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Characterising and modelling tool-ply friction of viscous textile composites

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Abstract

The paper describes two experimental methods for measuring the tool-ply friction behaviour of impregnated thermoplastic textile composites. These include the pull-through and pull-out tests on the one hand and experiments conducted using a commercial rheometer using custom designed platens on the other. Results from the techniques are compared and the relative advantages and disadvantages are discussed. A simple procedure to determine parameters in a so-called master curve, an empirical model relating the friction coefficient to normal pressure, velocity and temperature is demonstrated. The model is convenient for implementation in a numerical code. A predictive meso-scale model is also described that incorporates parameters such as fabric architecture, tow geometry and matrix viscosity. The model is based on lubrication theory and can predict steady state friction over a broad range of conditions. Significantly, unlike previous attempts to model tool-ply friction using a meso-structural approach, there is no need to experimentally determine the lubrication film thickness as this is an output of the model. Meso-scale model predictions are compared with predictions from the master equation and experimental data.

***Key words**: Friction, Viscous textile composite*

1. Introduction

Press forming of thermoplastic textile composites is potentially a fast and efficient method of production. However, while stretch-forming and deep-drawing of sheet metal (Kalpakjian, 2006) are today relatively well understood processes supported by sophisticated Computer Aided Engineering (CAE) tools (Chenot, 2005) the same cannot yet be said for textile composites. As such a large research effort is underway to create equivalent CAE tools for these materials. The manufacture of textile composite components of potentially complex double curvature geometries involves a forming stage in which dry or pre-impregnated reinforcement takes the required shape through deep-drawing. Wrinkling of the sheet during forming is an unwanted defect and can be inhibited via in-plane tension induced in the sheet using a blank-

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