Experimental Investigation of Flat Plate Solar Water Collector by Flow Pulsation and Metal Blocks

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***Abstract*— This study investigates thermal performance of a flat plate solar collector. The process involves the use of Aluminium metal blocks and forced pulsationof incoming fluid to determine the performance characteristics of temperature. Investigations are made to study performance characteristics of solar flat plate collector provided with set of aluminium metal blocks, runner/copper tubes, absorber plate and horizontal–rectangular channel. In the present work, experimental test is carried out for two different conditions. First for steady state condition and other for pulsating flow conditions. Comparison of above conditions shows that there is improved thermal performance of flat plate collector for the second condition i.e with pulsating flow condition. Improved thermal efficiency is achieved than for a steady flow condition.**

Keywords— Aluminium metal blocks, pulsation flow, collector efficiency.

INTRODUCTION

Now a days fossil fuels price are increasing fastly. Use of this fuel increases atmospheric pollution also cost of this fossile fuel is high. There is decreasing quantity of these fuels. There is increasing need to use natural resources. So one such method is the use of solar energy. One major type of this energy is the flat plate collector. Working of this collector is also simple. It is easy to handle and maintain.it is widely used in households applications.

It consist of absorber plate, aluminium metal blocks, runner/copper tubes, inlet and outlet manifold, Storage tank.

In this metal plate is used which absorbs the sun rays directly. This plate absorbs this heat and transfer it to the tubes through which water is flowing. this tubes are attached to the absorber plate. So the temperature of the fluid inside the tubes gets heated and we get high temperature at outside.

AIM AND OBJECTIVES OF PROJECT WORK

To measure the performance of flat plate collector using various experimental modifications in design of flat plate collector.

Flat plate collectors are designed for applications requiring moderate temperatures. Objective of this work is to presents extensive studies of the research carried out in order to investigate the flat plate collector performance. Detailed objectives of this work are as follows.

1. To increase heat transfer enhancement.
2. To perform analysis of flat plate collector provided with aluminium metal blocks and pulsation at the inlet pipe.

NEED OF PROJECT WORK

In this project pulsating disturbance in the fluid flow is created at the inlet pipe of a flat plate collector. It is a irregular fluid flow in a pipe which is created from pressure variations within the system which increases the heat transfer rate. It provides warm water with increase in the performance of solar collector.

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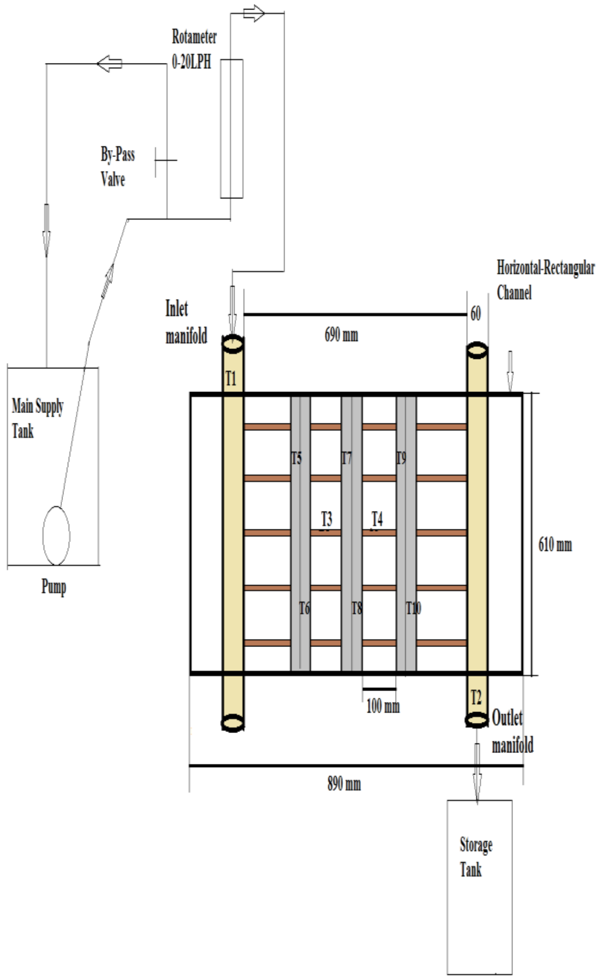
EXPERIMENTAL SET-UP



