Permeability determination of resistive welded carbon fabrics

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Introduction

A permeability determination approach for a new method of carbon material processing is presented in this work. The research was based on a bindered 12k plain weave and an electrical anode-to-cathode system developed by HS Weingarten.
The electrical conductivity of carbon is used to lead-in the power perpendicular through the fibres. Binder in between the fabric layers is then activated by generation of a thermal field. With defined pressure, current and voltage it was possible to achieve resistive welding.
Fabric's compaction, fibre volume ratio and thereby permeability changed locally due to the welding points. These variations were measured in the experiment and their influence on permeability was estimated to provide further recommendations for the preforming process in production.
Each sample consisted of three layers with a dimension of 290 x 290 mm and a fibre volume ratio of 55 %. The permeability test bench developed at the Institute of Aircraft Design was used for permeability testing. Radial constant pressure infusion process was monitored by an optical measurement system using glycerol 85 % as an injection fluid.
Simulations with the finite element code PAM-RTM™ (ESI Group) were conducted and the effect of resistive welding was reproduced.

Sample set-up

Each sample consisted of three layers of plain weave T700-12k-50c from Hexcel Holding GmbH Austria. The binder type E01 was applied on top of each layer. To prevent adhesive bonding between the thermoplastic binder and the anode-to-cathode system, the first layer of the lay-up was placed upside down (cf. Fig. 1) under perpetuation of the fibre orientation.

Fig. 1: Lay-up and binder orientation

To compare different contact pressures and therefore different fibre volume ratios, three welding spots located in three out of four quarters of the sample were produced (cf. Fig. 2).

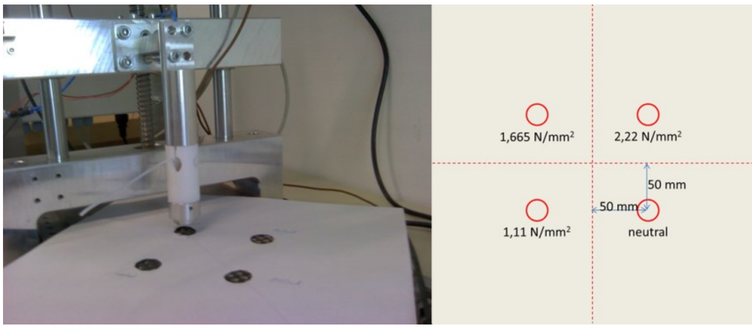

Fig. 2: Anode-to-cathode-system (left), welding spot location and contact pressure (right)

Flow front monitoring and permeability determination

Permeability test benches with transparent top mould (glass or acrylic glass) are state of the art testing equipment [1]. The main advantage of transparent mould material is visual flow front monitoring, which makes evaluation process simpler and cheaper compared to sensor based systems. For this study a permeability test bench with a transparent top, radial injection and a video based permeability determination algorithm was used.

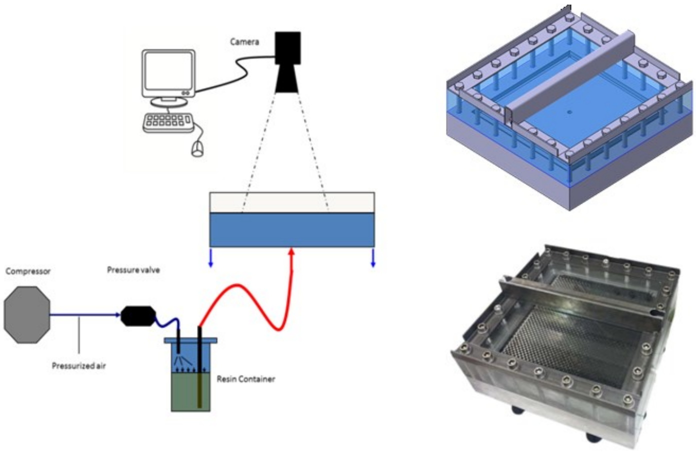

Fig. 3: Permeability test bench set-up (left), injection mould (right)

The flow front was monitored via digital camera. Video data served as an input for the permeability evaluation algorithm. The theoretical basis of the algorithm is the work of Adams [2].

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