CHAPTER 6

CONCLUSION AND SCOPE FOR FUTURE WORK

The investigations on heat transfer and friction factor characteristics for variant turbulators (WCCMT without bonding, WCCMT with bonding, WCCMT with bonding without centre core rod, TTP, TTPB, WC, WCT, BWCT and BWCTB) fitted in the double pipe heat exchanger have been studied and presented. According to the past studies, it is observed that there is no work carried out based on bonding the turbulator to the inner surface of the test section.

The specific contribution of the work is to study the effect of bonding the turbulator to the inner section of the test tube. And also the experiment was carried out at constant wall temperature boundary condition. The bonding of the turbulator resulting in metal to metal contact, hence there is no air gap between the turbulator and the tube, which leads to increase in heat transfer. Hence the results obtained from this research work can be used to design a condenser, oil cooler in compressor and in boiler. The variant turbulators are used based on the concept of bonding the turbulator to the inner surface of the test section (WCCMT without bonding, WCCMT with bonding with centre core rod, WCCMT with bonding without centre core rod, TTP, BTTP, WC, WCT, BWCT and BWCTB). The experiments are conducted to find the suitable one for the industrial applications. The conclusion arrived from the present work are presented in the following sections:
6.1 PLAIN TUBE

i) The plain tube data of Nusselt number and friction factor is verified with the standard correlations in order to ensure the performance of the experimental set up for turbulent flows. The maximum deviation observed for experimental Nusselt number and friction factor is ±12% and ±15% with the standard correlations values respectively.

ii) In addition, the plain tube correlations derived from the experimental results are found to represent the experimental data within ±5% for Nusselt number and ±7% for friction factor respectively.

6.2 VARIANT TWISTED TAPE WITH PINS (TTP)

i) The tape with lower twist ratio (y/w = 3.33) offered higher heat transfer enhancement than that of tape with higher twist ratio (y = 4.4 and 6.0) because the residential time of flow increases with stronger swirl level which causes the flow has more time to exchange the heat between the core and the wall.

(ii) The correlations are developed by fitting the TTP turbulent experimental data within ±9% & ±8% for Nusselt number and friction factor respectively.

6.3 VARIANT BONDED TWISTED TAPE WITH PINS (TTPB)

In general, TTPB yields higher enhancement in heat transfer due to bonding the twisted tape to the wall of the test section. Due to the bonding
there is increase in heat transfer in radial direction and hence there is increased convective heat transfer inside the test tube. Beside the above mentioned reason the twisted tape also disturbs the boundary layer thickness near the wall of the test section, which also leads to improved convective mode of heat transfer, and also it creates disturbance to the main swirl flow and there by developing secondary flow along the main swirl flow. Due to the above mentioned reason there is increase in heat transfer when compared to plain tube and tube fitted with TTP.

6.4 VARIANT WIRE COILED COIL MATRIX TURBULATORS

i) In comparison with WCCMT without bonding, WCCMT with bonding with centre core rod results in enhanced heat transfer because of increased heat transfer in the radial direction.

ii) In comparison made among the WCCMT with bonding with centre core rod gives increased heat transfer when compared with WCCMT with bonding without centre core rod, but the pressure drop for WCCMT with bonding without centre core rod is less when compared to Bonded WCCMT with centre core rod. The percentage decrease in friction factor for WCCMT without center core rod when compared with the WCCMT with centre core rod is 16.5% for P/D=0.23, 18% for P/D=0.45 and 21.5% for P/D=0.68. This is due to the fewer blockages to the water flow and there is more area for the water to flow inside the tube. The percentage increase in heat transfer for bonded turbulators with rod is about 14% when compared with bonded turbulator without rod. This is due to the secondary motion created by the turbulator and increased heat transfer in radial direction.
6.5 VARIANT WIRE COIL TURBULATORS

(i) The enhancement in heat transfer is high for BWCTB when compared to other wire coil turbulators. This is due to the tangential velocity component and lower flow cross sectional area, the mixing of fluid between fluid at the wall region and fluid at the core region induced by the generated centrifugal force has significantly ability to enhance the heat transfer. And also due to the effect of increased convective heat transfer inside the test tube because the BWCTB turbulator disturbs the boundary layer near the wall and also there is increase in heat transfer in radial direction due to bonding.

(ii) The percentage increase in heat transfer of BWCTB (P/D=0.697) when compared to BWCT of same P/D=0.697 is 8.66%.

(iii) The percentage increase in friction factor for BWCTB of P/D=0.697 is only 1.74% when compared to BWCT of P/D=0.697. The augmentation of heat transfer is very high than the increase in pressure drop for BWCTB (P/D=0.697) when compared to BWCT of P/D=0.697. This difference due to the increase in heat transfer in radial direction due to the bonding of the turbulator.

(iv) The percentage increase in heat transfer is lower for WC of P/D=1.86 when compared to all the other wire coil turbulators. The percentage increase in heat transfer for WC (P/D=1.86) is about 4.5%. This is due to less turbulence intensity created by the turbulator.
CONCLUDING REMARKS

In a nutshell, all the variant turbulators provided better enhancement in heat transfer than plain tube in turbulent flow conditions. In the group of variant turbulators used in the present work wire coiled coil matrix turbulator bonded to the inner surface of the test section provides highest heat transfer in turbulent flow conditions due to the effect of increased turbulence which improves fluid mixing near the wall of the test tube and also due to increased heat transfer in the radial direction. Therefore WCCMT with bonding can be used in place of plain tube to reduce the size of heat exchanger for industrial applications.

6.6 SCOPE FOR FUTURE WORK

(i) By using the same set of turbulators, heat transfer augmentation for various fluids can be studied.

(ii) Instead of using steam as isothermal source to maintain constant wall temperature hot water can be used as isothermal source.

(iii) These variant turbulators can be used for heat transfer augmentation studies also in refrigeration system.

(iv) For the same set of turbulators, heat transfer and friction characteristics can be studied for laminar flow condition.