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New analytical and numerical optical model for the laser assisted tape winding process

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Abstract

New analytical and numerical optical models are proposed for the laser assisted tape winding (LATW) of thermoplastic composites. The irradiation and reflection of the laser beam directly influence the heat flux and temperature distribution during the consolidation, hence the laser optics must be described and understood well for improved bonding quality. For the first time, a two-dimensional (2D) analytical solution is derived for the laser light distribution and reflection by combining the principle of energy conversation with unpolarized Fresnel equations. In the more comprehensive numerical model, a 3D ray tracing approach is incorporated in which a novel non-specular reflection model is developed predicting the anisotropic reflective behaviour of the composite. Heat flux distributions for the substrate and incoming tape are calculated. The analytical and numerical model results are shown to correspond. The non-specular and scattering reflection yields in a larger illuminated area with lower intensity for substrate and tape.

Keywords: A. Polymer-matrix composites (PMCs); C. Analytical modelling; C. Computational modelling; E. Tape; Laser assisted tape winding

1. Introduction

Laser assisted tape winding (LATW) is an automated process to produce tubular or tube-like continuous fibre-reinforced parts by winding a tape around a mandrel or liner. A schematic view of the process, which is very similar to laser assisted tape placement (LATP), is depicted in Fig. 1. The thermoplastic tapes are deposited onto a substrate

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