DESIGN AND DEVELOPMENT OF HEAT PIPE BASED HEAT EXCHANGER FOR EVACUATED TUBE SOLAR COLLECTOR

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Abstract : Design and development of heat pipe based heat exchanger for evacuated tubes collector is nothing but improvement in the current solar water heating systems. Factors affecting current system such as heat losses, low heat transfer rate etc., are resulting into reduction in efficiency of the solar collectors. Evacuated tubes with heat pipes have lower thermal masses, resulting in a faster response times. Heat pipe technology is the most effective method of heat transfer because of its extremely high thermal conductance and has wide range of applications. Heat exchanger also known as manifold plays vital role for increasing the efficiency of this new system. Many more factors related to improvement in energy economics, increase in energy consumption and efficiency is discussed in detail.

I. INTRODUCTION

Heat pipe is a heat transfer device having high efficiency of heat transfer due to its high thermal conductance. The high thermal conductance in heat pipe is due to phase change of working fluid. In heat pipe, heat is transferred from hot end to cold end by latent heat of vaporization. Heat pipes are used in computer to remove heat, air conditioners for waste heat recovery and industrial heat exchangers. Recently, heat pipes are used in solar collectors for efficient heat removal from solar collectors.
Solar water heating systems (SWHS) consists of solar collector, heat transfer device to remove heat from solar collector and a storage tank to store heat. There are two types of solar collectors viz-1) Flat plate collectors and 2) Evacuated tube collectors. In flat plate collectors, heat from the flat plate collector is removed by circulating water through the absorber plate and transferring heated water collector, heat from the ETC is transferred to storage tank by thermosyphon process. Recently heat pipes are used to remove heat from the ETC. In the present project, we plan to design heat exchanger based on heat pipe to remove heat from ETC. Due to high thermal conductance of heat pipe, heat transfer efficiency is increased considerably, thus improving overall efficiency of evacuated tube solar collector.
Our project consists of two parts viz-
1) Design and fabrication of heat pipe based heat exchanger suitable for ETC.
2) Study the performance of heat exchanger based on use of heat pipe.

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II. HEAT PIPE TECHNOLOGY

Heat pipe is a heat transfer device used to transfer heat, or thermal energy from one point to another having extremely high thermal conductance due to phase change of working fluid. It is a simple closed-loop device with no moving parts. They are also considered as heat super conductors. Generally, heat pipes are used in heat transfer systems as well as cooling systems. It has wide range of applications in space, computers, cell phones, electronics systems and industrial heat exchangers. It is being found that heat pipe has wide range of applications in solar collectors for transferring heat at higher rate.
Heat pipes are sealed tubes filled with working fluids. The combination of evaporation and condensation of working fluid is used to transfer heat in the heat pipes. Mostly, heat pipes are cylindrical in cross section and consist of wick structure on inner diameter. When heat is given to evaporator section the working fluid gains latent heat, due to which working fluid vaporizes. Hence pressure in that section increases. Due to increase in pressure the vapor flows at fast speed towards the condenser section. In condenser section heat transfer takes place and vaporized fluid again gets converted into liquid form due to removal of latent heat. This liquefied fluid is then pumped back to evaporator section through the wick structure due to capillary action. The adiabatic portion i.e. middle section of the heat pipe has a negligible temperature difference.
Heat pipes are generally made up of stainless steel, copper, aluminium, depending upon the application of the resulting heat transfer from working fluid. In the heat pipe acetone, methanol, ammonia, sodium and water are used as working fluid.

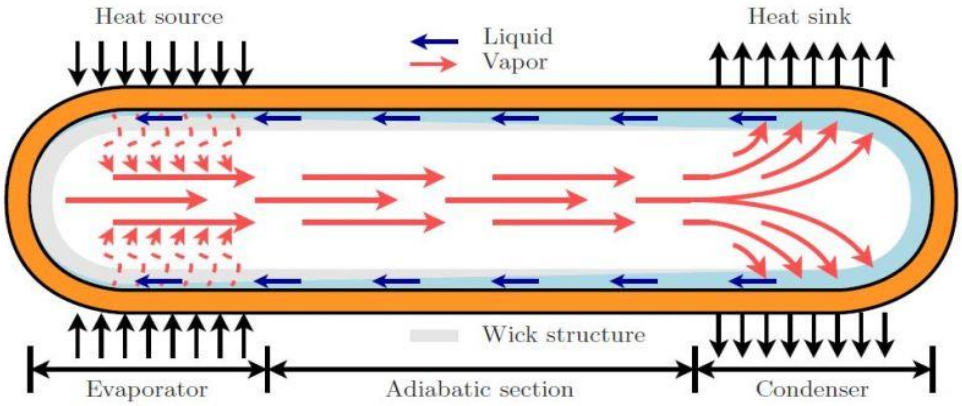

Fig 1.Construction and working of heat pipe[6]

III. SOLAR WATER HEATING SYSTEM

The solar water heating system is the technology to harness the plenty amount of free available solar thermal energy. The solar thermal energy system is designed to meet the energy demands. The solar technologies are commonly grouped into three major categories, generally differing in the ways they collect, store and use energy. The size of system depends on availability of solar radiation, temperature requirement of customer, geographical condition and arrangement of the solar system.

