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REVIEW ON HEAT TRANSFER THROUGH DIFFERENT TUBES AND PLATES USING WATER

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ABSTRACT

This paper deals with experiments performed on heat transfer through various tubes and plates using water and its various constituents. The heat transfer rate depends on different surface areas of the materials used. Here in these experiments the tubes and plates were exposed to different temperatures (outside temperature i.e. Atmospheric and temperature of water as well) and the rate of heat flow was measured at different temperatures. Heat transfer Coefficient varies with the temperatures. It may increase or decrease. So these differences in values were due to different heat transfer coefficients. Characteristic time plays very important role here. The change in flow of heat was measured at different intervals and the time was noted down. Experiments were performed using various setups and for each setup its actual thermal efficiency was calculated. The reason behind this calculation was to check the validity of results that were obtained by using various dimensionless numbers. The results obtained were within the range of actual thermal efficiencies. The numbers without dimensions like Nusselt Number, Reynold's Number, Prandtl Number etc, were used to calculate heat transfer rate through various tubes and plates. For the first performance, experiments were carried out using a simple tube or a plate exposed to given temperature and pressure and then at same temperature and pressure special tubes (for e.g. twisted tapes, helical etc) and plates. The observations were noted down for both the cases. Thus with the help of calculated thermal efficiency and observations from both the cases various results were obtained. The heat transfer rate values for both cases were compared. With the analysis of different results the researchers concluded by comparing heat flow rate of water in special tubes or plates to that heat flow rate in simple tubes and plates. For different type of water, heat fluxes given to the materials used were different. The heat flux given was controlled by A.C Power Supply.

I. INTRODUCTION

According to Modern Theory of Heat - "Heat is a form of Energy. Temperature is proportional to the mean kinetic energy of the substance. Aristotle said that, "Fire" was one of the four primary elements. Plato considered Heat to be a motion of particle. Therefore there are two theories of heat which explains the following facts: Heat is consumed when there is exchange of heat. The flow of heat is from higher temperature region to lower temperature region. Substances expand on heating. A certain amount of heat is required to change the state of body. People link this concept of heat to energy. The word energy has been widely used in TD i.e. thermodynamics. Energy has been a backbone for in recent times. According to the theories energy cannot be created and also it cannot be destroyed. It is present in various forms and can be converted to many of its type. Inventors of Heat have classified it as a form of energy and it can be transmitted in different modes of energy.

II.HEAT TRANSFER

Heat Transfer or HT can be defined as "The transmission of heat in form of energy from one region to another region". But it is very important to know that It is also used to determine the temperature of the body in transient as well as in steady and unsteady conditions. Heat transfer is studied in areas like internal combustion engines, furnaces, RAC (Refrigeration Air Conditioning) units, designing of heating and cooling systems, designing of motors, generators, turbines, transformers etc. One should not get confused between TD(Thermodynamics) and HT(Heat Transfer). If the state of the system is changed then TD is used to calculate the amount of work done, amount of energy released or absorbed whereas heat transfer is concerned with how much heat has been absorbed due to difference in temperature between two different surfaces. Thermal Conductivity (or TC) plays a very important role in transfer of heat. Materials with high TC are considered as good conductors and that with low are insulators. Similarly Heat Transfer Coefficient (or HTC) has a major impact on heat transfer rate. The value of HTC depends on thermodynamic properties of the material used and fluid properties like viscosity, density etc. TC is one of the properties of conduction of heat whereas HTC is the best property of convection. According to Fourier's Law of Heat Conduction the heat transfer rate in a material is directly proportional to the cross section area of the material. So materials like tubes (For e.g. - vertical, helical, concentric etc) and plates (finite and infinite thickness, horizontal, vertical, insulated etc) show different heat transfer rate.

2.1 Fourier's Law of Conduction

$$\boldsymbol{Q = \frac{-K*A*\Delta t}{\Delta x}}$$

K= Thermal Conductivity

A= Cross-sectional Area of the Material

$\frac{\Delta t}{\Delta x}$ = Temperature Gradient

Heat Flux can be determined from the material used. It is defined as heat flow rate per unit area per unit time. Temperature and Characteristic time changes with the flow of heat. Depending upon the material and the fluid used the time variation can increase or decrease. This increase or decrease in time results in change in HTC (Heat Transfer Coefficients).

