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A Numerical Thermo-Chemo-Flow Analysis of Thermoset Resin Impregnation in LCM Processes

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This paper presents a numerical framework for modelling and simulating convection–diffusion–reaction flows in liquid composite moulding (LCM). The model is developed in ANSYS Fluent with customised user-defined-functions (UDFs), user-defined-scalar (UDS), and user-defined memory (UDM) codes to incorporate the cure kinetics and rheological characteristics of thermoset resin impregnation. The simulations were performed adopting volume-of-fluid (VOF)—a multiphase flow solution—based on finite volume method (FVM). The developed numerical approach solves Darcy's law, heat transfer, and chemical reactions in LCM process simultaneously. Thereby, the solution scheme shows its ability to provide information on flow-front, viscosity development, degree of cure, and rate of reaction at once unlike existing literature that commonly focuses on impregnation stage and cure stage in isolation. Furthermore, it allows online monitoring, controlled boundary conditions, and injection techniques (for design of manufacturing) during the mould filling and curing stages. To examine the validity of the model, a comparative analysis was carried out for a simple geometry, in that the numerical results indicate good agreement—3.4% difference in the degree of cure compared with previous research findings.

Biography:

Dr Hatim Alotaibi is currently a Research Assistant Professor in Aerospace Engineering (Specialised in Computational Fluid Dynamics (CFD)) at King Abdulaziz City for Science and Technology (KACST). Alotaibi received his B.A.Sc. (2016) in Industrial Systems Engineering from University of Regina (Canada), MSc (2019) in Aeronautical Engineering from The Hong Kong University of Science and Technology (Hong Kong), and PhD (2023) in Aerospace Engineering from the University of Manchester (United Kingdom). Alotaibi's research focuses at using a combination of modelling, theory and simulation to study " advanced materials and manufacturing processes " that are complex due to multiscale nature of materials, the rheology of fluid, and multiphysics phenomena in which the interactions of various effects (thermal, chemical, electric or mechanical) lead to complex dynamics. His research is motivated by processing and manufacturing of different materials for aerospace structures and energy storage materials.)