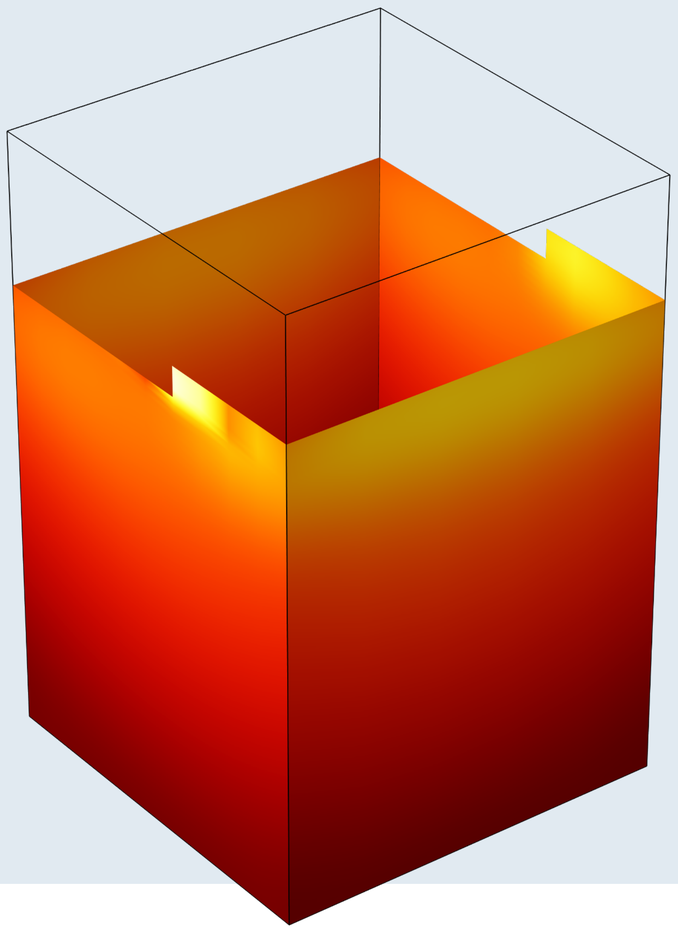

# Investigation for Thermal Analysis in COMSOL® for Fused Filament Fabrication

Thermal simulation of Fused Filament Fabrication (FFF) could help improving this innovative 3D printing technology. This study dives into the opportunities with COMSOL Multiphysics®.

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## Introduction

As a thermally driven process, a knowledge of the temperature of the deposited strands is critical FFF to ensure reliable and quality results. Zhang et al. developed a tool called T4F3 to calculate the in-process filament temperature during printing for square shaped parts [1]. Nain et al. [2] used the material activation method, available in the Structural Mechanics Module of COMSOL®, to model the material addition of the process. All these investigations focused on simple shapes with only one type of material. In this research, an investigation is made to assess the use of COMSOL Multiphysics® in developing thermal simulation of free-form FFF-printing processes. This could in the future help improving the FFF printing technology.

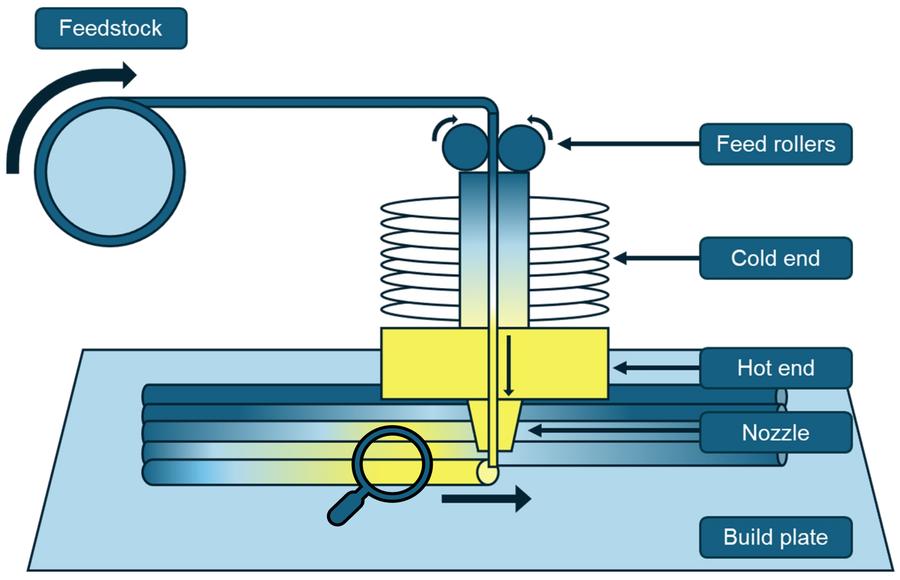


FIGURE 1. Schematic overview of the FFF process. The focus of this research is on the filament temperature.

## Methodology

A CAD-model of varying shape, from a simple figure to a complex profile, is converted with MATLAB® and imported into COMSOL (see FIGURE 2.). Conduction with neighboring strands and convection/radiation with the environment are modeled to investigate the temperature of each segment of deposited filament. As a first proof of concept a cube is modeled. A printing path is generated similar to the printing path used in T4F3 with the same process parameters. These results are compared, to look for further improvements.

## Results

A comparative study between T4F3 and COMSOL results show the same patterns in the temperature fluctuations of the printed filament. Although this is already a promising result, a couple of improvements are still needed. Temperature peaks show shifts in the time, as in temperature domain. This could be due to different meshing, activation, calculation and analyzation methods used in both softwares. The research presented in this poster should be seen as a first step towards free-form simulation of FFF printed parts, later enabling more adaptive printing strategies to increase quality and efficiency even more!

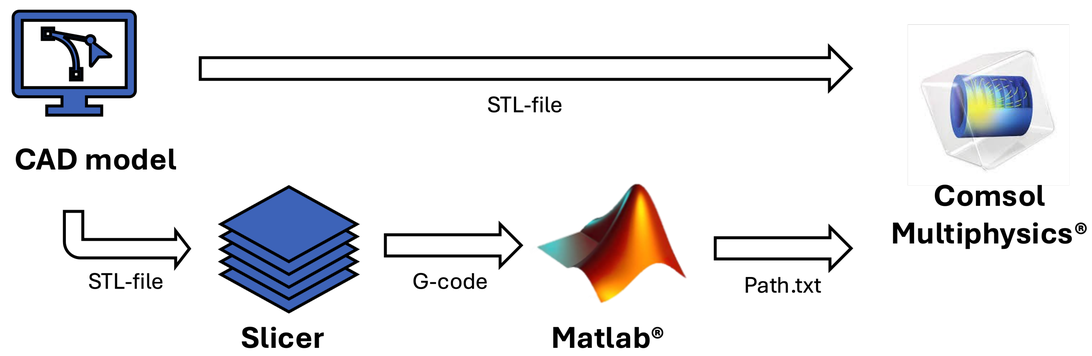


FIGURE 2. A global overview of the framework that enables the use of COMSOL Multiphysics in free-form FFF simulation.

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## REFERENCES

1. J. Zhang, B. Van Hooreweder, and E. Ferraris, “T4F3: temperature for fused filament fabrication,” Progress in Additive Manufacturing, vol. 7, no. 5, pp. 971–991, Oct. 2022, doi: 10.1007/S40964-022-00271-0/FIGURES/15.
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