$$\boldsymbol{q = \frac{\frac{Q}{A} * 1}{t}}$$

2.2 Newton's Law of Cooling or Heat Transfer by Convection

$$\boldsymbol{Q = h * a * (T - t)}$$

Q =Rate of convective heat

A = exposed Area

T = Surface temperature

t = fluid temperature

h = Heat transfer Coefficient

2.3 The Stefan – Boltzmann Law or Heat Transfer by Radiation

$$Q = F * A * \sigma * \left(T_1{}^4 - T_2{}^4\right)$$

Q= Rate of radiated heat

A = Area exposed

F = Factor

σ = Stefan – Boltzmann Constant

T = Temperature

2.4 Some Dimensionless Numbers

SR NO	Name	Symbol	Formula
1.	Biot Number	B_i	$\frac{1}{k} * h * l$
2.	Grashof Number	G_r	$\frac{1}{v^2} * l^3 * g * \beta * \Delta t$
3.	Stanton Number	St	$\frac{\frac{\frac{h*1}{\rho} * 1}{U} * 1}{C}$
4.	Reynolds Number	R_e	$\frac{\rho * U * x * 1}{\mu}$
5.	Schmidt Number	SC	v/D
6.	Sherwood Number	Sh	$\frac{h * x * 1}{D}$
7.	Prandtl Number	Pr	v/α
8.	Peclet Number	Pe	$R_e * \mathrm{Pr}$
9.	Lewis Number	Le	$\frac{\alpha}{D}$
10.	Nusselt Number	Nu	$\frac{1}{k} * h * x$
11.	Average Nusselt Number	$\overline{Nu}$	$\frac{1}{k} * \overline{h} * x$
12.	Graetz Number	Gz	$\frac{m}{l*k}$*Cp

2.5 Deterioration of Heat Transfer

When heat fluxes are high, the critical temperature which is pseudo is less than the temperature of the surface is known as Deterioration heat transfer.

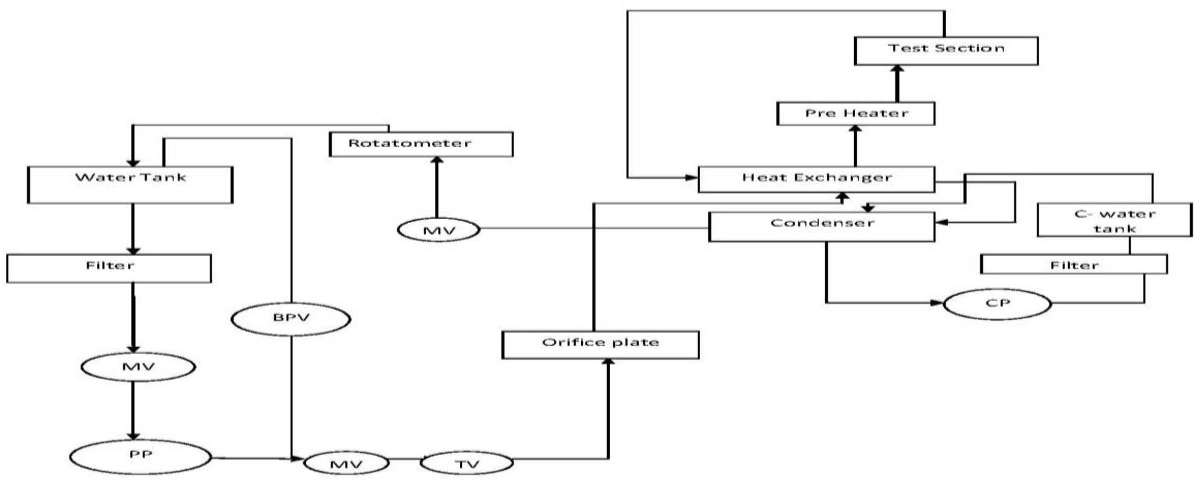
2.6 Improved Heat Transfer

Using of different types of insulations to improve the heat transfer coefficient is known as improved heat transfer.

III. REVIEW OF REASERCHERS

3.1 Jianguo Yan et al [1]

In this paper research was carried out on heat transfer of Sub-cooled water in swirl under the action of high heat fluxes. The experiment performed was carried out in a vertical circular tube with twisted tapes inside it in order to give a swirl flow. First of all the water from the water tank is demonized. It is pumped by a high pressure pump. The minimum pressure given was 40MPa. A part of water returned back to feed water tank through a bypass and the remaining went back to heat exchanger via mass flow meter. In this process the heat of the fluid was absorbed. The test section was heated in a pre – heater. The throttle valve suppresses the potential boiling instabilities. The heat transfer characteristics are studied when the water flows through the test section. Here the water is cooled and is sent back to water tank. From here the water is again circulated and the whole process is repeated. The main valve controls pressure and the back pressure valve controls the mass flux. The heat flux is controlled by A.C power supply.



Schematic Block Diagram Of Heat Transfer Through Sub-Cooled Water In Swirl Flow With Twisted Tapes

3.1.1 Nomenclature Used in the Block Diagram

- MV – Main Valve
- TV – Throttle Valve
- PP – Piston Pump
- BPV – Bypass Valve

- CP – Condensing Pump
- C – water tank – Cooling Water tank

Before the experiment was performed, thermal efficiency of the test sections was carried out by heat balance test. Thermal Efficiency here is calculated as increase in enthalpy by total power. It was found that thermal efficiency of the system was around 95% and the actual thermal efficiency of the system is between 93% and 97%. The heat transfer curve was calculated under two conditions i.e. constant heat flux and variable heat flux. In first performance the heat flux of the test section was kept constant. In second case the performance of the test section was increased gradually. The accuracy of the system was tested using a plane tube and then it was tested using a twisted tape tubes.