Schematic diagram of the Experimental set up

Components used are:
Aluminium Metal Blocks:

Aluminium metal blocks are used to increase the temperature of the runner tubes. As these tubes are inserted at the middle of these blocks. So heat absorbed by the absorber plate is first transfer to these blocks and then it is transferred to the runner tubes, so temperature of runner tubes increases.
Advantades

1) Easy machinability
2) Good absorption charecteristics
3) Light in weight

Pulsation Flow

Pulsation flow is used to increase the heat transfer rate of flat plate collector. This is done by disturbing the fluid flow in the inlet pipe. Aluminium rods are used for this purpose. These rods are inserted vertically in the inlet pipe to the end. These rods are placed at a specific distance from each other.
So we get better mixing of the water and in this way heat transfer rate increases.

Rotameter:

Rotameter is used here. This is used to regulate how much litres of water per hour should flow through the inlet pipe. So we get equal amount of supply throught the day. In this way we can calculate for particular litre of water how much temperature gets increased.

By-pass Valve:

The bypass valve is used to draw excess amount of water which is not required to flow through the inlet pipe. This excess water flows back to the main water supply tank.

Copper/ runner tubes:

Copper is an important component of solar thermal heating and cooling systems because of its high heat conductivity. These copper tubes are soldered between the inlet and outlet pipe.

Digital Temperature indicator:

Temperature indicator are used to get the temperature of various thermocouples which are situated at different positons.

EXPERIMENTAL PROCEDURE

It consist of aluminium metal blocks, copper tubes, inlet and outlet pipes, main water supply tank. First the pump pumps the water from the main supply tank, this water is then flow to the inlet pipe through the rotameter. The excess water is then flows back to the main supply tank with the help of bypass valve. This water is then flows to the copper tubes and then comes out at the outlet pipe. In this the absorber plate absorbs the sun rays this plate gets heated. This heat is then transfer to the aluminium metal blocks so the temperature of the blocks also increases. From the metal block this heat is passed through the the runner tubes. So the water inside these tubes get heated and we get higher temperature water at outlet. This the procedure for steady flow. For pulsating flow, the disturbance is created in the inlet pipe insertin rods vertically in the pipe.
Reading for 10, 15, 20 LPH is noted for steady and pulsation flow. It is found that for low flow rate that is for 10 LPH we get high efficiency.

RESULT AND DISCUSSION

1. For steady flow

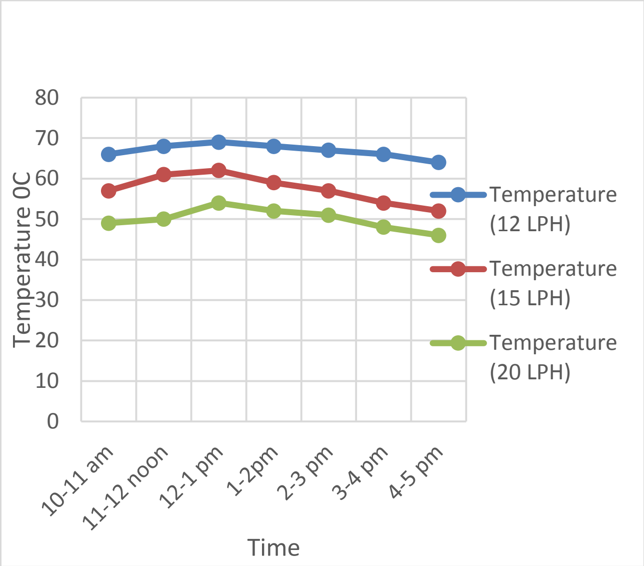


Figure 1 Comparison of graphs between day time (IST) Vs hot water outlet temperature as per different flow rate conditions.

Fig. 1 shows comparison of performance of the test set up for different flow rate conditions. The blue curve shows the maximum outlet temperature of water for 12 LPH. The maximum temperature of water recorded is 69° C. after increasing the flow rate the temperature of water decreases.

