CONVECTIVE HEAT TRANSFER OF MONO AND HYBRID NANOFLUID IN POROUS MICRO-CHANNEL: EXPERIMENTAL AND NUMERICAL APPROACH

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INTRODUCTION: Thermal energy storage (TES) systems are used to store or release thermal energy temporarily for later usage. The main purpose for the use of TES materials are due to fluctuating energy supply and demands along with varying production costs.

Experimental Approach

An experimental apparatus was developed to analyze the effect of pore density on the heat transfer characteristics within micro-channel porous media operating as heat sinks subjected to a forced flow. The test section consists of a porous micro-channel fluid chambers where the flow enters, a porous chamber containing the porous material, and a fluid chamber to allow the fluid to exit.

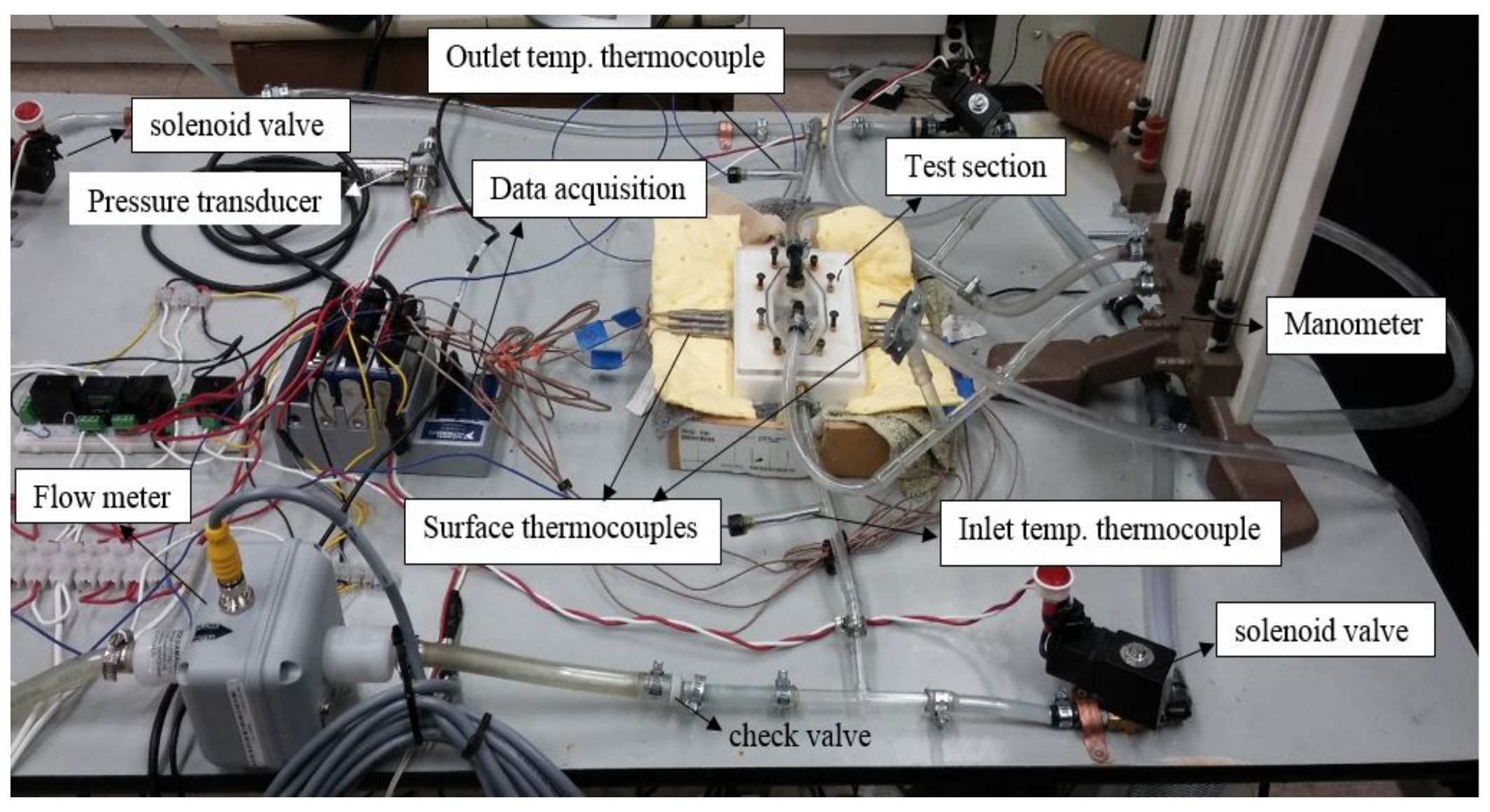

Figure 1. Experimental setup

COMPUTATIONAL METHODS: The finite element modeling assumptions are taken into consideration, the Brinkman- Forchheimer equation and energy equation which describe the fluid flow and heat transfer inside the porous micro channel are solved using the following formulation:

$$\frac{\rho_f}{\varepsilon}\left(\frac{\partial U}{\partial t}+(U\cdot\nabla)\frac{U}{\varepsilon}\right)=\nabla.\left(-pI+\frac{\mu_f}{\varepsilon}(\nabla U+(\nabla U)^T)\right)-\left(\frac{\mu_f}{K}+\beta_f|U|\right)U+F$$

$$\nabla\cdot\left(\rho_f U\right)=0$$

$$(\rho c_p)_{eff}\cdot\frac{\partial T}{\partial t}+(\rho c_p)_f\,U\cdot\nabla T=\nabla.\left(k_{eff}.\nabla T\right)$$

where ρ_f represents the fluid density, c_p represents the fluid specific heat, ε represents the porosity of the aluminum metal foam, p represents the pressure, U represents the velocity field vector, β_f represents the Forchheimer coefficient, F represents the body force. T represents the temperature, μ_f represents the water dynamic viscosity, K represents the permeability of the aluminum foam and k_{eff} represents the effective thermal conductivity of the aluminum metal foam when filled with fluid.

