SUPG stabilized free surface flow at composites processing

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ABSTRACT

To increase productivity of structural composites, the resin infusion processes like Resin Transfer molding (RTM) process are likely to be exploited for automotive components. Many investigations considering the simulation of resin consolidation in the RTM process have been considered, e.g., Larsson, Rouhi and Wysocki [1]. These investigations normally neglect the capillary effect between the air and resin phases at the flow front, generally leading to an inaccurate prediction of the flow front pressure and saturation rate. In the present contribution, we propose a novel model (completely in-line with the TPM) that treats the resin and air as a multi-phase flow processes to model the resin free surface during RTM processing. The model is based on the idea of a linear mixture pressure assumption to substitute the intrinsic pressure of each phase while considering the capillary effect in a phenomenological way, as proposed by e.g. Brooks and Corey [2]. Our new model matches the one of Chavent et al. [3] very well except nearby the flow front region. Moreover, both the new model and Chavent's model show less diffuse behavior at the flow front, completely in–line with practical observations.

A staggered approach is employed to handle the coupling between mixture pressure and the saturation degree. However, at the flow front, problems arise with a numerically induced oscillating behavior of the degree of saturation. This is due to that the equation describing the saturation degree involves a convection-diffusion-reaction term. In order to stabilize the solution at the flow front, a Streamline-Upwind Petrov-Galerkin (SUPG) stabilization technique by Hughes and Brooks [4] is used to add an artificial stabilizing term to the original weak formulation to smoothen the solution. In addition, an important practice is that the value of saturation degree should lie between 0 and 1. To handle this problem, an extra penalty term is added to the weak formulation, regulating the solution of the saturation degree between 0 and 1. Numerical results are presented for an RTM infusion problem, where it is a key issue to properly resolve the flow front progression. The model yields quite robust simulation results, and the linear mixture pressure assumption gives a high computational efficiency. Because of the consideration of the capillary pressure, this model can handle various cases of RTM process as a general CAE tool in composites industry.

REFERENCES

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