

Performance Analysis of Flat Plate Collector by changing Geometry of Absorber tube A Review

Ganesh K. Badgujar¹, Shubhangi G. Kamble²

P.G. Student, Department of Mechanical Engineering, N.M.U GHRIEM, Jalgaon, Maharashtra, India¹

Assistant Professor, Government College of Engineering Jalgaon (Autonomous), Maharashtra, India²

ABSTRACT: Sun emits energy due to fusion reaction of Hydrogen atom, which is almost inexhaustible. Solar Energy available on atmosphere of earth is approximately 1367 w/m^2 . Whole world search for alternate source of energy until fossil fuels are exhausted. India is country gifted by God with lots of sunshine more than nine month in year. Extensive work has been done on flat plate collector to increase performance still there is very limited literature available on performance enhancement by changing geometry of absorber tube. This paper summarise the all previous work on FPC in order to enhance performance using various geometry such as circular, semi-circular, elliptical ,triangular, square and rectangular shape of absorber tube .

KEYWORDS: Geometry of absorber tube, Performance FPC, Tube shapes, Efficiency.

I. INTRODUCTION

Solar Energy is economical, freely available and inexhaustible source of energy. Traditionally solar energy is used for drying and heating applications. It sustains life on the Earth. Due to global oil crisis in 1973 demand of solar energy increases and large focus of all researchers concentrated to solar appliances. Uses of solar energy have been increased from recent years due to decreasing fissile fuel resources along with air pollution and global warming concern. Lots of research work is going on to use the maximum available solar energy.

Flat Plate collector is easiest, least expensive to fabrication, installation and maintenance. It used both direct and diffused solar radiation. It is used in house, apartments, buildings, hospitals, schools, restaurants, dairy, agricultural and industrial area. Main parts of FPC are Absorber plate, Raiser or absorber tube, glazing, casing, cover strip and thermal insulation. Number of geometrical parameters are affects the performance of flat plate collector such as selective surface, number of covers, spacing between cover and absorber. Absorber is made up of metallic material such as copper, steel or aluminium and surface is painted by epoxy black coating. It has high absorption, high conduction and low re-radiation.

II. LITERATURE REVIEW

Ranjitha P. Et al. (2013) did experimental investigation on solar collector panel with circular cross section tube for result of flow and temperature distribution. These results are validated with ANSYS CFD simulation results. Set up consist of absorber pipe 0.8 m long with inner dia. 0.0127 m and pipe to pipe distance is 0.11 m. Header pipe is 0.8 m long with inner dia.0.0254 m. Transparent glass is 0.004 m thick and glass to absorber distance is 0.035 m. Overall dimensions are $1.003 \times 0.503 \times 0.105 \text{ m}$. It was conclude that experimental results are quite close to CFD predictions. [1]

Time	Ambient temperature in K	Radiation in w/m ²	Experimental Inlet temperature K	Experimental Outlet temperature K	CFD Outlet temperature K
8	299	878.5	306	306	307.2
9	299.5	1125.8	307.3	310.2	309.5
10	301.5	1316.8	308.6	312.8	311.33
11	303.5	1444.3	310.4	320.6	317.5
12	304	1501.8	313.2	326.3	323.8
13	304.5	1485.8	315.1	329.2	327.1
14	306	1397.3	323	332.3	329.6
15	305	1241.3	319.2	330.4	328.8
16	304	1025.3	316.5	325.1	324.75

Fig.1 Outlet temperature results of circular absorber Tube

Yuechao D. Et. al. (2015) investigated novel flat plate solar water heater using micro heat pipe array with selective coating closely arrangement as shown in fig. MHPA has high heat transfer rate, high reliability, high compressive strength, low cost and small thermal resistance. This new FPC has high heat transfer ability, relatively low heat loss, resistance to freezing, preventing leakage and most important elimination of welding. It was shown that novel collector has excellent thermal performance. [2]



Fig.2 Cross Section of MHPA

K.A. Muhammed Yarshi & Dr. Benny Paul (2015) analyse the effect of change in shape of absorber tube for flat plate collector performance. He investigated the effect of mass flow rate and absorber material on FPC efficiency. Set up consist of absorber tube of 0.8 m long with inner dia. 0.012 m. Header pipe of 0.8 m long with dia. 0.024 m, glazing area is 0.5 m². Overall dimensions are 1×1.5×0.1 m. He studied collector with circular and semi-circular absorber tube performance. It was examine that outlet temperature of semi-circular collector is greater than conventional circular collector due to increasing absorbing area. [3]

