Cfd Modelling Of Rectangular Microchannel With Increase In Heat Flux And Effect On Nusselt Number

Aneesha Gogineni
Faculty: Ikram Ahmed

Department of Mechanical Engineering

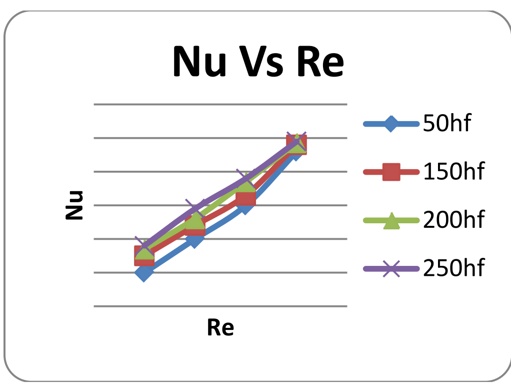
Abstract: A laminar convective heat transfer coefficient of a rectangular microchannel is investigated under constant heat flux value throughout the wall. Two dimensional numerical simulations were performed using the FLUENT and GAMBIT software packages for a rectangular microchannel with a breadth of L and a length of 200L. Based on the temperature distributions obtained from simulations, both the local and average Nusselt numbers for different Reynolds numbers ranging from 100 to 400 for different heat flux values are determined.

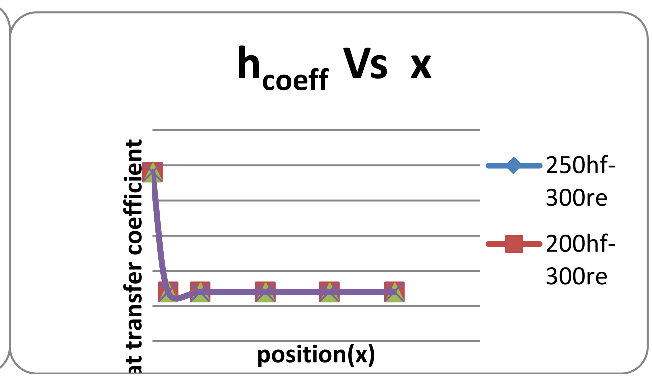
1. Introduction

Recently, much research has been conducted on microchannels due to their high heat transfer performance, and these experimental studies proved to be successful.Lee determined Nusselt numbers as a function of aspect ratio [2]. Experimental data was collected to find the Nusselt numbers and a linear relationship was observed between the Nusselt number and Reynolds number. Three-dimensional numerical simulations for trapezoidal and triangular channels of the laminar flow and heat transfer of water in microchannel flow were performed. The studies showed that fully developed Nusselt number for the microchannels simulated increases with the increasing Reynolds number, rather than a constant.

2. Experiment, Results, Discussion, and Significance

A microchannel was modeled in GAMBIT with the required dimensions and the mesh density of the microchannel taken 10x400(Fig.2). The boundary conditions were applied in GAMBIT design, and then exported to FLUENT. The inlet is taken as velocity inlet and outlet is taken as pressure outlet.The case file was read from the GAMBIT file followed by a grid check and scaling process. The properties were obtained to select fluid for further calculations which lead to the next step of applying the boundary conditions. The solution converged at 250 iterations and the surface temperature and bulk temperature values were used in calculating. Using these temperatures, the heat transfer coefficient and Nusselt number were calculated. The results are shown in Figure.1 below. At a particular position, for different Reynolds numbers and heat flux values the Nusselt numbers were calculated and graphs were drawn to illustrate the variations. At different positions, the average Nusselt number was calculated and compared with a single position values. Grid independence was done to verify the accuracy of the results.





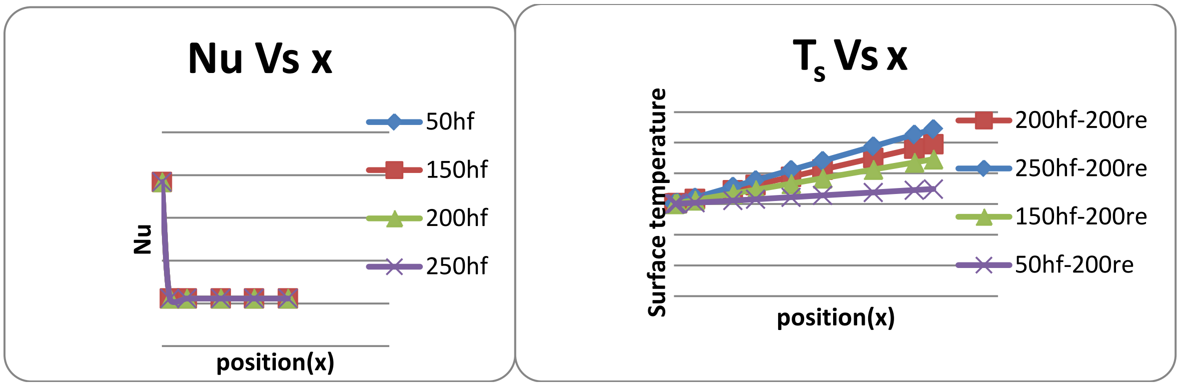


Fig. 1 Graph for Nusselt number, Heat transfer coefficient and temperature

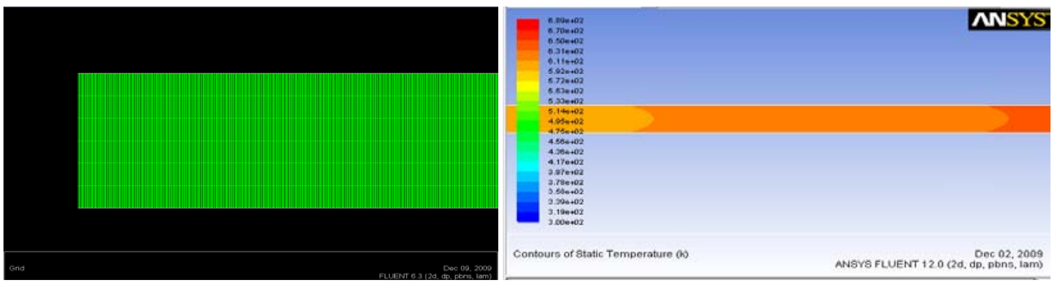


Fig.2 Gambit mesh model and fluent model

3. Conclusions

Theoretically in a conventional duct, the Nusselt number in the fully developed laminar heat transfer is constant, but in the microchannel the Nusselt number increases with an increase in Reynolds number. This is because the constant value (8.23) is for an ordinary conventional channel but in the case of microchannel heat transfer process is more efficient, perhaps due to thin boundary layer. The hydraulic diameter is very small and hence the Nusselt number is very small.In case of heat transfer coefficients and Nusselt numbers, there is a major decrease for the first positions and as it goes on the values are becoming constant and hence using the FLUENT, it can be stated that in a thermally developing flow of fluid with constant properties, heat transfer coefficient and the Nusselt numbers are constant, independent of position.The heat transfer intensity is very high while entering the channel but it decreases gradually while flowing through the downstream. This also indicates that after the fluid flowing through a long channel is fully developed. Thus such a microchannel can be used in heat exchangers, heat sinks, MEMS, microelectronics, biomedical, fuel processing and aerospace.

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