

Effect of polymer characteristics on slurry stability for slurry-based impregnation for thermoplastic CF-tape manufacturing

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Introduction

Unidirectional carbon fiber-reinforced polymers are strong, stiff and lightweight. These material properties make them attractive to for aerospace application. Thermoplastic polymers have high toughness and the ability to be remelted and reformed, making them a more sustainable option. Thermoplastic prepreg tapes are the basic functional unit used for constructing large structural components like aircraft wings. Traditional method of producing thermoplastic tapes using melt impregnation involves flow of molten resin through the fiber tows. Due to high viscosity of thermoplastic resins, this process is not suitable for manufacturing high fiber volume fraction tapes. Such tapes are manufactured using slurry-based impregnation where micron-size polymer particles are suspended in water as transfer liquid which spontaneously penetrates fiber bundles (Fig 1a) due to its low viscosity and strong capillary action, followed by water removal, and melt consolidation.

At TU Delft, thin ply high fiber volume fraction prepreg tapes are manufactured using kiss or Nip roll techniques in combination with a spreading mechanism (Fig 1b). The fiber volume fraction of the tape manufactured with this method is highly dependent on the slurry rheology, particle size distribution, particle shape and particle sedimentation. The particles infiltration is also influenced by the impregnation technique.

Aim: The aim of this study is to understand the effect of particle characteristics like size distribution, content, shape, thickener and sedimentation on the slurry characteristics and final tape characteristics for both kiss and nip roller.

Activities & Expectations

To achieve the aim of this project, the following activities need to be undertaken:

1. Determination of the effect of particle size and size distribution on slurry rheology, independent of material properties.
2. Developing an understanding of effect of particle shape in conjunction with material properties (density, zeta potential,...).
3. Development of generalized models to study variation of particle, material and geometrical characteristics such that a stable slurry 'recipe' can be obtained.
4. Understanding effect of thickener in conjunction with polymer content on slurry rheology.
5. Correlation of the slurry stability requirements with required 'agitation' in the reservoir for both kiss-roller and nip-roller and determine the differences in pick-up, impregnation quality as function of slurry behavior (if any).