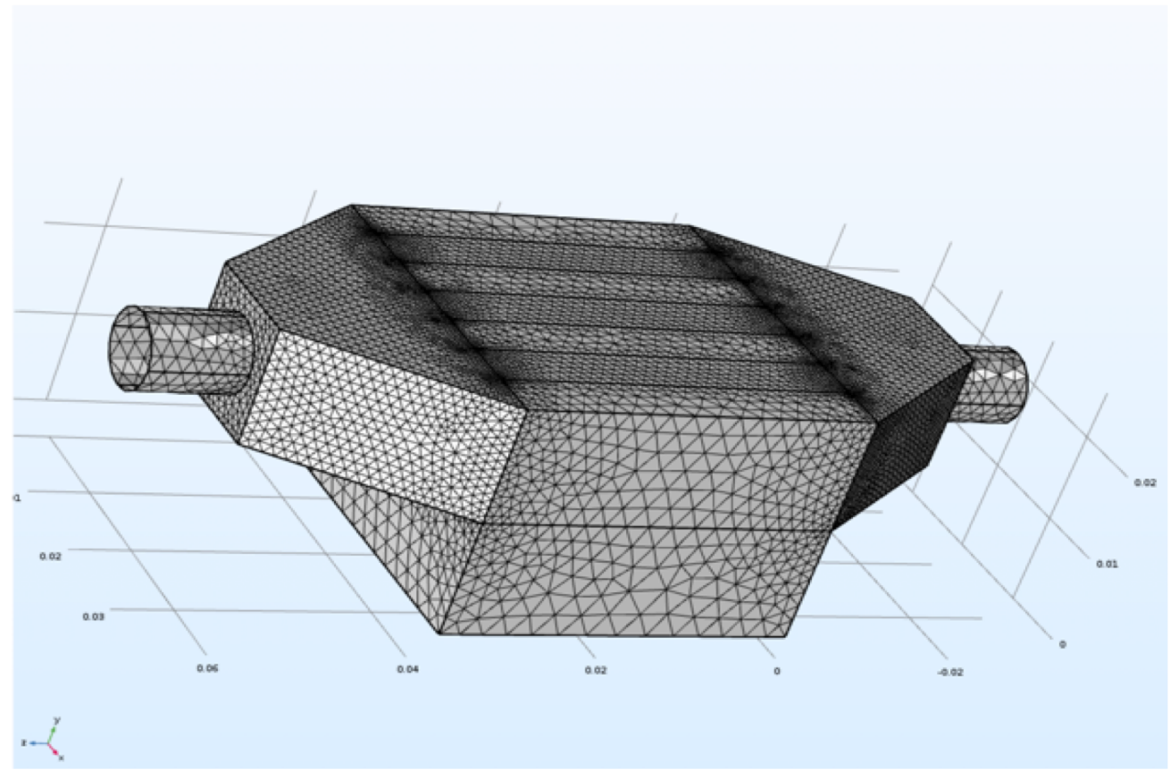

Figure 2 Finite element mesh

RESULTS: The experiment was conducted for four different flow rates of mono nanofluid of 0.23 US gallon per minute (USGPM), 0.18 USGPM, 0.15 USGPM and 0.1 USGPM respectively. The heat flux applied at the bottom of the plate was the other variable investigated in this experiment. It consists of three different heat fluxes of around 12 W/cm^2, around 7 W/cm^2 and finally around 5W/cm^2.

