

# INFLUENCE OF PREFORMING TECHNOLOGY ON THE OUT-OF-PLANE IMPREGNATION BEHAVIOR OF TEXTILES

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## Introduction

The emerging resin pressure distribution during out-of-plane impregnation, as provided e.g. during Advanced/Compression Resin Transfer Molding (ARTM/CRTM), causes a hydrodynamic compaction of the fiber structure. Knowledge about the influence of material parameters, process parameters, and preforming technology on the hydrodynamic impregnation behavior of textiles can be applied to predict the material behavior during impregnation or to specifically influence the impregnation process in order to increase efficiency.

## Objectives

Different possibilities to influence the hydrodynamic impregnation behavior of textiles by preforming technology are investigated. Different industrial relevant glass fiber woven and non-woven fabrics are examined. Samples of the woven textile are treated with sewing and binder technology and compared to untreated reference samples. Furthermore, the influence of shearing - as it occurs during the forming step within the preforming process - on the hydrodynamic impregnation behavior of woven and non-woven fabrics is investigated.

## Experimental set-up

A novel system (Figure 1), capable of reproducing the conditions during out-of-plane impregnation, is applied [1]. It comprises sensor technology for saturated out-of-plane permeability measurement and on-line compaction monitoring. Thus, the interdependency during the impregnation process, which has a strong influence on the material behavior, can be taken into account. In a single measurement several process conditions, in terms of pressure drop/flow rate, can be subsequently set to deeply investigate the material behavior.

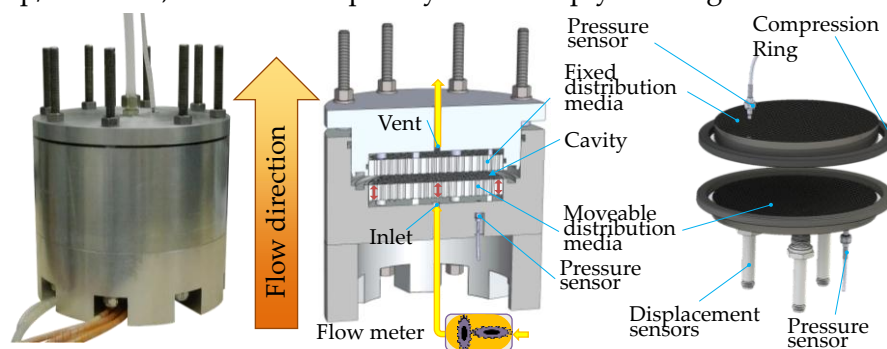
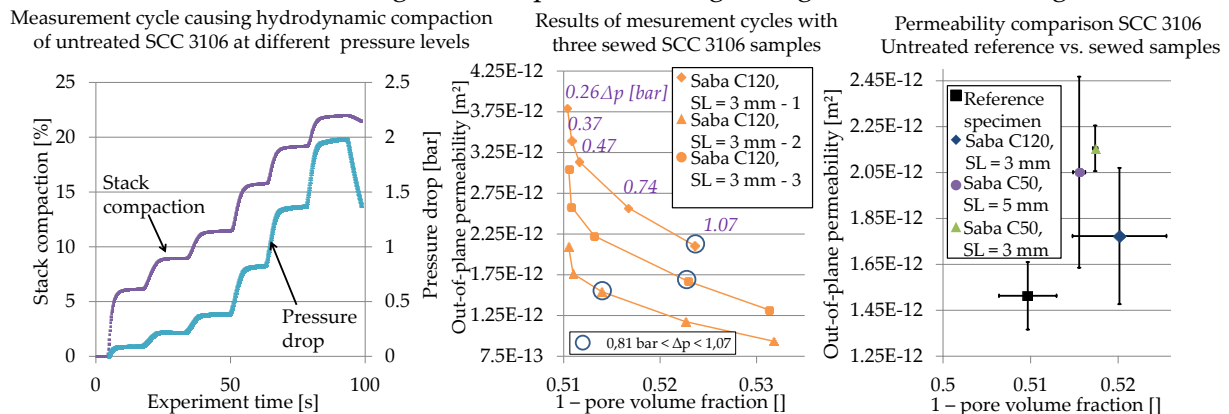


Figure 1: System for saturated out-of-plane permeability measurements and on-line compaction monitoring (left), influence of sewing threads on hydrodynamic impregnation behavior (right).

## Results

The stepwise pressure increase causes a corresponding hydrodynamic compaction of the textile stack (Figure 2, left). This leads to a decrease of the pore volume fraction and consequently the measured permeability drops with increasing pressure (Figure 2, middle). Each curve represents one measurement cycle with a new sample. Material inhomogeneities lead to variations in the impregnation behavior. Accordingly, the interpolated permeability - pore volume curves differ. In previous studies it was found, that due to pressure-dependent asymmetries of the pore volume distributions only values at similar pressure drops are comparable [1]. This is also meaningful since e.g. for description of ARTM the reaction to a certain resin pressure is needed. Thus, for the comparison of the hydrodynamic impregnation behavior with the untreated reference specimen and differently sewed samples, only the data points marked by rings were used. They show the material behavior in a certain pressure range. Their depiction is simplified to an average value with error bars representing the variations concerning the measured pore volume and permeability at the certain pressure drop (Figure 2, right). Besides the obvious influence of the different sewing configurations on the pore volume fraction it was observed, that sewing generally increases the out-of-plane permeability of the textile. Systematical variation of the sewing parameters can be used to specifically influence the permeability. A higher sewing thread thickness (SABA C50 - 60 tex vs. SABA C 120 - 24 tex) and a shorter stitching length (SL = 5 mm vs SL = 3 mm) increase the permeability. Sewing also influences the hydrodynamic compaction behavior. Specific sewing parameters can almost fully impede variations concerning compaction. By impeding nesting or changing the pore space volume also binder is useful for influencing hydrodynamic impregnation behavior. Concerning the mechanical changes through preforming it was found that preliminary compaction cycles strongly increase the reproducibility of the hydrodynamic behavior. Shearing decreases the pore volume fraction but also increases resistance against compaction through the geometrical rearrangements.



**Figure 2: Hydrodynamic compaction at different pressure drops (left), permeability changes due to compaction at different pressure drops (3 repetition measurements, middle), comparison of reaction to certain pressure range of reference sample and three sewing thread variations**

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## References

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