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RESEARCH ARTICLE OPEN ACCESS

Heat Transfer Enhancement in Heat Exchangers Using Turbulator

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ABSTRACT:
A heat exchanger is a device facilitating the convective heat transfer of fluid inside the tube. Heat transfer augmentation using twisted tape or coiled wire sometimes called “turbulator”, are experimentally investigated in the present work. Experiments are performed for Reynolds number ranging from laminar to turbulent. Heat transfer without turbulator is compared with heat transfer with turbulator. The experimental results reveal that use of turbulator leads to increase in heat transfer and friction loss over those of without turbulator.

Key Words: Convective heat transfer coefficient, Turbulator, Nusselt Number, Reynolds Number, Turbulent flow.

I. INTRODUCTION

The convective heat transfer of fluid inside the heat exchanger tubes is extensively used in many engineering applications, such as thermal power plants, chemical processing plants, air conditioning equipment, refrigerators, and radiators for automobiles. To date, attempts have been made to reduce the size and cost of heat exchangers. In parallel flow energy is transferred along the length from the hot to the cold fluid so the outlet temperatures asymptotically approach one another. The other is counter flow where the two streams enter at opposite ends of the heat exchanger and flow in opposite directions. Temperatures within the two streams tend to approach one another in a nearly linearly fashion resulting in a much more uniform heating pattern.

Parallel flow results in rapid initial rates of heat exchange but rates rapidly decrease as the temperatures of the two streams approach one another. Counter flow provides for relatively uniform temperature differences and, consequently, lead toward relatively uniform heat rates throughout the length of the unit. Experimental setup has been fabricated and a series of experiments conducted to know the friction factor and Nusselt number variation with Reynolds number.

1.1 Turbulent Flow:

Fluid flow in which the fluid undergoes irregular fluctuations, or mixing. The speed of the fluid at a point is continuously undergoing changes in magnitude and direction, which results in swirling and eddying as the bulk of fluid moves in a specific direction. In case of a circular pipe if 3000<= Re <= 5x10^6.

II. OBJECTIVE OF PROJECT:

Heat transfer augmentation using turbulator. To performance evaluation criteria to assess the real benefits using turbulators are determined. To generate a more compact and economic Heat Exchanger with lower operation cost can be obtained

III. EXPERIMENTAL APPARATUS AND METHODS

A double pipe heat exchanger with provision to permit cold water in the annulus in opposite directions is available. Hot water from the geyser flows through the inner tube. The heat transfer takes place across the wall of the inner tube. The cold water in the annulus is made to flow in the direction of hot fluid, which is the parallel flow. This experiment can be made using either parallel or counter flow operation. This experiment was conducted as parallel flow operation.

Fig 1: experimental setup in working condition

Fig 2: Brass Tube

3.1 PROCEDURE:

Configure the experiment for parallel flow heat exchanger operation. Set the required cold water mass flow rate to 2 lpm constant . Repeat this for mass flow rate, of 1.6, 1.4, 1.2 etc for hot water. Record the temperature readings in the table.Now set the required cold water mass flow rate Mc to 1 lpm constant. Initially set the hot water mass flow rate Mh to 0.8 lpm. Wait until 5 minutes before the four temperature readings are recorded. Repeat this as above and record the temperatures in the table. After finish up the experiment, turn OFF the heating elements, close the valve for hot and cold water. In heat transfer with turbulators, circular coil springs are inserted in the inner tube. With the presence of these coils springs, turbulence occurs inside the tube and heat is transferred. The diameters of inner and outer tubes are same as of the simple heat transfer. The heat transfer area is also the same. Each circular coil insert diameter is of 3 mm and 1600.2 mm long approx. Repeat the procedure with turbulator.

