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EXPERIMENTAL STUDY ON FABRICATION OF FINNED TYPE COUNTER FLOW HEAT EXCHANGER

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Abstract:

Heat transfer enhancement is an active and important field of engineering research since increase in the effectiveness of heat exchanger through suitable heat transfer augmentation techniques. The double pipe heat exchanger is a device used to transfer heat from hot fluid from cold fluid. In which the inside tube carrying hot water and outside tube carrying cold water. Considerable enhancements were demonstrated in the present work by using numbers of rectangular fins fitted over inner tube along its length. For various increase surface area the rate of the heat transfer was calculated theoretically by logarithmic mean temperature difference method. It is show that the suggested method of heat transfer enhancements is much more effective than existing methods, since in an increase in the heat transfer co-efficient. The aim of augmentation heat transfer is to reduce the size and cost of the heat exchanger.

Key Words: Fins, Heat Exchanger, Heat Transfer Coefficient, Fluids & Logarithmic Mean Temperatures.

1. Introduction:

In cold or arctic climates, it is often difficult to get at traditional mechanical ventilation system to function as intended during the long winter. The ventilation heat loss without heat recovery is significant due to the large number of degree days and draft will also cause problems. If the outdoor air in cold regions is ventilated directly into the building through openings or diffusers, the occupants will normally feel draft because of the very low outside temperature. This is probably the reason why occupants often block the ventilation openings resulting in poor indoor climate and higher risk for moisture problems. Continuous moisture problems will typically cause damage to the building, e.g. as rot or mould fungus, which have been documented several times to be unhealthy for human beings.

Heat exchangers are devices used for effecting the process of heat exchange between two fluids are at different temperatures. Heat exchanger are used in various industrial applications and are devices that are installed to permits the heat transfer of thermal energy between two or more fluids at different temperatures without having direct contact .

A periodic flow type of heat exchanger is called a regenerator. Therefore the thermal designing of heat exchangers can be based on the knowledge gained. Comprehensive treatment of heat exchanger design will involve many factors besides the heat transfer analysis like size, weight, structural strength, pressure drop and cost. Heat can transfer between the surface of a solid conductor and the surrounding medium whenever temperature gradient exists.

a. Conduction
b. Convection
    i. Natural Convection
    ii. Forced Convection

1.1. Heat Exchanger:

Heat exchanger is a device which transfers the heat from a hot fluid to a cold fluid. These are devices the mostly employed in areas of power production. One simple example of a heat exchanger is cooling tower. The Heat exchanger process in Heat exchanger can be described by the principles of conduction, convection, radiation and evaporation. Heat exchangers are of various types and they are classified on the following basis. Here we are going to discuss only about the relative directions of the fluid Motion.

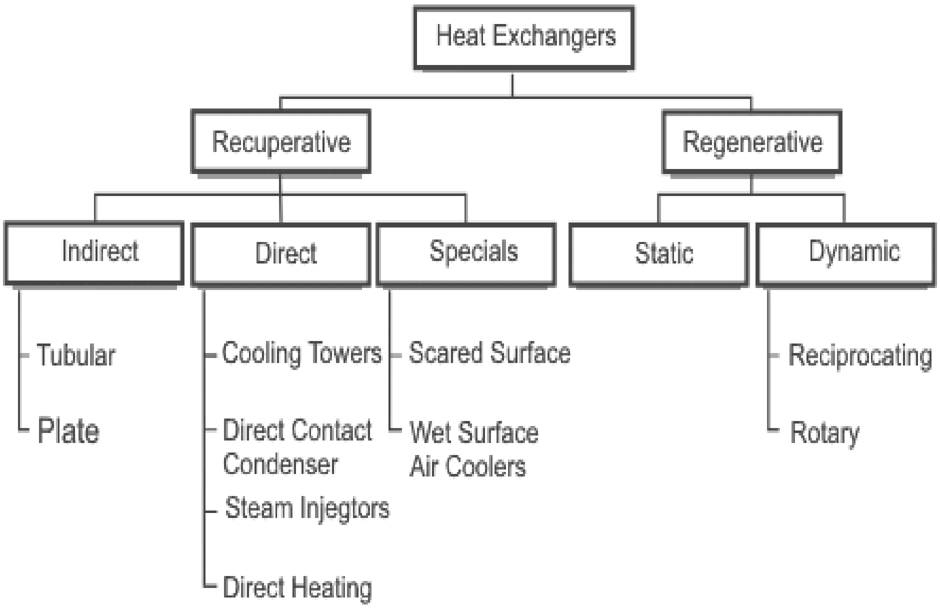

Figure 1: Types of heat exchangers

1.2. Design of Heat Exchanger:

The heat of hot gases from the incinerator is recovered by passing through the shell and tube – heat exchanger. The different types of the heat exchanger were discussed in the previous chapter. In this topic the design considerations while designing the heat exchanger are discussed.

