NUMERICAL SIMULATION FOR COMPRESSION MOULDING OF CARBON FIBRE SHEET MOULDING COMPOUND

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Abstract

Compression moulding of long discontinuous carbon fibre based Sheet Moulding Compound (SMC) has attracted growing interests for high-volume automotive applications due to a number of advantages such as lower material wastage compared to continuous fibre prepregs, and relatively fast processing speed compared to many other composites manufacturing processes. A dedicated, solid mechanics-based model for SMC was previously developed by the authors [1] where compressive stress-strain response for the material was derived using a squeeze flow testing method. The proposed model demonstrated significant improvement compared to existing commercial packages in terms of compressive force prediction and the simplicity in the implementation in general finite element packages, but still possess some limitations such as the assumptions of incompressibility and perfect slip (no friction) boundary conditions at the material/tool interface. Existing studies in the literature revealed that the level of compressibility of SMC depends on the testing conditions, such as test rates and temperatures, which complicates its flow behaviour [2]. Further, studies in SMC rheology found its deformation behaviour as plug flow in which the speed decreases sharply in close proximity to the boundary layers [3], suggesting the presence of friction at the material/tool interface.

This study aims to further develop the previously proposed modelling approach to support the simulation of SMC compression moulding. A commercial carbon fibre/vinyl ester SMC with 25mm fibre length and 57% weight friction is studied. The compressibility of the material is investigated via partial closure tests on the squeeze flow rig and is considered when deriving the compressive stress-strain relation. The newly acquired pressure data was used for deriving the coefficient of friction (CoF) for the material/mould interface. The stress-strain relationship is implemented to model the squeeze flow test in ABAQUS/Explicit using the in-built plasticity model. The force-displacement and pressure results from the simulation is compared to the experimental data to assess the accuracy of the model and investigate the effects of the friction on the current modelling approach.

The key findings from this study include: firstly, the tested commercial SMC material has a compression limit of 70%, in agreement with other similar studies, and the volume retention vs strain relationship can be expressed using a power law function (Figure 1); secondly, the use of frictionless or constant CoF model at the material/mould interface offers better correlations with experimental data at lower compression ratios (up to ~80%) but worse correlations at higher compression ratios, where a pressure dependent CoF model offers worse correlations at lower compression ratios but better correlations at higher compression ratios. (Figure 2)

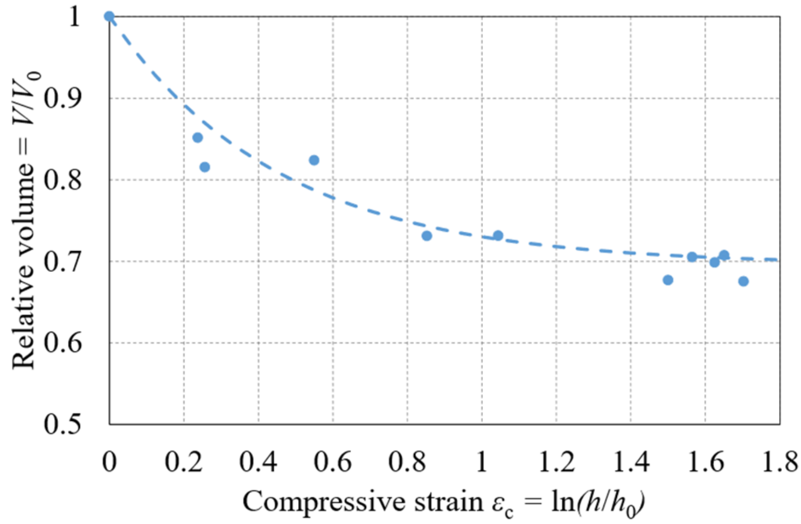

Figure 1: Relationship between the volume retention and the true compressive strain obtained experimentally (dots) and through the fitting of a power law function (dashed line)

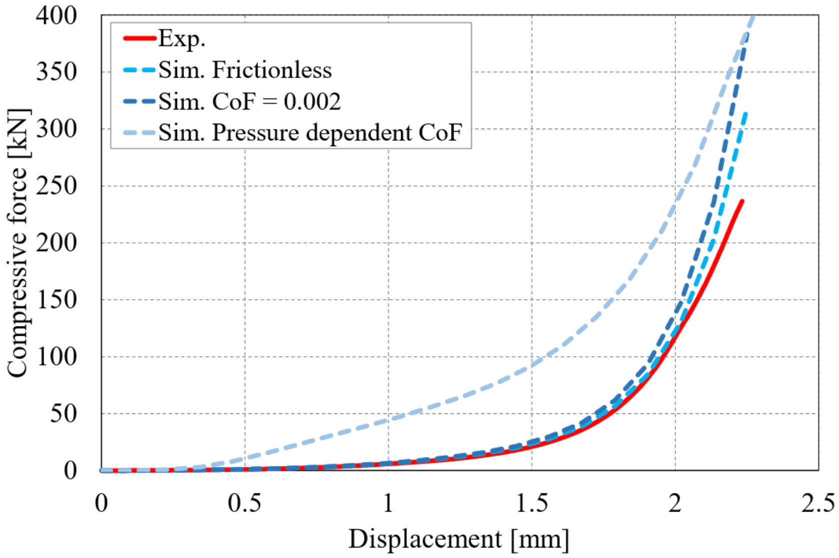

Figure 2: Comparison of compressive force-displacement curved between the experimental data and numerical simulation results using different CoF models.

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