HEAT TRANSFER CHARACTERISTICS OF GASEOUS FLOWS THROUGH MICROCHANNELS

A THESIS

Submitted in partial fulfillment of the requirements for the award of the degree

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by

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CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in the thesis entitled **HEAT TRANSFER CHARACTERISTICS OF GASEOUS FLOWS THROUGH MICROCHANNELS** in the partial fulfillment of the requirements for the award of the degree of **DOCTOR OF PHILOSOPHY** and submitted in the **DISCIPLINE OF MECHANICAL ENGINEERING, Indian Institute of Technology Indore**, is an authentic record of my own work carried out during the time period from July 2011 to September 2015 under the supervision of **Dr. Santosh K. Sahu, Assistant Professor, Indian Institute of Technology Indore**.

The matter presented in this thesis has not been submitted by me for the award of any other degree of this or any other institute.

Hari mohan 21/09/2015

Signature of the student with date
(HARI MOHAN)

This is to certify that the above statement made by the candidate is correct to the best of my/our knowledge.

18/1/2016

Signature of Thesis Supervisor with date
(Dr. SANTOSH K. SAHU)

HARI MOHAN has successfully given his Ph.D. Oral Examination held on ________.

Signature of Chairman, OEB Date: 18/1/2016	18/1/2016 Signature of Thesis Supervisor Date:	Ritunesh Kumar Signature of Convener, DPGC Date: 18/1/2016
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ABSTRACT

Present dissertation reports the theoretical investigations pertaining to the analysis of heat transfer characteristics of gaseous flows through various microdevices. The objective of the present study is to analyze the heat transfer characteristics of gaseous flows through parallel plate microchannels and micropipe by employing various constant heat flux boundary conditions and incorporating various effects such as: rarefaction, viscous dissipation, second order velocity slip, temperature jump and shear work at the solid boundaries. The analysis of heat transfer phenomenon at microscale is useful in various scientific and industrial applications such as: design of microfluidic devices (micro-pump, micro-valves, micro-turbine), cooling of electronic devices and rarefied gas flows.

In this study efforts have been made to study the heat transfer characteristics of gaseous flows through parallel plate microchannels and micropipe with different constant heat flux boundary conditions. The variable separable method is employed to obtain closed form solutions for the Nusselt number as the function of various modeling parameters such as: Knudsen number, viscous dissipation and heat flux ratio. Initially, efforts have been made to analyze the heat transfer characteristics of gaseous flows through parallel plate microchannels by considering second order velocity slip and temperature jump boundary conditions. Further, the analysis is extended to evaluate the heat transfer characteristics of gaseous flows through isoflux micropipe with second order velocity slip and temperature jump boundary conditions. The deviation in the Nusselt number obtained from the second order slip model and the first order slip model is discussed.

Later on, efforts have been made to study the sole or combined effect of various parameters, namely, first order velocity slip, temperature jump, second order velocity slip, second order temperature jump, viscous dissipation and asymmetric heat flux ratio on the heat transfer characteristics of gaseous flows through parallel plate microchannels. The variation of Nusselt number with Brinkman number is not continuous and singularities are observed at different Brinkman number for each Knudsen number. With the increase in heat flux ratio and Knudsen number, the onset of singularity point is found to shift towards the higher values of the Brinkman number.

In addition, attempts have been made to study the effect of shear work on the heat transfer characteristics of gaseous flows through parallel plate microchannel and micropipe by employing constant heat flux boundary conditions. The effect of viscous dissipation, second order velocity slip and temperature jump are taken into consideration for the analysis. In all the cases, closed form expressions are obtained for the temperature distribution and Nusselt number as the function of various modeling parameters. Present predictions are verified for the cases that neglect the effect of viscous heating and microscale effects.

Key words: Brinkman number, Knudsen number, Nusselt number, slip flow, temperature jump, velocity slip, heat flux ratio