Assessing fibre orientation quality in reclaimed carbon fibre materials from flow, thermal and mechanical properties.

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I - Introduction

Background
To date, advanced composites are mostly made by encapsulating long, stiff, slender carbon fibres in a thermosetting matrix because of excellent properties and ease of processing the polymer from a liquid into a glassy solid. However, their long-term sustainability has recently been questioned because of high scrap volume, and no viable recyclable methods.
An increasing effort is being put towards developing more sustainable composite materials and associated forming processes. For example, fibres and polymers are combined at the last possible stage of the manufacturing process to avoid expiry dates. In addition, any waste fibre is reclaimed and reprocessed into non-critical composite parts. Recycled materials have found limited application to date because the fibre orientation is random, negating the performance benefit of the carbon fibre materials.

Material

Blab la on the process of reclaiming.

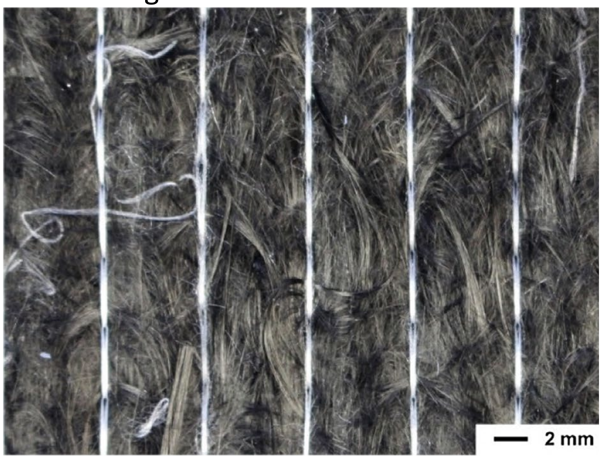

Figure 1: reclaimed carbon fibre bed [

Objectives
This work aims at characterizing the quality of the fibre orientation in the commercially available reclaimed carbon fibre bed. Firstly, better orientation in the fibre bed enable to taylor blanks with respect to the expected loading. Secondly, a better orientation of the fibre usually result in a better fibre packing and thus a better fibre content, desirable for proper mechanical properties.

II – Methods

A quantification of the orientation of the fibres in this random map can make use of the classical orientation tensor mathematical tool [3]. In this framework, the second order orientation tensor ***a*** is sufficient to determine any second order tensorial material properties as long as two scalars (obtained from a unidirectional analysis) are known.

In this work, tensorial properties of the material are quantified (permeability, heat conductivity, linear elasticity) and can thus infer the orientation tensor.

The orientation tensor itself gives a quantification of the quality of the fibre orientation. The degree of orientation *D* can indeed be quantified as:

$$D = \max(|\lambda_i|)/\sum\lambda_i$$

where λ_i are the eigenvalues of the tensor ***a***.

Effect on heat transfer

The anisotropic conductivity tensor of the dry reclaimed fibre bed is characterized using the PIMS bench [4]. It consists of an inverse method applied on the temperature measured using a planar instrumented heating pad that generates tridimensional heat fluxes in the sample (fig. 1).

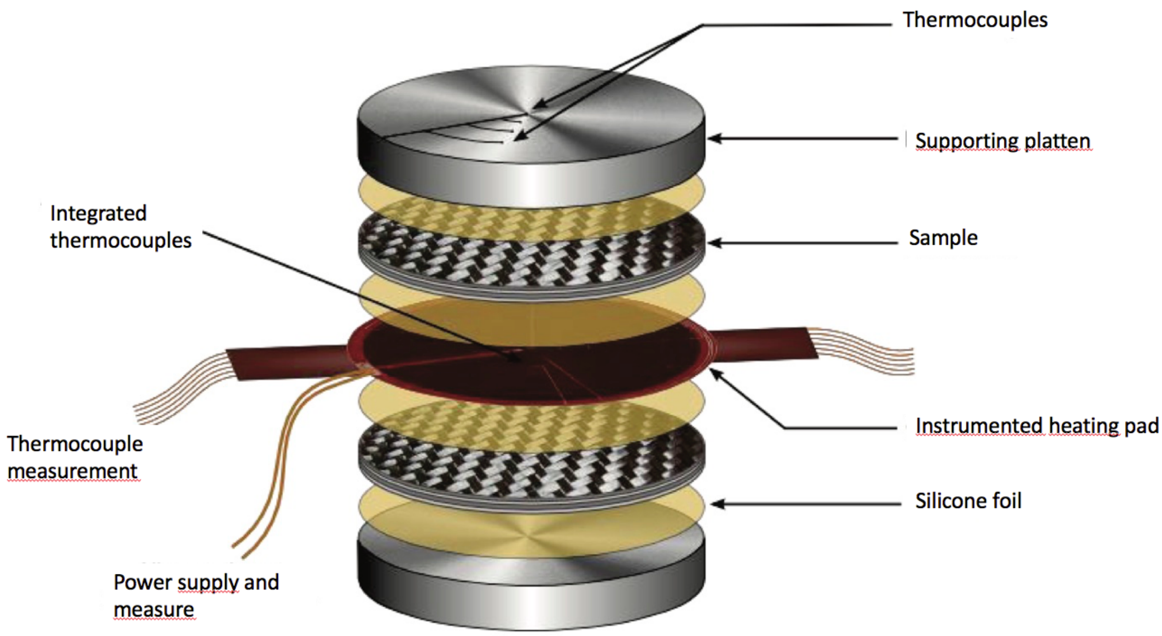

Figure 2: PIMS bench. The instrument pad applies a heat source and measure the temperature to two composite samples. An inverse method enables to obtain the anistropic conductivity tensor.

Effect on resin flow

The anisotropic permeability tensor is obtained by instrumenting an RTM mould with a 2D pressure sensor device [5]. The pressure map versus time is acquired during infusion. The flow front position and permeability tensorial property can thus be assessed.

Effect on final elastic properties

The elastic properties of virgin unidirectional and reclaimed carbon fibre composites were investigated in previous work [1,2,5].

III - Results and Discussion

IV - Conclusion

Quality of a reclaimed fibre bed strongly relies on the quality of the fibre orientation. This orientation quality can be quantified using a norm of the orientation tensor.
In this work, the orientation tensor of a reclaimed fibre bed was assessed using various characterization techniques (heat transfer, permeability, elasticity).

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[3] Advani, S., & Tucker III, C. L. (1987). The use of tensors to describe and predict fiber orientation in short fiber composites. Journal of Rheology, 31(8), 751–784.

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[5] Kratz, Zschenderlein, Levy, "In-process flow front detection in reclaimed carbon fibre materials using surface mapping sensors", FPCM 14 Conference, Lulea, Sweden, 2018

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