Analysis of Heat Generation in Double Pipe Heat Exchanger: An Experimental Evaluation and Comparison of the Heat Transfer rate in the Surface Contact of the Elliptical Fin

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Abstract- *This article has presented the heat generation in elliptic fin heat exchanger. The experiment successfully completed and compared with the existing method and it finalized the elliptic fin has more rated heat transfer than other four methods (Tube-Tube, Rectangular inline arranged fins, Annular and Spiral rod) in double pipe heat exchanger. This project suggested to focus on the analysis of elliptical fin heat exchanger and then how heat transfer rate higher on the elliptic fin. These techniques are used to find out the heat loss from the surface and related temperature of fluid motions and also used to find the effectiveness, which is compared for different flow rates and the maximum possible heat transfer in double pipe heat exchanger. Mainly the extended surface used to increases the heat transfer rate then it has proved on the possible results are compared with the thermodynamic analysis of heat transfer in experiment and simulation.*

Keywords: ***Elliptic Fin, Heat Transfer, Heat Exchanger, Thermodynamic Analysis and Spiral Rod.***

1. INTRODUCTION

The extended surface in heat exchanger is gaining industrial importance because it gives the opportunity to reduce the heat transfer surface area required for a given application and thus reduces the heat exchanger size and cost, increases the duty of the exchanger for fixed surface area, reduces logarithmic mean temperature difference (LMTD) for fixed heat duty and surface area and reduces pumping power for fixed heat duty and surface. Heat transfer in extended surface heat exchanger has been subjected of many experimental and analytical investigations techniques. These techniques required external power, such as surface vibration, fluid vibration, injection, suction, and electrical or acoustic fields. Passive technique employs the special surface geometries for various fins, such as extended surfaces and rough surfaces. Two primary methods exists when analyzing heat exchangers: Logarithmic mean temperature difference (LMTD) and E-NTU.

M Kannan, Ramu S, There are three different methods of heat exchanger were examined . extended surface, obstruction device and swirl flow device with different geometric dimensions executed in experiments then the experiments results was compared with the available method and they finalized annular method is the best method and achieved higher rate heat transfer. The experimental result has compared with simulation result. Both result matched exactly, so the experimental work got perfect result of the three methods. [1]

PB Dehankar, The main objective of the paper, they have analysed optimization for heat transfer parameters standardization of experimental setup. That standardization implemented by Wilson plot techniques and derived exact mass flow rate between the range of 0.02 kg/sec to 0.033 kg/sec to examined the parameters of friction factor and Reynolds number. [2] Pankaj D lad, This project work focused on FEA concentric pipe heat exchanger analysis because abnormal behaviour of cold and hot fluid passes through the pipe. They have optimized the dimensions various parts (Inner pipe, tube sheet and Nozzle). They have analysed different stages of deflection and von- mises stresses by using ANSYS 15.0 software. Finally they observed thickness optimization results in experiment and ANSYS software. [3] HS Patel, This article received about the performance evaluation and CFD analysis for involve the concept of Nano technique practically involved to determine the exact system by using ANSYS CFX software. As above discussion concluded on the paper (1) as possible to dispersed water can significantly enhance the correction heat transfer and heat transfer rate by Nano particles compositions. [4]

Ayush Kumar, New techniques have developed in the project. CDD convergent divergent spring tubular were placed in the inner tube and effect on heat enhancement and friction factor also investigated. They maintained certain value for Reynolds number and Nusselt number. Then they got friction factor 287% while Nusselt number increased by 28% where the experimental parameter confirmed like as overall heat transfer analyse against mass flow rate. [5] Nice Thomachan, This article worked on the analysis of fluid domain in ANSYS workbench. They were boundary conditions defined. They found effectiveness of heat exchanger with 100 mm pitch is higher than that of other devices. [6] Shiva Kumar, In this study determined three different methods of profile executed. They are longitudinal fin, rectangular, triangle and parabolic. The numerical studies were approached for finding mass flow rate conditions both inner and outer tube. That simulation results also compared with unfinned and finned area. Fin concave parabolic profiles exhibited minimum pressure drop and has reduced by 38% and 65% compared to triangle and rectangular finned tube. [7]

