Plenary Lecture
EMI-INSA Lyon 2019

Fabrication of High Performance Parts by Liquid Composite Molding and Application to Polymer Based Composites

François Trochu, Professor
Département de génie mécanique
École Polytechnique de Montréal, Canada

Abstract

Liquid Composite Molding (**LCM**) regroups a family of manufacturing processes to fabricate high performance composites based on injecting a liquid phase through a solid porous material. When the liquid cools down, evaporates or chemically reacts, a composite part is created by the combination of two phases. An increasing number of industrial applications are now in production or currently developed to fabricate polymeric, metallic or ceramic composites. The theoretical background to model these processes is based on two basic laws governing liquid flows and consolidation in porous materials pioneered in Civil Engineering by Darcy and Terzahgi. Permeability turns out to be a key parameter to model liquid injection processes through fibrous reinforcements. This presentation aims to show how the scientific background developed initially in Civil Engineering was successfully applied to composite manufacturing.

The concept of permeability can be extended from the classical saturated permeability of Darcy's law to model different polymer based injection processes such as *Resin Transfer Molding* (RTM), *Vacuum Assisted Resin Infusion* (VARI) or *Liquid Resin Infusion* (LRI), namely resin infusion with distribution media. Several examples of application to polymer composites will be presented to illustrate how the unsaturated, equivalent, flexible and apparent permeability have been used successfully or are being considered to simulate reactive resin flows through porous materials and fabricate high performance aircraft, automotive, marine or wind energy composites.

Current challenges encountered in *Liquid Injection Molding* will also be discussed. In particular, the use of granular materials appears promising to create adaptive molds and reduce tooling costs. This is especially necessary to make parts of large dimension such as ship hulls or wind blades. It is the case also for many infrastructure applications. Granular materials have been investigated for a long time in Soil Mechanics. It turns out that they can provide a unique material for composite tooling because they can deform, and at the same time, if needed, provide rigidity under vacuum. Examples of adaptive injection technology will be presented.