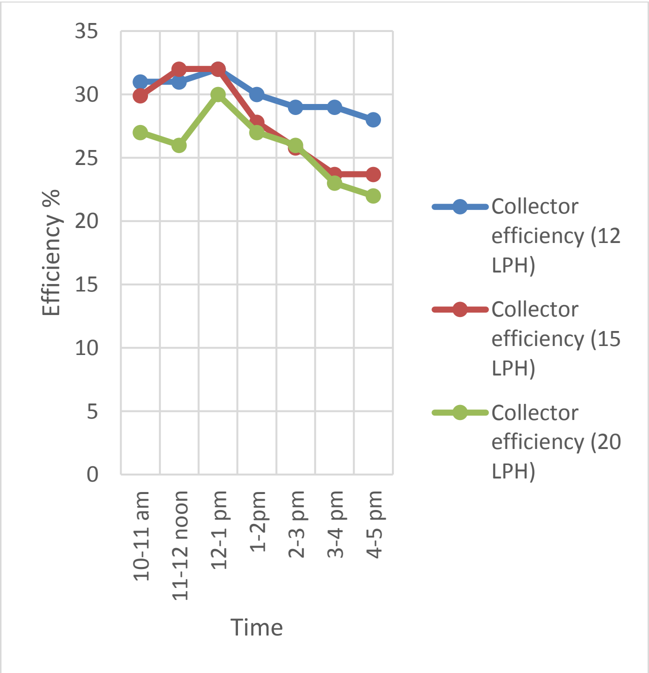


Figure 2 shows the Comparison of graphs between day time (IST) Vs collector efficiency as per different flow rate conditions

Fig. 2 shows comparison of performance of the test set up for different flow rate conditions. The blue curve shows the highest values of the efficiency at 12 LPH. The maximum efficiency is found to be 69 ° C. After increasing the flow rate the efficiency falls down. Minimum value of efficiency is 22° C at 4pm to 5pm.

2. For Pulsation flow

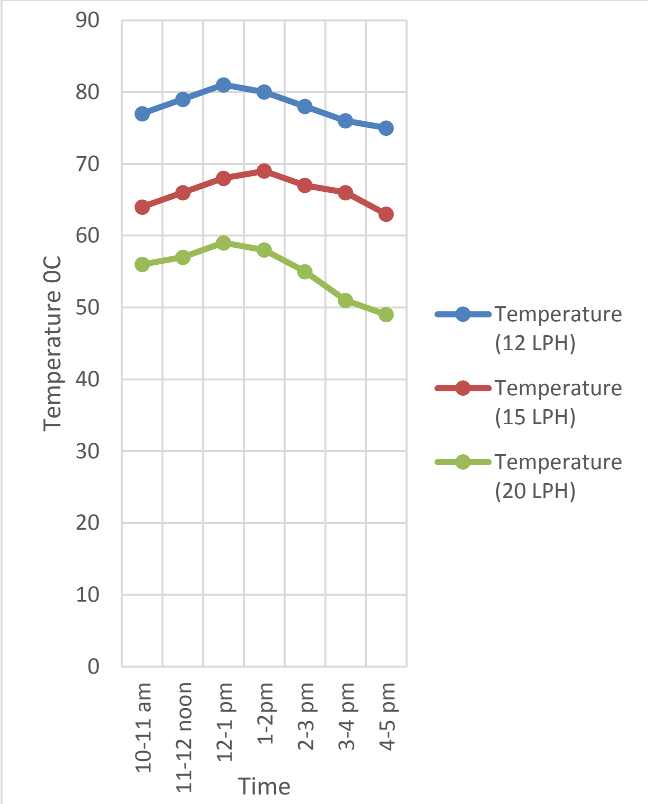


Figure 3 Comparison of graphs between day time (IST) Vs hot water outlet temperature as per different flow rate conditions.

Fig. 3 shows comparison of performance of the test set up for different flow rate conditions. The blue curve shows the maximum outlet temperature of water for 12 LPH. The maximum temperature of water recorded is 81° C. after increasing the flow rate the temperature of water decreases.

