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EFFECT OF DIFFERENT ABSORBER TUBES ON PERFORMANCE OF FLAT PLATE COLLECTOR

A REVIEW

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Abstract

Flat-plate collectors (FPC) are used to harness the solar radiations to heat the water specifically used for household purpose. The thermal efficiency of FPC is mainly affected by the shape of the absorber tubes and the absorbing capacity of absorber plate. The objective of the present paper is to summarised all previous work on FPC in order to enhance performance using various geometry such as circular, semi-circular, elliptical, triangular, square, rectangular and aerofoil shape of absorber tube.

Keywords: *Different absorber tubes, Performance FPC, Tube shapes, Efficiency.*

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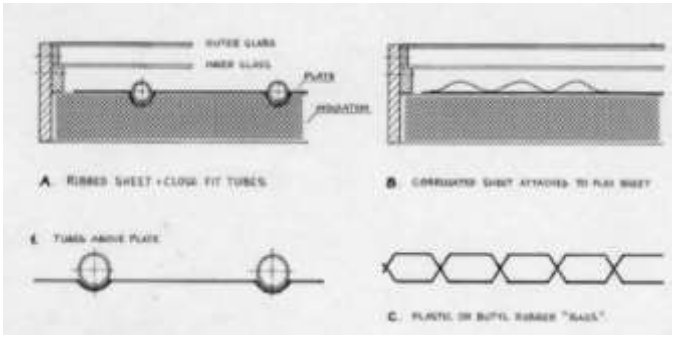
1. INTRODUCTION

In the view of depletion in conventional energy sources, many researchers have carried out the research work in the field of renewable energy sources. There is a wide application of flat plate collectors which uses both direct and diffused solar radiation. The main components of flat plate collectors are absorber tubes, absorber plate, casing and insulation to prevent the thermal energy loss. Many researchers have carried out their research work in the field of FPC in order to enhance its thermal performance.

2. LITERATURE REVIEW

Sunil Amrutkar Et. al. (2012) evaluated the performance of FPC with various geometric shape of absorber. He expect that with same collector higher efficiency may be obtain. Varying the absorber material efficiency of FPC is also vary. He compare various types of collector and reduce losses by conduction & convection. By reducing collector area and decreasing no. of tube,cost of collector is also reduced. [1]



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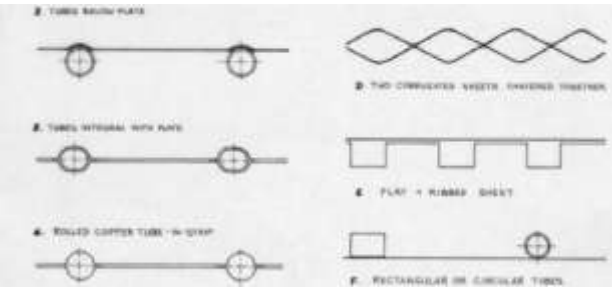


Fig.1Various Absorber tube shape

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.

Ranjitha P. Et al. (2013) did experimental investigation on solar collector panel with circular cross section tube forresult of flow and temperature distribution. These results are validated with ANSYS CFD simulation results. Set upconsist 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 mlong with inner dia.0.0254 m. Transparent glass is 0.004 m thick and glass to absorber distance is 0.035 m. Overalldimensions are 1.003×0.503×0.105 m. It was conclude that experimental results are quite close to CFD predictions. [2]

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.2 Outlet temperature results of circular absorber Tube

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 thatperformance of collector increases. Set up consist collector box of 1 m length and 0.5 m width, absorber tube is0.017×0.017×0.017 m, 0.8 m long and 0.0005 m thick. These results are comparing with CFD simulations. [3]

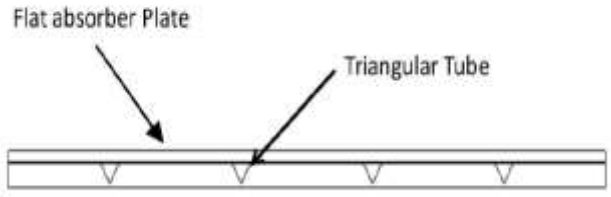


Fig.3 Triangular shape absorber tube

It concluded 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

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 cupper 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. [4]

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 concluded that Absorber A has more efficiency than Absorber B.