Fig 3: Inner tube with turbulators

Fig4: Turbulator used

IV. RESULTS AND DISCUSSION

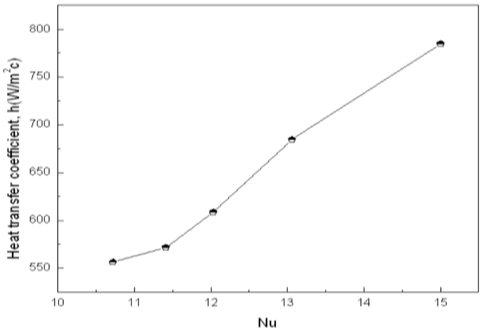

Fig 5: h vs Nu for 2lpm (without turbulator)

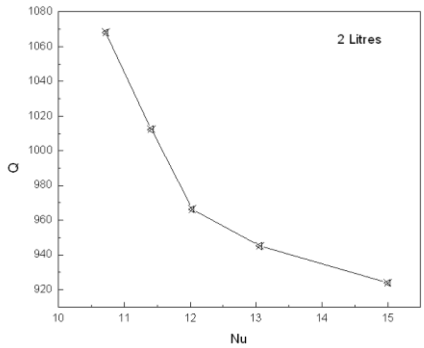

Fig 6: Q Vs Nu (without turbulator)

The rate of Heat Transfer coefficient from heat exchanger with Nusselt number for mass flow rate 2 lpm is shown in fig.5. As expected, the heat transfer coefficient increases gradually with increase in Nusselt number due to higher mass flow rate. It is also observed that the heat transfer coefficient increases with increasing values of Nu, at a particular value of Q.

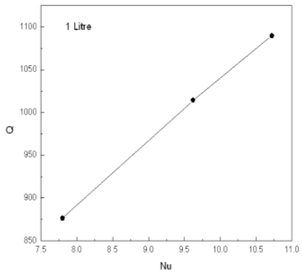

Fig 7: Q Vs Nu 1 lpm (without turbulator

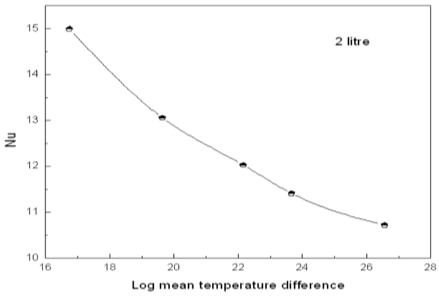

Fig 8: Nu vs LMTD (without turbulator)

The rate of Heat transfer from the fluid with Nusselt Number is shown in Fig 7, as expected the Heat transfer rate decreases gradually with increase in Nusselt number as difference of temperature is higher. It is also observed that the Heat transfer rate decrease with increase in values Nu at higher mass flow rate of fluid. The rate of Heat transfer from the fluid with Nusselt Number is shown in Fig 7, as expected the Heat transfer rate increases gradually with increase in Nusselt number as difference of temperature is higher. It is also observed that the Heat transfer rate increase with increase in values Nu at lower mass flow rate of f

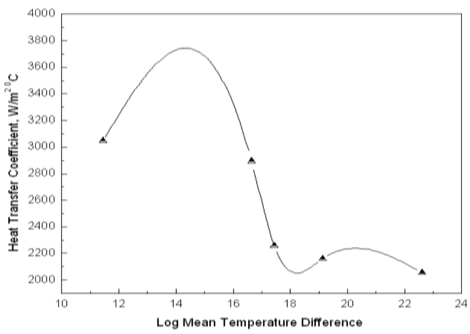

Fig 9: h Vs LMTD for 2 lpm

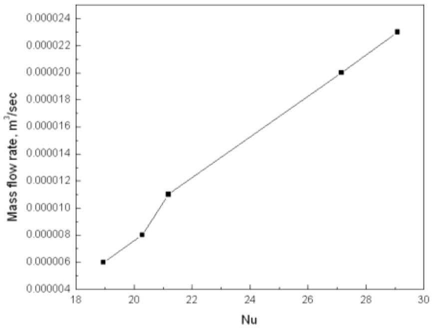

Fig 10: m Vs Nu (with turbulator)

Fig 8 shows that the effect of Nusselt Number with logarithmic mean temperature difference. It is observed from Fig 8 Nusselt Number decreases gradually with increase in logarithmic mean temperature difference due to temperature difference in fluids is higher. It is also observed from Fig 8 decrease in Nusselt number with increase in logarithmic temperature difference at all points, this may be obtained without turbulence method only.

