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Simulation and Testing of Resin Infusion Manufacturing Processes for Large Composite Structures

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ABSTRACT

The use of composite materials in large primary structures such as wind turbine blades has dramatically increased in recent years. As these structures get larger, new manufacturing processes are required to make them possible. Larger parts require more expensive tooling, and the need for accurate process modeling in the design of tooling is becoming essential. Although there are several processes capable of producing large parts (10 m - 50 m), they all have one common feature. In order to alleviate the problem of forcing the resin to flow large distances though the fabric, they use a distribution system to spread the resin over the surface of the part. The resin then flows a substantially shorter distance between the channels or through the thickness. The goal of this work was to develop a modeling technique that could accurately model these processes, yet not so complex as to loose its utility. In this study, the flows through the different regions of the mold are examined individually. These regions include the injection system, the distribution channel, and the fabric. The governing equations for each region are then combined to form a comprehensive model that accounts for the flow through each region simultaneously. A series of tests were conducted to verify the models of the individual components, as well as the comprehensive model. The model correlated well with experiments and revealed critical information about these types of processes. A major conclusion is that an accurate and straightforward model can be created for large scale processes, using the small scale bench tests performed in this study. Also, the governing equations developed here from Darcy flow and Stokes flow aid in understanding how the scaling of key parameters affects the process as a whole. Variations in the geometry of the channel, the fabric thickness and fabric properties such as permeability and compressibility can be accounted for in the model.