ISO-STANDARDISED PERMEABILITY TEST REQUIREMENTS ARE ON THE LIMIT OF THE ACHIEVABLE MEASUREMENT PRECISION

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Abstract

The standard [1] “Test methods for the experimental characterization of in-plane permeability of fibrous reinforcements for liquid composite moulding” stipulates the following requirement for the cavity thickness: “The maximum deflection shall be <2 % at the target mould height, when the inner surfaces of the mould are pressurized to the pressures expected during testing. […] During a permeability test, the difference between the mould height at centre and any other point in the mould shall be <2 %”. There are two methods for adjustment the mould height: “[…] spacers, i.e. shims, are inserted between the bottom and top parts of the injection mould. Alternatively, the mould height is set using a press where the displacement is controlled through the use of linear variable differential transformers (LVDT) or laser distance sensors”. For a typical fabric stack thickness of 3 mm, a 2% threshold corresponds to 60 µm.
The paper deals with the second method. The combination between compressibility and permeability in a single test is relevant in cases combining both processes, such as vacuum infusion (VI), because changes in the compaction response can easily be correlated with the measured permeability. Two types of measurements are used: direct measurement of the cavity gap with laser displacement sensor and indirect measurement, which uses displacement of the Universal Testing Machine (UTM), which closes the mould, corrected by the UTM compliance curve. The paper summarises the results from [2, 3].

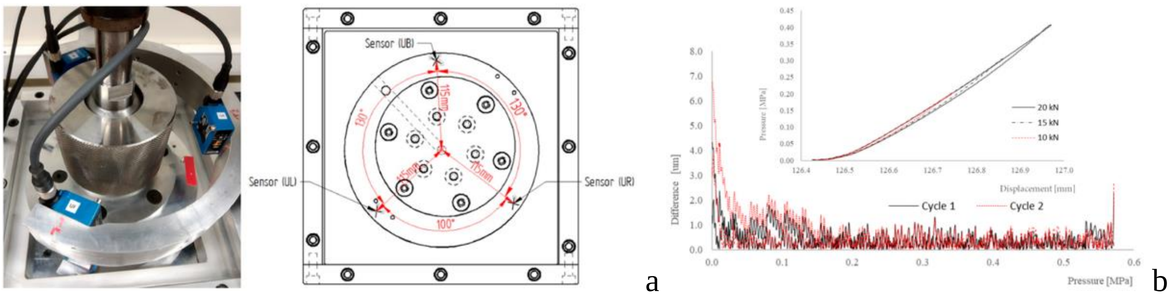

Figure 1 Sensors placement (a) and repeatability of the compliance curves (b)

The cavity thickness is measured by three laser sensors, model CP08MHT80, with a resolution of 8 µm, linearity of 0.1% and a temperature drift <5 µm/°C (Figure 1a). The zero-thickness point is set by registering the measured displacement when the compaction plates are pressed together at a pressure of 0.6 MPa. The machine compliance is registered in the full load range thus the zero-thickness point can be selected across the displacement range and subtracted from the measured displacement.

Figure 1b illustrates the repeatability of the compliance curves, recorded by the UTM. The error, introduced by this variability can lie between 2 and 5 μm for low pressure, below 0.1 MPa, and is below 1 μm for pressure of 0.2 – 0.5 MPa. The compliance curves, registered by the sensors, demonstrate much higher shift, up to 35 – 45 μm. This discrepancy can be attributed to the sensors' higher sensitivity to minor changes in the plate's orientation, as well as their susceptibility to external interferences such as external interferences or vibrations from the compaction plate's movement.

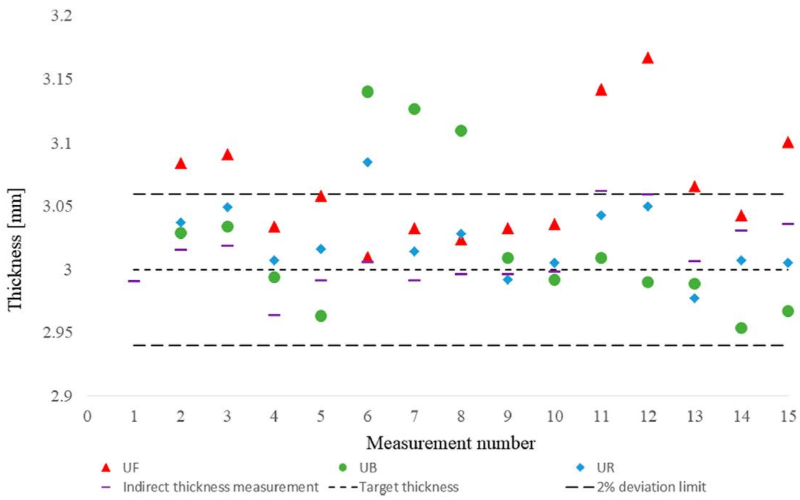

Figure 2 Recorded thicknesses during tests. UF(front), UR (right), and UB(back) are measured by the three laser sensors. The positions refer to the sensor's location above the compaction plate. The indirect thickness measurement method uses the displacement measured by the UTM to calculate the distance between plates. The dashed lines represent the target thickness and the 2% deviation limit

Figure 2 reports results of 15 successive measurements of the cavity thickness with the target of 3.0 mm. The laser sensors placement in the half rig compromises the thickness accuracy. This is because the half rig vibrates and moves slightly when the compaction plate moves. For that reason, the zero-thickness measurement had to be re-regestired between permeability measurements. On top of that, the fact that the sensors are placed at 50 mm from the compaction plate causes a linearity error of 50 μm which further increases the uncertainty in the thickness measurement. The combination of these situations caused the thickness accuracy to vary over time, and bad (over the 2% threshold) accuracy of the direct measurement. The accuracy of the indirect measurement is within the 2% threshold.

Conclusion. The accuracy / stability of the cavity thickness measurement is on the limit of both direct (laser sensors) and indirect measurements. The indirect (compliance-based) measurement is free of variability of the sensors measurements, caused by vibrations and effects of location of the sensors.

References

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