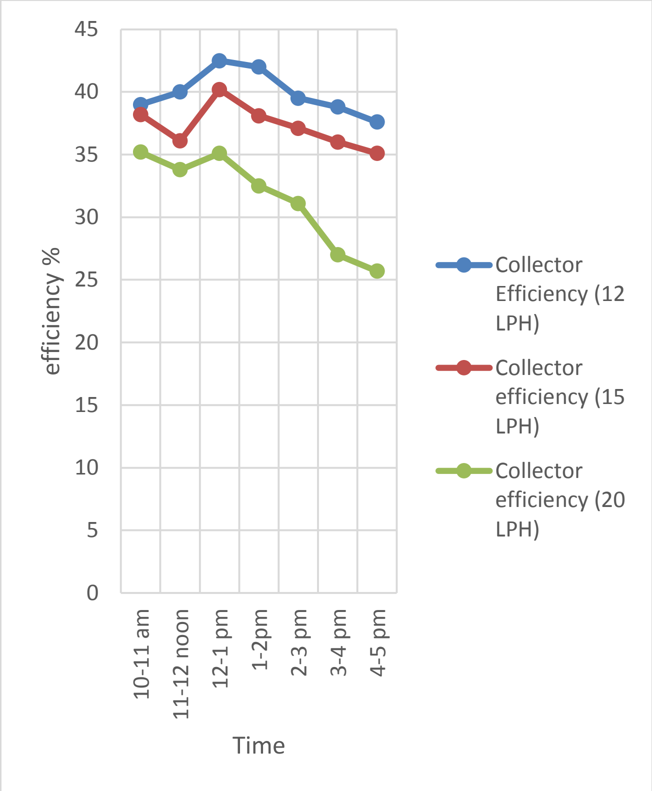


Figure 4 shows Comparison of graphs between day time (IST) Vs collector efficiency as per different flow rate conditions.

Fig. 4 shows comparison of performance of the test set up for different flow rate conditions. The blue curve shows the highest values of the efficiency at 12 LPH. The maximum efficiency is found to be 42.5 ° C. After increasing the flow rate the efficiency falls down. Minimum value of efficiency is 25.7° C at 4pm to 5pm.

3. Variation of Nusselt number with respect to Reynold number

Steady flow condition, for 12 LPH

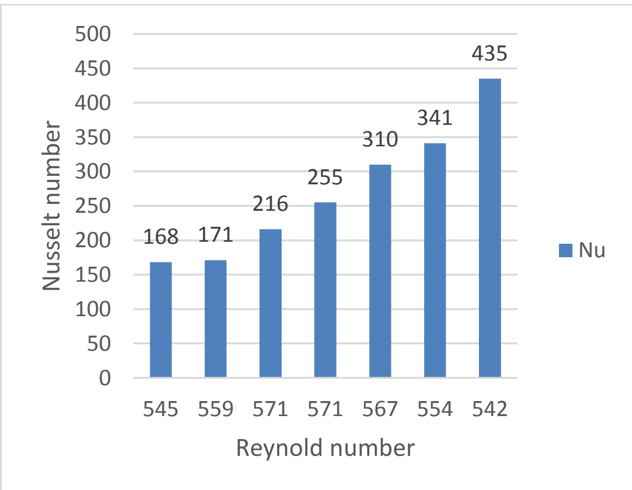


Fig. 5 Reynold number Vs Nusselt number (For 12 LPH)

Figure 5 shows that Nusselt number increases as the Reynold number increases. After this nusselt number goes on increasing but Reynold number decreases this is because values of temperature goes on decreasing after 2pm so it decreases the value of Reynold number. The maximum value of nusselt number is 435 and maximum value of Reynold number is 571. The figure represents the performance for steady flow condition at 12 LPH.

