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SOLAR WATER HEATER COLLECTOR TUBE OPTIMIZED PERMORMANCE ANALYSIS

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ABSTRACT
The use of solar energy is increasing rapidly in both industrial and domestic purposes and one of its useful purpose is production of hot water with the help of solar water heater , which plays an important role in energy conservation. By utilizing the solar energy instead of the usual electrical energy the cost as well as electric energy can be saved and also its efficiency is comparatively more than the electrical energy conversion. Due to this advantages its implementation is rapidly increasing in domestic. Solar water heater is a very simple device and efficient way to absorb energy from the sun rays and use it. Therefore improvement in their operating condition & geometrical would definitely result in saving conventional fuel and cost. The objective of this study is to suit the best collector tubes design and also to validate the mass flow rate of water inside the collector tube in an natural circulation solar water heater system. The existing solar water heating systems the optimum mass flow rate is 0.1 kg / m2 with circular shape as the collector tube. For this purpose an analysis has been carried out in Ansys fluent software and the results shows that the maximum mass flow rate inside the collector tube is 0.6 kg / m2 ,dynamic pressure of 4.30×10^5 Pa , flow velocity of 5.91×105 l/m2 & relative temperature of 367° K. for triangle shape collector tube groove.

INTRODUCTION
Solar energy is the primary energy source for our planet as it is responsible for providing energy for plant growth (photosynthesis) and providing the warmth that makes our planet habitable. Solar water heaters use the solar energy from the sun to generate heat (not electricity) which can then be used to heat water. The core of a solar water heater is a solar collector and a storage tank. A solar collector is basically a glazed, insulated box with a dark-colored interior and, usually, a bunch of tubes or passageways for water flow. (Glazing is a coat of material, typically glass, that aids in heat retention.) The solar collector turns the sun's radiation into heat. A storage tank is exactly what it sounds like. It holds the water. that's the basic setup, and some systems aren't much more complicated than that. The first distinction among solar water heaters is cut and dry: passive or active? An active heater uses electrical pumps and controls to move water around the system. A passive heater uses nothing but forces of nature. Passive is the simpler of the two.

Solar is an excellent clean energy source: Its fuel, sunlight, is limitless, free and emits nothing when converted into energy. The problem with solar, as most of us know, is its efficiency. Solar photovoltaic technology, or PV, is less efficient at converting its fuel into electricity than, say, a wind turbine. But when you're talking about heating water (as opposed to powering light bulbs or stereos), the sunlight doesn't need to become electricity. It needs to become heat. And turning sunlight into heat is no problem. Which is not to say solar water heaters have no drawbacks. In this article, we'll find out how a solar water heating system works, which factors determine its efficiency, how you could make your own, and why you might or might not want to. At its core, a solar water heater does one thing: It uses sunlight to warm water.

Solar water heating system with capacity of 50 to 100 liters per day has been installed in more than 30,000 homes throughout India the requirement of hot water per day for industrial and commercial sector is around 2,40,000 liters. According to the overall installed capacity of thermal collectors in India is capable of producing around 25 million liters of hot water per day at 60°- 70°C.

But there are concern like **Temperature**: If you live in a very cold location, direct heater models (batch, thermosiphon and direct-active) might be unavailable to you due to the risk of freezing, **Home orientation**: To have an efficient setup, you need to have a mounting location with considerable sun exposure; city dwellings may not qualify. **Water quality**: If your home's water is particularly hard or acidic, you may not be a candidate for an active system. Hard or acidic water can corrode water-circulation systems. **Power requirements**: Since active systems rely on electrically powered machinery, they won't work during a power outage. **Building regulations**: Some areas, like those prone to earthquakes, have strict weight limits for roof-mounted equipment. A solar water heater might be too heavy.