The rate of Heat transfer coefficient from hot fluid with log mean temperature difference for mass flow rate of 2 lpm is shown in Fig 9. As expected, the rate of Heat transfer coefficient gradually decreases with increasing in Log mean temperature difference due to difference of fluid at inlet and outlet is high. It is also observed that minimum value in log mean temperature difference is obtained at lower Heat transfer rate. This may be because of with turbulence intensities at the outlet.

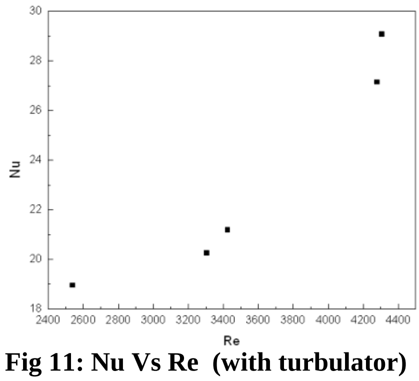

Fig 11: Nu Vs Re (with turbulator)

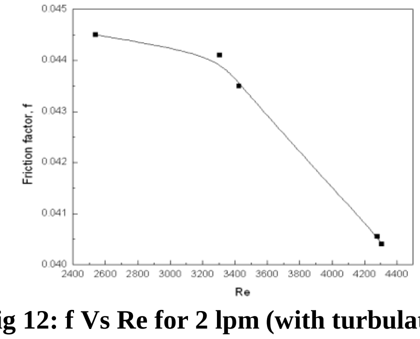

Fig 12: f Vs Re for 2 lpm (with turbulator)

Fig11 shows that variation of mass flow rate with Nusselt Number. It is observed from Fig10 that increases in mass flow rate increases Nusselt number due to Heat transfer Coefficient of fluid is high. It is also observed from Fig10 the Nusselt number is drastically increasing as the flow is turbulent. Effect of Nusselt Number with Re as shown in Fig 11.It is observed from the Fig 11 increases of Nusselts number with increase of Reynolds Number. It is also observed from Fig 11 the mass flow rate of the fluid increases the Nusselts Number is drastically increasing due to increase of velocity of a fluid flow

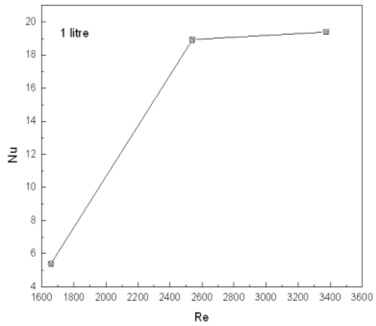

Fig 13: Nu Vs Re 1 lpm (with turbulator)

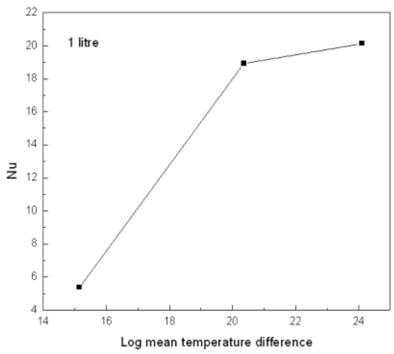

Fig 14: Nu Vs LMTD 1 lpm (with turbulator)

Fig 12 shows that increase of Reynolds number results in the decrease of Friction Factor. It is observed from Fig 12 Friction Factor is drastically decreasing due to increase in Reynolds Number. It is also observed that experimental values are good agreement with the standard correlation equation of friction factor .Variation of Nusselt number with Reynolds Number at mass flow rate of fluid at 1 lmp is shown in Fig 13. It is observed from the Fig 13 maximum Nusselt Number is obtained at maximum Reynolds Number i.e. Re = 2500. It is also observed from the fig the Nusselt Number is decreasing due to mass flow rate of fluid.

