Experimental analysis of concentric tube heat exchanger with dimpled surface

M.Subramanian[1] , Dr.D.lenin singara velu[2],I.Justin antony raj[3] , J.Sebastin joyal[4]

[1 3 4] Assistant Professor, Department of Mechanical Engineering, Vandayar engineering college , Thanjavur-613501-TN-india.

[2] Assistant professor ,Department of production engineering ,NIT-Tiruchirappalli, TN-INDIA.

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Abstract: An experimental investigation on the convective heat transfer and friction factor characteristics in the plain and ellipsoidal with both side dimpled tube and zigzag dimpled tube under turbulent flow with constant heat flux is presented in this work using water as a working fluid. Heat transfer techniques are referring to different method used to increase rate of heat transfer without affecting much the overall performance of the system. Several studies on the passive techniques of heat transfer have reported in the past decade .Present study is to modify the inner tube of concentric tube heat exchanger with dimpled tube. The effects of the dimples on the friction factor and thermal performance are determined in a circular tube with a fully developed turbulent flow for different Reynolds number. The experimental and analysis results are revealed that the use of water in ellipsoidal with both side dimpled tube increases the heat transfer rate with negligible increase in friction factor compared to plain tube.

Keywords: ***Double pipe heat exchanger, Inner dimple tube, concentric tube heat exchanger.***

1. INTRODUCTION

Effective utilization of available energy becomes need of hour today and obviously requires effective devising when it concerns with heat energy the devices are heat exchangers. Heat exchanger may be defined as equipment which transfers the energy from a hot fluid to a cold fluid with maximum rate and minimum investment and running cost .There are numerous types of heat exchanger which varies in structure and function according to the need .Waste heat is the heat which is generated in a process by way of fuel consumption or chemical reaction and then “dumped” into the environment even though it could still be reused for some useful and economic purpose. The essential quality of heat is not the amount but rather its”value”. The strategy of how to recover this heat depends in part on the temperature of the waste heat and the economics involved.

2. LITERATURE SURVEY

J.E.Kim. et al(2012) Above researcher conducted the experiments on numerical study on characteristics of flow and heat transfer in a cooling passage with protrusion in dimple surface .Four different protrusion heights are considered and protrusion height to channel height (h/H) of 0.05,0.10,0.15 and 0.20.Water as test fluid analysis and experimental method and also 40% negligible pressure drop,24% increase heat transfer ,increase friction factor up to 5-6% and volume goodness factor slightly increases by 4%. **J.Kukulka et al.(2011):** Above researcher conducted the experiments on development and evaluation of enhanced heat transfer tubes , enhancement tube and smooth tubes are compared and also material is enhanced 304L stainless steel tube and steel. Dimpled tubes minimize the fouling rate and also provide heat transfer performance gains in excess of 100%.**A.Garcia et al.(2011):** Above researcher conducted the experiments on the influence of artificial roughness shape on heat transfer enhancement :corrugated tubes, dimpled tubes and wire coils ,corrugated tubes ,dimpled tubes and wire coils are compared .Reynolds numbers higher than 2000,the use of corrugated and dimpled tubes is favoured over the wire coils. **S.Suresh et al.(2010)** Above researcher conducted the experiments on experimental studies on heat transfer and friction factor characteristics of Cuo, water, nano fluid under turbulent flow in a helically dimpled tube, helically dimpled tube and plain tubes are compared. The heat transfer results showed that Nusselt number with dimpled tube and nano fluids under turbulent flow is 19%,27% and 39%(0.1 %,0.2% and 0.3% volume concentrations of nano particles in a fluid).Friction factors are about 2-10%higher than the plain tube. **Research Gap:** Above researcher is not done with “From theoretical calculation, the overall heat transfer coefficient is increased and also effectiveness of the dimpled tube with concentric tube heat exchanger is increased 8%compare to plain tube concentric tube heat exchanger” and not researched over the dimpled tube is used in concentric tube heat exchanger in various applications .

