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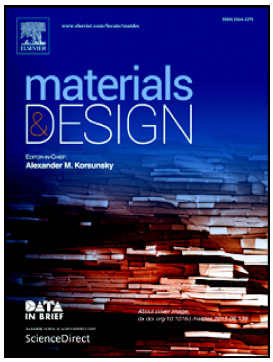

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A multi-step biaxial bias extension test for wrinkling/de-wrinkling characterization of woven fabrics: Towards optimum forming design guidelines

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Abstract

Wrinkling is one of the most common flaws taking place during the forming process of textile composites with complex mould geometries. It is of importance to designers to be able to predict the minimum amount of forces that are required to diminish the wrinkles in useful regions of the final product, through applying appropriate boundary conditions enforced at the blank holders. Towards this goal, herein a multi-step biaxial bias extension (MBBE) characterization test has been proposed to assess the magnitude of the required transverse de-wrinkling forces that can smooth out wrinkles of different sizes, formed at different shear angles of a plain weave fabric. Employing image processing and 3D scanning during the MBBE test, the local shear angles and dimensions of wrinkles were characterized and correlated to the measured forces. It was shown that applying excessive transverse loads to yarns can result in a very narrow formability window and eventually cause fiber breakage, hence suggesting critical role of forming optimization, given different part shapes and fabric types.

Keywords: Woven fabrics, Wrinkling, Defect mitigation/De-wrinkling, Mechanical characterization, Forming design analysis.

1. Introduction

Over the past few decades, a variety of continuous fiber-reinforced composites have been adopted in different sectors of industry where the weight and performance benefits overshadow the application of monolithic materials such as steel. Known examples of such sectors include aerospace, energy, and marine [1]. In particular, 'textile' composites (woven, knitted, braided, etc.) have been recognized as an attractive reinforcement category due to their integral fibrous architectures, high formability, and multi-directional material properties [2]. The moderately low tooling costs of textile composite manufacturing processes have already made them the main material of use in numerous low-volume production or prototyping applications [3]. Yet there is a growing interest to employ such composites in higher-volume applications. However, this requires a sound and comprehensive understanding of their mechanical behaviour such that the upstream design methodologies can take into account both optimal processing parameters and the final product design features of selected textile preforms.