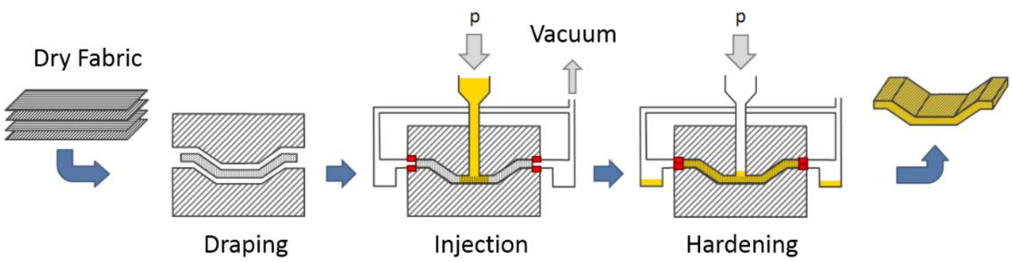
A Graphical User Interface for Simulating Resin-Transfer-Molding Combining LS-DYNA and OpenFOAM

M. Wagner[1], M. Martins-Wagner[1], A, Haufe[2], C. Liebold[2]

[1]Ostbayerische Technische Hochschule Regensburg
Laboratory for Finite Element Analysis and Structural Dynamics
Regensburg, Germany

[2]DYNAmore GmbH
Stuttgart-Vaihingen, Germany

The paper describes parts of the joint research project Swim-RTM including several industrial and academic partners. Its goal is to combine LS-DYNA and the open-source CFD solver OpenFOAM® to simulate the production process of continuous fiber-reinforced plastics, particularly the resin-transfer-molding (RTM) process, in which the layers of dry fabric (unidirectional or woven) are formed in the mold (draping) and then filled with liquid resin with high pressure at injection points (see Fig. 1). Through a combined analysis of both the structural mechanical and the fluid dynamical phases, a better prediction and thereby optimization of the textile components properties as well as injection points can be achieved, improving the manufacturing process.



The draping simulation of the fabric layers is carried out with LS-DYNA, while the injection simulation of the matrix material is performed in full 3D with OpenFOAM®. A key question that has to be answered in this research project is how local porosities and tensorial permeabilities for the fluid simulation can be derived from the structural computation in the draping step.

The purpose of the presented subproject is to develop a graphical user interface (GUI) to enable the simulation of the entire RTM process of long-fiber-reinforced components including the transfer of simulation results from the draping to the injection phase and backwards (see Fig. 2). The complete simulation task is relatively complex and involves several software packages, meaning a high effort for the user to get familiarized with. To circumvent this, the GUI aims at requiring from the user only the minimum necessary input data, creating and running the simulation and mapping tasks in the background, and showing graphically all demanded intermediate and final results.

For the draping step several current fabric materials such as *MAT_34, *MAT_234, *MAT_235, *MAT_249 are available. Several modelling techniques for the composite setup are also conceivable, including a workflow similar to metal forming applications. In the injection step the fabric is modelled as a porous medium and different transport models and liquid resin types are at hand.

For the data transfer between the draping and injection models, i.e. the mapping of data between shell and volume meshes within the developed GUI, first the OpenFOAM® volume mesh is converted to LS-

DYNA format and the necessary passing parameters are extracted from the output files, then a mapping algorithm from DYNAmore GmbH is invoked, and finally the OpenFOAM® command files are created. After the injection simulation is started and successfully terminated, information, such as the distribution of air inclusions or the shear force distribution to analyze the reorientation of component fibers, are available and can be transferred back to the LS-Dyna shell mesh for further computations, for instance a crash simulation. A backward data mapping between the volume and shell meshes can then be performed inside the GUI.

An example of the GUI application for the simulation of the resin transfer molding of an L-shaped component is presented.