Steady flow condition, for 15 LPH

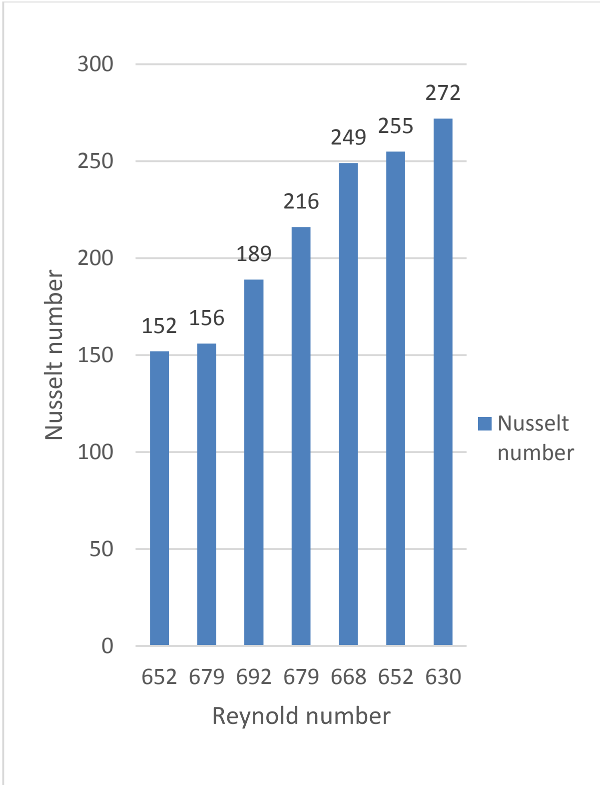


Fig. 6 Reynold number Vs Nusselt number (For 15 LPH)

Figure 6 shows that Nusselt number increases as the Reynold number increases. After this nusselt number goes on increasing but Reynold decreases this is because values of temperature goes on decreasing after 1pm so it decreases the value of Reynold number. The maximum value of nusselt number is 272 and maximum value of Reynold number is 692. The average value of nusselt number decreases as compare to steady flow at 12 LPH as flow rate increases. The figure represents the performance for steady flow condition at 15 LPH.

