DEVELOPMENT AND ASSESSMENT OF A NUMERICAL MODELLING CODE FOR THE THERMOPLASTIC PROFILE EXTRUSION COOLING STAGE

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On the extrusion of thermoplastic profiles, upon the forming stage that takes place in the extrusion die, the profile must be cooled at a high rate to assure increased productivity, but avoiding high temperature gradients, to minimize the level of induced thermal residual stresses. These objectives are conflicting, since the increase of the cooling rate usually promotes higher temperature gradients. Due to the non-linear nature of the material behaviour and the large number of processing conditions involved, the employment of numerical modelling tools is mandatory to properly understand the system behaviour and to support its design. To model the profile extrusion cooling system, the temperature distribution must be computed both at the metallic calibrator and at the polymeric profile, which are in contact through a common interface. The traditional computational tools available for this purpose, start by assuming a certain temperature distribution in both domains, which are used to compute the interface heat fluxes. Subsequently, these new heat fluxes are used to update again the temperature distribution in both domains. This gives rise to an iterative process, which must be substantially relaxed to assure convergence. This relaxation as the direct impact on the computational time consumed to achieve a converged solution. In this work, we present the development a new coupled numerical solver, developed in the framework of the OpenFOAM® computational library, that computes the temperature distribution in both domains simultaneously, aiming to minimize the requied computational time. The solver was verified by comparison of its predictions with analytical solutions (for simple problems), through the Method of Manufactured Solutions and with results published in the literature [1]. In this work, the solver was experimentally assessed with an industrial case study. Subsequently, to evidence the novel numerical tool potential, the same industrial case study is employed in a sensitivity analysis, aiming to quantify the importance and effect of the main process variables.

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References

[1] F. Habla, C. Fernandes, M. Maier, L. Densky, L. Ferrás, O. S. Carneiro, O. Hinrichsen and J. M. Nóbrega, Appl. Thermal Eng. 100, 538-552 (2016).