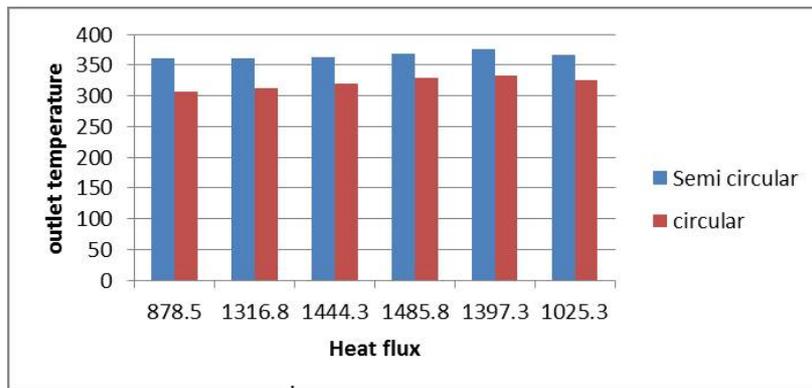


Fig.3 Comparison of Circular & Semi-circular absorber tube

It was understand that by changing fluid mass flow rate collector efficiency increases and used of copper, steel and aluminium as absorber material, the efficiency of collector increase as conductivity of absorber increases.

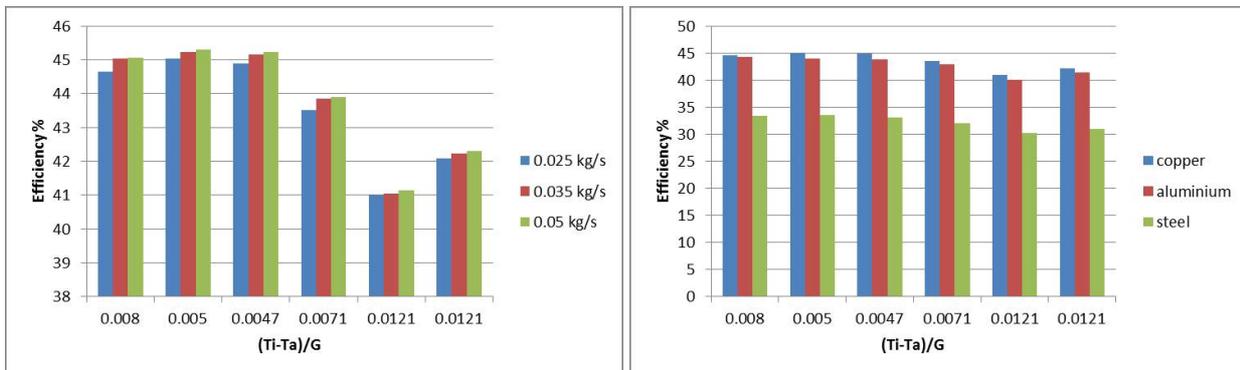


Fig.4 Effect of mass flow & absorber material on Efficiency

Basavanna S. and K.S. Shashishekar (2013) investigated triangular absorber tube in FPC. Triangular absorber tube is attached in order to increase the contact surface area between tube and plate, which will enhance heat absorption so that performance of collector increases. Set up consist collector box of 1 m length and 0.5 m width, absorber tube is 0.017×0.017×0.017 m, 0.8 m long and 0.0005 m thick. These results are comparing with CFD simulations. [4]

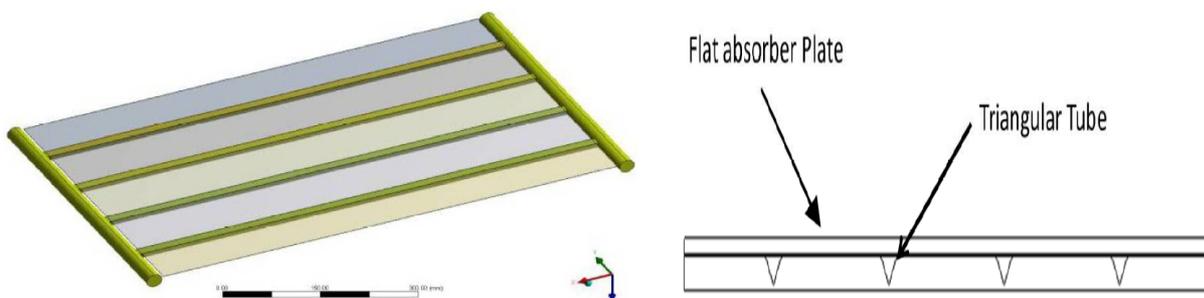


Fig.5 Triangular Shape absorber tube

It was conclude that triangular tube increases the outlet temperature due to increase in contact surface area between absorber tube and plate, resulting more heat absorption with increasing pressure drop due to triangular tube shape that's why performance of collector increases.