Steady flow condition, for 20 LPH

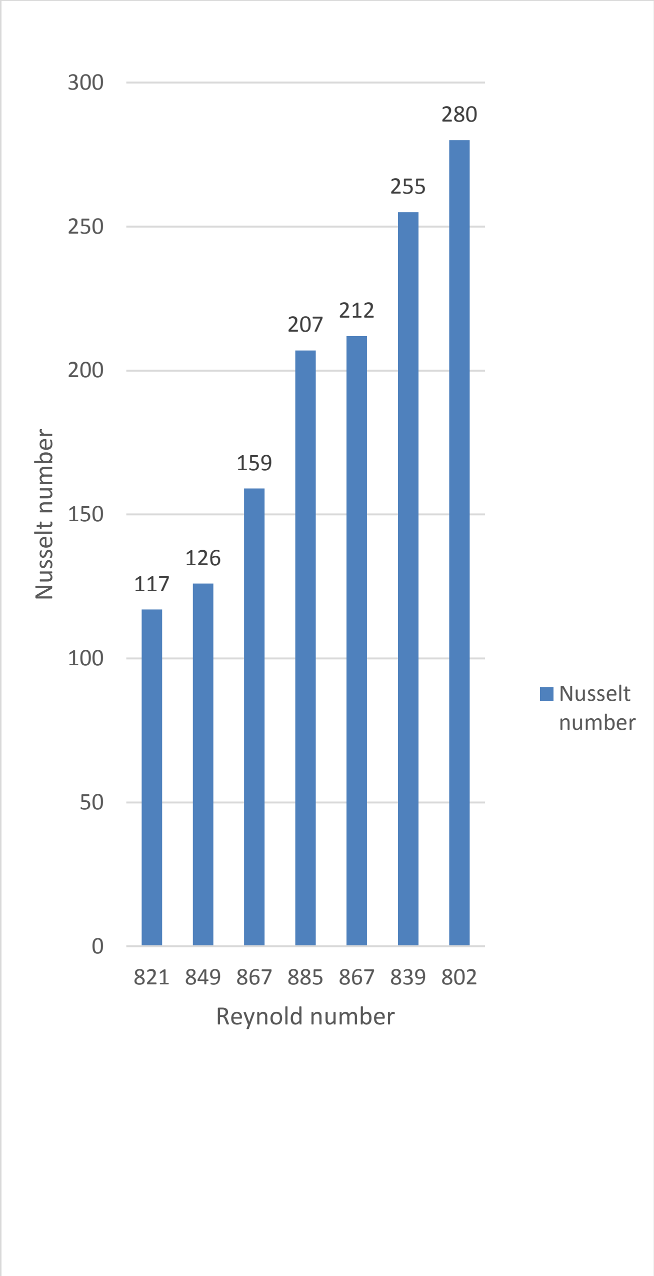


Fig. 7 Reynold number Vs Nusselt number (For 20 LPH)

Figure 7 shows that Nusselt number increases as the Reynold number increases. After this nusselt number goes on increasing but Reynold decreases this is because values of temperature goes on decreasing after 2pm so it decreases the value of Reynold number. The maximum value of nusselt number is 267 and maximum value of Reynold number is 886. The average value of nusselt number decreases as compare to steady flow at 12 LPH and 15 LPH as flow rate increases. The figure represents the performance for steady flow condition at 20 LPH.

4. Variation of Nusselt number with respect to Reynold number

Pulsating flow condition, for 12 LPH

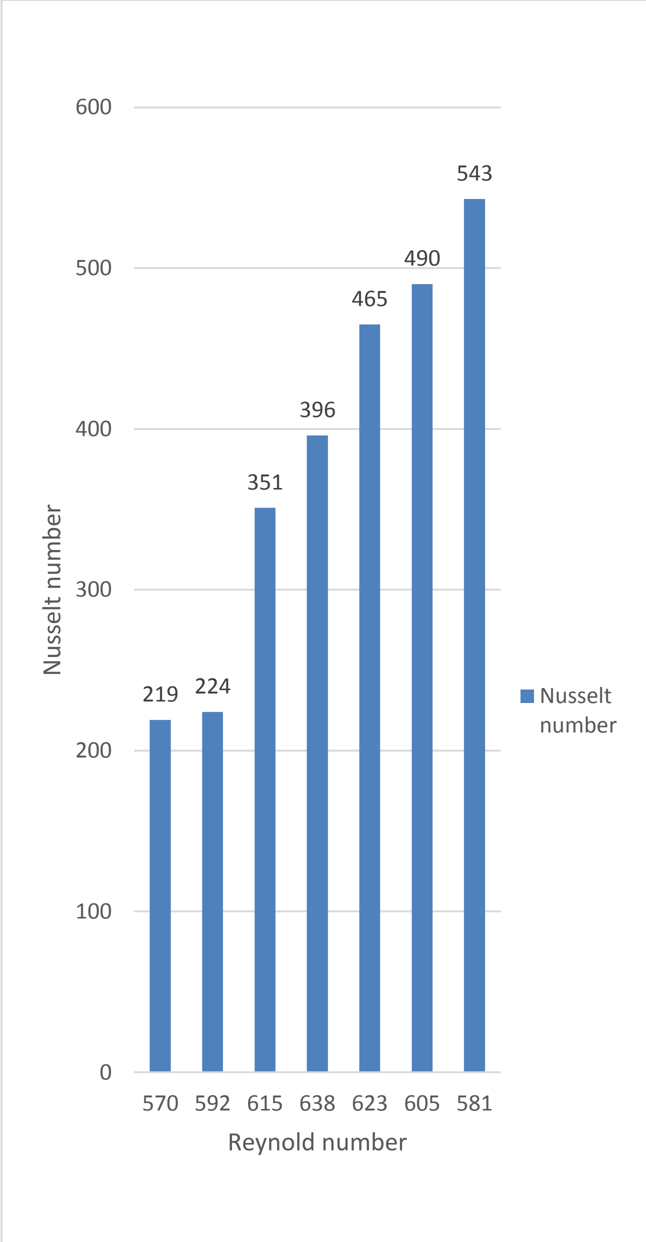


Fig. 8 Reynold number Vs Nusselt number (For 12 LPH)

Figure 8 shows that Nusselt number increases as the Reynold number increases. After this nusselt number goes on increasing but Reynold decreases this is because values of temperature goes on decreasing after 2pm so it decreases the value of Reynold number. The maximum value of nusselt number is 543 and maximum value of Reynold number is 637. The average value of nusselt number is high as compare to steady flow process as pulsation increases the rate of heat transfer. The figure represents the performance for pulsating flow condition at 12 LPH.

