
Study of the tow buckling and tow sliding defects during the complex shape forming of synthetic and vegetal fibre reinforced structural composites.

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Abstract

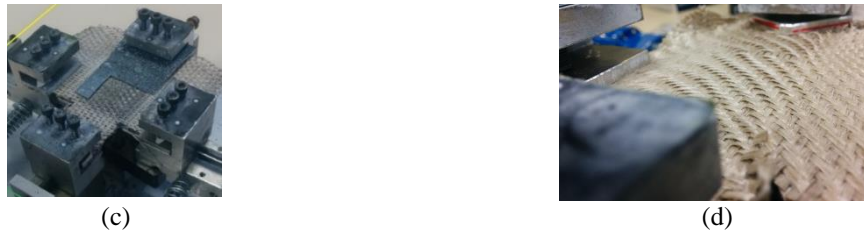
During the complex shape forming of fibrous reinforcements for structural composites manufacturing, multiple defects could appear. These defects, such as tow buckling and tow sliding, depend on the initial loading conditions, the shape of the preform and the characteristics of the material. While mechanisms behind the formation and development of both defects are yet to be fully understood, we focused on this work on investigating the buckling defect. In order to do so, we used optical field measurements techniques to monitor the kinematics involved and adapted an analytical model to predict the appearance of such defects.

Keywords: Composites manufacturing, Preforming defects, Textile reinforcement, Tow buckling, Full field measurement.

1. Introduction

Fibre reinforced composites receive an ever growing interest, as their interesting mechanical properties, low cost and progressively mastered manufacturing techniques [1]. The complex shape forming of fibre reinforced composites might be done using techniques such as Resin Transfer Molding or Thermoplastic-Matrix Composites Stamping to produce seamless materials [2] but it can be less productive than regular laminates and susceptible to produce defects that alter the mechanical properties of the composite [3].





Thus, it is essential to fully understand and anticipate the appearance of defects such as the tow buckling which will be the focus of this study. In the literature, the buckling defect appears on woven reinforcements and seems to be the result of the in-plane bending of the tows coupled with initial loads and reinforcement properties, thus a buckling device, presented in Figure 1, was made to reproduce those conditions in a controlled environment [4].

Figure 1: *Tow buckling principle and appearance of the buckles on the reinforcement surface*

2. Experimental study

The buckling device was improved upon and instrumented with load cells. Three full field optical systems (stereo-DIC, Fringe projection, Various-focus microscopy) were considered to be used either alone or simultaneously with a comparison of the reconstructed surface of a tow presented in Figure 2. “Half-cross” samples were loaded in the device, which allows the in-plane bending of only one direction of the tows up to a 40° angle from the initial tow position. The influence of multiple parameters, such as initial loading in either weave directions, reinforcement’s mechanical and geometrical properties, was investigated.

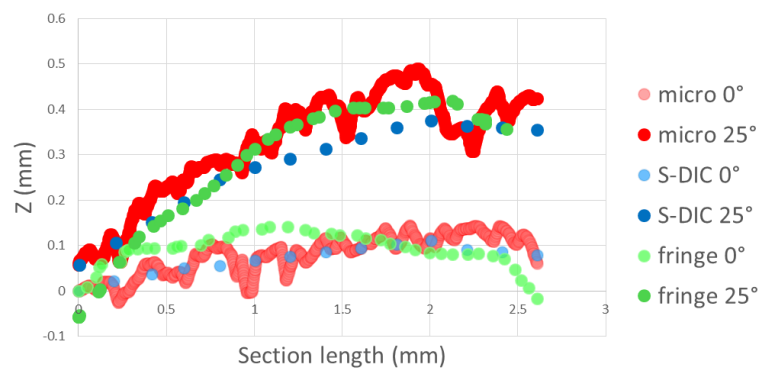


Figure 2: *Buckles profiles comparison using stereo-DIC, Fringe projection and Various-focus microscopy at tow bending angles of 0° and 25°*

3. Analytical modelling

An analytical framework based on the buckling of orthotropic homogenous plate was investigated for the buckling of in-plane curved tows. The differential equation for plate bending was solved by using the Rayleigh-Ritz approach [5]. Resulting in the critical compressive load for buckling, from which the critical radius for buckling was identified. The analytical results were compared to the experimental data for validation.

References

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