Controlling temperature gradients to increase inter- and intralayer bond strength in fused filament fabrication: a 3D modelling study and design

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Abstract: Fused filament fabrication (FFF) is an additive manufacturing (AM) technique for polymeric part production with applications in areas such as medical devices, sporting equipment and general prototyping. One of the limitations with this technique is the anisotropy intrinsic to the stepwise and directional deposition of material. This creates inter- and intralayer weld zones and voids, each of which are potential weak zones and decrease the strength of the final part. It is thus important to maximize the strength of these weld zones and minimize the voids. On the molecular scale, the bonding quality is influenced by interdiffusion, hence, chain mobility, which, under melt conditions, is governed by chain reptation [1]. It is known that the temperature strongly influences the chain mobility between polymeric phases so that its temporal evolution is an important factor to control the bond formation. Expanding on the already published work on nozzle exit flow modelling [2], the current work numerically investigates the thermal behavior during FFF deposition for four layers consisting out of two strands each and compares the influence of different process parameters such as the nozzle and bed temperature and the layer height. The simulations are based on an ABS material for which a Cross-Arrhenius model is fitted and all relevant thermo-physical properties are measured. Currently, more parameters are investigated, together with the void formation and apparent part roughness [3].

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