Comparison of Outlet Temperature for Triangular Tube					
Time	Ambient Temp in K	Radiation in w/m ²	Exp Inlet Temp K	Exp. Outlet Temp K	CFD Outlet Temp K
8	300.5	878.5	305.0	305.0	306.5
9	301.0	1125.8	305.3	309.6	309.4
10	302.0	1316.8	310.3	315.4	314.8
11	302.5	1444.3	312.0	319.8	320.2
12	303.5	1501.8	314.2	323.1	324.4
13	305.0	1485.8	315.3	325.3	328.1
14	307.5	1397.3	319.4	330.4	328.7
15	305.5	1241.3	318.8	327.3	327.2
16	304.0	1025.3	316.9	324.2	324.6

Vishal Shelke and Chinmay Patil (2015) his objective is to analyse the effect of variations in shape of tube for FPC. He did comparative CFD study of circular and elliptical shape absorber tube and find temperature distribution of water inside solar collector. It was conclude that elliptical tube give maximum outlet temperature of water for same heat flux and water inlet temperature as compared to circular geometry. [5]

Time	Inlet Temp in °C	Heat Flux in w/m ²	Outlet Temp of Circular Tube in °C	Outlet Temp of Elliptical Tube for case 5 i.e. B = 0.5 A in °C	Difference in Elliptical & Circular Tube in °C
9.31	33	470	42.288	45.9757	3.6877
10.15	38	520	48.27	52.354	4.084
11.15	43	535	53.57	57.7297	4.1597
11.45	45	540	55.67	59.839	4.169
12.35	44	535	54.57	58.73	4.16
13.15	43	520	53.27	57.3645	4.0945

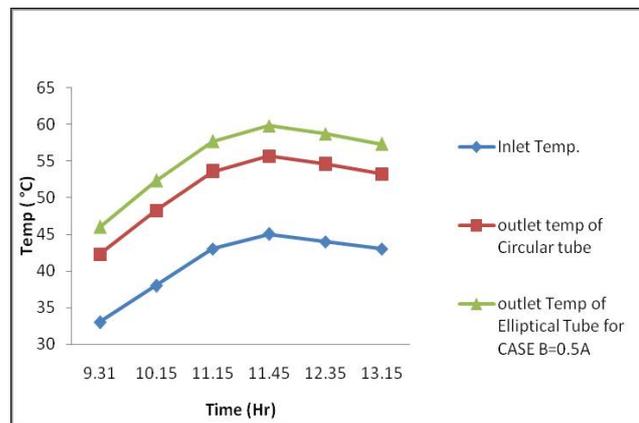


Fig.6 Comparison of inlet & outlet temperature between circular & elliptical tube

Marroquin-De Jesus Angel Et. al.(2013) did experimentation on two FPC of circular and rectangular cross section of absorber tube. Absorber A made up of steel channel of rectangular cross section, collector box of 1.47×0.89×0.01 m dimension, galvanized header tube of 1.1 m long and 0.0381 m dia., rectangular cross section 10 sheet of 1.47×0.08×0.01 m separated 0.01 m from each other. Absorber B is of nine copper tube each 1.47 m long and 0.0127 m dia. With circular cross section. These are Separated by 0.09 m from each other welded to two header tube of copper of 1.1 m long and 0.0381 m diameter. Both set up painted by fast dry black paint with glass of 1.6×1×0.004 m . [6]

Absorber A has highest variation in middle of fluid path as value of 347 k, 346 k and 345 k for three different tube. For same location in absorber tube B has result as 345.5 k, 344.5 k and 344.5 k for different tube. It was conclude that Absorber A has more efficiency than Absorber B.



