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HEAT TRANSFER AND FLUID FLOW THROUGH A RIBBED PASSAGE IN STAGGERED ARRANGEMENT*

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Abstract– Fluid flow and heat transfer are computed through a rib-roughened duct of square cross-section. The staggered ribs are attached along the two opposite walls of the channel to augment heat transfer. Simulations are performed with an incompressible SIMPLEC finite volume collocated code. Five different versions of k-ω and k-ε turbulence models are employed. The molecular Prandtl number is 0.71 and the Reynolds number based on the bulk velocity and the height of the channel is 100000.

The predicted flow field and heat transfer show a relatively good agreement with the experimental results for different employed turbulence models, although the predicted flow field results are much better than the heat transfer results.

Employing a variable turbulent Prandtl number according to the Kays and Crawford relation shows only a small difference in the estimated turbulent heat transfer fluxes. The influence of constant turbulent Prandtl numbers ranging from 0.5 to 0.92 is also examined and it is found that it has a significant effect on the simulation results of the heat transfer.

Keywords– Rib-roughened channel, staggered ribs, heat transfer augmentation, turbulent Prandtl number

1. INTRODUCTION

In the design of thermal systems and engineering apparatus, the prediction of heat transfer and pressure drop performances is an essential task. In recent years, serious attempts have been made to achieve higher heat transfer rates in devices such as heat exchangers, cooling passage for the gas turbine blades, electronic equipment, etc. Substantial energy savings, more compact and less expensive apparatus with higher thermal efficiency are the main reasons for this demand. Vortex generation is a promising technique for heat transfer augmentation. In this method, transversal and longitudinal vortices are passively generated using tools with the vortex generators such as fins, ribs and wings. The use of the surface protuberances is a passive heat transfer augmentation method and is based on developing boundary layers or streamwise fluctuations, creating swirl or vortices and flow destabilization or turbulence intensification [1-3].

An early numerical/experimental investigation regarding the rib-roughened passage for internal cooling was made by Liou et al. [4]. Their results were used to evaluate codes and turbulence models in the 7th ERCOFTAC Workshop. Iacovides [5] performed the computation of the periodic flow and heat transfer through stationary and rotating ducts of a square cross-section, with the rib-roughened walls. The square-sectioned ribs, normal to the flow direction are employed in inline and staggered arrangements. Mean flow predictions were satisfactory while the coefficients of the wall heat transfer were not as close to data as the flow predictions. The effect of thermal boundary conditions on numerical heat transfer

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