3. EXPERIMENTAL DETAILS:

Fig.1.Experimental set up

Figure1.shows the experimental setup is used to conduct the experiments .It consists of double pipe heat exchanger consisting of a test section ,electric geyser to supply constant hot water and the control system.The test section is a copper as an inner tube and an outer galvanised iron pipe .The outer pipe is well insulated using glass wool held with jute rope to reduce heat losses to the atmosphere .Tap water is sent to geyser and then the heated water is directed to the inner tube through a control valve. Temperature measuring devices are to measure the inlet and outlet temperature of hot water and outlet of cold water .The inlet temperature of cold water is measured using mercury thermometer.

Fig.2.Inner dimple tube

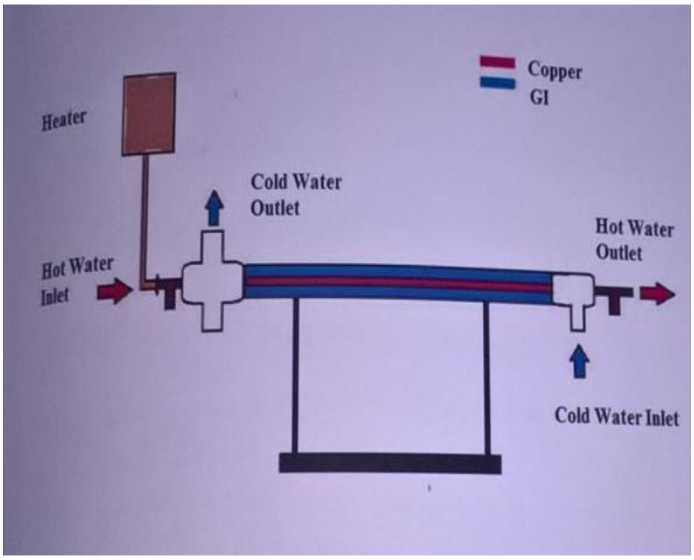

Fig.3.Schematic diagram

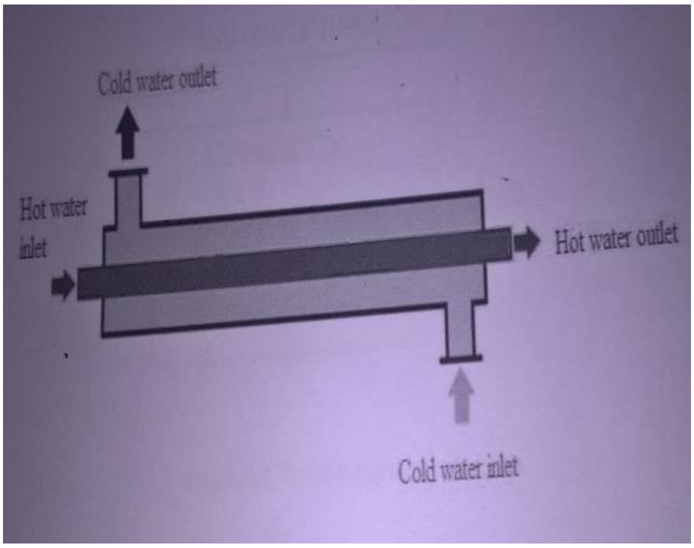

Fig.4.Passive heat transfer by augmentation method

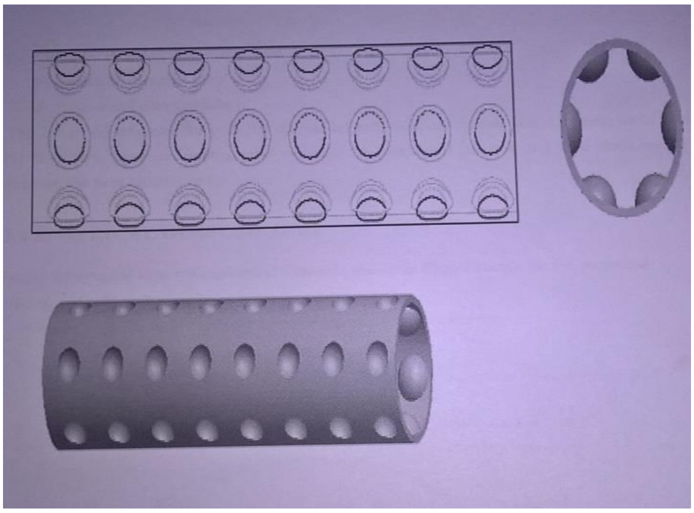

Fig.5.Dimpled tube

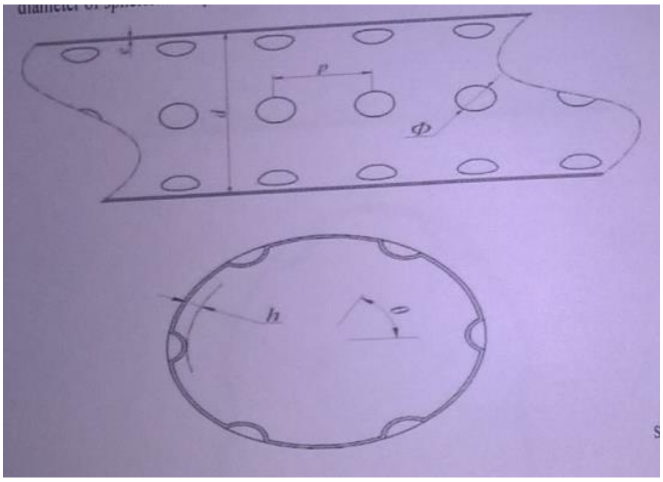

Fig.6.Spherical dimpled tube

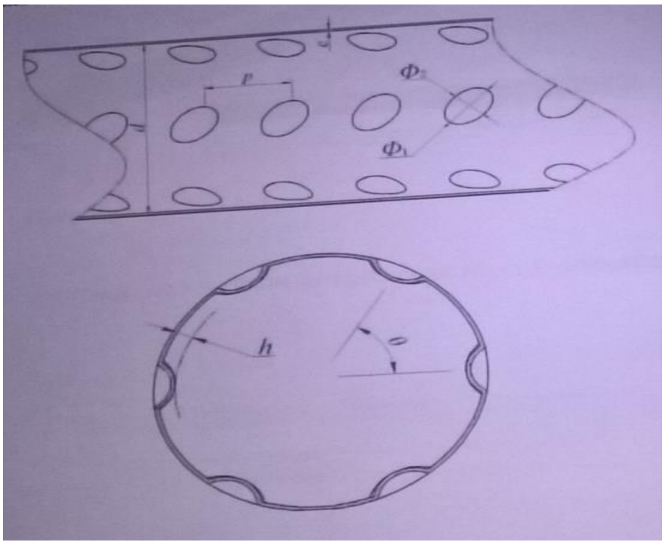

Fig.7.Ellipsoidal dimpled surface

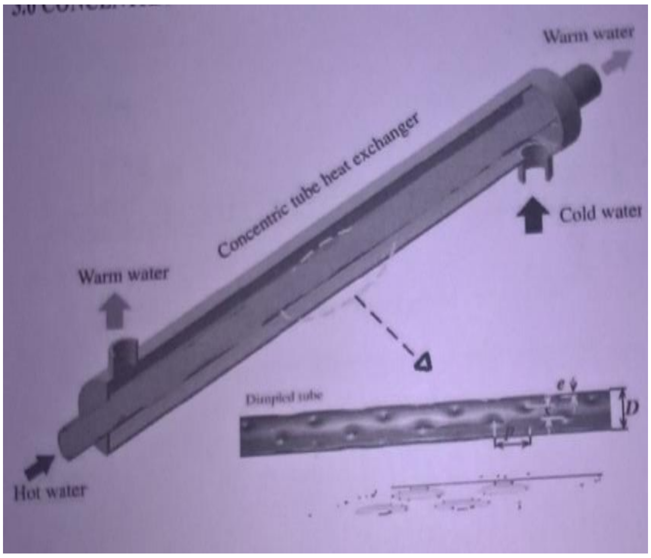

Fig.8.Concentric tube heat exchanger (Dimple surface)

