Thermal Analysis of 3D Printer Extruder Using Ansys AIM

For an all-metal 3D printer extruder, simulations of varying geometries show that the best heat sink design has a straight stem with short diameter and long fins. This design outperformed the reference commercial heat sink. It was able to maintain a temperature below the glass transition temperature, which suggests it is a possible design for a passively cooled printer extruder.

/ Products Used

- Ansys AIM®

/ Challenge

Fused deposition modelling is the most widely used process for 3D printing. An extruder deposits small amounts of melted plastics to form layers that harden quickly. Thermal performance of the printer extruder is critical to the success of the process, and the filament must remain cool until it reaches a heated nozzle, where it undergoes a rapid transition above the glass transition temperature. This study was undertaken to design an all-metal passively cooled extruder because this would avoid the need for a cooling fan or the addition of a synthetic insulator.

This work was performed as part of the 2015 University of Waterloo Engineering Analysis and Design Symposium, in which students took engineering design problems from concept to simulation and validation in under two weeks.

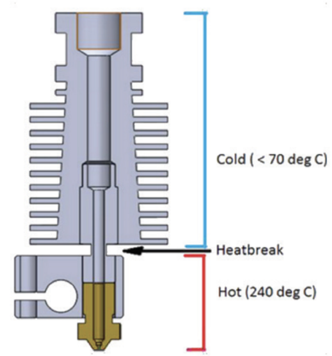
/ Solution

Five simulations were produced for each model of the printer extruder with a different heat sink design. The first design was based on a commercial product. Four other designs were then created with variations to two parameters: the diameter of the heat sink's fins and the stem geometry.

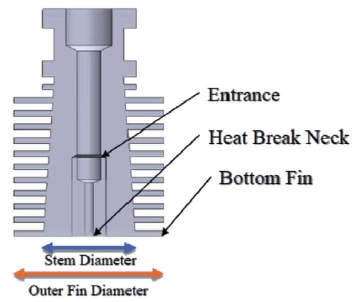
In each of the steady-state simulations, a temperature boundary condition of 240 C was applied to all surfaces that contact the heating element. Free convection boundary conditions were applied to all exterior surfaces to simulate a design with no cooling fan. Radiation was also considered from the exterior surfaces. The values applied for the thermal emissivity of the materials and the thermal convection coefficient were determined using empirical results. Each steady-state simulation calculated the final temperature distribution and was used to determine the efficiency of the heat dissipation.

/ Results

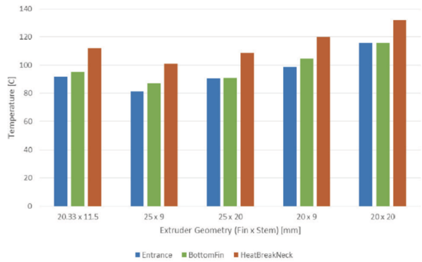
The initial model was based on a commercial product, so the physical extruder was used to validate the simulation. When at steady state, the temperature in the reference extruder was 95 C at the top and 90 C at the bottom of the heat sink fin. Compared to the empirical results, the simulation produced temperatures to an accuracy of 4.2%, which is sufficiently small for the temperature range being studied.



Printer extruder geometry.



Reference points for data collection.



Temperature for different heat sink design variations.

/ Conclusion

The simulation results show that the best design is the geometry with the large fin diameter and straight stem. This design does maintain a cold-end temperature below the glass transition temperature, making its configuration a possibility for a passively cooled extruder design.

For more information on Ansys AIM, see:

ansys.com/Products/Multiphysics/Ansys-AIM

To discover how Ansys software can be used in education, visit:

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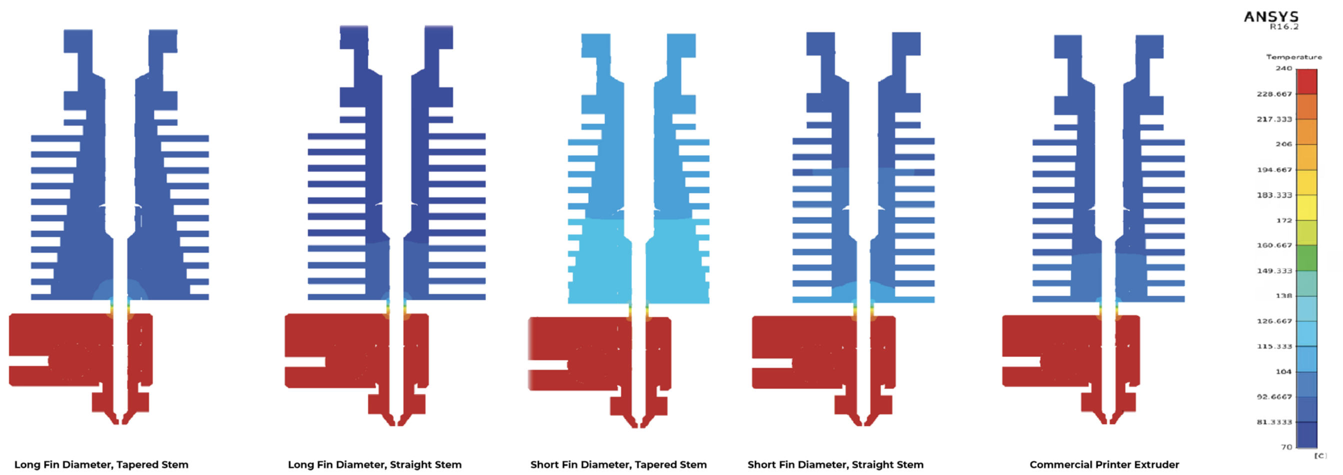

Temperature simulation for five designs for the printer extruder.

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