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Simulation on Influence of Environmental Conditions on Part Distortion in Fused Deposition Modelling

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Abstract : Fused deposition modelling (FDM) is one of the additive manufacturing techniques that has become highly attractive in the industrial and academic sectors. However, parts fabricated through FDM are highly susceptible to geometrical defects such as warpage, shrinkage, and delamination that can severely affect their function. Among the thermoplastic polymer feedstock for FDM, semi-crystalline polymers are highly prone to part distortion due to polymer crystallization. In this study, the influence of FDM processing conditions such as chamber temperature and print bed temperature on the induced thermal residual stress and resulting warpage are investigated using the 3D transient thermal model for a semi-crystalline polymer. The thermo-mechanical properties and the viscoelasticity of the polymer, as well as the crystallization physics, which considers the crystallinity of the polymer, are coupled with the evolving temperature gradient of the print model. From the results, it was observed that increasing the chamber temperature from 25°C to 75°C lead to a decrease of 1.5% residual stress, while decreasing bed temperature from 100°C to 60°C, resulted in a 33% increase in residual stress and a significant rise of 138% in warpage. The simulated warpage data is validated by comparing it with the measured warpage values of the samples using 3D scanning.

Keywords : finite element analysis, fused deposition modelling, residual stress, warpage
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