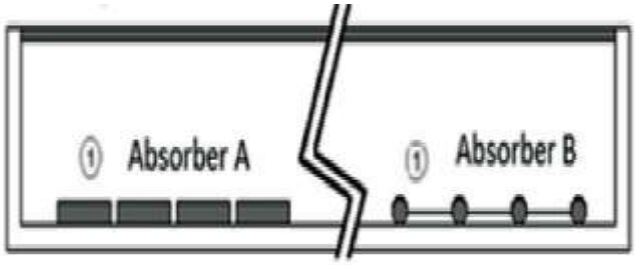


Fig 4 Circular and Rectangular absorber tube

Alokkumar (2014) did comparative study on FPC by changing circular and semi-circular geometry of raiser tube. He concluded 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. [5]

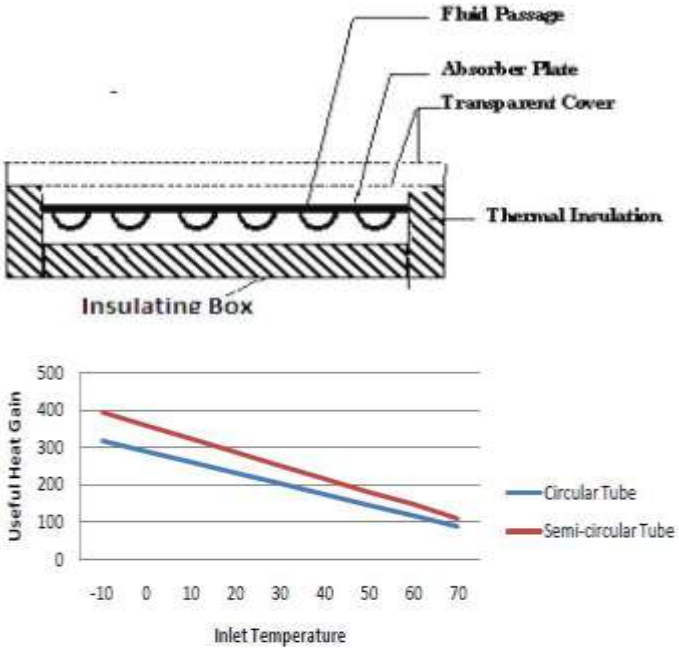


Fig.5 Heat gain by circular & semicircular absorber tube

Yuechao D. Et. al. (2015) had carried outinvestigated 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. [6]

Fig.6 Cross Section of MHPA

K.A. MuhammedYarshi&Dr. Benny Paul (2015) haveanalysed the effect of change in shape of absorber tube for flatplate collector performance. He investigated the effect of mass flow rate and absorber material on FPC efficiency. Setup consist of absorber tube of 0.8 m long with inner dia. 0.012 m. Header pipe of 0.8 m long with dia. 0.24 m, glazingarea is 0.5 m^2. Overall dimensions are 1×1.5×0.1 m. He studied collector with circular and semi-circular absorber tubeperformance. It was examine that outlet temperature of semi-circular collector is greater than conventional circularcollector due to increasing absorbing area. [7]

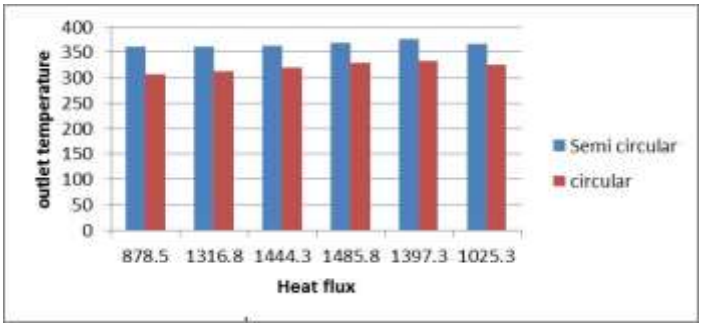
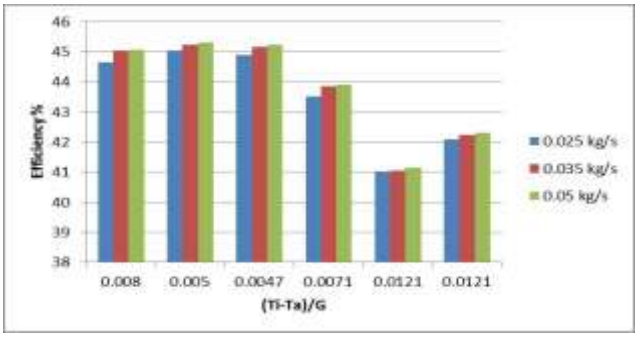