4.METHODOLOGY

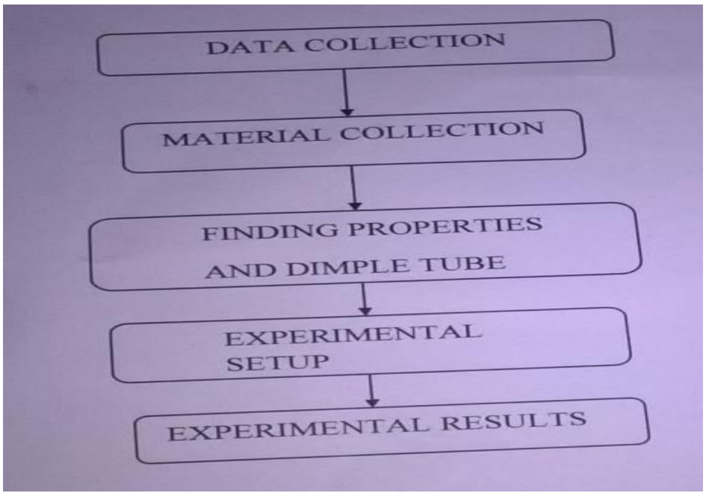

Fig.9.methodology

Table1. Specifications of double pipe heat exchanger

SPECIFICATIONS	INNERTUBE(mm)	OUTER TUBE(mm)
Inner diameter(D1)	25	50
Outer diameter (D2)	28	52
Length(L)	2000	1800
Thickness(T)	1.6	2
Layout	circle	Circle
Number of tube(n)	1	1
Material	copper	G1

Table 2. Specifications of dimpled tube

SPECIFICATIONS	SYMBOL	DIMPLED TUBE(mm)
Inner diameter	D1	25
Outer diameter	D2	28
Depth of dimple	E	1.3
Length	L	2000
Thickness	T	1.6
Diameter of dimple	D	3.5
Material	copper	copper

Table 3. Material properties of double pipe heat exchanger

PROPERTIES	INNER TUBE(COPPER)	OUTER TUBE(GI)
Density Kg/m³	8954	7850 kg/m³
Specific heat capacity J/kg k	0.3831	452J/kg k
Thermal conductivity W/m k	394	70.7 W/m k
Thermal diffusivity m²/s	11.24	20.34 e⁻⁶ m²/s

Table 4. Properties of shell side fluids

properties	Density kg/m³	Kinematic viscosity (m²/s)	Absolute viscosity (N s/m²)	Specific heat capacity (J/kg k)	Thermal conductivity (W/mk)
Cold water	995.65	1.48×10^{-5}	0.017	2331	0.272

Table 5. properties of inner tube side fluid

properties	Density kg/m³	Kinematic viscosity (m²/s)	Absolute viscosity (N s/m²)	Specific Heat capacity (J/kgk)	Thermal conductivity (W/mk)
Hot water	992.2	0.163×10^{-6}	0.012	1922	0.091

Table 6.velocity

V	Re	D	µ	p
0.120577	3000	0.025	0.001003	998.2
0.160769	4000	0.025	0.001003	998.2
0.200962	5000	0.025	0.001003	998.2
0.241154	6000	0.025	0.001003	998.2
0.281346	7000	0.025	0.001003	998.2

Re	Nu	f(p)	Variable V	Δp	Constant V	Δp
3000	22.72366	0.012767	0.120577	7411.457	0.201	20595.22
4000	29.86552	0.011465	0.160769	11831.89	0.201	18494.36
5000	36.9177	0.010547	0.200962	17007.08	0.201	17013.56
6000	43.89922	0.009852	0.241154	22875.91	0.201	15892.1
7000	50.82252	0.0093	0.281346	29392.32	0.201	15001.79