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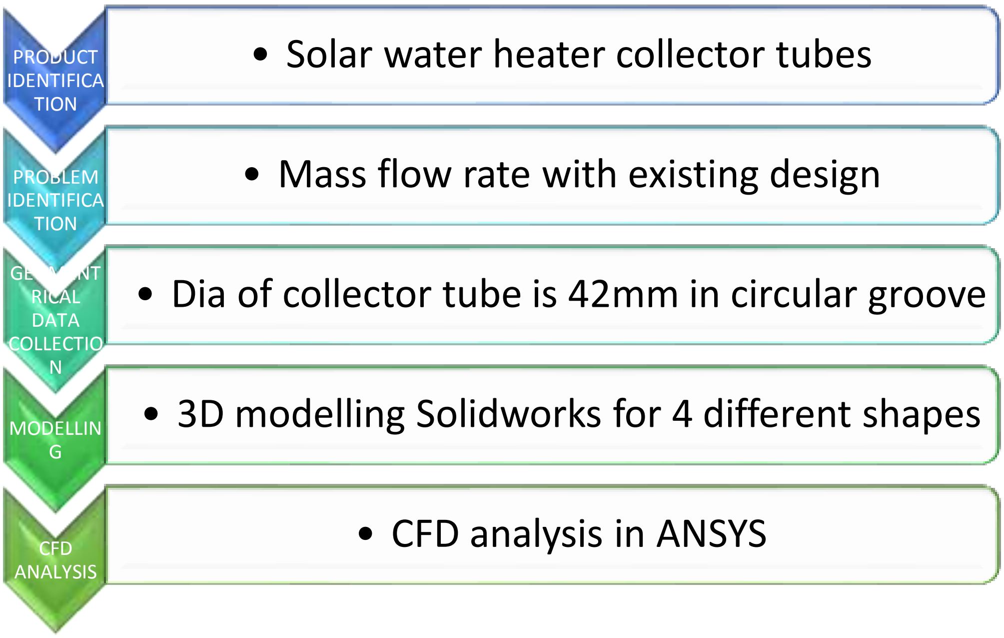
In this study the already existing solar water heater panel model has reengineered and the new model has been created by using solid works software. Finally the whole assembly is imported to ANSYS FLUENT software and the prescribed shapes like circle,square,rectangle and trapezoidal are considered for best temperature conductivity and the mass flow rate inside the collector tube is calculated numerically by using it.

METHODS

Methodologies of this study starts with the product selection (solar water heater collector tubes) and continue with problem identification it refers to the problem as the existing collector tube's mass flow rate with the existing tube circular groove is not as much effective as much i.e due to its reengineering the mass flow rate can be improved , followed by collection of geometric data from an already existing solar water heater collector system and goes to creation of model using solid works software finally it ends with the CFD analysis in ansys fluent for optimization



PROBLEM IDENTIFICATION

In the existing solar water heating systems, the overall thermal performance reduces due to non- uniform flow in riser tubes. The overall thermal performance and efficiency is higher in variable header system due to uniform velocity.

GEOMETRICAL DETAILS

The absorber-water pipe assembly formed an inner box, which in turns is mounted in an outer box, the space between the absorber-water pipe assembly and outer box is filled with wood shaven as insulating material. The front surface of the box is then covered with 4 mm thick clear plain glass and air gap between the plate and the glass cover is 76 mm. the overall dimension of flat-plate solar collector is 1130x830x190 mm and the effective glazing area is 0.7 m^2.

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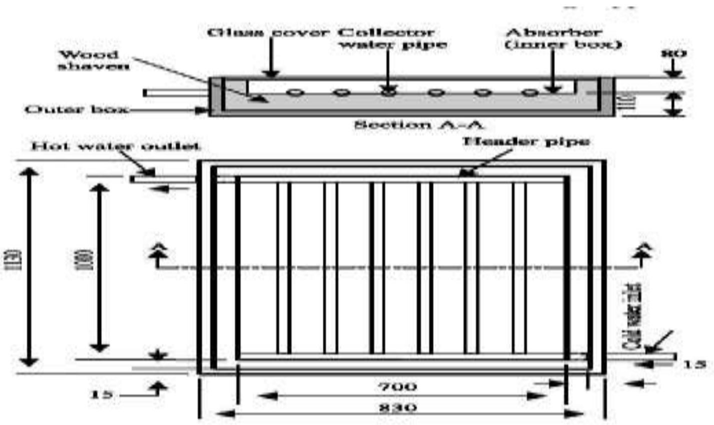

Fig 1 : Existing collector dimensions

3D MODELING

The above three dimensional model of solar water heater panel was created by solid works software with the over all dimensions of this panel is same as in the fig 1 i.e 1130x830x190 mm with the collector tube dia of 42 mm.in circular shape inner groove