Fig.7 Circular and Rectangular absorber tube

Alok kumar (2014) did comparative study on FPC by changing circular and semi-circular geometry of raiser tube. He conclude that FPC with semicircular cross section tube has absorbed more heat than that of circular cross section tube due to increasing surface area of contact between tube and absorber plate which increase efficiency of FPC. [7]

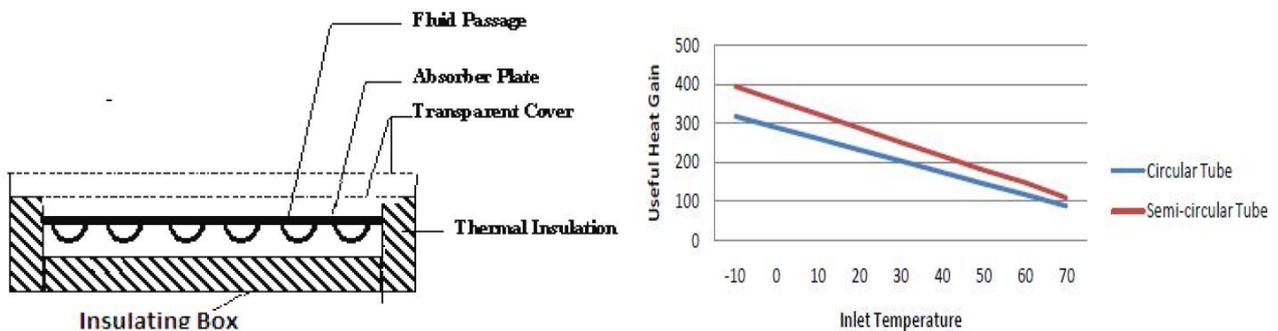


Fig.8 Heat gain by circular & semicircular absorber tube

Rahul Gorle Et. al.(2016) did comparative study of conventional FPC using semi-circular tube and collector using trapezoidal shape with four sided reflective mirror for performance analysis. Results shows that maximum increase in temperature is found to 6.4°C and increase in heat gain is 45.79 %. [8]

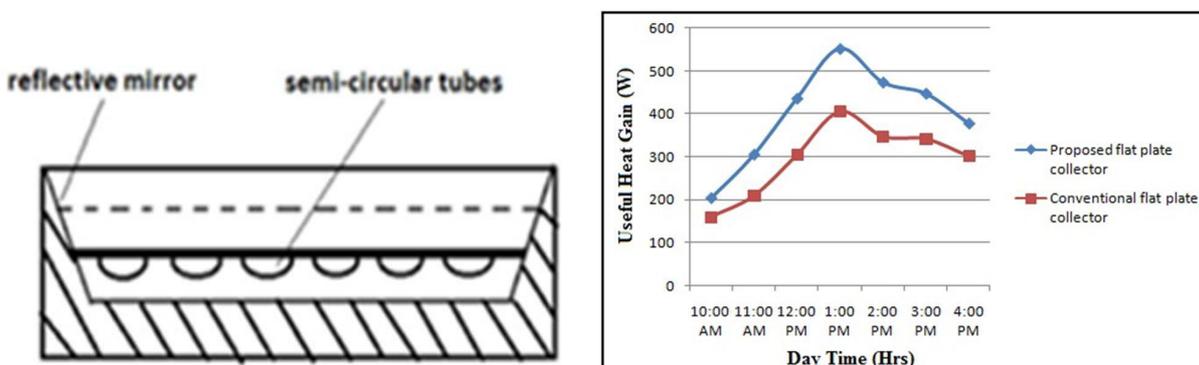


Fig.9 Temperature Variation in absorber tube

Dattatray chincholkar & P. kulkarni (2016) compare solar flat plate collector with circular , elliptical ,Triangular and square shape absorber tube to determine performance of FPC. After experimentation it was conclude that efficiency of FPC of elliptical cross section enhance by 9-12 %,efficiency of trangular cross section enhance by 15-19 % ,square cross section don't show any enhancement . [9]



Time	Inclination angle 30° and flow rate 100 LPH			
	Instantaneous collector Efficiency (%)			
	Circular	Elliptical	Triangular	Square
10.00	36.75	51.01	56.54	39.75
10.30	45.87	51.19	56.06	48.54
11.00	49.90	54.76	57.03	52.60
11.30	55.65	55.44	60.10	56.93
12.00	58.81	63.19	66.92	60.71
12.30	59.89	66.11	69.88	55.90
1.00	68.40	74.33	78.17	68.12
1.30	62.02	67.88	70.02	62.47