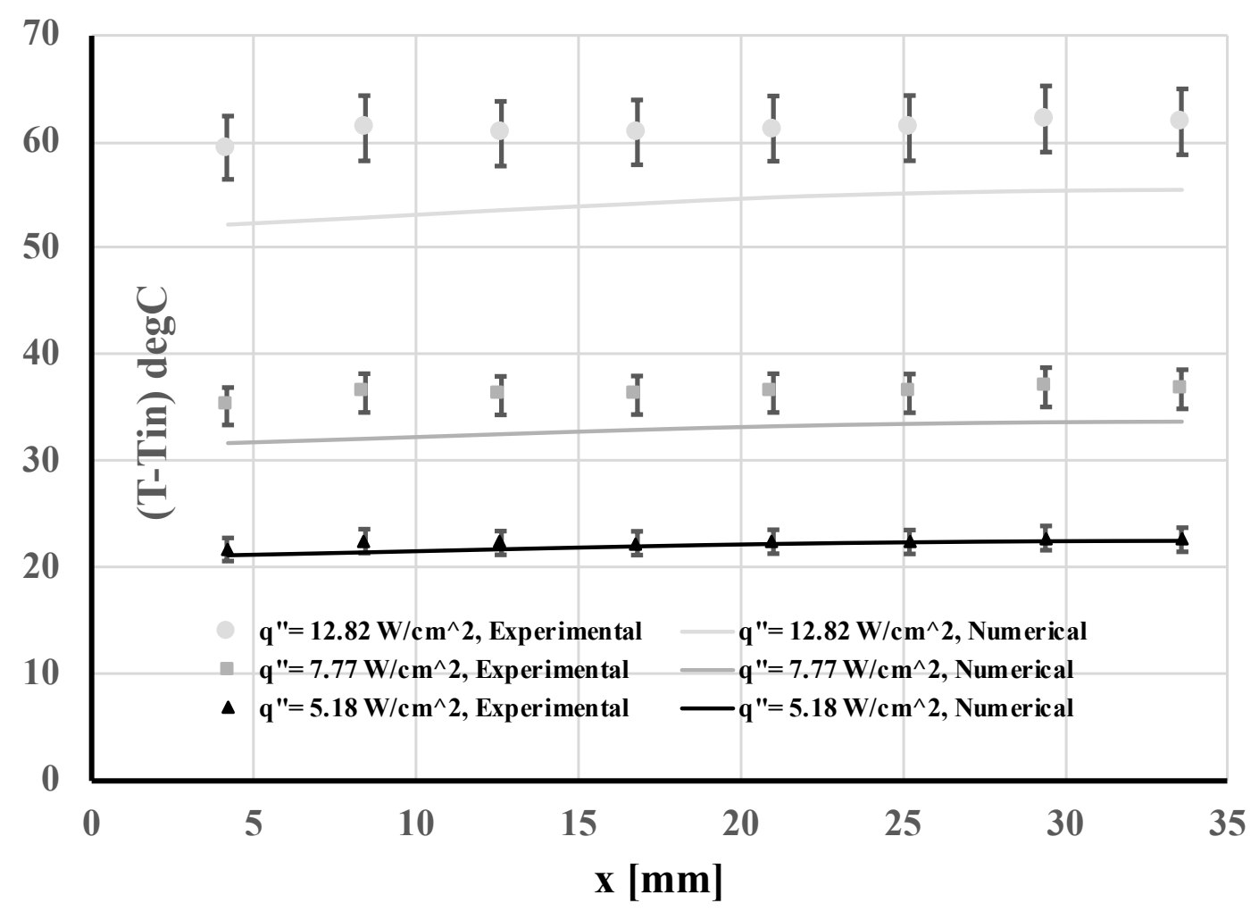

Figure 3 Temperature variation 1 mm below the microchannel (flow rate = 0.23 USGPM)