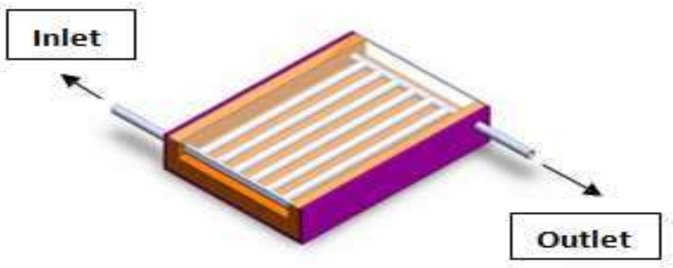

Fig 2 : 3D Modeling of solar water heater collector

In this paper the shape of the solar water heater collector tubes is also modified i.e the existing collector tubes has circular inner groove and this circular inner groove is modified as square,triangle and trapezoidal inner groove whose design are shown below fig 3,4,5

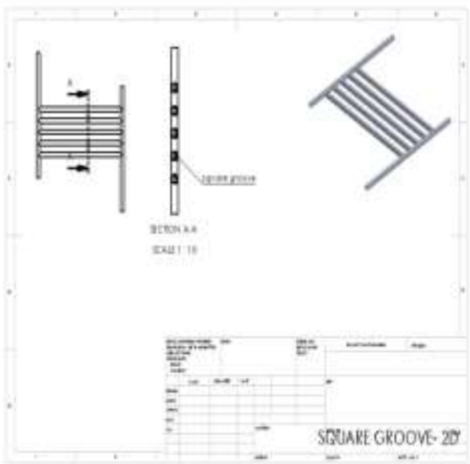

Fig 3 : Square groove

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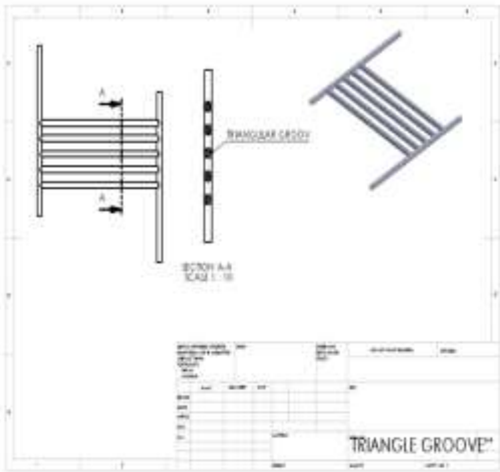

Fig 4 : Triangle groove

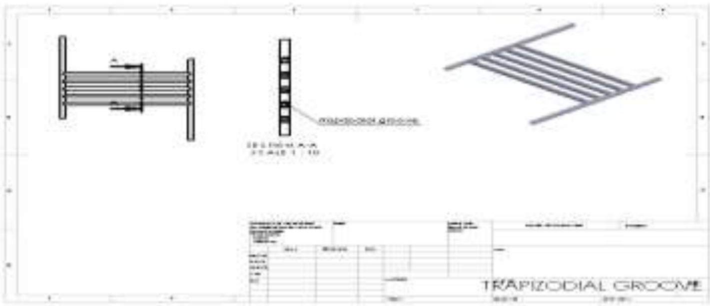

Fig 5 : Trapezoidal groove

CFD Analysis

CFD analysis is carried out to optimize the mass flow rate of water inside the collector tube by means of the following step

1) Model creation
   We have already discussed about the three dimensional model creations. Created model is imported to ANSYS
2) Mesh generation
   After importing the three dimensional model, the imported model is meshed with help of mesh options. Meshed model is shown in Fig.6
3) Applying boundary condition
   After mesh generation boundary conditions are given to this system. In this solar water heater there are two boundary conditions well defined. (Inlet & Outlet).
4) Initialization
   The solver functioning areas its initialization values in constant mass flow rate 300 k ,pressure distribution analysis insert 1bar ,velocity magnitude 0.6m/s its initialized it.
5) Solution converged plot
   In solver stage optimum results computed with the solution converged plot. Fig.7 shows the solution converged plot which is taken from ANSYS/CFD. If optimum result reached at that time the above mentioned solution converged plot is appeared.

