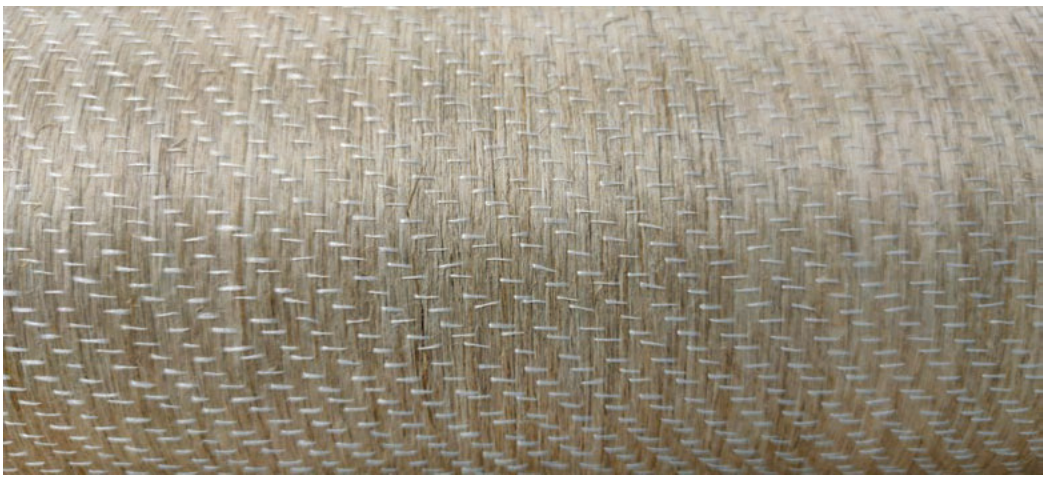
Sustainable composites for structural parts in automotive applications with focus on crashworthiness and environment (SECURER)

Publik rapport



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Projekt inom Sustainable and environment friendlier car component.

FFI Fordonsstrategisk Forskning och Innovation

VINNOVA Energimyndigheten TRAFIKVERKET FKG VOLVO SCANIA VOLVO

Innehållsförteckning

1 Sammanfattning

Face to the challenge of reducing the CO2 footprint of its products, the automotive industry needs solutions to reduce its materials impact, from production to recycling. With this purpose, natural fibers, particularly cellulosic reinforcements, have been used intensively by the sector in semi-structural components throughout the last decade. However, low mechanical properties and moisture intake reduce the chances to exploit the low carbon footprint weight saving prospects and good crashworthiness, that makes these materials valuable. Recently, another type of fibers which are also classified as natural, have attracted attention, those are basalt-based fibers. These materials provide a sustainable alternative to synthetic manmade reinforcements without the common downsides of other natural fibers. Basalt-based fibers are of mineral origin and have very stable geometry as well as mechanical properties. Its use in combination with other natural fibers may be an effective way towards environmentally friendlier, sustainable materials in the automotive sector. Therefore, the current project focused on the hybridization of basalt-based fibers with carbon and flax fibers. Four different fabric types have been used in this study: Unidirectional UD basalt-based; UD flax; UD carbon; Flax/Basalt-based twill. Combining these different fabrics seven composite laminates were manufactured. Tensile and bending tests were applied, and the specific stiffness and strength were measured. Hybrid laminates show a very promising result. Moreover, analytical, and numerical simulations are used to predict elastic properties that may be obtained by using various hybridization strategies.

2 Bakgrund

The use of natural fibers in textiles is dating thousands of years back but use of these materials in composites for cars and airplanes started almost 100 years ago: in 1930s flax fiber and phenol formaldehyde matrix was used by Aero Research Limited for aircraft construction and flax/hemp fibers were used in composites for the body-work of a Henry Ford car. However, the development of natural fiber as composite reinforcement somewhat paused since Owens-Corning commercialized glass fibers which triggered massive use of synthetic composites in airplanes and boats. But in the past two-three decades the research on composites based on natural fibers intensified and resulted in wider use of these materials as construction materials [A], including automotive industry [B] (materials for car door panels, roof, boot linings, etc).

