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THERMAL AND HYDRODYNAMIC CHARACTERISTICS OF FORCED AND MIXED CONVECTION FLOW THROUGH VERTICAL RECTANGULAR CHANNELS

ABSTRACT

This paper presents experimental and numerical studies for the case of turbulent forced and mixed convection flow of water through narrow vertical rectangular channel. The channel is composed of two parallel plates which are heated at a uniform heat flux, whereas, the other two sides of the channel are thermally insulated. The plates are of 64 mm in width, 800 mm in height, and separated from each other at a narrow gap of 2.7 mm. The Nusselt number distribution along the flow direction normalized by the Nusselt number for the case of turbulent forced convection flow is obtained experimentally with a comparison with the numerical results obtained from a commercial computer code. The quantitative determination of the normalized Nusselt number with respect to the dimension-less number Z = (Gr/Re21/8Pr0.5) is presented with a comparison with previous experimental results. Qualitative results are presented for the normalized temperature and velocity profiles in the transverse direction with a comparison between the forced and mixed convection flow for both the cases of upward and downward flow directions. The effect of the axial locations and the parameter Gr/Re on the variation of the normalized temperature profiles in the transverse direction for both the regions of forced and mixed convection and for both of the upward and downward flow directions are obtained. The normalized velocity profiles in the transverse directions are also determined at different inlet velocity and heat fluxes for the previous cases. It is found that the normalized Nusselt number is greater than one in the mixed convection region for both the cases of upward and downward flow and correlated well with the dimension-less parameter Z for both of the forced and mixed convection regions. The temperature profiles increase with increasing the axial location along the flow direction or the parameter Gr/Re for both of the forced and mixed convection regions, but this increase is more pronounced in the case of the mixed convection flow. For the forced convection region, the velocity profile depends only on Re with no difference between the upward and downward flow directions. Whereas, for the case of mixed convection flow, the velocity profile depends on the parameter Gr/Re with a main difference between upward and downward flow. These results are of great importance for any research reactor using plate type

fuel elements or for any engineering application in which mixed convection flow through rectangular channel is encountered.

KEYWORDS
mixed convection, rectangular channels, turbulent flow
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REFERENCES [view full list]

1. Belhaj, M., Aldemir, T., Predicting Onset of Nucleate Boiling in Plate - Type Cores under Upward Laminar Flow Conditions, Transactions of the American Nuclear Society, Vol./Issue 61 (1990), pp. 455-457
2. Elbakhshawangy, H. F., et al., Flow and Heat Transfer Characteristics through Narrow Vertical Rectangular Channels, M. Sc. thesis, Ain-Shams University, Cairo, 2003
3. Gebhart, B., et al., Buoyancy-Induced Flows and Transport , Hemisphere Publ. Corp., New York, USA, 1988
4. Sandip Dutta, et al., Adverse and Favorable Mixed Convection Heat Transfer in a Two-Side Heated Square Channel, Experimental Thermal and Fluid Science, 18 (1999), pp. 314-322
5. Nubuhide Kasagi, Mitsugu Nishimura, Direct Numerical Simulation of Combined Forced and Natural Turbulent Convection in a Vertical Plane Channel, Int. J. of Heat and Fluid Flow, 18 (1997), 1, pp. 88-99
6. Aung, W., Worku, G., Mixed Convection in Ducts with Asymmetric Wall Heat Flux, Journal of Heat Transfer, 109 (1987), 4, pp. 1039-1041
7. Hamadah, T. T., Wirtz, R. A., Analysis of Laminar Fully Developed Mixed Convection in a Vertical Channel with Opposing Buoyancy, Journal of Heat Transfer, 113 (1991), pp. 507-510
8. Abu-Mulaweh, H. I., Measurements of Laminar Mixed Convection Flow Adjacent to an Inclined Surface with Uniform Wall Heat Flux, International Journal of Thermal Sciences, 42 (2003), 1, pp. 57-62
9. Abu-Mulaweh, H. I., Armal, B. F., Chen, T. S., Measurements of Laminar Mixed Convection Flow Adjacent to a Vertical Plate - Uniform Wall Heat Flux Case, Journal of Heat Transfer, 114 (1992), 4, pp. 1057-1059
10. Karekar, D., Robert, M., Heat Transfer, West Publishing Company, Minn., USA, 1989
11. Jackson, J. D., Fewester, J., Heat Transfer and Turbulent Buoyant Convection, Hemisphere Publishing Corp. and McGraw-Hill (Ed. B. Spalding), New York, USA, 1977
12. McAdams, W. H., Heat Transmission, McGraw-Hill, New York, USA, 1954
13. Usui, T., Kaminaga, M., Combined Forced and Free Convection Heat Transfer Characteristics in a Narrow Vertical Rectangular Channel with 2.5 mm in Gap Heated from Both Sides, Journal of Nuclear Science and Technology, 26 (1988), pp. 580-590
14. Holman, J. P., Heat Transfer, Seven Edition, McGraw-Hill, Metric edition, New York, USA, 1992

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