Ahmet N.Ereslan, Turgut Tokdemir (2008) in their paper stated that the variable thickness annular fin mounted on a hot rotating rigid shaft is considered. Thickness of fin various radially in a continuous variable non linear elliptic from. The heat transfer and deformations in the fins subjected to both centrifugal force and radial temperature gradients. A variable thickness annular fin mounted on a hot rotating rigid shaft was considered. The thickness of the fin assumed to vary radially in a continuously variable nonlinear elliptic form. An energy equation that accounts for the conduction, convective heat loss from peripheral and edge surfaces, thickness variation and rotation is adopted. For given heat and centrifugal loads the temperature distribution in the fin and the corresponding state of stress is obtained by means of the analytical solutions of energy and thermo elastic equations, respectively. [8] Mi sander Mon, Ulrich gross (2004) reported that the effect of fin spacing on four row annular finned tube bundies in staggered and line arrangement are investigated by 3D numerical study. To investigate the velocity and temperature distribution between fins. The flow behaviour of the developing boundary layer, the horse shoe vertex systems, and thermal boundary layer developments in the annular finned tube banks will be visualized. The effects of fin spacing on four-row annular-finned tube bundles in staggered and in-line arrangements are investigated by the three-dimensional numerical study. Renormalization group theory (RNG) based k-ε turbulence model is allowed to predict the unsteady flow and conjugate heat transfer. According to the flow visualization results, the boundary layer developments and horseshoe vortices between the fins were found to be substantially dependent on the fin spacing to height ratio and Reynolds number. The heat transfer and pressure drop results for various fin spacing are presented. In addition, the numerical results are compared with the existing correlations. [9]

Cihat Arslanturk (2005) obtained simple correlation equation for optimum design of annular fins with uniform cross section. The fin volume to obtain the dimensionless geometrical parameters of the with maximum heat transfer rates. The optimum radii ratio of an annular fin which maximizes the heat transfer rate has been found as a function of Biot number and the fin volume, the data from the present solutions is correlated for a suitable range of Biot number and the fin volume. The simple correlation equations presented in this work can assist for thermal design engineers for optimum design of annular of uniform thickness. [10] B.Kundu,P.K.Das (2007) reported that the performance of elliptic disc fin has been analyzed using a semi analytical technique. It has shown that the efficiency of such fin can also be predicted very closely using sector method. Optimum elliptical fin dissipate heat at higher rate compared to annular fin when space restriction exists on both sides of the fin. Even when the restriction is on one side only, the performance of elliptical fin is comparable to that of eccentric annular fin for a wide parametric range. Efficiency of an elliptic fin predicted by different methods. [11] Chine-Nan lin , Jiin-yuh jang (2002) stated the two dimensional analyses for the efficiency of an elliptic fin under dry, partially wet and fully wet and fully wet condition of different range value for axis ratio, biot-number and air humidify. This paper presents a two-dimensional analysis for the efficiency of an elliptic fin under the dry, partially wet and fully wet conditions of a range of value for axis ratios, Biot numbers, and air humidifies. It is shown that the fin efficiencies increase as the axis ratio Ar is increased. For a given axis ratio Ar, the fin efficiency decreases as the fin height l^* or Biot number is increased. The conventional 1-D sector method overestimates the fin efficiency resulting in increasing error as the axis ratio Ar is increased. In addition, using experimentally determined heat transfer coefficients, it is found that both the fully dry and wet elliptic fin efficiencies are up to 4– 8% greater than the corresponding circular fin efficiencies having the same perimeter. [12]

Behnia et al (1998) compared numerically the heat transfer performance of various commonly used fin geometries (circular, square, rectangular and elliptical).They fixed the fin cross sectional area per unit base area, the wetted surface area per unit base area, and the flow passage area for all geometries. They found that circular pin fins outperform square pin fin and elliptical fins outperform plate fins. They also found that elliptical fins work best at lower values of pressure drop and pumping work whereas round pin fins offer higher performance at higher values. [13] Chapman et al (1994) investigated experimental the parallel plate fins and cross-cut pin fins in low air flow environments and compared these fins with elliptical pin fin heat sinks. They used equal volume heat sink in their experiments. They found that the overall thermal resistance of the Parallel plate fin was lower than the other two design, whereas the heat transfer coefficient was higher for elliptical pin fin than the other two designs. [14] Ota et al (20,21) (1983-1984) studied experimentally heat transfer and flow around an elliptical cylinder of axes ratios 1:2 and 1:3.Their experimental results show that heat transfer coefficient of the elliptical cylinder is higher than that of a circular one with equal circumference and pressure drag coefficient of the former are much lower than that of the later. [15] &[16]

