HYBRIDISATION OF CARBON AND NATURAL FIBERS FOR SUSTAINABLE COMPOSITES IN AUTOMOTIVE APPLICATIONS

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ABSTRACT

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 [1]. However, low mechanical properties and moisture intake reduce the chances to exploit the low carbon footprint weight saving prospects and good crashworthiness [2] 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 fibres. The basalt-based fibers are of mineral origin and have very stable geometry as well as mechanical properties, moreover, they are intrinsically little reactive to water absorption. 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 study focuses on the hybridisation of basalt-based fibers with carbon and flax fibers. One of the main objectives is to explore what is the most efficient, yet practical, method to hybridize different reinforcement to attain best synergetic effect from interaction of different reinforcements. To achieve this goal the composites are manufactured by using reinforcement in different forms, e.g. unidirectional layers and hybrid fabrics (see Fig. 1). Moreover, analytical calculations (e.g. rule-of-mixtures, laminate theory) and numerical simulations are used to predict elastic properties that may be obtained by using various hybridization strategies. The experimental part of this study includes manufacturing and testing of composite laminates. 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 (square plates with side length of approximately 20 cm). The specification of fabrics and laminates are given in Table 1. All plates were manufactured through vacuum infusion process with a two component epoxy as resin. The micrographs of composite cross-sections are presented in Fig. 2.

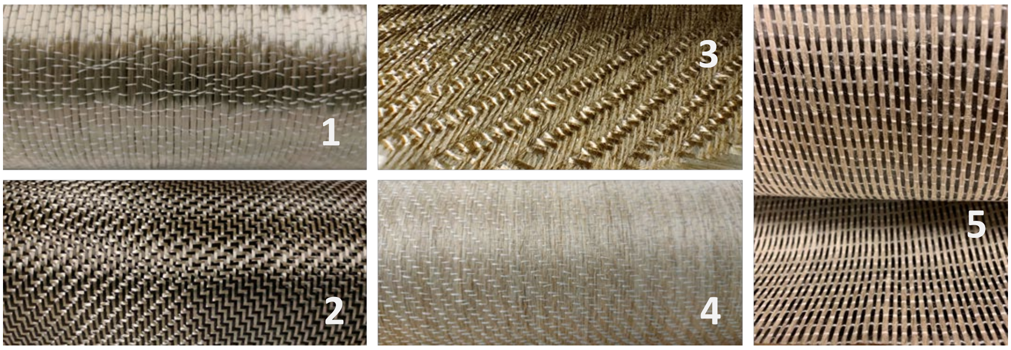

Figure 1 UD and hybrid fabrics: basalt (1), CF/basalt (2), flax/basalt (3), flax (4), flax/CF (5).

Table 1 Specification of fabrics and laminates with epoxy matrix

Fabrics			Laminates		
Material	Layup	Aerial weight (g/m^2)	Reinforcement	Layup	Targeted V_f
Flax	UD	150	Carbon UD	[0]	0,5
Basalt-based	UD	300	Flax UD	$[0_8]$	0,5
Carbon	UD	205	Basalt UD	$[0_6]$	0,5
Flax/Basalt	Twill 50/50	250	Basalt/Flax UD	$[0^B/90^B/0^F/90^F/0^F/90^F/0^B/90^B]$	0,25/0,25
			Basalt/Flax UD	$[0^B{}_2/0^F{}_2]_S$	0,25/0,25
			Basalt/Flax Fabric	$[(0/90)^{BF}{}_4]$	0,25/0,25
Basalt (B), Carbon (CF), Flax (F)			Carbon/Flax UD	$[0^{CF}/0^F{}_2]_S$	0,25/0,25

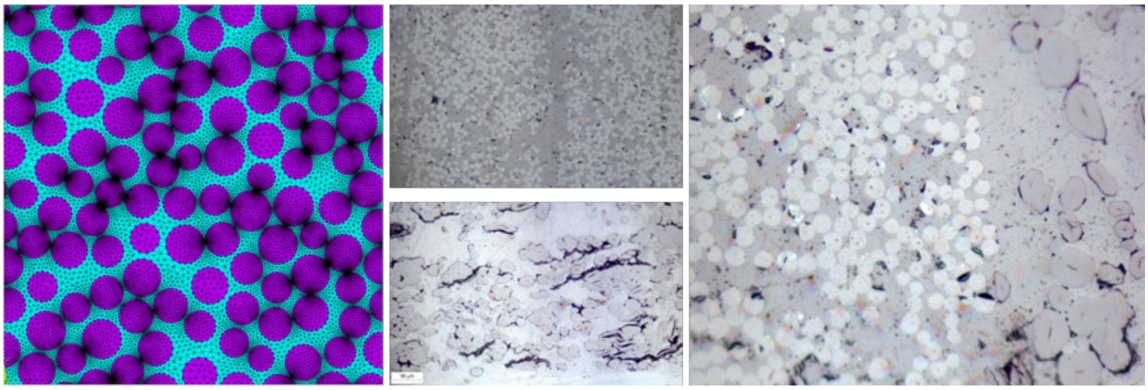

Figure 2 Model unit for FEM (left), micrographs of basalt (middle top), flax (middle bottom) and hybrid basalt/flax composite (right).

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 targeted volume fraction of fibers is 0.5 with actual values between 0.35 and 0.45. The experimental results were compared to the analytical calculations and numerical simulations. The unit for numerical model used for evaluation of transverse modulus of composite is shown in Fig. 2.

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