Fig.7 Comparison of Circular & Semi-circular absorber tube

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.



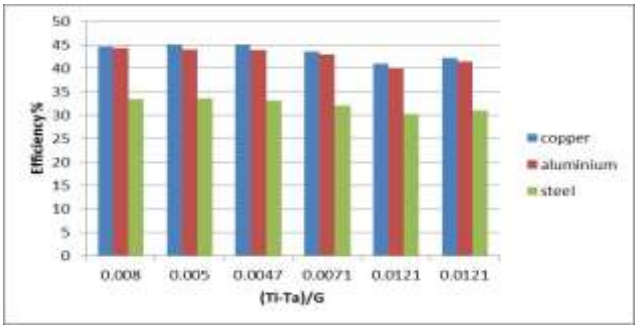


Fig.8 Effect of mass flow & absorber material on Efficiency

Vishal Shelke and ChinmayPatil (2015) have been analysed 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. [8]

Time	*Inlet Temp in °C*	*Heat Flux in w/m2*	*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

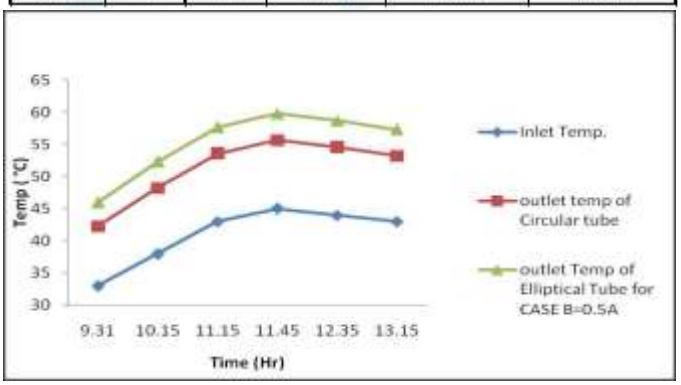
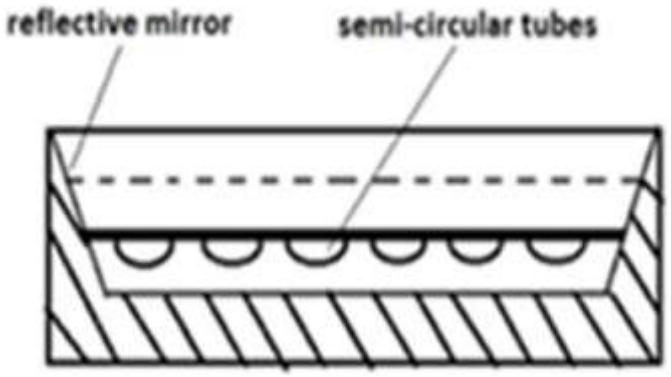


Fig.9 Comparison of inlet & outlet temperature between circular & elliptical tube

Rahul GorleEt. 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. Result shows that maximum increase in temperature is found to 6.4°C and increase in heat gain is 45.79 %. [9]