2. EXPERIMENT METHODOLOGY

The basic heat exchanger was hooked up to both hot and cold water flows in a parallel-flow mode. The cold water flow was an open circuit while the hot water flow was a closed circuit. This method having to construct as usually like tube within a tube. The water was heated to the desired temperature by a heating element. Adjusting the electrical energy input to the heating element controlled the water temperature. The temperatures at the inlet and exit were measured by the use of threaded thermometer. In the present work only passive enhancement techniques were considered. [1] experimental procedures are given same for all methods.

2.1 Elliptic methods

Elliptic fin is a normal type of extended surface (fins) resembles like the shape of ellipse used to make effective heat transfer in the heat exchanger.

2.2 Elliptic Fin Profile

Fig 1. Elliptical Fin [1]

Table 1 Tabulation for Parallel & Counter flow mode

Type of flow	Hot Fluid Temperatures (°C)		Cold Fluid Temperatures (°C)		Time taken to collect 1 lit of water (s)	
	In (T1)	Out (T2)	In (t1)	Out (t2)	Hot water	Cold Water
Parallel	46	42	25	35	56	18
Counter	44	39	26	35	60	17

3. RESULT AND GRAPH

3.1 Parallel Flow

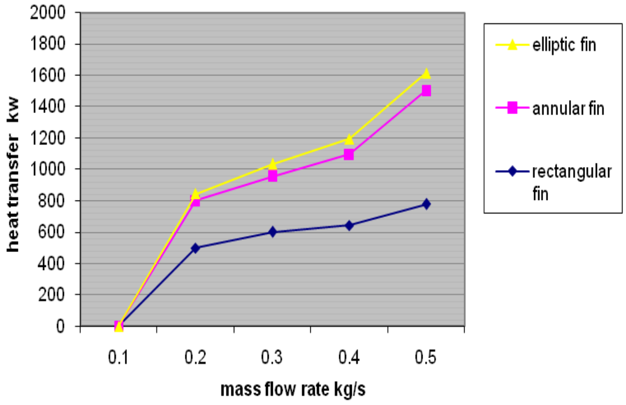

Chart 1. Heat transfer vs Mass flow rate

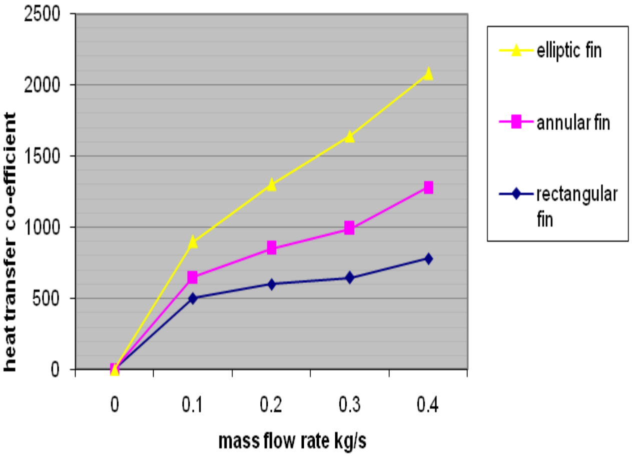

Chart 2. Heat transfer coefficient vs mass flow rate

3.2 Counter Flow

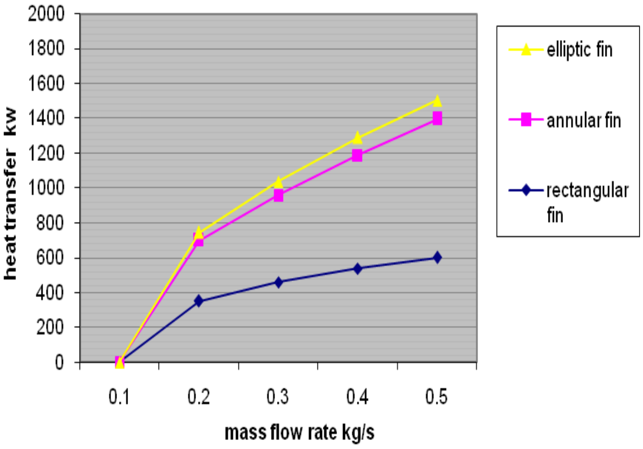

Chart 3. Heat transfer vs Mass flow rate

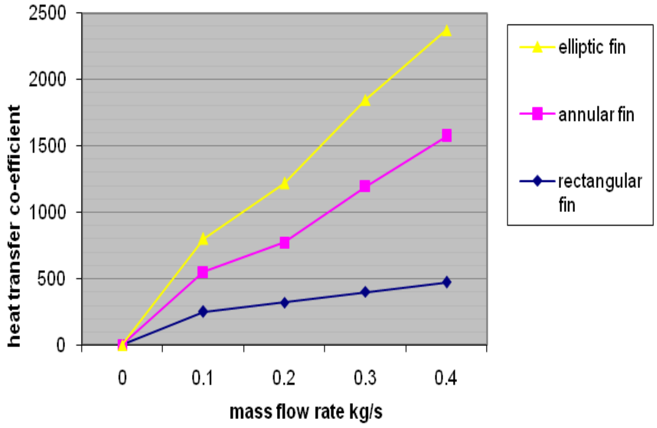

Chart 4. Heat transfer coefficient vs mass flow rate

3.3 Elliptic Fin Method

Parallel flow process

Heat transfer for hot fluid qh =596 W
Heat transfer for cold fluid qc =2325.5 W
Average heat transfer Q =1460 W
LMTD =12.74°C
heat transfer co-efficient h h=2297.8 W/m^2K
Effectiveness Є =2.45

Counter flow process

Heat transfer for hot fluid qh =348W
Heat transfer for cold fluid qc=2215W
Average heat transfer Q=1280 W
LMTD =10.87°C
heat transfer co-efficient h =2361.11 W/m^2K
Effectiveness Є =3.68