3.1.2 Materials Used

- Circular Tubes with Twisted Tapes
- Plane Tube
- A.C Power Supply
- Thermocouples
- Water

3.1.3 Result

- For Sub-cooled water in swirl flow, heat transfer is similar to that in straight flow.
- Twisted Tape enhances the heat transfer rate.

3.2 Qing Zhang et al [2]

In this research we have studied Heat Transfer to the supercritical water (SW) upward flow in a vertical tube with internal helical ribs. In this the researcher has studied that if specific heat of supercritical water is high then pressure and temperature is high.

Three methods to measure the supercritical pressure:

- Normal Heat Transfer
- Deteriorated heat transfer
- Improved heat transfer

The heat transfer of SW depends on wall temperature and we have observed that wall temperature of a smooth tube is higher than ribbed tube. This test is based on HTC and wall temperature.

For SW the HTC and wall temperature flow depends on bulk fluid enthalpy which is similar to both the tubes. Heat transfer in ribbed tube is decreased by the decrease of mass flux and increases with the increase of heat flux.

- The ratio of Nusselt Number of enhanced tubes to smooth tubes is given as

$$\frac{Nu}{Nus} = c * R * e^{m} * P^{n}$$

Nu = Nusselt Number

Nus = Nusselt Number of smooth tube

e = Roughness Height

m, n = constants

P = Roughness Pitch

3.3 Materials Used

- Supercritical Water(SW)
- Ribbed Tube
- Smooth Tube

3.4 Results

- Under heat transfer deterioration or without it heat transfer to the Supercritical Water flow in ribbed tube is enhanced when compared to smooth tube.
- HTC ratio of ribbed tube to smooth tube is very large.

3.5 Kaichun Li et al [3]

Studied heat transfer and flow on solar water heater with elliptical collector tube. Researcher concentrated on friction factor and heat transfer properties of a solar water heater and found that solar water heater with full length twist lower for flow resistance and good for heat transfer. The performance of heat transfer on solar water heater was calculated. In this paper the inner surface of the collector tube was elliptical in shape and outer surface was circular. Total heat transfer is given as:

$$\boldsymbol{Q = m * Cp * (T - t)}$$

Cp = Specific heat of flow
T = Inlet temperature of tank
t = Outlet temperature of tank

There are some assumptions like the tank should not contain any air particles except water completely. Heat loss through the layer of insulation is assumed to be zero. The flow is laminar and not turbulent. There is no exchange of heat between collector tube and surroundings. The tank is placed horizontally.

The density decreases as the water on the top half of the tube wall flows towards the tank with the help of body force. The water in lower half moves downwards due to gravity..Thus the bottom half of the tube has highest density. Similarly on the top half of the tube wall velocity of the water is higher than the velocity of water in the lower half. A shear layer is formed because water in top half and bottom half flows in opposite direction.

3.5.1 Materials Used

- Elliptical tube
- Circular tube
- Solar Water Heater

3.5.2 Results

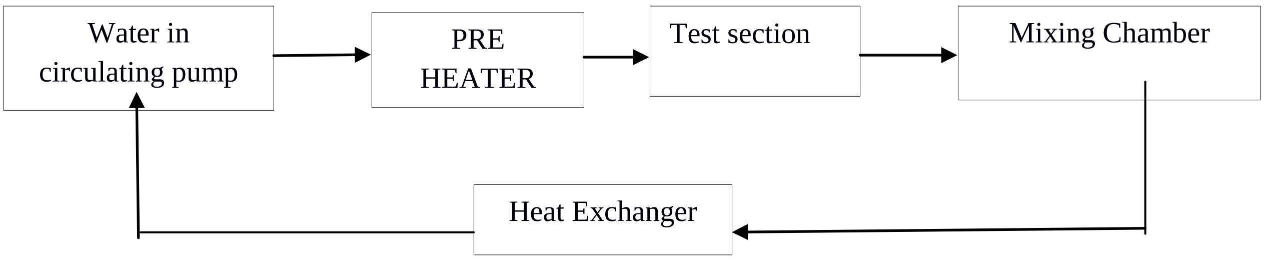
- Temperature distribution across the tube is similar as calculated before.
- As the ratio of cross section of major axis and minor axis decreases, the velocity of fluid.

