Experimental Study on Heat Transfer Enhancement and Pressure Drop in Fin-Tube Heat Exchangers Using Winglet Vortex Generators

ABSTRACT

The present work is an experimental study of heat transfer enhancement and pressure drop in fin-tube heat exchangers with vortex generators. This study is focused on the development of a new compact heat exchanger by enhancing the local convective heat transfer coefficient. Small triangular pieces known as delta winglet pairs are responsible for generation of artificial vortices in this work. The aim of the present work is to optimize the size and location of the winglet pairs in fin-tube arrangements. For achieving the same a special test rig was designed and developed in order to carry out experiments. Four different test models of heat exchanger were designed and fabricated to test the proposed concept. The first test model with single heater and parallel plates was used for experimental analysis of the effect of winglets size (aspect ratio) and location on heat transfer enhancement. For this purpose eight different sets of triangular pieces with various base width and height of 12mm were tested at two different flow conditions (Re = 2274 and 3050). The main parameter to be measured in this work was the temperature distribution on central fin of all the test models. For this purpose a temperature sensing grid with 23 T-type thermocouples was used for the measurement of temperature distribution. Computer aided data acquisition system was used to collect instantaneous temperature distribution.

All the winglets enhanced the local heat transfer coefficient by several hundred percent mainly in the recirculation zone. Winglet with aspect ratio of (Λ=1.33) which is responsible for the highest enhancement in heat transfer rate i.e. 44.2% and relatively low increase in pressure drop (20.03%), was selected as the best shape for the winglet.

The level of enhancement in heat transfer rate also depends strongly on the location of the winglet. In this study five different locations of the winglet pair were tested and compared with the case without winglet. Among the five locations, X = Y= 0.5D showed the highest enhancement in average Nusselt number(46.64%) and followed by the location X = 0.4D, Y= 0.6D with 42.17% . The X, and Y are measured from the center of the tube.

The test models-2, 3 and 4 with multiple heaters of three rows inline arrangement were used for the performance evaluation of new compact heat exchangers. All the forgoing test models, consist of 9 heaters and the only difference is in their blockage ratio, i.e. the ratio of transverse pitch to longitudinal pitch. The other dimensions are same in all the three test models. In case of test model-2, i.e. blockage ratio (B.R=0.75), the maximum enhancement in average Nusselt number and percentage increase in friction factor due to the presence of winglets were 53.33% and 46.4% at Re = 1366 respectively.

In case of test model –3 i.e. (B.R=0.71), the maximum enhancement in Nusselt number and friction factor were 57.16% and 28.24% at Re = 2916 respectively. The corresponding values for the case model – 4 (B.R=0.66) were 65.95% and 43%.

The conclusions that are drawn identify a plausible choice regarding the optimal size and location of the winglets. Such vortex generators show a great promise for enhancing the heat transfer rate in fin-tube heat exchangers.