Heat enhancement using Gyroid Structure and metal foam for Different Porosity and Cooling fluids: Experimental and Numerical Approaches

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Porous media has been used in engineering applications for many years. The advantage of such material is its lightweight and efficient cooling process. Metal foam is one class of porous material and is produced by industry. Thus, the user is limited by the available porosity, permeability, and design. Designing a new class of material using triply periodic minimal surfaces has been available for a long time. This mathematical formulation is currently used to create different structures suitable for the thermo-fluids discipline, material discipline, and biomedical field.

Various researchers in the field of engineering have used porous media for many years. The present paper studies heat enhancement using two different types of porous media. In the first type, porous metal foam media was used experimentally and numerically for heat extraction. The porous medium was replaced with a porous structure using the Gyroid model and the triply periodic minimum surfaces technique in the second type. The Darcy–Brinkman model combined with the energy equation was used for the first type, whereas Navier–Stokes equations with the energy equation were implemented for the second type. The uniqueness of this approach was that it treated the Gyroid as a solid structure in the model. The two types were tested for different heat fluxes and different flow rates [1,2]. A comparison between the experimental measurements and the numerical solution provided a good agreement. By comparing the performance of the two types of structure, the Gyroid structure outperformed the metal foam for heat extraction and uniformity of the temperature distribution. Despite an 18% increase in the pressure drop in the presence of the Gyroid structure, the performance evaluation criteria for the Gyroid are more significant when compared to metal foam. Figure 1 presents the gyroid with a porosity of 0.7 in the test section. Results revealed that;

1. For the metal foam, it is found that the temperature distribution along the flow is increasing toward a non-uniform cooling.
2. For the metal foam, a thermal boundary is developed along the flow, and means of breaking this thermal boundary layer must be addressed
3. Uniform temperature distribution is achieved experimentally and numerically for the Gyroid structure. The structure design allowed the break of the thermal boundary layer.
4. The pressure drop in the metal foam appears to be less than the pressure drop in the Gyroid by an average of 18%
5. Comparing the performance of the two structures for identical conditions shows that the Nusselt number is higher for the Gyroid structure. This led to the belief that lower temperatures were achieved and a better cooling process was needed.

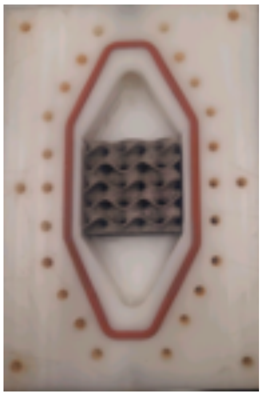

Figure 1 Experimental test section

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[2] Saghir, M.Z., Kerme, E.D., Hajialibabei, M., Rasheed, H., Welsford, C. and Al-Ketan, O., 2024. Study of the Thermal and Hydraulic Performance of Porous Block versus Gyroid Structure: Experimental and Numerical Approaches. *Energies*, *17*(4), p.861.