Fig.10 Comparison of circular, elliptical, Triangula & square models

Mahesh Thakare and M. Khot (2016) Did experimental investigation on formed tube of circular,triangular, square and elliptical shape absorber tube .Graph of Efficiency Vs time plotted for different flow rate as 25 LPA, 50 LPA, 75 LPA and 100 LPA for circular ,triangular, square and elliptical model. It is conclude that efficiency of triangular tube is maximum as compared to other tube also efficiency is directly proportional to flow rate. It is depends on Intensity of sun light. [10]

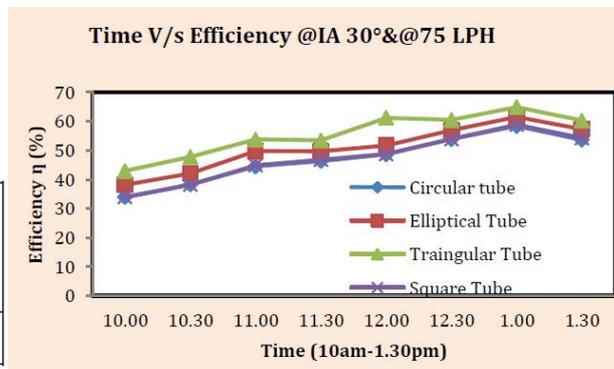
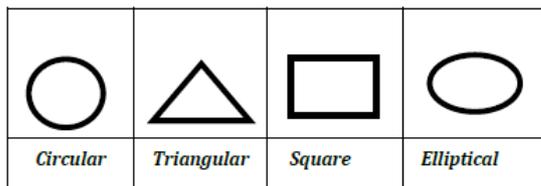


Fig.11 Comparison Time Vs Efficiency

Sunil Amrutkar Et. al. (2012) evaluate the performance of FPC with various geometric shape of absorber. He expect that with same collector higher efficiency may be obtain. Varing the absober material efficiency of FPC is also vary. He compare various types of collecior and reduce losses by conduction & convection. By reducing collector area and decreasing no. of tube ,cost of collector is also reduced. [11]

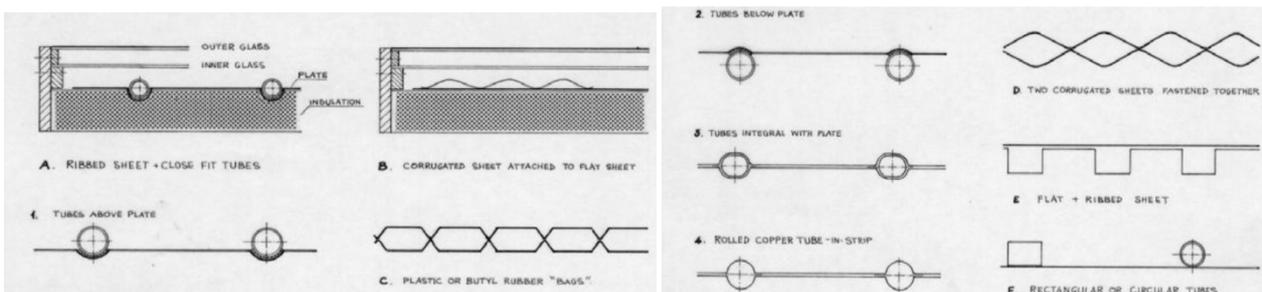


Fig.12 Various Absorber tube shape

It was conclude that there is huge scope in order to reduce collector area and minimizing the number of tube which require for water circulation in FPC. For same outlet temperature reduce area and cost of collector by changing its geometry of absorber tube in FPC.

III. CONCLUSION

- FPC with semi-circular cross section absorber tube has more heat transfer rate than that of circular cross section absorber tube.
- efficiency is directly proportional to flow rate. As mass flow rate increase the efficiency of collector, also get increases.
- Efficiency of FPC increase by changing absorber with high thermal conductivity material
- Efficiency of triangular tube is maximum as compared to other tube
- Efficiency depends on intensity of sun light.
- Reducing the area of FPC with increasing diameter of tube by reducing raiser length increase performance of collector.
- Sandwich type solar collector gives adequate level of efficiency which is inexpensive and easier to manufacture.
- Absorber with trapezoidal profile of plate gives optimal efficiency so it is better choice for solar collector.

From above paper it is conclude that performance of Solar Flat plate collector can be increase by changing geometry of absorber or absorber tube due to increase in surface area of contact between absorber and fluid flowing tube.

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