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ABSTRACT

New Finite Element Modeling Approach for the Pultrusion Process of Long Fiber Reinforced Polymeric Matrix: Application to 3D Printing

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Pultrusion-based 3D printing is a promising manufacturing technique for producing large structural profiles [1]. However, to scale up, it is essential to increase the production mass flow rate. Nevertheless, scaling up and optimizing process parameters remain a challenge, as adjustments are typically performed empirically, involing expensive trial-error experiments and are time consuming. In this context, a Digital Twin approach for the pultrusion process of long fibre thermoplastic composites, enabling a deeper understanding of the underlying physics and facilitating process optimization, is presented. Process parameters such as pulling speed, preheating and nozzle temperatures effects on the temperature and quality of the pultruded material are investigated. Consequently, a finite element model (FEM) using the COMSOL Multiphysics software tools was set up with the Volk et al. model [2] as a literature reference, initially developed for the glass fiber reinforced polyethylene terephthalate (GF/PET) composite. Volk's et al. model considers the PET matrix flowing through fiber tows as a porous media (Brinkman equations) which limits the description of the physics involved. To improve this, a laminar flow model applied to the effective properties of the GF/PET composite is presented in this work and takes into account the temperature dependency of the thermal specifications of the composite and the evolving fraction of air initially present between the fibres and the printing head. Results showed around 2.2 times faster convergence time compared to the Volk's model, with almost same results.

[1] K. Minchenkov, S. Gusev, A. Sulimov, O. Alajarmeh, I. Sergeichev, et A. Safonov, Mater. Des., 232, 112149 (2023).
[2] M. Volk, J. Wong, S. Arreguin, et P. Ermanni, Compos. Part B Eng., 227, 109339 (2021).