4. SIMULATION RESULTS

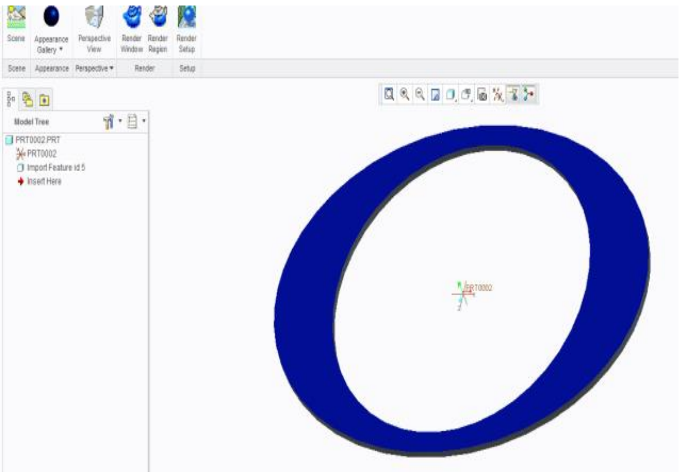

Fig 2. Modelling of Elliptic Fin by using CREO Software

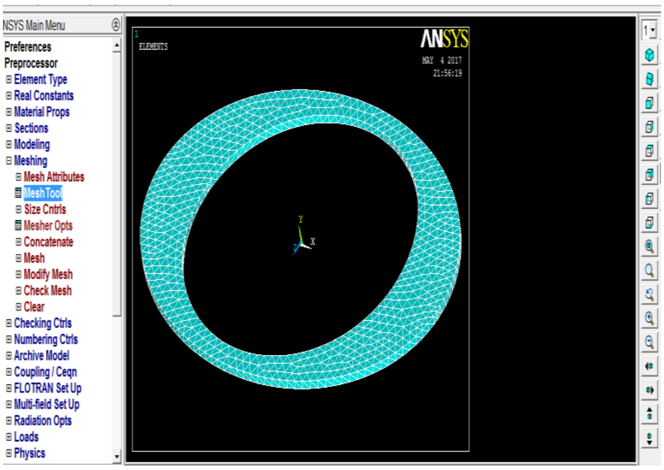

Fig 3. Meshing of Elliptic Fin by using ANSYS Software

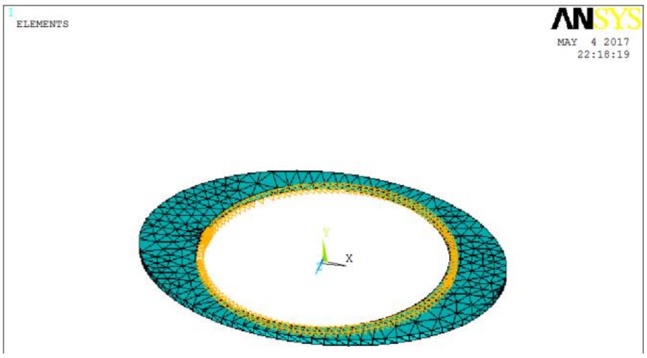

Fig 4. Surface contact of heat generation area

Size of the element = 8

Number of divisions = 10

4.1 Outer dimension and of elliptic fin DOF, all Temperature.

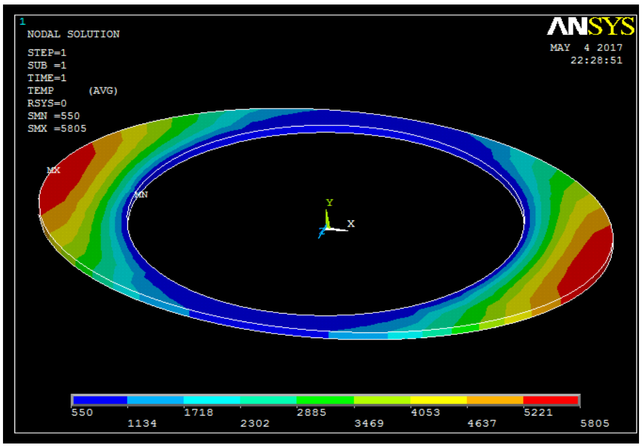

Fig 5. Surface contact of heat generation

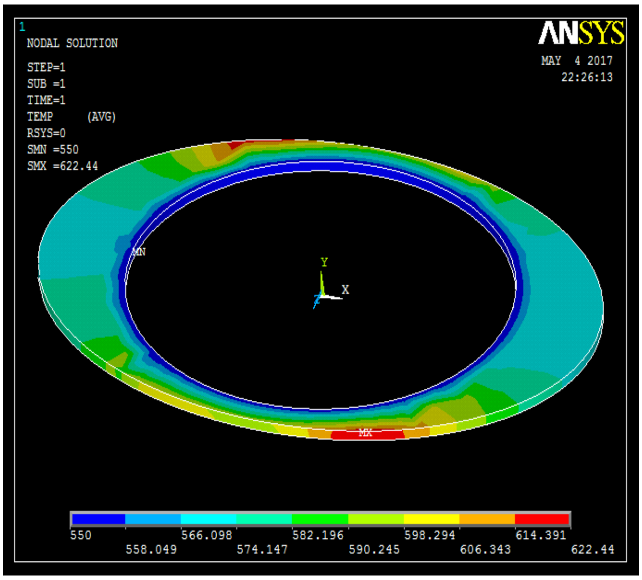

Fig 6. Contour Temperature for Elliptic fin

4.2 Analysis of Heat generation in Elliptic Fin

$$\frac{q}{A} = \frac{Q}{V}$$

Volume of Sphere= $4/3\ \pi r^3$
Volume of Cylinder = $\pi\ r^2\ L$
Volume of Elliptic = $4/3\ r_1\ r_2$
$V = \frac{4}{3} \times \pi \times r_1 \times r_2$
$V = \frac{4}{3} \times \pi \times 0.812 \times 0.527$
$V = 1.7924 m^3$
Area of Elliptic $A = \pi \times a \times b$
a = Semi-Major Axis
b = Semi-Minor Axis
$A = \pi \times 0.527 \times 0.012$
$A = 0.0198\ m^2$
Heat Generation
Parallel flow mode
$q = \frac{Q}{V} = \frac{1460}{1.7924} = 814.55\ W/m^3$
Counter flow mode
$q = \frac{Q}{V} = \frac{1280}{1.7924} = 714.12\ W/m^3$

5. CONCLUSION

Five different methods have experimented and compared with this project finally. The maximum attainable heat transfer found in elliptic fin methods. These methods concluded and compared theoretically by review, experimentally, analytically and mathematically. This project reported to focus on maximum heat generation on the fin by using Ansys software tool, I got clear result in heat generation area and the future work also identified and focus on the FEM (Finite Element Method) for finding nodal solution of heat transfer position and direction of maximum heat transfer possible and compose material structure order for the direction of heat by heat treatment process on specified materials.

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