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Experimental Investigation of Enhanced Heat Transfer of Viscous Fluid in an Oil Cooler using Wireloop Tube Inserts

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Abstract: The present work is an outcome of experimental work carried out to identify the enhancement ratio by insertion of wire loop tube inserts in an oil cooler on tube side carrying viscous oil.Hence usage of enhanced heat transfer techniques by inserting wire loop inserts on the tube side can enhance the heat transfer coefficient by about 3-4 times and the size of the heat exchanger can be reduced.

Keywords: Reynolds number,Nusselt number,Prandtl number, Rate of heat transfer, heat transfer coefficient, wireloop tube inserts,enhancement

I. Introduction

Arthur E.Bergles [1] emphasizes on enhancement techniques using Swirl flow devices including vortex generators, twisted-tape inserts, and axial core inserts with screw type windings.
The rapid growth of world literature on this subject indicates that enhancement is now a major specialty area in heat transfer research and developments energy and material shortages become more important factors in the overall cost of thermal systems, industrial utilization of enhancement will increase. Enhancement of heat transfer coefficient by various types of tube inserts like Twisted tape inserts, Helical coiled inserts, Core rods and wire matrix elements is associated with increase in the pressure drop pressure drop. Sacrificing velocity of tube side fluid can reduce increase in the pressure drop associated with increase in heat transfer coefficient. G.T.Polley [2] S.B.Uttarwar and M.RajaRao [3] presented the comparisons of enhanced heat transfer coefficients for wire coil inserts of different Geometrical variants and also the correlation for Nusselt number in wire-coil insert tubes. An important feature was observed in the case of laminar flow heat transfer augmentation is that the net improvement in the heat transfer coefficient is much greater than that observed for turbulent flow heat transfer. To assess the benefit of using enhancement techniques like Twisted tape, wire coiled and helically coiled ribbons as tube inserts in smooth pipes extended performance evaluation criteria (PEC) have been implemented at different constraints by Zimparov and Penchev[4].

II.. Heat Transfer Enhancement Techniques

The heat transfer enhancement technology provides many advantages in heat exchanger applications.
In recent years, it had been widely applied to heat exchanger applications in Refrigeration, automotive, process industries etc. Webb[5], Bergles[6],Kalinin et al.[7].
From Newton's law of cooling, the rate of heat transfer to or from a fluid flowing in a tube can be expressed as

$$Q = h_{*}A_{s*}\Delta T_{ave}$$

Where 'h' is the average heat transfer coefficient
'A_s'is the heat transfer surface area(it is equal to ΠDL for a circular pipe of length L and diameter D)
'ΔT_{ave}'is some appropriate average temperature difference between the fluid and the surface.
From the above equation, 'Q' can be increased by increasing 'h' or by increasing 'A_s'
Hence, enhanced heat transfer[1] can be achieved by two methods . They are by
i)Enhanced surfaces and by
ii)Enhanced heat transfer coefficient.In the present work,enhancement of heat transfer coefficient is achieved by using turbulence promoters called wire loop tube inserts are used.

III. Methodology & Equipment

Equipment include shell and tube heat exchanger,water pump, oil pump with all necessary instrumentation for measuring flow rates, temperatures ,pressures and a data logger were used
Experiments were conducted with and without wire loop inserts at different oil flow rates maintaining the oil inlet temperature as 55°C, 70°C & 85°C.
Tube Side Fluid: Oil (ISO-VG-32 grade)
Shell Side Fluid: Water
The various parameters monitored and recorded are as follows

- Oil tank temperature
- Oil flow rate

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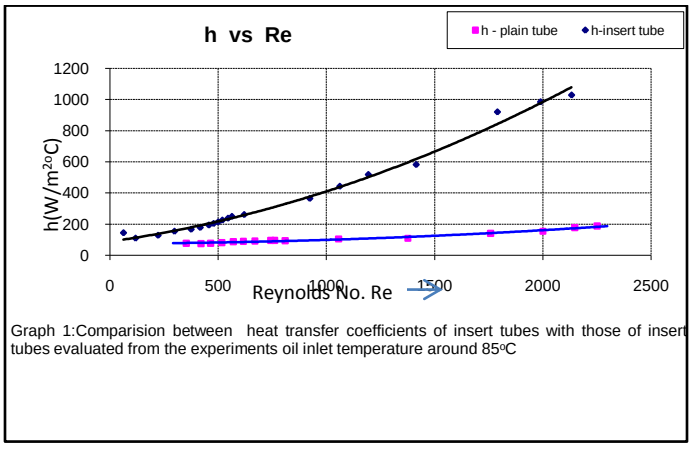
- Water flow rate
- Water inlet temperature
- Water outlet temperature
- Oil inlet temperature
- Oil outlet temperature
- Oil inlet pressure
- Water inlet pressure
- Differential pressure across heat exchanger
- Tube wall temperatures at different locations

The above obtained values are substituted in the formulae available both theoretical and Experimental values for calculation of rate of heat transfer(Q), heat transfer coefficient(h), non dimensional numbers (Re,Pr,Nu).Heat transfer coefficients obtained for insert tubes and plain tubes are tabulated and Graphs are plotted as shown below



Graph 1:Comparision between heat transfer coefficients of insert tubes with those of insert tubes evaluated from the experiments oil inlet temperature around 85°C

TABLE 1Comparison of heat transfer coefficient of insert tubes with plain tubes wrt Reynolds numbers

IV.Observations & Conclusions

In insert tubes compared to plain tubes tube side heat transfer coefficient and hence Nusselt numbers have enhanced by1.7-5.5 times with Reynolds numbers from 350 -2100 from the experiment with oil inlet temperature around 85°C.

hinserts	166.2	225.06	260.58	364.31	442.14	581.34	983.87	1027.6
hplain	76.85	82.03	90.23	93.41	105.11	108.9	154.31	178.5
Re	350	520	615	850	1060	1400	1900	2150

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