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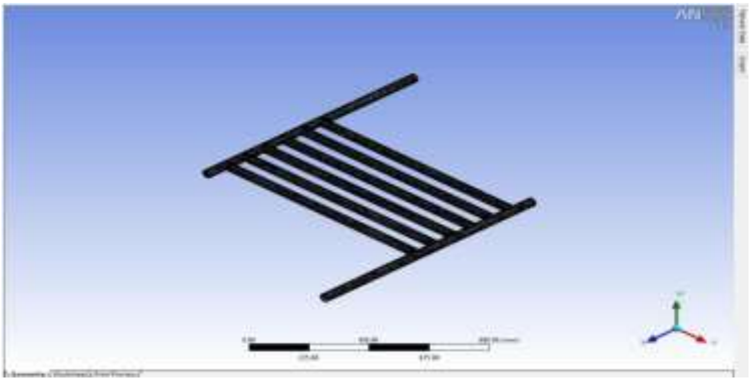

Fig 6 : Mesh Generation

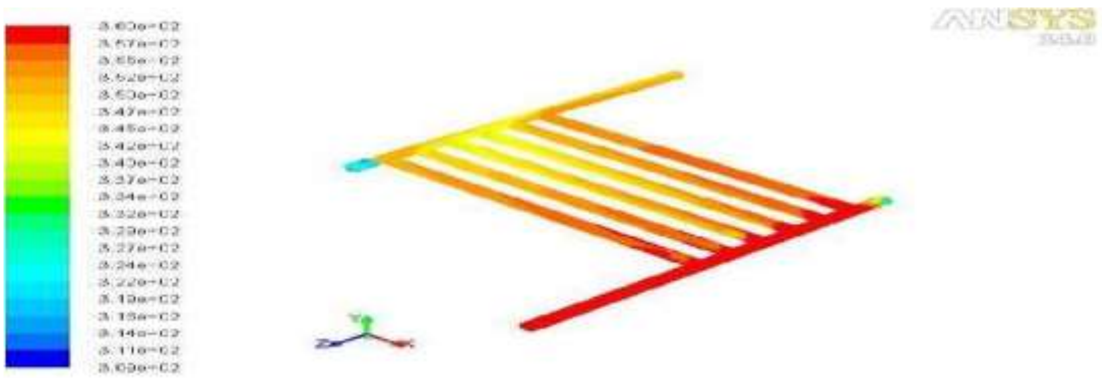

Fig 7 : Temperature result for circular groove

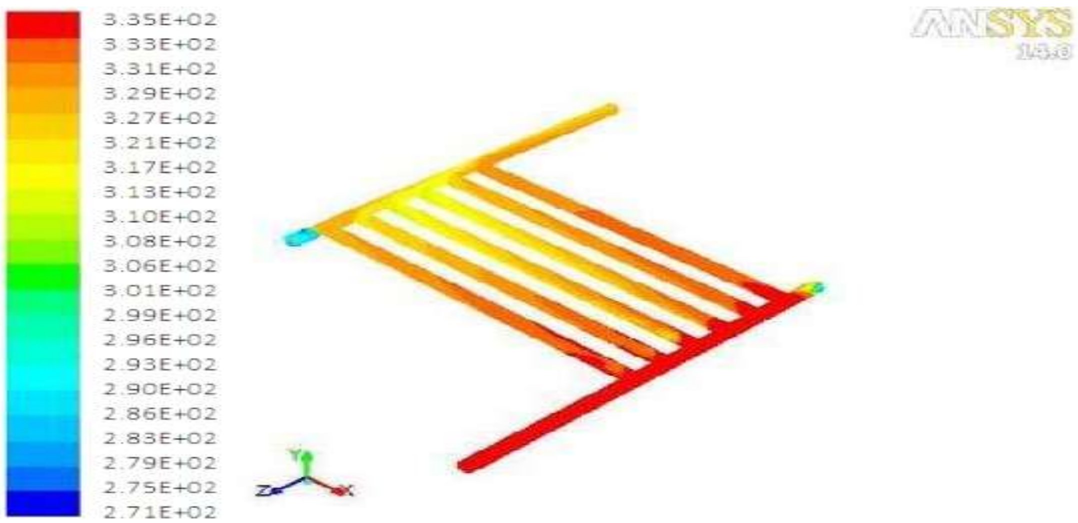

Fig 8 : Temperature result for Square groove

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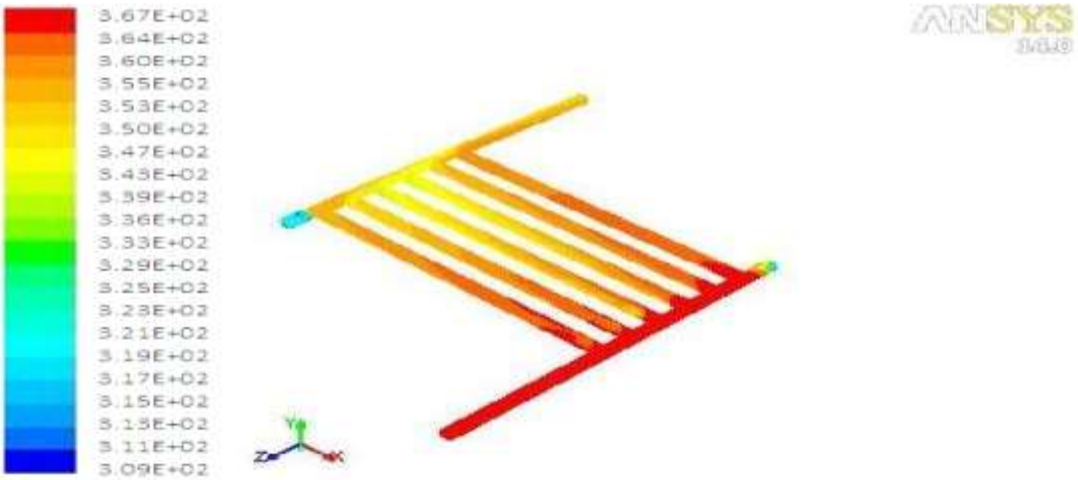

Fig 9 : Temperature result for Triangle groove

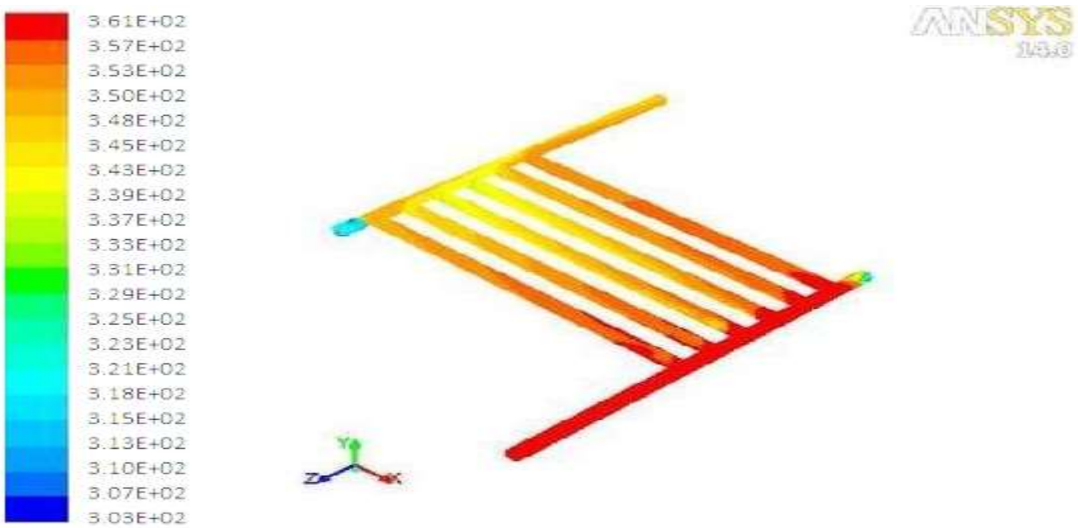

Fig 10 : Temperature result for Trapezoidal groove

RESULTS AND DISCUSSION

From the above fig 7,8,9,10, shows the analysis result for the maximum temperature for different shapes like circle, square, triangle, trapezoidal. And among the different shapes the triangle shaped inner groove has showed an higher temperature of 367 when compared to the existing circular groove, therefore the triangle groove is preferred over the circular groove (Table 2)

