CHAPTER 1
INTRODUCTION

1.1 Motivation for Research

Extensive research efforts have been focused on reducing the consumption of nonrenewable energy. Improving the efficiency of the universal process of heat exchanger is one of such area which continues to attract a lot of attention. Enhancing the efficiency of heat transfer is useful in a variety of practical applications such as macro and micro scale heat exchangers, gas turbine internal airfoil cooling, fuel elements of nuclear power plants, power semiconductor devices, electronic cooling, combustion chamber liners, bio medical devices, etc.. . Compact heat exchangers have been one of the subjects of study for number of researchers over the recent years to improve heat exchanger performance. In a compact heat exchanger there are three important aspects of heat transfer should be considered. The first aspect is the convection of heat from the fluid to the wall of the heat exchanger. The heat is then conducted through the walls. Finally, the heat is removed from the surface by convection to the heated flow flowing over it. In air coolers, the air-side resistance to heat transfer in compact heat exchangers comprises between 70-80 percent of the total resistance and, hence, any improvement in the efficiency of compact heat exchangers is focused on augmenting the air side convective heat transfer.

1.2 General Discussion of Enhancement Techniques

Heat transfer enhancement technique play a vital role in situations at which the heat transfer coefficient are generally low. Enhancement techniques may be classified as passive techniques, which do not required external power, and active techniques, which required external power. Passive techniques, where inserts are used in the flow passage to augment the heat transfer rate, are advantageous compared with active techniques, because the insert manufacturing process is simple and these techniques can be easily employed in an existing heat exchanger. In the design of compact heat exchangers, passive techniques of heat transfer augmentation can play an important role if a proper passive insert configuration can be selected according to the heat exchanger working conditions(both flow and heat transfer conditions). Passive techniques comprise the use of corrugated surfaces, extended surfaces, baffled flow, swirled flow, fluid additives and porous media.

Active techniques include surface vibration, fluid vibration and injection. Primary, there are three popular techniques to enhance heat transfer in channels. The first type is the boundary layer disturbance that is created by periodically placed ribs on the heat transfer surface. The second is the impinged cooling that uses high velocity jets to cool the surface of interest. The last one is the internal flow swirl or tape twisters that create a significant amount of bulk flow disturbance.

Heat exchangers have several industrial and engineering applications. The design procedure of heat exchangers is quite complicated, as it needs exact analysis of heat transfer rate and pressure drop estimations apart from issues such as long term performance and the economic aspect of the equipment. The major challenge in designing a heat exchanger is to make the equipment compact and to achieve a high heat transfer rate using minimum pumping power.

1.3 Flow Phenomena inside Corrugated Passage

Corrugated passages are often used in heat exchanger systems to enhance the heat transfer rate. The enhancement of convection is most effectively achieved by limiting the continuous growth of boundary layers through periodical interruptions, separations and destabilizations. To enhance convection, periodical corrugated passage mainly rely on the generation of vortices that interfere with the growth of boundary layers by separating and, eventually destabilizing them. To reduce thermal resistances, vortices must not only separate but also recirculate the fluid between core and wall regions of the flow passage. The passage, which have streamwise periodic cross-sections, can be classified as identical modules on the streamwise direction, where the fully developed flow and temperature fields repeat periodically after a certain entrance length. This assumption enables many researchers to confine the calculation domain to cover only one of these modules without dealing with the entrance region.

1.4 Objectives of the Present Work

The objective of the present work is to study experimentally and numerically the forced convection for air flow in corrugated channels with in-phase wall corrugations for different corrugated configurations. The influence of the flow rate represented by Reynolds number(100-1000), corrugation aspect ratio(0.2-0.5), relative spacing ratio(0.5-3), cutting edge ratio (0-0.6) and corrugation shape (triangular, trapezoidal and sinusoidal) on the flow characteristics and heat transfer are presented. The results of this study are of importance for the selected corrugated plate geometry configuration for the efficient design of heat exchangers to enhance their thermal performance.

1.5 Outline of the Thesis

The thesis is divided into seven chapters. The first chapter is aimed to tie the thesis together. In chapter 2, a comprehensive review about the enhancing heat transfer using surface corrugation for both corrugated tubes and corrugated channels is presented. The description of the test rig and method of evaluation are presented in chapter 3. The description of physical problem, its mathematical model and the methodology used for obtaining a numerical solution of the problem with CFD code FLUENT 6.2 are given in chapter 4. The experimental results are discussed in chapter 5 and the numerical simulations and the model validation are presented in chapter 6. Chapter 7 highlights the significant conclusions of the present study and introduces recommendations for further extension in this field.