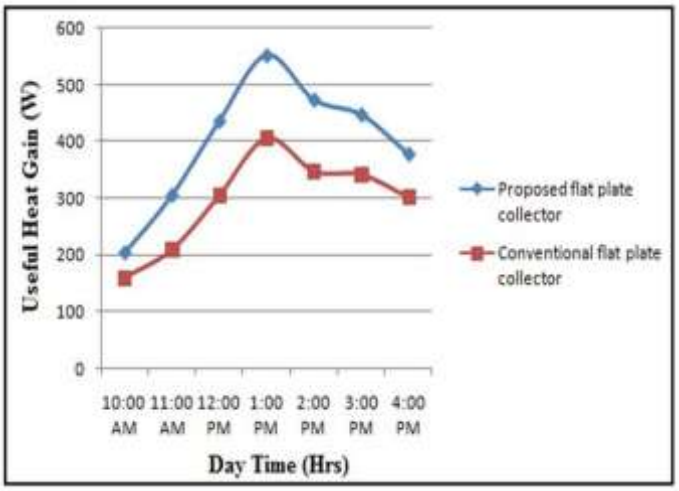


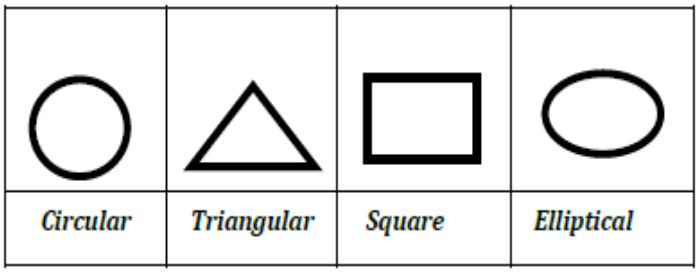
Fig.10 Temperature Variation in absorber tube

Dattatraychincholkar& P. kulkarni (2016) compared 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 triangular cross section enhance by 15-19 % , square cross section don't show any enhancement. [10]

Inclination angle 30° and flow rate 100 LPH				
Time	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 11Comparison of circular, elliptical, Triangular & square models

Mahesh Thakare and M. Khot (2016)didexperimental investigation on formed tube of circular,triangular, squareand 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 ismaximum as compared to other tube also efficiency is directly proportional to flow rate. It is depends on Intensity ofsun light. [11]



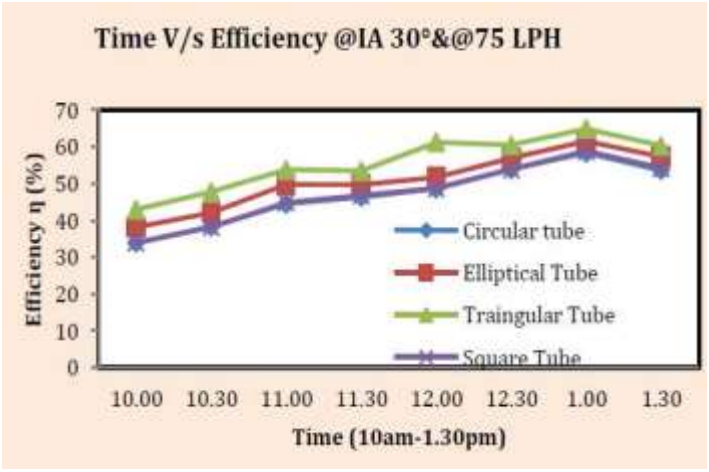


Fig 12 Comparison Time Vs Efficiency

Ganesh K. Badgurjar and Shubhangi G. Kamble (2017) Summarised 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.[12]

PankajN.Shrirao Et al. (2018) have been investigatedthe performance of a solar flat plate collector using aerofoil and circular shape absorber tubes. The experimental data is compared for both the solar flat plate collectors. Based on the experimental results it can be concluded that FPC with aerofoil shape absorber tubes gained more amount of solar radiation as compared with the circular shape absorber tubes. It is observed that with increase in mass flow rate of water flowing through the absorber tubes, the efficiency of both the collectors also get increases. Absorber with aerofoil shape gives optimal efficiency due to increase in surface area of contact between absorber plate and fluid flowing through the tubes so it can be concluded that the use of aerofoil shape absorber tubes isbeneficial in conventional flat plate collector.