The most suited cellulosic natural fibers (in terms of mechanical performance) are those fibers that are obtained from the outer layer of a plant, these are so-called bast fibers. The fibers with highest mechanical performance are flax and hemp, these fibers exhibit stiffness that is comparable and strength that is slightly lower than properties of glass fiber [C]. Considering that density of natural fibers is much lower than that of glass, these materials are of great interest for automotive industry as there is need for weight saving as well as low CO2 footprint. The sustainability of natural fibers is also an advantage with much lower energy requirements to produce natural fiber mats compare to the same material from glass fiber [D]. There is steady growth of demand for the natural fibers in automotive industry and the trend will continue in the coming decade. However, majority of current applications are within non-structural parts of the cars with only fraction of cases where natural fiber composites are considered for load carrying components [D, E]. This is because even though the natural fiber shows good mechanical performance with very attractive ecological and economic benefits there are some shortcomings of these materials which one should be aware of when designing structural composites. First of all, these fibers may possess non-uniform and non-reproducible properties due to the growing/weather conditions. Secondly, these materials are very sensitive to temperature and moisture, not to mention high flammability, incompatibility with hydrophobic polymer matrices, degradation at high processing temperatures. Some of these disadvantages may be overcome by additional fiber surface treatment or/and additive to matrix while others are not so easy to deal with.

One of the methods to increase performance of natural fiber composites and avoid abovementioned problems is to combine these fibers with another type of reinforcement. Such approach is known as hybridization, and it is an efficient way to enhance performance of natural fiber composites as well as reduce sensitivity to external factors (e.g. environment) [F].
The aim of this project was to investigate the performance of hybrid fiber reinforced polymer composites for structural parts in automotive applications. Four different fabric types have been used in this study: UD basalt-based; UD flax; UD carbon; Flax/Basalt-based twill. Combining these different fabrics seven composite laminates were manufactured and tested. Tensile and bending tests were performed, and the specific stiffness and strength were measured. Hybrid laminates (UD Flax/UD basalt) showed a very promising result compared to other laminates.

3 Syfte, forskningsfrågor och metod

Suitable materials were selected, and seven composite laminates were manufactured. All plates were manufactured through vacuum infusion process with a two-component epoxy as resin. The selected materials were ordered by Gestamp and the manufacturing was done by LTU. The volume fraction was measured, and samples were prepared for testing. Tensile tests and 3-point bending tests were performed by LiU. Analytical calculations and numerical simulations are used by LTU to predict elastic properties. A comparison between the experimental and the numerical results was performed.

4 Mål

The aim of this project was to investigate the performance of hybrid fiber reinforced polymer composites for structural parts in automotive applications. Four different fabric types have been used in this study: UD basalt-based; UD flax; UD carbon; Flax/Basalt-based twill. Combining these different fabrics seven composite laminates were manufactured and tested. Tensile and bending tests were performed, and the specific stiffness and strength were measured. Hybrid laminates (UD Flax/UD basalt) showed a very promising result compared to other laminates.

5 Resultat och måluppfyllelse

The aim of this project was to investigate the performance of hybrid fiber reinforced polymer composites for structural parts in automotive applications. And one of the main objectives was to explore what is the most efficient, yet practical, method to hybridize different reinforcements to attain best synergetic effect from interaction of different reinforcements. To achieve this goal composite laminates were manufactured by using reinforcement in different forms, e.g. unidirectional (UD) layers and hybrid fabrics. Analytical calculations and numerical simulations are used to predict elastic properties that may be obtained by using various hybridization strategies. The experimental part of this project includes manufacturing and testing of composite laminates. Seven composite laminates were manufactured. All plates were manufactured through vacuum infusion process with a two-component epoxy as resin. To study the influence of hybridization method and evaluate synergetic effect of interaction between various reinforcements, laminates with similar layup have been produced by stacking UD fabric layers and by using woven hybrid fabric (the UD and cross ply laminates were made). The experimental results were compared to the analytical calculations and numerical simulations. Tensile and bending tests were applied, and the specific stiffness and strength were measured. Hybrid laminates showed a very promising result. The results of this project were successfully presented at one of the best European conferences: CompTest 2023. All partners gained a lot of knowledge regarding hybridization, how

to handle natural fibers during manufacturing, and all agreed to publish the outcomes of this project in a scientific journal paper.

6 Spridning och publicering

6.1 Kunskaps- och resultatspridning

Hur har/planeras projektresultatet att användas och spridas?	Markera med X	Kommentar
Öka kunskapen inom området	x	A great knowledge regarding hybrid materials was gained
Föras vidare till andra avancerade tekniska utvecklingsprojekt		
Föras vidare till produktutvecklingsprojekt	x	A new larger proposal is under discussion as a continuation of this work
Introduceras på marknaden		
Användas i utredningar/regelverk/ tillståndsärenden/ politiska beslut		

6.2 Publikationer

The results were presented as an oral presentation during one of the best European conferences, Comptest 2023 which was held in Girona between May 31- June 2. (Link to the conference: https://comptest2023.udg.edu/). All partners agreed to publish the obtained results in a scientific journal paper.

7 Slutsatser och fortsatt forskning

The knowledge gained during this project will be used to apply for new research projects.

8 Deltagande parter och kontaktpersoner

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