An Investigation into the Influence of Compression on 3D Woven Preform Thickness and Architecture

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Abstract : 3D woven textile composites continue to emerge as an advanced material for structural applications and composite manufacture due to their bespoke nature, through thickness reinforcement and near net shape capabilities. When 3D woven preforms are produced, they are in their optimal physical state. As 3D weaving is a dry preforming technology it relies on compression of the preform to achieve the desired composite thickness, fibre volume fraction (Vf) and consolidation. This compression of the preform during manufacture results in changes to its thickness and architecture which can often lead to under-performance or changes of the 3D woven composite. Unlike traditional 2D fabrics, the bespoke nature and variability of 3D woven architectures makes it difficult to know exactly how each 3D preform will behave during processing. Therefore, the focus of this study is to investigate the effect of compression on differing 3D woven architectures in terms of structure, crimp or fibre waviness and thickness as well as analysing the accuracy of available software to predict how 3D woven preforms behave under compression. To achieve this, 3D preforms are modelled and compression simulated in Wisetex with varying architectures of binder style, pick density, thickness and tow size. These architectures have then been woven with samples dry compression tested to determine the compressibility of the preforms under various pressures. Additional preform samples were manufactured using Resin Transfer Moulding (RTM) with varying compressive force. Composite samples were cross sectioned, polished and analysed using microscopy to investigate changes in architecture and crimp. Data from dry fabric compression and composite samples were then compared alongside the Wisetex models to determine accuracy of the prediction and identify architecture parameters that can affect the preform compressibility and stability. Results indicate that binder style/pick density, tow size and thickness have a significant effect on compressibility of 3D woven preforms with lower pick density allowing for greater compression and distortion of the architecture. It was further highlighted that binder style combined with pressure had a significant effect on changes to preform architecture where orthogonal binders experienced highest level of deformation, but highest overall stability, with compression while layer to layer indicated a reduction in fibre crimp of the binder. In general, simulations showed a relative comparison to experimental results; however, deviation is evident due to assumptions present within the modelled results.

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