Master's Thesis Defense Announcement
Mechanical and Aerospace Engineering Department
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EVALUATING THE THERMAL PERFORMANCE OF TOPOLOGY OPTIMIZED LOW-COST 3D PRINTED HEAT-EXCHANGER MADE OF COPPER

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Abstract

The performance of a heat exchanger is highly dependent on the overall surface area available for heat transfer. Designing heat exchangers with greater surface areas meant bigger size, weight, and volume of heat-exchanger thus making it unfeasible to produce. Design and manufacture of compact-sized heat exchangers is a difficult task, as it would require the use of complex surface modeling and complex surface cutting. But with the advent of 3D printing technology, it has become easier to manufacture heat exchangers having complex designs producing larger surface areas as they add material layer by layer rather than cutting it away.

The focus of this thesis is to design, manufacture and evaluate the thermal performance of 3D printed heat exchangers. A unique method of carrying out thermal topology optimization on cylindrical heat exchangers using ANSYS workbench has been discussed. The results from the topology optimization have been used to achieve complex designs. A comparative study was carried out between the topology optimized designs and the conventional straight fin heat exchanger design to analyze their thermal performance using steady-state thermal analysis. The designs were then 3D printed on a Lultz-Bot 3D printer using a copper-PLA filament. To achieve parts made of pure copper, the sintering process was carried out and various sintering techniques were explored to combat issues like oxidations, loss of structural integrity, and porosity in the sintered parts. The results from the initial validation study showed that the optimized design performed better and thus a detailed CFD analysis was carried out to study the performance of the heat exchanger. Results from the sintering process showed that the best-sintered parts were achieved when sintering was done in a vacuum environment at 1000C and above for longer periods. Lastly, experimental setups were designed using N2 gas tanks, heaters, and cylindrical tubes to simulate the flow of fluid through the heat exchanger and study its performance.