3.6 H.Y.GU et al [4]

Carried out experiment on supercritical water flowing in upward direction in circular tube. Two different tubes were taken with diameter (inner) 10mm and 7.6mm. Both this tubes are exposed to pressure of 23MPa to 26MPa and temperature of 240°C to 460°C. the error was calculated at each point on the tube. The setup consists of four loops- i.e. main test loop, water purification loop, cooling water loop, IC system. The setup has circulating pump, heat exchanger (2), mixing chamber and accumulator.

The circulation pump drives the water. The pre-heater heats this water to constant value and sends it to test section. This water leaves the test section at 550°C. mixing chamber cools the water and sends it to heat exchangers. Then the water moves out of the heat exchanger and goes back to circulation pump. The cycle is repeated.

3.7 Block Diagram



3.8 Result

- Increase in temperature leads to decrease in heat transfer coefficient.
- As the bulk temperature reaches supercritical point, Prandtl Number of water increases and thus heat transfer coefficient also increases.

3.9 Yong Li et al [5]

Experiment was carried out to find the characteristics of Heat transfer of Marangoni Condensation (MC) for water – Ethanol mixtures on a horizontal plate. The phenomena of MC show high HTC in drop wise condensation region. The horizontal plate used was made of copper. These plates are fixed with epoxy plates. Due to horizontal surface it was very difficult to remove condensate automatically without any external force. Therefore wiper was used to remove the condensate from the surface. For transmission power two magnets were used to enable vacuum condition. Thermocouples were fitted in the copper plates. The pressure transducer measured the vapor pressure. To measure ethanol vapor concentration UNIFAC method was employed. The characteristic properties of heat transfer were calculated using the temperatures of plate and vapor temperature. It was found that as the condensate grew, the temperature inside the copper plate changed. As the wiper started brushing the surface characteristic time started. When the condensate achieved a stable state characteristic time ended and the wiper also stopped working. It was seen that increase in vapor surface temperature difference, characteristic time decreased. But as the ethanol vapor temperature increased, characteristic time increased slightly.

3.9.1 Results

- Increase in vapor to surface temperature difference and ethanol vapor temperature, heat transfer coefficient also increases.
- Stable State was achieved.

IV. CONCLUSION

This review paper concentrated on heat transfer rate through various materials like tubes and plates. It was found that heat transfer coefficient had a major impact on results obtained by different researchers. On the given conditions heat transfer coefficient was either found to be decreased or increased. Thus system achieved a stable state.

REFERENCES

[1]. Jianguo Yan, Quicheng Bi, Laizhong Cai, Ge zhu, Qizheng Yuan – "Sub cooled Flow boiling heat transfer of water in circular tube with twisted tape inserts under high heat fluxes" - Accepted on 6th April, 2015 - Experimental Thermal and Fluid Science 68 (2015) 11–21.

[2]. Qing Zhang, Huixiong Li, Weiqiang Zhang, Liangxing Li, Xianliang Lei-"Experimental study on heat transfer to supercritical water upward flow in a vertical tube with internal helical ribs"- Accepted 28 May 2015 - International Journal of Heat and Mass Transfer 89 (2015) 1044–1053.

[3]. Kaichun Li, Tong Li, Hanzhong Tao, Yuanxue Pan, Jngshan Zhang-"Numerical investigation of flow and heat transfer performance of solar water heater with elliptical collector tube"- International Conference on Solar Heating and Cooling for Buildings and Industry, SHC 2014.

[4]. H.Y.Gu, M Zhao, X Cheng-"Experimental study on heat transfer to supercritical water in circular tubes at high heat fluxes" - Accepted 1 March 2015 - Experimental Thermal and Fluid Science 65 (2015) 22–32.

[5]. Yong Li, Jinshi Wang, Fei Shao, Nana Chen, Junjie Yan – "Heat transfer characteristics of Marangoni condensation for ethanol-water mixture on horizontal plate" - Accepted 3 July 2015 - International Journal of Heat and Mass Transfer 90 (2015) 561–567.

[6]. Heat and Mass Transfer (SI Units) By Er.R.K. Rajput – S. Chand Publishing.

[7]. https://en.wikipedia.org/wiki/Marangoni_effect

[8]. http://www.thermopedia.com/content/1173/

[9]. Heat Transfer by J.P.Holman - 8th Edition - Mcgraw – Hill

[10]. https://www.ohio.edu/mechanical/thermo/property_tables/H2O/H2O_Compressed.html

[11]. Heat Transfer A BASIC APPROACH By M.Necati OZISIK - Mcgraw – Hill

[12]. Fundamental Of Heat and Mass Transfer - Fifth Edition – by Frank P. Incropera, David P. Dewitt –Wiley India Pvt. Ltd.

[13]. http://dspace.mit.edu/bitstream/handle/1721.1/61457/HTL_TR_1968_051.pdf?sequence=1

[14]. http://heattransfer.asmedigitalcollection.asme.org/article.aspx?articleid=1434458