Pulsating flow condition, for 15 LPH

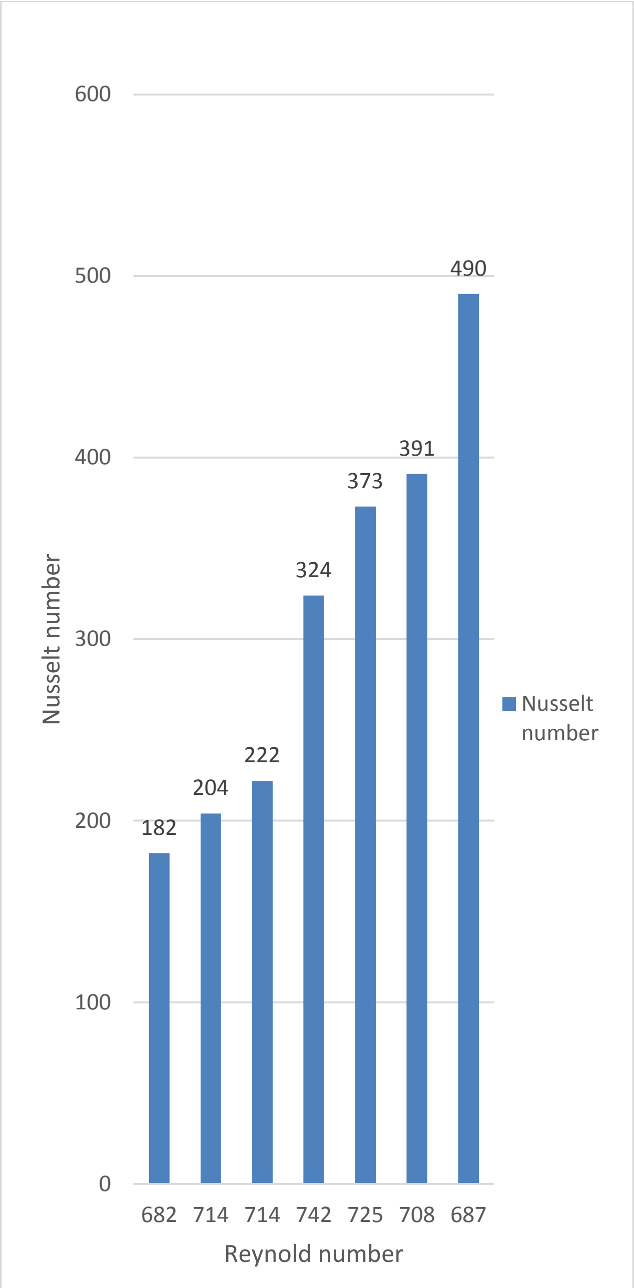


Fig. 9 Reynold number Vs Nusselt number (For 15 LPH)

Figure 9 shows that Nusselt number increases as the Reynold number increases. After this nusselt number goes on increasing but Reynold decreases this is because values of temperature goes on decreasing after 2pm so it decreases the value of Reynold number. The maximum value of nusselt number is 490 and maximum value of Reynold number is 742. The average value of nusselt number is low as compare to pulsating flow process at 12 LPH because as flow rate increases temperature decreases. The figure represents the performance for pulsating flow condition at 15 LPH.