The main consideration that taken into account in the design of heat exchanger for the particular application are

a) Thermal design
b) Mechanical design
c) Hydraulic design

1.2.1. Thermal Design:

It is primarily concerned with the determination of the heat transfer surface area revised to the heat transfer at specified rate for the given flow rates and temperatures of fluids.

1.2.2. Mechanical Design:

The mechanical design involves the consideration of operating temperature and pressure. The tube hoses cannot be drilled very closed together since it weakness the tube sheet there by the strength of the tube sheet is reduced. The corrosive characteristic of one or both fluids may play an important role in the mechanical design of a heat exchanger.

1.2.3. Hydraulic Design:

The hydraulic design involves with the pressure drop in the shell side and tube side. By the definition of hydraulic radius corresponds to the area of a circle equivalent to a non- circular flow cannel and consequently in a right angles to the direction of flow. The equivalent diameter for the shell is four times the hydraulic radius for the given pattern.

De = 4 * free area / wetted area.

2. Experimental Procedure:

In the experience, the temperature T1, T2, T3, T4 are noted, after achieving the constant flow rate. The flow of water is varied by adjusting the value, for various flow rate, the inlet and outlet of the hot and cold water temperatures were noted for doing calculation.

Where, T_{hi} = hot water inlet.

T_{ho} = hot water outlet.

T_{ci} =cold water inlet.

T_{co} = cold water outlet

2.1. Rectangle Fin Type Heat Exchanger:

Rectangle fin exchanger is a type of compact heat exchanger where the heat transfer surface area is enhanced by providing the extended metal surface interface between the two fluids and is called as the fins. Out of the various compact heat exchangers, rectangle-fin heat exchangers are unique due to their construction and performance. They are characterized by high effectiveness, compactness, low weight and moderate cost. As the name suggests, a rectangle fin heat exchanger (RFHE) is a type of compact exchanger that consists of a stack of alternate flat plates called 4 parting sheets and corrugated fins brazed together as a block. Streams exchange heat by flowing along the passages made by the fins between the parting sheets. Separating plate acts as the primary heat transfer surface and the appendages known as fins act as the secondary heat transfer surfaces intimately connected to the primary surface. Fins not only form the extended heat transfer surfaces, but also work as strength supporting member against the internal pressure. The side bars prevent the fluid to spill over and mix with the second fluid. The fins and side bars are brazed with the parting sheet to ensure good thermal link and to provide the mechanical stability. Arranged together in a monolithic block to form a heat exchanger.

2.2. Fin Materials:

Rectangle fin heat exchangers are generally, made from an alloy of aluminum or stainless steel. However, the process temperature and pressure dictates the choice of the material. Aluminum alloys are particularly suitable for low temperature applications because of their low weight and excellent ductility and increasing strength under such conditions. In general, the fins or secondary surfaces and the side bars are usually joined to the separating plate by using dip brazing technology or more recently vacuum brazing technique. In our project set we use only fin material is copper because its thermal conductivity is high, hence they reduce heat from the hot body effectively. Figure 2 shows the rectangular fins arrangement on inner circular pipe.

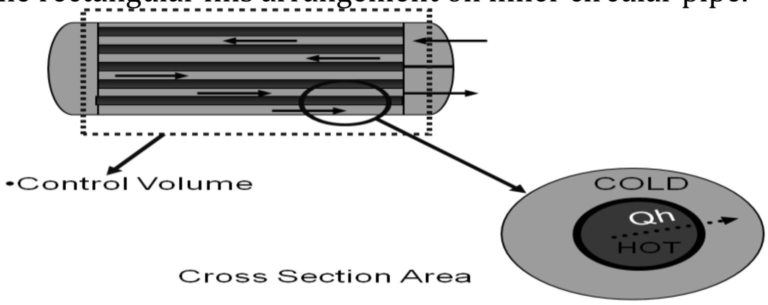

Figure 2: Schematic Representation of Rectangular Fins Arrangement on Inner Circular Pipe

3. Experimental Setup:

The setup consists of a inner tube and an outer tubes. The inner tube is provided with an external fin, to improve the active surface area.

