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Modeling of the Thermal Field in Fused Deposition Modeling

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Additive manufacturing is a widely adopted technology representing a viable alternative to traditional subtractive manufacturing techniques used to fabricate a physical part using computer-aided design. What started as a rapid prototyping technique quickly evolved into a fully customized small-scale parts production. It is based on incremental deposition or sintering of the material in thin layers. Our research focuses on Fused Deposition Modeling (FDM), where molten thermoplastic is extruded from a nozzle.

The newly deposited volume heats the underlying layers leading to non-uniform temperature distribution induced in the printed part. The high-temperature gradients can lead to partial melting of small details, layer delamination, not-sticking to the print bed, and the occurrence of residual stresses. The FDM process typically takes hours or days to produce complex large parts. Therefore, the ability to accurately predict the thermal field is essential for subsequent mechanical analysis of the production process [1] and possibly for the G-code optimization to mitigate the mentioned issues.

Our paper presents a numerical model for predicting the thermal field during the FDM process. It is based on a G-code software emulator [2] and a nonlinear and non-stationary heat transfer Finite Element (FE) model. The nonlinearity originates from temperature dependence of model parameters, namely heat capacity, heat conductivity, and heat transfer coefficient. Therefore, we have conducted several experiments to obtain the thermal-dependent material properties of the most common AM materials, i.e., PETG and PLA. Finally, the capability of the modeling tool is verified by a comparison of calculated thermal fields against thermal fields obtained from a real 3D printing process by a thermal camera.

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REFERENCES

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