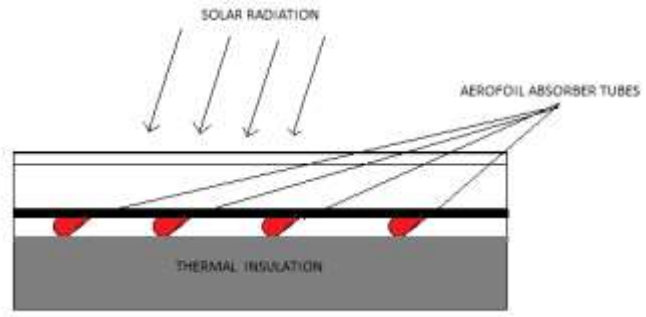


Fig 13 FPC with Aerofoil absorber tubes

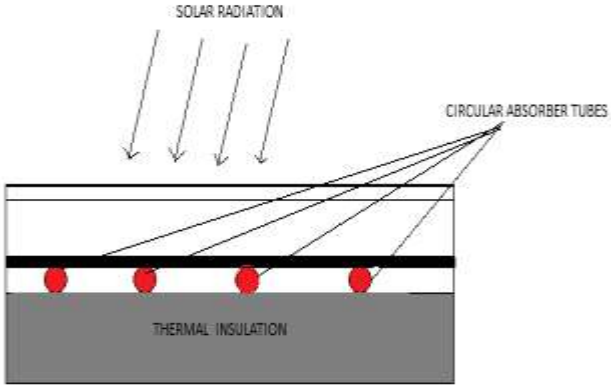


Fig 14 FPC with Circular absorber tubes

Fig.15 Cross section of Aerofoil absorber tubes

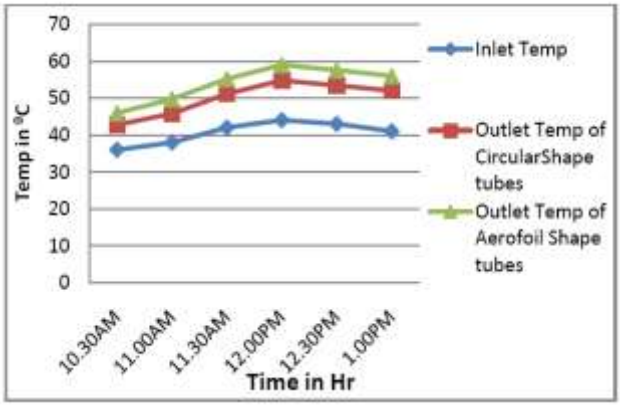


Fig.16 Comparison of Outlet temperature results of circular and aerofoil shape absorber tube

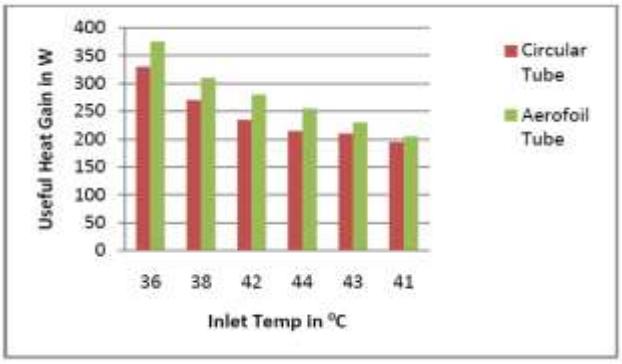


Fig.17 Useful Heat gain by circular and Aerofoil shape Absorber Tubes

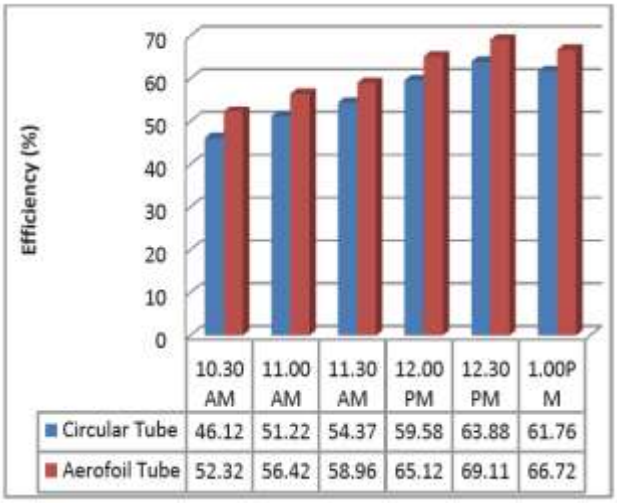


Fig 18 Comparison of FPC Efficiency for circular and aerofoil shape absorber tubes

3. CONCLUSION

From above review 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.

4. ACKNOWLEDGEMENT

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