Performance of Additively Manufactured Thermal Insulation with Geometric Voids in Hypersonic Conditions

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This project investigates the use of internal voids in 3D-Printed insulative walls as a potential proof of concept for more effective insulation to anisotropically move heat across the heated surface, rather than through a wall. The purpose is to create a more effective insulation method, that is lighter and more available to aircraft design, specifically when designing aircraft for sustained hypersonic flight (greater than Mach 5). Samples are 3Dprinted and subjected to constant heat flux for experimental testing, which is analyzed using a one-dimensional transient heat analysis. Multiple models are also designed for ANSYS simulations, which allows for three-dimensional transient heat analysis of more complex void geometries. The results provide an initial proof of concept that different internal void geometries provide anisotropic heat flow across the heated surface. These results are confirmed through numerical analysis of transient heat analysis in one dimension, and computer modeling of transient heat analysis in three dimensions. These tests show that voids which span perpendicular to the direction of the heat flow increase the anisotropic heat flow and decrease the heat measured through the voided sample.

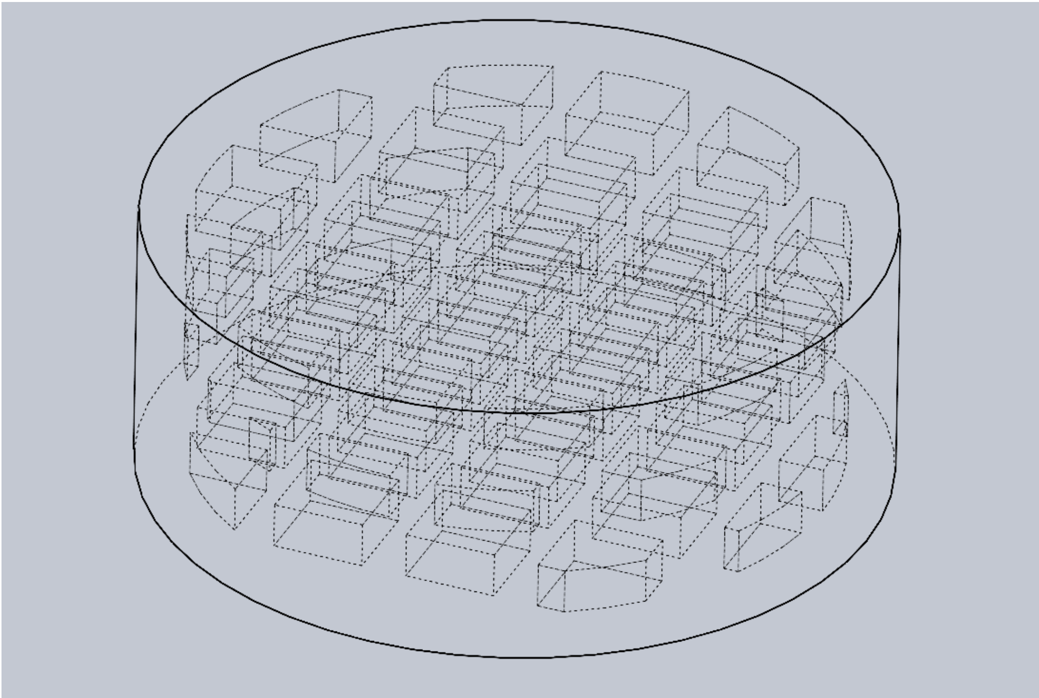

Figure 1: Cubic-Void Sample from Solidworks

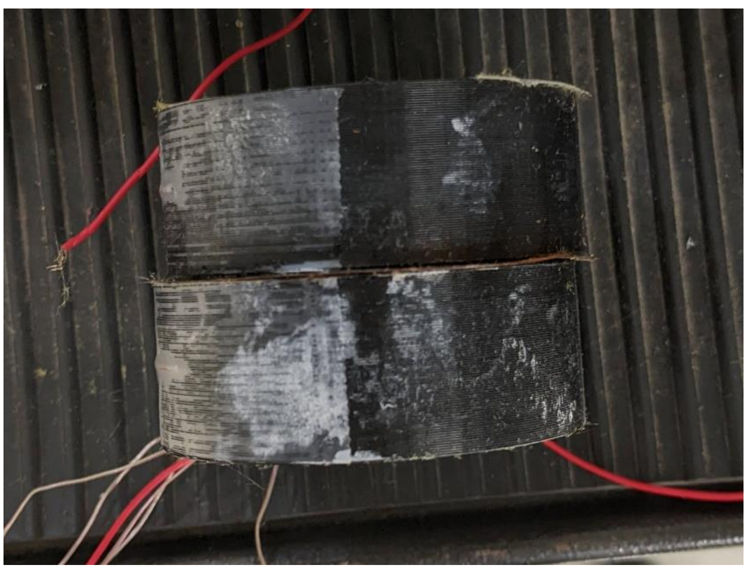

Figure 2: Samples with Heater