Investigation on role Fluid Mechanics in Nip-Roll Setup for composite tape manufacturing


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Introduction

Unidirectional carbon fibre-reinforced polymers are strong, stiff and lightweight. These material properties make them attractive to a variety of industries, including aerospace, marine and automotive. In manufacturing unidirectional tapes, thermoset or thermoplastic polymers can be used. Thermoplastic polymers have certain advantages over thermosets such as ability to be remelted and reformed, recyclability and sustainability. On the other hand, the high viscosity of the thermoplastic polymer makes direct melt impregnation challenging, especially at high fibre volume fractions. One way to address this, is to impregnate the dense fibre bundles with a water-based polymer slurry rather than molten polymer: polymer-based particles are suspended in water as transfer liquid which spontaneously penetrates fibre bundles due to its low viscosity and strong capillary action, followed by water removal, and melt consolidation. Nip roll is one of the techniques that uses the slurry impregnation method in TU Delft tape line setup (Fig 1a). In the nip roll setup, carbon fibers move in between two nips where the slurry is placed (Fig 1b). Understanding fluid mechanics in between the two nips are essential points for achieving well impregnated fibres.

In this research, we specifically focus on the role that fluid mechanics play on thermoplastic tape microstructure, in correlation with manufacturing parameters such as nip gap and line speed.

Aim: The aim of this research is to investigate fluid behavior experimentally and theoretically determine the velocities between the two rollers.

Activities & Expectations

To achieve the aim of the research study, the activities needed to be performed are listed below.

- Perform fluid dynamics simulations in between the two rollers. Underline the influence of viscosity, roller speed, and line (fiber) speed.
- Characterize the viscosity of the slurry with different particle and thickener concentrations.
- Perform experiments in between two rollers to measure particle velocity by using particle image velocimetry (PIV) with different different slurry rheologies without fibers.
- Investigate the effects of fibres in between the rollers.
- Combine the theoretical and experimental results.

This study will enrich your understanding of fluid mechanics, colloids, simulation and experiment skills to understanding of unidirectional carbon fibre-reinforced thermoplastic composite manufacturing method. Moreover, you will be familiarized with several characterization methods.

The student is willing to learn new concepts. Background in fluid mechanism has an advantage but not necessary.

Fig 1a

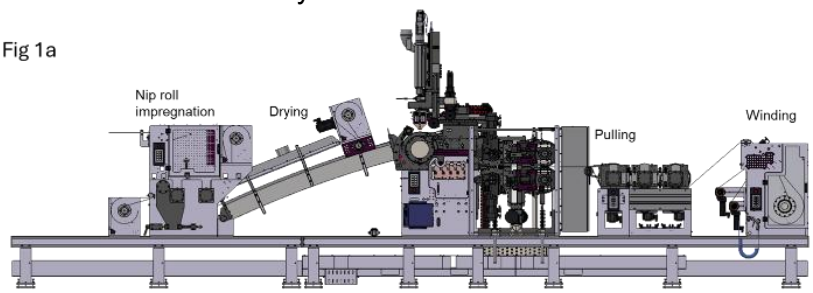
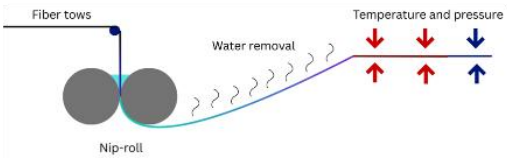


Fig 1b



This work is suitable for Master students. Sounds interesting? Please get in touch!