Pulsating flow condition, for 20 LPH

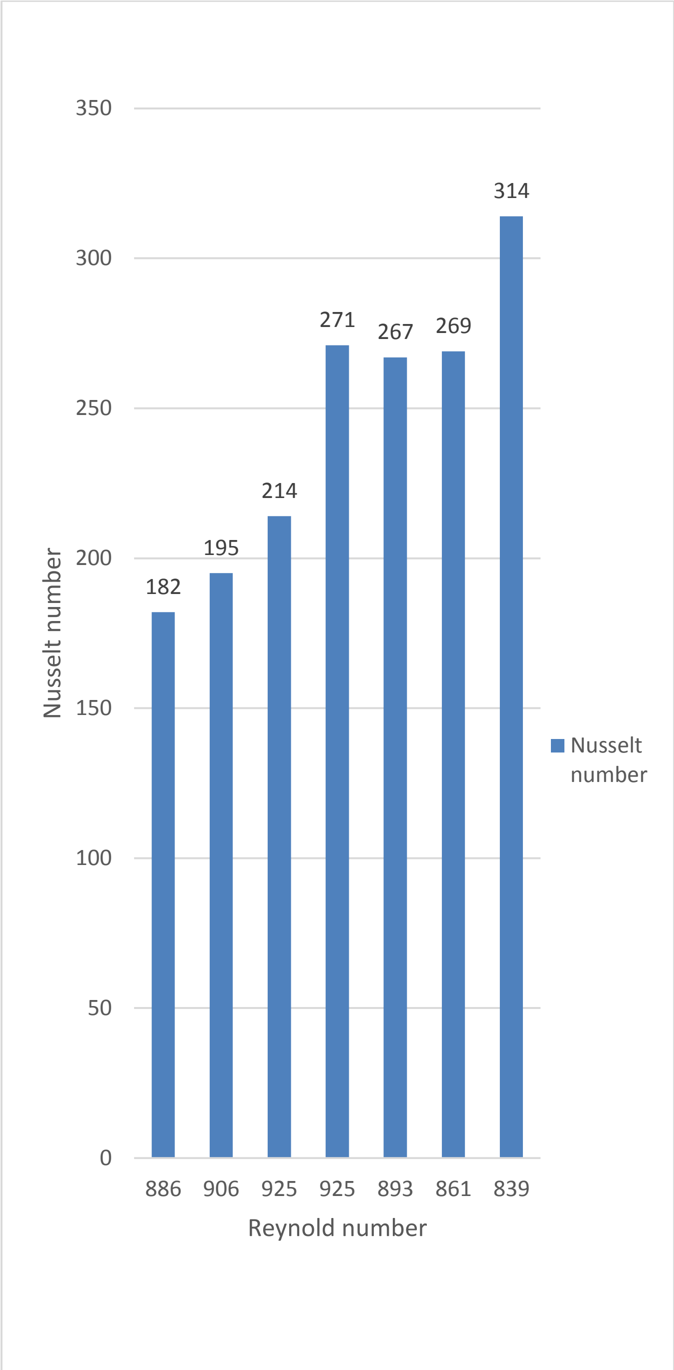


Fig.10 Reynold numberVs Nusselt number (For 20 LPH)

Figure 10 shows that Nusselt number increases as the Reynold number increases. After this nusselt number goes on increasing but Reynold decreases this is because values of temperature goes on decreasing after 2pm so it decreases the value of Reynold number.. The maximum value of nusselt number is 314 and maximum value of Reynold number is 937. The average value of nusselt number is low as compare to pulsating flow process at 12 LPH and 15 LPH. The figure represents the performance for pulsating flow condition at 20 LPH.

CONCLUSION

1. When a flat plate collector is provided with aluminium metal blocks, it shows the improvement in temperature of water. As the copper /runner tubes through which water is flowing is passed from the middle of these metal blocks. So when heat is transmitted from absorber plate to these metal blocks it gets heated and then this heat is transferred to the runner tubes so the water inside the tubes get heated These metal blocks are used as these metal blocks conduct heat readily than the runner tubes which are normally used and soldered between the headers manifold in a conventional flat plate collector.
2. When a flat plate collector is provided with aluminium metal blocks and making the inlet flow of the fluid pulsating, the improvement in thermal performance is observed as compare to conventional flat plate collector. As creating the pulsation inside the inlet manifold, disturbance in the fluid flow occurs so fluid get a chance to mix in a better way so heat transfer rate increases. the time required to heat fluid is less than conventional collector.

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