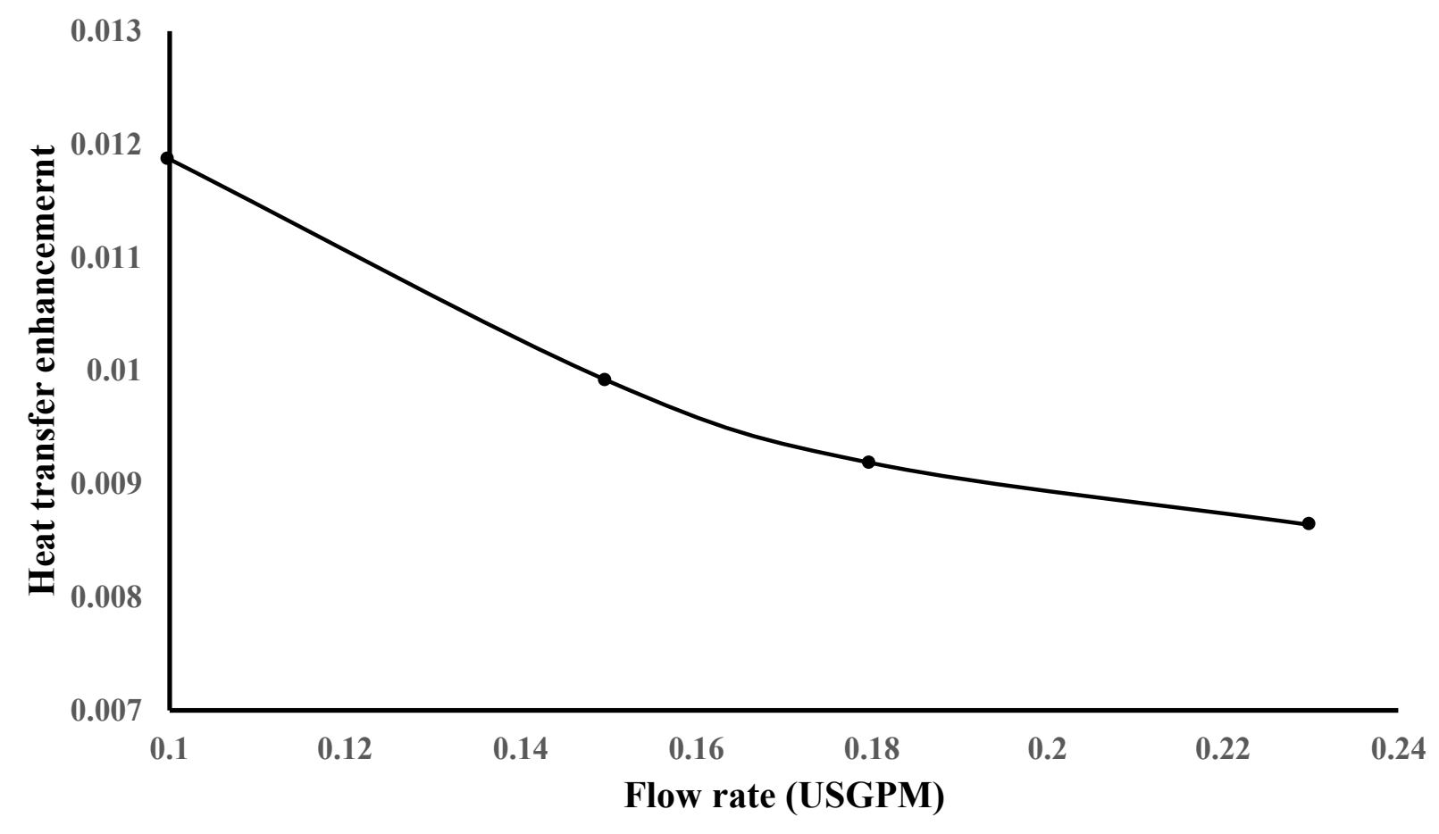

Figure 4. Heat transfer enhancement of hybrid fluid over mono nanofluid as function of the flow rate

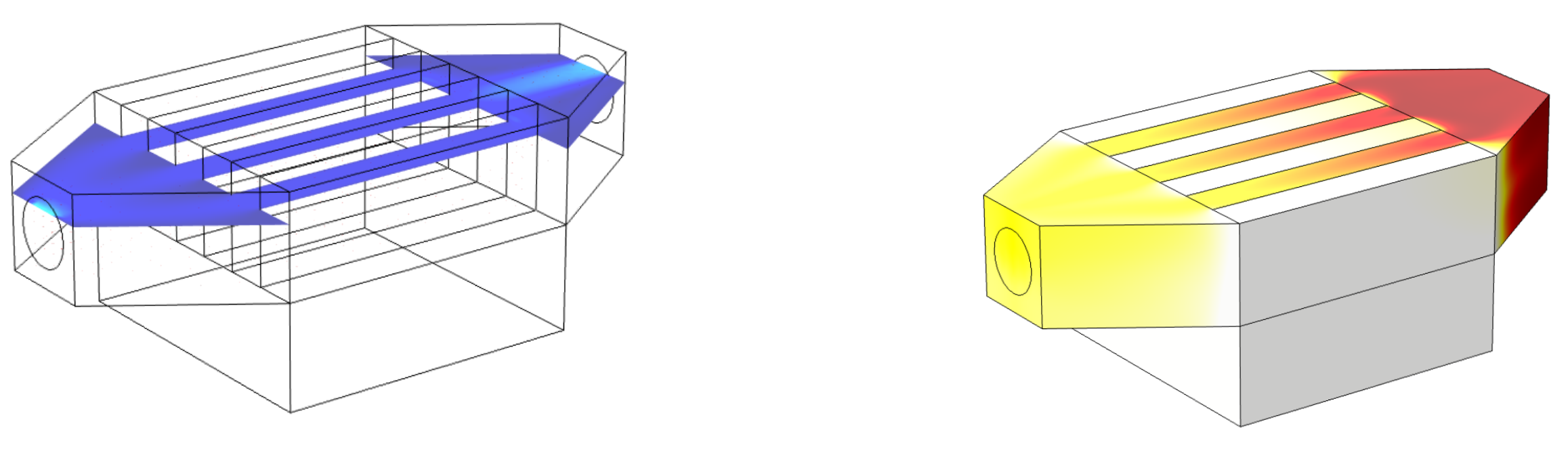

Figure 5 Flow and heat behavior inside the channels

CONCLUSIONS: We have demonstrated the usefulness in using hybrid fluid instead of mono nanofluid for heat enhancement. The results were shown for four different flow rates and the computation was conducted for different composition of mono nanofluid of water and Al_2O_3 nanoparticles. It appears that the usage of hybrid nanofluid is more appropriate for heat transfer enhancement than using mono nanofluid in porous media

REFERENCES:

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