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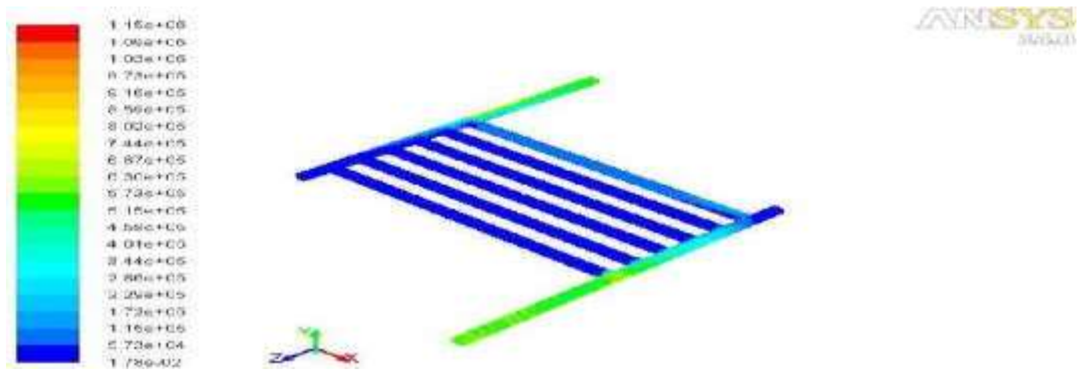

Fig 11 : Contour plot of dynamic pressure

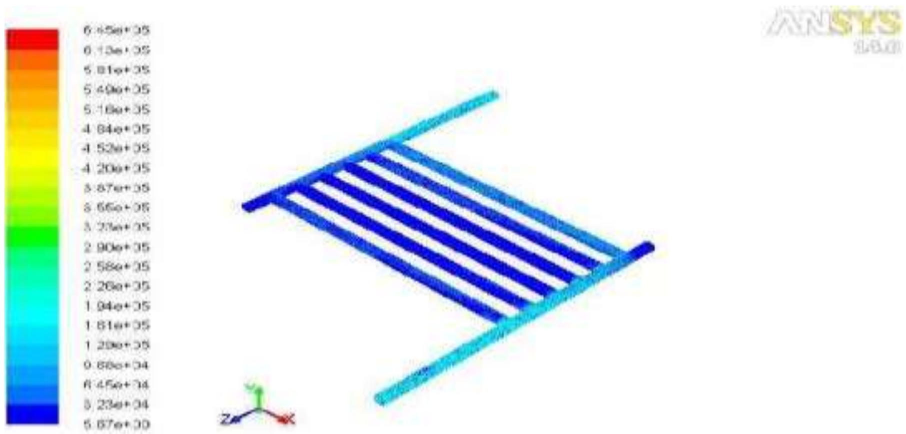

Fig 12 : Contour plot of flow velocity

The above analysis shown in fig 11,12 states that the counter plot for the dynamic pressure and flow velocity as 1.15×10^5 Pascal and 6.45×10^5.per m^2 i.e shown that the maximum pressure that the tubes can with stand under the maximum temperature is around 6.28E06 Pascal, that is the pressure is above the normal pressure of water. The maximum velocity that can be obtained under the pressure is around 6.45E05 which is well enough for the domestic and normal industrial purpose. The introduction of various mass flow rate in uniform flow analysis and considered the best mass flow rate which achieve in 0.6 kg/ms (Table :1).

1) Mass flow rate Vs Dynamic pressure

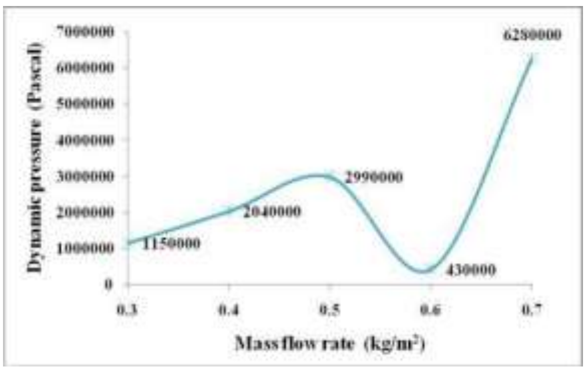

Fig 12 : Effect of mass flow rate at different dynamic pressure condition

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The above figure (Fig.12) shows clearly that the increasing of mass flow rate which causes the increased value of dynamic pressure. Maximum dynamic pressure of 4.30×10^5 Pa has been obtained at the mass flow rate of 0.6 kg / m^2

