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THE LES AND DNS SIMULATIONS OF HEAT TRANSFER AND FLUID FLOW IN A PLATE-FIN HEAT EXCHANGER WITH VORTEX GENERATORS*

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Abstract– Unsteady three-dimensional DNS and LES simulations for resolutions up to about 1.2 million points were performed to investigate the fluid flow and heat transfer in a plate-fin heat exchanger with vortex generators. The Prandtl and Reynolds numbers are 0.71 and 2000, respectively. An incompressible finite volume code based on a fractional step technique with a non-staggered grid arrangement and a multigrid pressure Poisson solver was used. From these simulations, the heat transfer and fluid flow were studied using instantaneous and time-averaged quantities such as the velocity components, pressure, vorticity, turbulent stresses, temperature fluctuations and Nusselt number. This study shows that the temperature fluctuations, the turbulent kinetic energy, and the unsteadiness effects are stronger in the regions, where the longitudinal vortices are more active. In this study, the effects of spatial resolution and the angle of incidence of the vortex generators are also investigated. A comparison between DNS and LES simulations for the present study shows that the predicted structures of fluid flow and temperature fields are similar for both methods.

Keywords– Heat transfer enhancement, vortex generators, large eddy simulation (LES), direct numerical simulation (DNS)

1. INTRODUCTION

Compact heat exchangers are widely employed in engineering applications, especially in the automotive industry, air-conditioning and refrigerant apparatus. Improvements in the design of these heat exchangers have encouraged many researchers over time to develop more compact and less expensive heat exchangers with high-energy performance. Needing high performance thermal systems has forced researchers to use different augmentation methods of heat transfer. Different mechanisms such as creating electric or acoustic fields, surface vibration, fluid additives and using a special surface geometry may be used for heat transfer enhancement, which can be classified in two groups: main-flow and secondary flow enhancement in an active or passive way [1, 2]. Methods such as electric or acoustic fields, surface vibration and mechanical devices are called active because they require external power, whereas the passive methods, which use a special surface geometry or fluid additive do not require external power. Wavy, louvers and strip fins are examples of passive main-flow enhancement methods, while flow pulsation is an active main-flow method. The use of surface protuberances is a passive secondary flow method and is based on developing boundary layers, creating swirl or vortices and flow destabilization or turbulence intensification [3]. In general, mixing the main flow, reducing the flow boundary layer, raising the turbulent intensity, and creating the rotating and secondary flow are the main reasons for the rise of heat transfer rate. A comprehensive review of the progress in passive heat transfer enhancement is found in [2-4]. In recent years, vortex generators such as fins, ribs, wings, etc have been used successfully as a powerful way for the enhancement of heat in the development of modern heat exchangers. The vortex generators are special surfaces that are used to generate secondary flow or vortices by swirling and destabilizing the flow. Due to the pressure difference between the

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