A solar water heating systems have found technical and economic feasibilities and huge domestic and commercial applications. This system generates hot water and this hot water demands are met mainly by the use of electric heaters. But electric heaters are costly and not eco-friendly because they mainly use fossil fuels. But nowadays, this system can be easily implemented at a low cost. These systems are grouped into two, namely active and passive solar water heating systems. SWHS consists of collectors which are employed for flat plate type solar collectors or evacuated type solar collectors to collect solar energy and due to this hot water is generated and this water is stored in an insulated storage tank. The total system with solar collector, storage tank and pipelines is called solar hot water system.

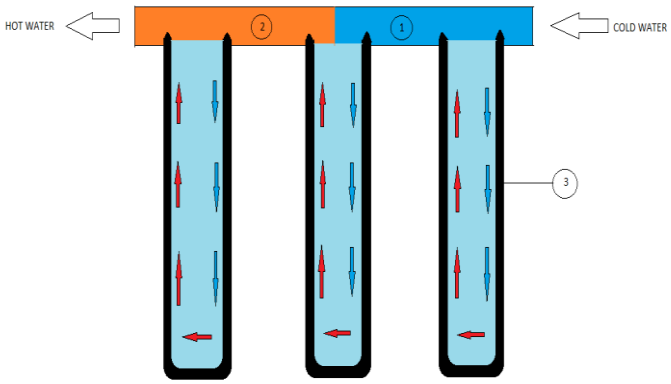

Fig.2 Solar Water Heating System with Evacuated Tubes

1.	COLD WATER
2.	HOT WATER
3.	SOLAR TUBES

Table.1 Components of SWHS with ETC

4. IDEA BEHIND THE PROJECT

The demand of human comforts is increasing day by day in this century. Due to this, the use of fossil-fuels and non-renewable energy is increasing. Currently solar, solar-electric, and pure electric water heaters are mostly used. Use of electric heaters is the reason for more energy consumption which leads to increase in energy rate and financial cost as well. Presently used solar water heating systems have some flaws due to which the efficiency may reduce. There are chances of mixing of hot and cold water. So the rate of heat losses may increase resulting into reduced efficiency.

Use of evacuated tubes with heat pipe technology is the most effective method than the present systems. Heat pipe has very high heat transfer rate over long distances along with phase transition having minimum temperature difference. Evacuated tube collector being cylindrical in shape the incident sunrays on the tube is at 90 degrees throughout the day. Hence, absorption rate is very high. Heat pipe is placed inside the evacuated glass tube. The heat absorbed by the evacuated glass tube is transferred to heat pipe. The heat generated from the heat pipe is then transferred to required application without any heat losses. The creation of vacuum inside the glass tube results into reduced convection and conduction heat losses. Therefore, we can get higher efficiency using this system.

4.1 PROBLEM STATEMENT

Increasing population has led to increase in demand for human comfort conditions. This has led to excessive use of non-renewable energy resources resulting into very bad impact on environment. So, this causes depletion in ozone layer and there is increase in greenhouse effect. Use of non-renewable energy resources such as electric heaters demands increase in financial issue such as electricity bill and increase in energy rates.To avoid problems regarding environment in future, use of solar energy is one of the most efficient alternatives needed today. So, solar energy is the most effective method for hot water generation using evacuated tube collector with heat pipe technology. Use of evacuated tube collector with heat pipe technology would help in improvement in energy economics, increase in energy efficiency and consumption as well.

4.2 OBJECTIVES

1. To design heat pipe based heat exchanger.
2. As a application use of heat pipe based heat exchanger in ETC.
3. To increase heat transfer efficiency using heat pipe with low solar insolation.
4. To study the performance of heat pipe based heat exchanger.

4.3. ADVANTAGES

1. High heat transfer rate.
2. High thermal conductivity.
3. High heat transfer efficiency.
4. Minimization in convection and conduction heat losses.
5. Faster and uniform distribution of heat.

5. CONCLUSION

1. By using this system we can obtain high heat transfer efficiency with minimum heat losses.
2. High heat transfer rate can be achieved.
3. Quick heat generation

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