Table 7. Plain Tube

5. RESULT AND DISCUSSION

HOT WATER TEMPERATURE DIFFERENCE:

Hot water Inlet :327K

Table 8.Hot water Temperature Difference

Re	Hot water outlet (both side dimple)	Hot water outlet (zigzag dimple)	Hot water outlet(plain)
3000	314	315	318
4000	317	317	320
5000	318	317	321
6000	318	318	322
7000	319	319	322

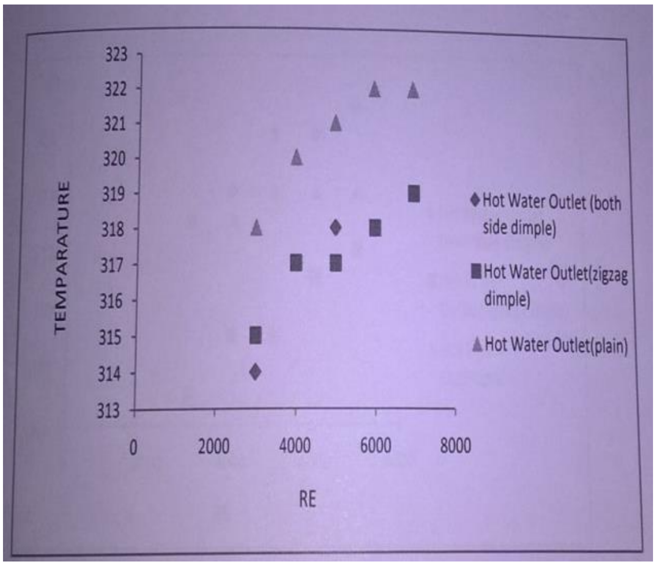

Fig.10.Hot water temperature difference

Cold water inlet:303

Table 9. cold water Temperature difference

Re	Hot water outlet (both side dimple)	Hot water outlet (zigzag dimple)	Hot water outlet (plain)
3000	313	307	313
4000	314	309	313
5000	316	309	314
6000	316	311	314
7000	317	312	314

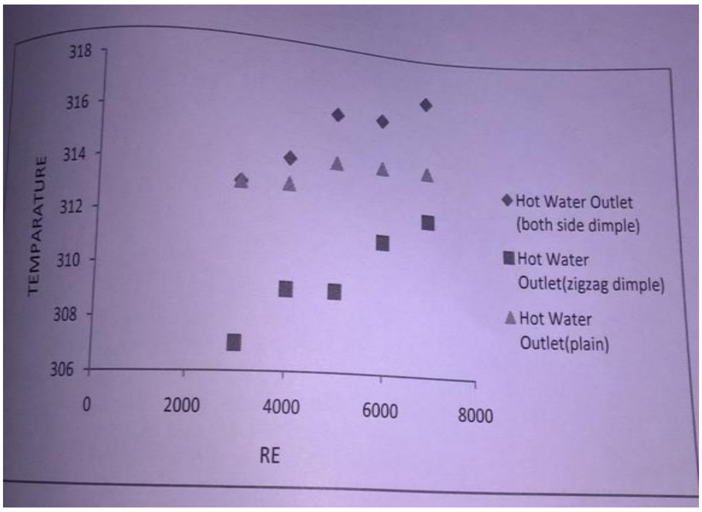

Fig.11.Cold water temperature difference

6. CONCLUSION

- Augmented surfaces are increasing the heat transfer coefficient with a consequent increase in the friction factor.

- Investigation dimpled tube is used for this project.
- From theoretical calculation, the overall heat transfer coefficient is increased and also effectiveness of the dimpled tube with concentric tube heat exchanger is increased 8% compared to plain tube concentric tube heat exchanger.
- From theoretical results ,the dimpled tube heat exchanger gives better performance.
- The dimpled tube is used in concentric tube heat exchanger in various applications will give higher heat transfer.

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