TRANSPORT PHENOMENA OF NON-NEWTONIAN FLUIDS IN CIRCULAR CURVED TUBES

by

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CERTIFICATE

This is to certify that this thesis entitled *'Transport phenomena of Non-Newtonian Fluids in Circular Curved Tubes'* being submitted by ***Ms. Shobha Agrawal*** to the Indian Institute of Technology, Delhi for the award of the degree of Philosophy is a record of bona fide research work carried out by her. Ms. Shobha Agrawal has worked under our supervision and has fulfilled the requirement for the submission of the thesis.

The results contained in this thesis have not been submitted in part or in full, to any other university or Institute for the award of any degree or diploma.

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(SHOBHA AGRAWAL)

ABSTRACT

Complex flow situations such as in curved tube configurations have an important role in the field of chemical, mechanical, aeronautical and civil engineering, since the existence of secondary flow in curved ducts causes higher heat and mass transfer and reduced axial dispersion as compared to straight tubes. Practically little effort has been made to understand the transport phenomena of non-Newtonian fluids flowing through curved tubes inspite of their importance in the area of polymer, biomedical and biochemical processing. The study of transport phenomena of non-Newtonian fluids in curved tube will contribute substantially in designing and better understanding of the performance of coiled tube reactors/heat exchangers.

In order to provide a unified, detailed and necessary information of the transport phenomena of non-Newtonian fluids in circular curved tubes the present study has been divided into three sections:

(1) MOMENTUM TRANSPORT

This section addresses the phenomenon of steady, fully developed, isothermal, incompressible and laminar flow of power law fluids in a toroidal type coiled tube. The governing equations for fully developed laminar flow of power law fluids have been solved analytically using perturbation technique and relaxing Dean's (1927,1928) constraint. The analytical solution of velocity profiles are limited to small values of Dean number. To overcome the limitation of small Dean number (N_{De}), the phenomenon of fully developed laminar flow of power law fluids has been analyzed numerically using finite difference successive over-relaxation method. The numerically computed results are compared with published theoretical and experimental results.

(2) HEAT TRANSPORT

In this section the phenomenon of laminar forced convection of power law fluids in the thermal entrance region of circular curved tube has been investigated. The present analysis intends to shed light on the clarification of the physical mechanism involving the interaction between the secondary flow and the developing temperature fields for power law fluids. The governing equation of heat transfer for constant fluid properties, negligible free convection, viscous dissipation and axial conduction is solved numerically by using alternative direction implicit method. The numerically computed results are found to be in good agreement with the experimental correlation.

(3) MASS TRANSPORT

The present section comprises the phenomenon of axial dispersion with significant molecular diffusion for power law fluids flowing through circular curved tube. The analysis has been studied under the frame work of Taylor's dispersion theory (1953). The analytical solutions of effective diffusion coefficient which were computed using perturbation solution are restricted to the small range of Dean number and Dn^2Sc i.e. from 1 to 500 and hence the analysis has a limited application in chemical industries where normally the fluids conform to a large value of Schmidt number. To overcome the limitation of small range of Dn^2Sc the axial dispersion phenomenon of power law fluids flowing through circular curved tube has been analyzed using spectral finite difference technique. The numerical results, in general, are found to be in good agreement with the experimental data.

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