DEVELOPMENT OF AN INNOVATIVE PREFORMING PROCESS FOR THE HIGH-VOLUME AUTOMOTIVE SECTOR

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Introduction
In order to establish CFRP in high-volume automotive applications, there is a need to reduce the current cost levels [1,2]. One setting lever to reduce costs is the improvement of manufacturing processes. Hence a new cost-efficient preforming process based on dry fibre placement (DFP) is being developed which delivers dry fibre structures for the production of CFRP parts in a subsequent high-pressure resin transfer moulding (RTM) process. One major challenge is the injection of the DFP preforms. Common infiltration induced defects are pores, dry spots and fibre wash-out. To enhance the injection behaviour, it is proposed that small gaps are included between the fibre tows directly in the layup process. The goal of this study is to characterise different gap configurations with permeability measurements, and to correlate the permeabilities with real part injections made at high pressure.

Materials and methods
For this study, plate preforms with a size of 570 mm x 570 mm were made by DFP of dry fibre tows. Each tow had an aerial weight of 150 g/m² and was produced out of a 50K carbon-fibre roving by spreading it directly in the DFP process. The final layup consisted of 12 layers with three different fibre orientations (+45°, -45°, $[0°]_8$, -45°, +45°). A complete areal weight of 1800 g/m² was reached. Between the layers a powder binder was deposited to stabilize the preforms for handling and injection. The gaps were inserted at different positions as listed in Table 1.

Table 2: *Preform configurations*

Configuration	Gap Position	Gap offset between 0°-layers	Size
Baseline	None	None	0 mm
1	+/- 45° layers	None	2 mm
2	0° layers	Aligned	2 mm

The injection was done in a HP-RTM process using a closed-cavity mould at pressures up to 100bar. The epoxy resin is injected in a small gap above the preform, and then pressed into the preform through the thickness. Hence the permeability was characterised in a through-thickness (K3) permeability apparatus.

Results
The permeability results show a relatively low K3-permeability for the baseline configuration, as compared to textiles such as NCFs or wovens. The preforms made with

DFP are denser, and more easily compacted to higher fiber volume fractions (FVF). Preliminary results also show that gaps which are inserted can change permeability significantly. Here especially gaps in the 0°-layers (configuration 2) improve the permeability as shown in Figure 1. On the other hand gaps that are inserted just in the 45°-layers (configuration 1) do not create higher permeabilities respective to the baseline configuration.

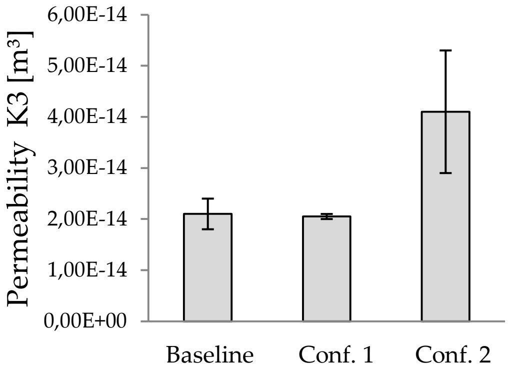

Figure 1: *K3-Permeability at 0,60 FVF*

The recorded pressure peaks of the HP-injection can also be influenced by gaps. First results show that gaps in 0°-layers (Conf. 2 in figure 2a) reduce the injection pressure compared to the baseline configuration. Part micrographs show that the gaps are still visible in the final part but their size is reduced by fibre wash-out. As shown in Figure 2 the fibres are more evenly distributed over the thickness of the plate and the dry spots can be reduced.

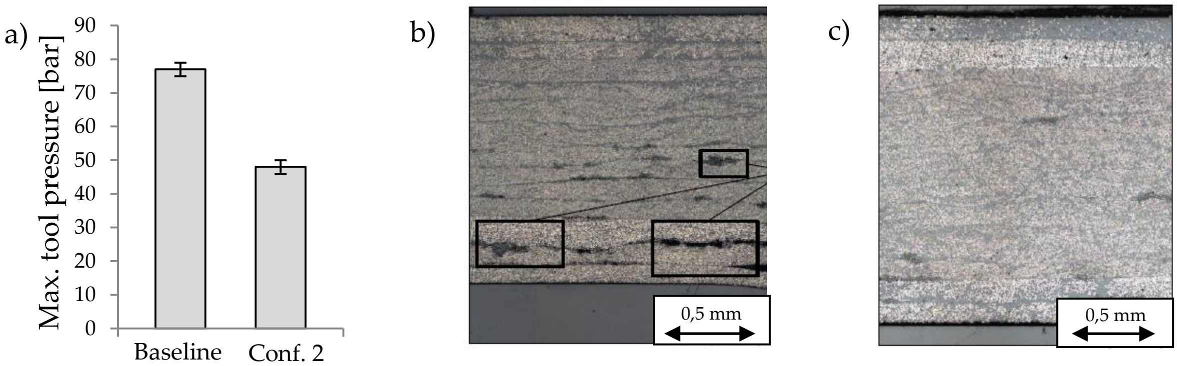

Figure 2: *a) Maximum tool pressure for Baseline and Conf. 2; b) Micrograph of Baseline; c) Micrograph of Conf. 2*

Conclusion

The first results show a promising influence of gaps on the injection behaviour. Especially in the 0°-layers the gaps improve permeability, lead to lower injection pressures and better laminate quality. As the preforms are very dense without any stitching or weaving pattern the package of 0°-layers creates a barrier for the resin in the baseline configuration. Gaps in these layers provide a significantly easier flow path for the resin.

References

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