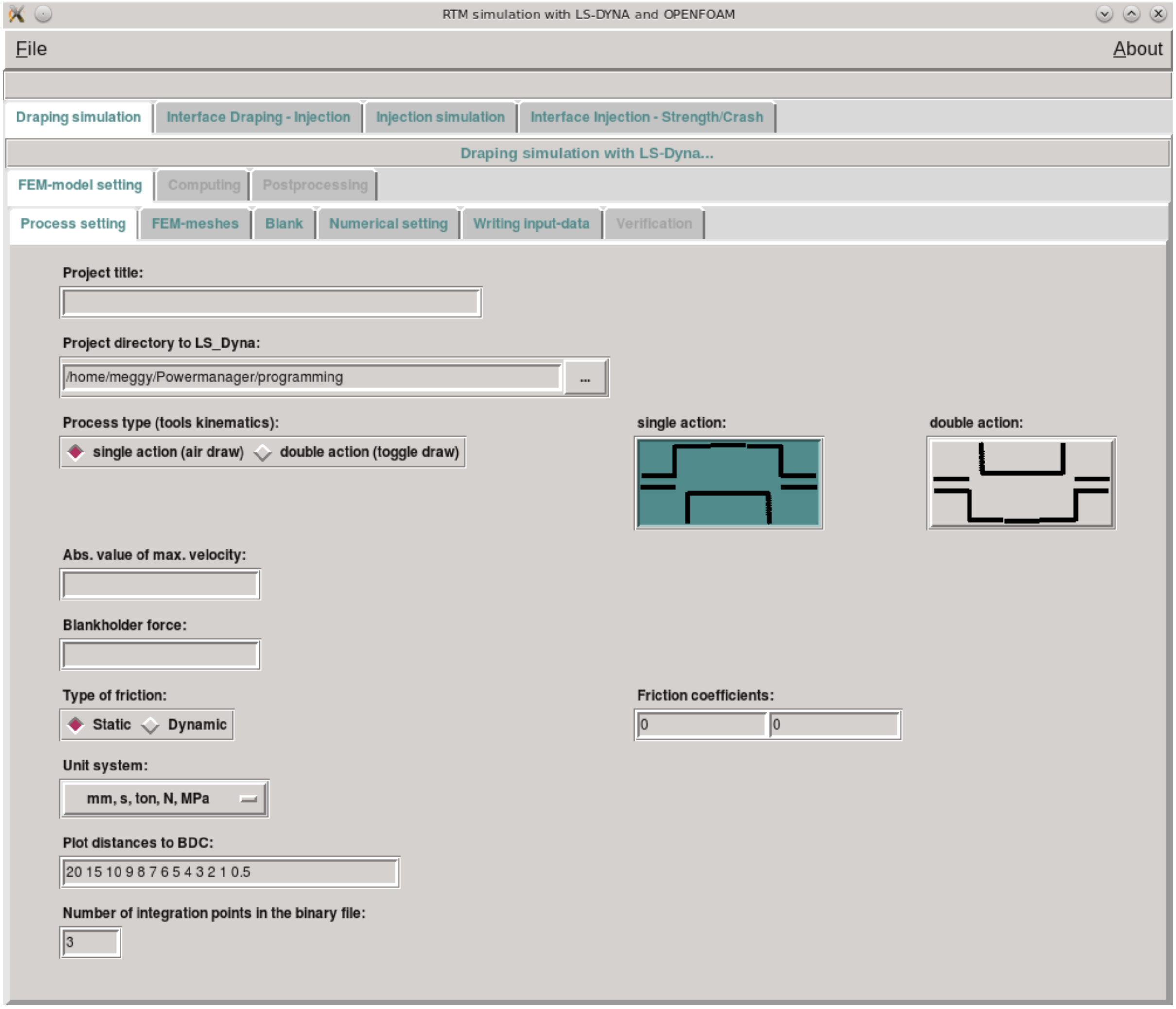


Fig. 2. Start page of the GUI for RTM processes with LS-Dyna and OpenFOAM®.

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