2) Mass flow rate Vs Flow velocity

The Fig.13 shows the effect of velocity of water flow at different mass flow rates. At the mass flow rate value of 0.3 kg / m^2 initial flow velocity of water is high then its velocity suddenly gets the drastic changes at mass flow rate of 0.4 & 0.5 kg / m^2 again the flow velocity suddenly increased at the mass flow rate of 0.6 kg / m^2.Finally the maximum velocity can be obtained at the mass flow rate of 0.6 kg / m^2

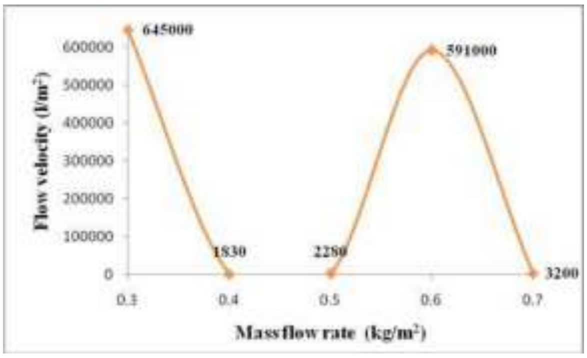

Fig 12 : Effect of mass flow rate at different velocity level

1) Mass flow rate Vs Total temperature

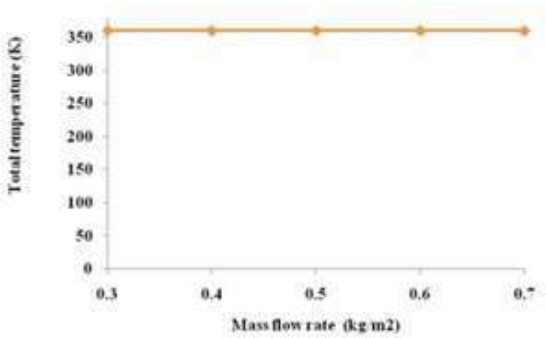

Fig.13 Effect of mass flow rate at total temperature

From the above figure (Fig 13) it has been shown that temperature is constant 367 K upto the maximum analyzed mass flow rate of 0.7 kg/m^2

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TABLES

Table 1: Tabulation for mass flow rate and velocity

MASS FLOW RATE	DYNAMIC PRESSURE	VELOCITY	TOTAL RELATIVE TEMPERATURE
Kg/m^2	[PASCAL]	m/s	K
0.3	1.15E06	6.45E05	367
0.4	2.04E06	1.83E03	367
0.5	2.99E06	2.28E03	367
0.6	4.30E05	5.91E05	367
0.7	6.28E06	3.20E03	367

Table 2: Tabulation for mass flow rate and velocity

INNER GROOVE OF SECTION	CIRCULAR INNER GROOVE	TRIANGULAR INNER GROOVE	SQUARE INNER GROOVE	TRAPEZOIDAL INNER GROOVE
Heat flow rate[K]	360	**367.20**	334.7	361.4

CONCLUSION

This study is carried out in solar water heater by using CFD software. Results show that maximum mass flow rate is achieved more than experimental values. At the mass flow rate of 0.6 kg / m^2 maximum velocity has been obtained 5.91 $\times 10^5$ l / m^2.The simulated velocity at the different mass flow rate compared and the results are discussed in detailed manner. Results proved that the maximum mass flow rate of these systems can be obtained up to 0.6 kg / m^2.

Above comparing the table 1,2 and the analyzed figures , the best flow of 0.6 is already done it. Mass flow rate to functionally while pressure will increases velocity also increases the best inner grooves The mass flow rate to considering best velocity to increases. Our discussing to best simulate 0.6 mass flow rate handling best inner groove in **Triangular that time main relative temperature 367.4 k maximum level**

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