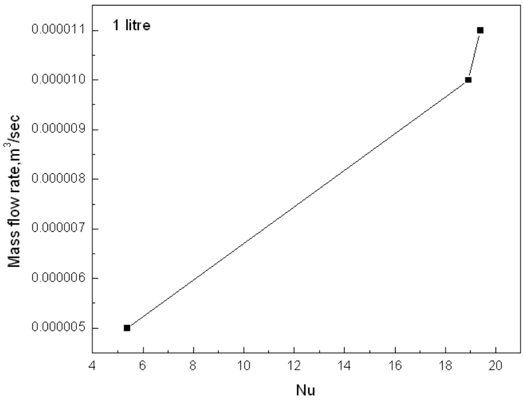

Fig 15: m Vs Nu 1 lpm (with turbulator)

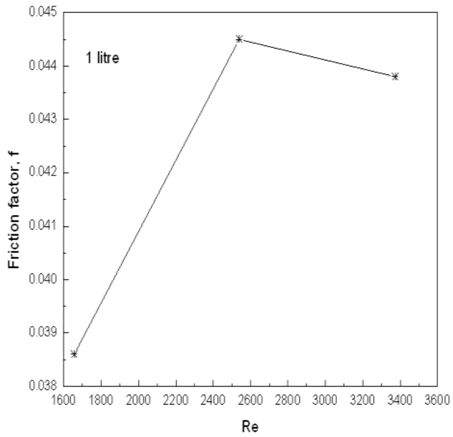

Fig 16: f Vs ReS for 1 lpm (with turbulator)

Fig 14 shows the variation of Nusselt Number with LMTD.It is observed from the Fig 14 increase in Nusselt Number, increase in Difference between the temperatures of the fluid in Logarithmic mean temperature case. It is also observed from Fig 14 increase in Heat Transfer Coefficient decrease in Logarithmic mean temperature values due to, decrease in mass flow rate of fluid flow Fig 15 shows mass flow rate with Nusselt Number. It is observed from Fig 15 increase in Reynolds number results in increase of mass flow rate due to increase in velocity of a fluid flow. It is also observed that at certain Reynolds Number, the mass flow rate is constant, after that it becomes constant as the flow becomes laminar

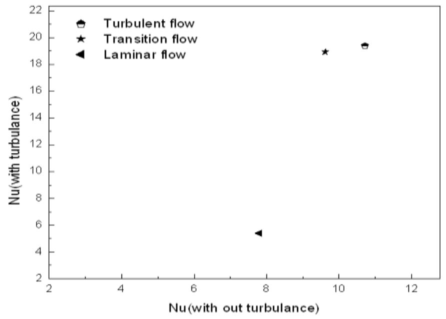

Fig 17: Nu Vs Nu for different flow

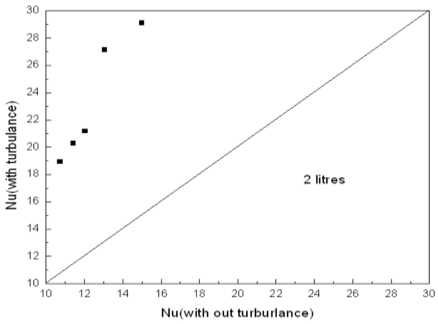

Fig 18: Nu Vs Nu for mass flow rate Of 2 lpm

Fig16 shows that increase of Reynolds number results in the increase of Friction Factor. It is observed from Fig 16 Friction Factor increases with increase in Renoylds Number and decreases, due to mass flow rate of fluid. It is also observed that experimental values are good agreement with the standard correlation equation of Friction factor. Fig 16 illustrates the effect of Nusselt Number with turbulence on Nusselt number without turbulence for different flows. It is observed from Fig 17 Nusselt Number with turbulence increases with increase in Nusselt Number without turbulence due to higher Reynolds number. It is also observed that maximum value is obtained in Nu (with turbulence) and Nu (without turbulence) in turbulent flow only, resulting in higher value of Reynolds number.

Fig 18 shows the effect of Nusselt Number with turbulence on Nusselt number without turbulence for mass flow rate of 2 lpm. It is observed from Fig 18, all experimental values shows good agreement between Nu (with turbulence) with Nu (without turbulence). It is also observed from Fig 18 that experimental values are good agreement with mass flow rate of 2 lpm

V. CONCLUSIONS:

Experiment was performed to investigate heat transfer characteristics with turbulator for different regime. Use of turbulator causes high heat transfer augmentation. According to Pongjet Promvonge, enhancement efficiency which is the ratio of heat transfer coefficient of an augmented surface to that of a smooth surface with air as cooling medium is 220% - 265%

In present investigation, water at room temperature is used as cooling medium, for which heat transfer coefficient enhancement efficiency is 355%-422%. Nusselt number ratio is 1.63-2.07

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