Coupling fluid-solid-porous mechanics in transient regimes

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ABSTRACT

Composite materials have become a growing need in aeronautic industry. Infusion-based processes are considered for manufacturing composite structures [1]. This work is part of the Hexcel-Mines Saint-Etienne Chair for Advanced Numerical Modelling of Infusion-based Processing for New Generation Composite Structures aiming at modelling the infusion processes in a High Performance Computing framework.

Modeling these processes consist in coupling fluid, solid, and porous mechanics in isothermal conditions as depicted in Figure 1. First, two fluid flow regimes are coupled (1), representing the resin flow in both a highly permeable distribution medium (Stokes) and low permeability (∝1E−15m²) fibrous orthotropic preforms (Darcy). This coupling is achieved with efficient ASGS stabilized monolithic finite element formulations. Second, weak coupling algorithms are used along for coupling solid / fluid mechanics (2) in the wet preforms at both macro and micro scales, and for the fluid / level-set problems (3) - (4). The level-set approach used to capture the flow front will rely on the physical velocity, computed from the Stokes-Darcy problem on a fixed grid, to evaluate the flow front motion. The level-set is also coupled with the nonlinear solid mechanics by updating the properties and receiving the corresponding displacement (5).

To minimize computation time, multi-core processors are used. To transfer the different parameters of the problem through the communicating processors, Message Passing Interface (MPI) environment is chosen [2]. MPI is a standardized and portable message-passing system designed to function on a wide variety of parallel computing architectures [3]. A first attempt is made to couple the fluid mechanics with a level set function, or with the solid mechanics. Compared with other classical methods, the calculation time is found to be the most reduced with MPI.

REFERENCES

