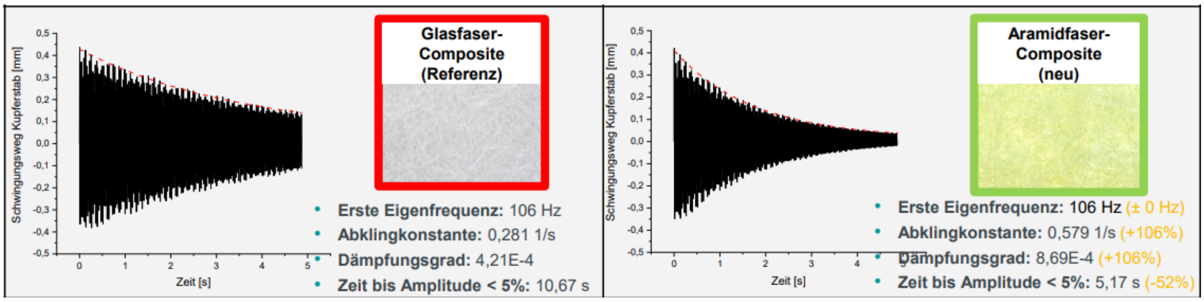

Fig. 2: Comparison of the damping properties of the GFRP reference (left) and a variant based on hybrid nonwoven developed in the project (right)

As Fig. 2 shows, the developed variant has significantly improved damping properties. With the same excitation at a natural frequency of 106 Hz, a doubled decay constant and thus also a doubled degree of damping could be achieved. The time until the amplitude decays to < 5 % could be halved. By using more dampable support elements, vibrations that occur are eliminated much more quickly, which leads to a reduction in the load on the conductor rods and thus extends the service life of the insulation system of the conductor rods.

In the case of the second demonstrator to be considered here, the lightweight bearing shield, a tool for manufacturing the bearing shield with rCF nonwovens was developed based on the structural analysis. Fig. 3 shows the demonstrators produced in the course of the optimisation work with an increasing proportion of recycled carbon fibres. On the left in the picture, the proportion of rCF is only 2 % and 98 % are primary carbon fibre structures; in the variant on the right in the picture, the proportion of rCF is 100 %.

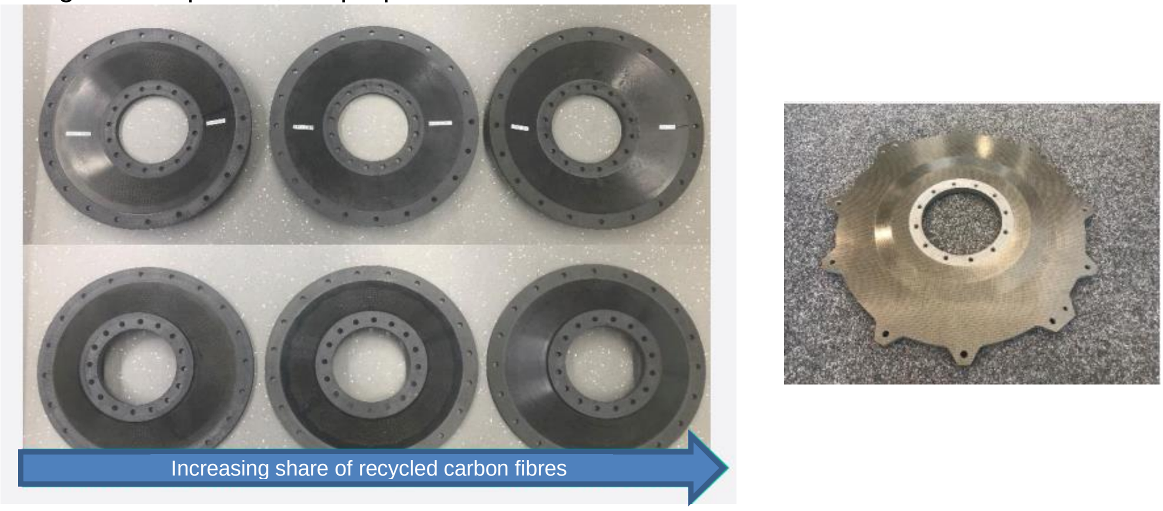

Fig. 3: Various types of manufactured lightweight bearing shields made from rCF nonwovens

As Fig. 3 shows, corresponding demonstrator geometries were first manufactured as blanks and then reworked accordingly. The investigations showed that compared to the variant made of virgin carbon fibres in RTM process, a reduction of the CO_2 equivalent by 14 % is possible with the same performance. Using the prepreg process with a bio-resin shows potential for reducing the CO_2 equivalent by almost 70 %.

Summary

As a result of the project, solutions based on hybrid nonwovens or on nonwovens made from 100 % recycled fibres were developed for all within the project defined applications and led to several demonstrators including comprehensive characterisation.

Within the framework of the project, the hybrid approach (previously known only in the area of recycled carbon fibres) could also be extended to the use of natural fibres and recycled aramid fibres. The technology demonstrations were carried out using different composite technologies and thus showed the broad possibilities of transferring them to industrial sector.

Acknowledgement

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