The total length of the inner pipe is 1500mm.

The total length of the outer pipe is 1050mm.

The inner and outer diameter of inner pipe are d_{in}, d_{out} in millimeter

Both the inner and outer pipe are made of (G.I)

The outer tube is insulated with cotton rope to minimize heat loss to the surroundings. Four thermometers are used to measure the inlet and outlet temperature of the hot and cold water. A 3kw water heater is used to heat the cold water from the sump or from the storage tank. Figure 3 and 4 shows the schematic representation of front view, top view and side view of inner tube of heat exchanger.

Figure 5 shows the complete experimental setup in which the investigation was conducted to determine the effective heat transfer.

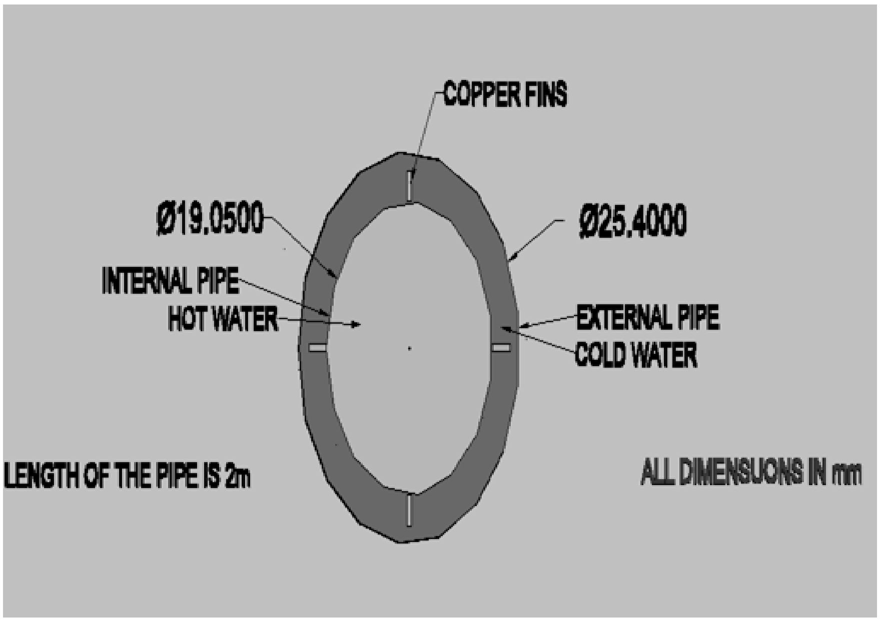

Figure 3: Schematic Representation of Front View of Inner and Outer Tube of Heat Exchanger.

Figure 4: Schematic Representations of Top View and Side View of Heat Exchanger

Figure 5: Schematic Representation of Full Experimental Setup

3.1. Design Calculation for Selection for Pipe Diameter:

Diameter of supply pipe: 1”
Radius r = D/2 = 0.5”
Cross section of surface pipe $A = \pi r^2$
Substituting THE VALUE: $A=\pi*25.4^2=506mm^2$
Diameter of inner pipe = ¾”
Diameter of external pipe = 2”
Area of cold water flow $= \pi(D^2 - d^2) = 1741mm^2$
Area of each fin = $6*6 = 36mm^2$
Total area of fins = Area of each fin * Number of fins =4 * 36 =$144mm^2$
Active area of cold water flow = 1741- 144 =$1597mm^2$

For the sake of continuous flow, the velocity of cold water is kept less than that of the velocity of the supply pipe..

Velocity of cold water = ¼ (Velocity of supply velocity)
Quantity of water required per unit time = 1597mm3
Quantity of water available per unit time = 506 * 4 =$2024mm^3$
Available Quantity ≥ Required Quantity
2024≥1597

Hence, the design is safe.

3.2. Formula Used for Calculations:

Nusselt number, $Nu=0.023*Re^{0.8}*pr^{0.4}$
Heat transfer co-efficient $h_i= (Nu*k/d)$
Logarithmic mean temperature difference
$(LMTD)= ((T_{hi}-T_{co})-(T_{ho}-T_{ci}))/\ln((T_{hi}-T_{co})/(T_{ho}-T_{ci}))$
Heat transfer rate $Q= u_o A \Delta T$
Where A is area of heat transfer
$A=\pi dL$
Where u_o is over all heat transfer rate $u_o=1(1/h_o+((r_o/k)\ln(r_o/r_i))+(r_o/r_i)1/h_i)$
Heat transfer rate $Q=u_o A \Delta T$

3.3. Tabulation for Plain Pipe:

Table 1: Experimental Reading for Plain Pipe

S. No	Hot Water Inlet Temp (T_{hi}) °C	Hot Water Outlet Temp (T_{ho}) °C	Cold Water Inlet Temp (T_{ci}) °C	Cold Water Outlet Temp (T_{co}) °C	Time For Hot Water Per 1 Litre (Th)	Time For Cold Water Per 1 Liter (Tc)
01	54	52	37	40	18	08

3.4. Tabulation for Pipes with Fins:

Table 2: Experimentation Readings for Pipe with Rectangular Fins

S. No:	Hot Water Inlet Temp (T_{hi}) °C	Hot Water Outlet Temp (T_{ho}) °C	Cold Water Inlet Temp (T_{ci}) °C	Cold Water Outlet Temp (T_{co}) °C	Time For Hot Water Per 1 Litre (Th)	Time For Cold Water Per 1 Liter (Tc)
01	54	46	35	38	18	08

The experimentation was carried out on the two different heat exchangers, in that one having a plain inner pipe and another one having a fin attached inner tube. From both the experiments the readings are taken for the observation and listed in the Table 1 and 2 which is given above. From the table we have clearly seen the temperature of the hot water outlet is considerably reduced in the fin type heat exchangers. By using the formulas the theoretical calculations for the heat transfer also made. And determines the overall heat transfer by the fin type heat exchanger is 1453.5J and the plain type heat exchanger's heat transfer is 1017.5J. This shows the contribution of the rectangular fins in the effective improvement of heat transfer.

The rectangle-fin heat exchanger is suitable for use over a wide range of temperatures and pressures for gas-gas, gas-liquid and multi-phase duties. They are used in a variety of applications. They are mainly employed in the field of cryogenics for cryogenic separation and liquefaction of air, natural gas processing and liquefaction, production of petrochemicals and large refrigeration systems.

4. Conclusion:

The work of designing a high effective heat exchanger capable of continuously defrosting itself seems to be successful. Good accordance between the calculated and measured efficiency was found at dry condition. The design criteria of a simple construction and cheap materials were full filled, which gives the possibility of local production in the arctic regions. The volume of the exchanger could be a barrier and therefore further development/optimization of the design is necessary (minimizing the volume).Further development could be an integration of the unit in the building envelope or an improved controlling system that gives the possibility of controlling the section switch time as a function of the inlet temperature. Also, the distribution of the extracted air flow (90% and 10%) when defrosting could be optimized.

5. References:

1. H. Tommerup, S. Svendsen, "Ventilation with heat recovery", Proceeding of the Seventh Nordic Symposium on Building Physics in Nordic Countries, vol. 2, Technical University of Denmark, pp 756-765, 2005.
2. P.T. Ninomura, R. Bhargava, "Heat recovery ventilators in multifamily residences in the arctic", Ashrae Transactions, Vol.5, pp 961–966, 1995.

3. E.G. Phillips, R.E. Chant, D.R. Fisher, B.C. Bradley, "Comparison of freezing control strategies for residential air-to-air heat recovery ventilators", ASHRAE Transactions, Vol.11, pp 565-574, 1989.
4. J. Kragh, J. Rose, S. Svendsen, "Mechanical ventilation system with heat recovery in cold climates", Proceeding of the Seventh Nordic Symposium on Building Physics in Nordic Countries, vol. 2, Technical University of Denmark, pp 765-775, 2005.
5. Barron R.F, "Cryogenic Heat Transfer", Taylor and Francis, Vol.10, pp 311-318, 1999.
6. Shah R. K. and Sekulic D. P,"Fundamentals of Heat Exchangers", John Willey & Sons Inc. Vol.8, pp 10-13, 1993.