Design and Fabrication of Highly Efficient Conical Collector with Thermal Energy Storage Unit in Solar Water Heating Application

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Abstract— Solar energy is a major renewable energy source with the potential to meet many of the challenges facing the world. There are many reasons to promote its share in the energy market. This power source is increasing in popularity because it is versatile with many benefits to people and the environment. Hence we could easily utilize this energy source in a better way with the help of a high efficient solar collector. In this system a conical collector is used for better heat entrapment. Since it has a conical shape it could provides better sunlight absorption and due to its configuration the tubes for water flow have been arranged in a spiral manner which gives water enough time to get heated by absorbing maximum amount of heat during its travel through the tubes. Yet another drawback of solar energy is its non-availability during off sunshine hours. Thermal energy storage materials could find a remedy to this problem. In this system as a thermal storage material PCM is used. PCM like paraffin wax could easily intensify the heat distribution in any of the solar based system . For the thermal storage purpose a three layered PCM tank comprises of a mild steel tank and a stainless steel tank is designed with copper tubes winded inside. In order to evaluate the performance of conical collector coupled with thermal storage unit they are used in solar water heating application. Hence the hot water from collector will flow through PCM tank and the phase change occurs to this thermal storage material. The thermal energy stored with in the phase change material is later be used during off sunshine hours. Using a microcontroller unit the temperature level is sensed and accordingly the valve is controlled in the solar water heater .The pump system in the water heater is also regulated using a switch with the help of a relay module. Hence the system performance will be more efficient. By using the same collector and thermal storage unit the system can be used in any of the solar based applications rather than water heating.

Key words: Conical Collector, Thermal energy Storage Unit, Controlling Unit

I. INTRODUCTION

As we know, in one way or other solar energy is the ultimate source for all other energy sources. Many solar based applications can be widely used nowadays. But the main drawback of this application is that the availability of this energy sources constantly. So for its proper utilization a good thermal storage unit is also needed. Here a conical collector coupled with a latent heat thermal storage is adopted. So that because of the geometry of the collector the solar energy can be utilized in a better manner. By using paraffin wax as a latent heat storage energy can be utilized during off sunshine hours also. For evaluating this setup this system is used in water heating application. Also to make the system more efficient the pump as well as valve operations are regulated using a controlling unit with Atmega 16.So the manual operation can be reduced to a great extent.

In current status utilizing solar energy in a better manner is possible using this system. Water heating is very simple application of solar energy that can be easily adopted. Make use of solar energy by storing it and utilize whenever intensity is less is a better option to increase its utilization.in this system main objective is to develop a high efficient collector coupled with thermal storage unit to make it use in solar water heating application. Hence the working of system wont be interrupted even in the absence of sunlight.

In this project solar collector was designed first. Proper geometry for the collector was selected for proper solar energy absorption. Selected proper materials to be used as absorbing surface and water passage surface. As a next step selected proper thermal storage unit. Designed a thermal storage tank with proper insulation. Selected the best thermal storage material that can be used for night operation of solar water heater. Done Experiments with and without thermal storage material and results were analyzed.

II. SYSTEM DESCRIPTION

Geometry of collector is very important in case of designing a solar collector. Sunlight should reach symmetrically on all position of collector so that conical shape was opted for designing a solar collector. Frame work done using mildsteel pipe with grade 304 and 22guage.Conical surface is 3ft height and 2ft diameter. Slanting height is 1m.Base of the conical collector is made using mild steel in which each side is .65m. The material selection for building the solar collector walls was narrowed to three materials that were the most accessible both in terms of purchasing and availability. The first choice was sheet metal, which would have been easy to manufacture but the thermal conductivity isn't the best. The second choice was aluminum, which was easy to manufacture, relatively cheap but also lacks the most important property which was thermal conductivity desired. The third material was copper, which has all of the required properties to build a solar collector, starting with the most important which is a high conductivity value. The manufacture of a solar collector made out of copper it would be a viable option since it is relatively easy to mold into shape, and to cut to desired shape. Copper plate covered on the mild steel surface. Copper tube of size-3/8x.58mmx50'.15 m copper tube wounded over the 30 collector. Since copper has good solar height absorbing power than other materials it is used on entire frame and pipe system. Total surface area of collector is 0.96m².The manufacture of a solar collector made out of copper would also be a viable option since it is relatively easy to mold into shape, and to cut to desired shape. They are black painted to increase the absorsivity of the solar energy as shown in figure1.

Fig. 1: Conical Collector

As a thermal storage unit latent heat thermal storage PCM is used. Paraffin wax is selected as a thermal storage material. It is a three layered tank which holds the thermal storage material. Outer surface of tank is made of GI coated mild steel with 30cm each square surface with 1ft height that is 27litre capacity .Tank is well insulated using glass wool to avoid the heat transfer losses . Cylindrical Stainless steel tumbler is given at inner layer which could hold the capacity of 8kg storage material with volume of 0.009cubic meter .Inside the tumbler 2m of spiral copper tube is placed as shown in figure 2.

Between the inner steel tumbler and copper tube thermal energy storage material like paraffin wax is filled as shown in figure3. The overall fabricated thermal storage tank is shown in figure 4.

Fig. 2: Thermal Storage Inner Tank with Copper Tube

Fig. 3: Thermal Storage Tank with Paraffin Wax

Fig. 4: Overall View of Thermal Storage Tank

Automatic control over the system will improve the performance of the system. Major two factors which is to controlled is water pumping and output valve operation.to reduce the manual work this can be controlled using embedded systems. In this water heater ATMEGA16 is used as microcontroller which controls the whole unit.LM35 used as temperature sensor to sense the outlet water temperature. Two relay modules were provided to operate valve and pump. Pump is operated with help of switch. Valve is regulated with the help of a temperature sensor. When water becomes above 45◦c the valve kept open. LCD display is provided to show the readings.

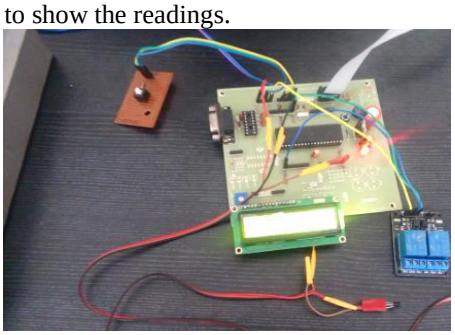

Fig. 5: Controlling Unit

In the Complete Fabricated model therefore the major components are solar collector, thermal energy storage tank, water storage tank. Solar collector for collecting the maximum solar energy and enhance the performance of the system. The water storage tank is used to collect both the cold water as well as the hot water to the system. Thermal storage tank is used to store solar energy and use it whenever the solar power got reduced. During the day time valve 1 will kept open and valve 2 will get closed water from storage tank will directly pump towards the solar collector and the hot water will pumps through the thermal storage tank and pumps to water storage tank. The hot water can be collected from the storage tank. During night time valve 1 get closed and valve 2 kept open .The water from storage tank will move towards the thermal storage tank and moves towards the water storage tank and hot water can be collected.

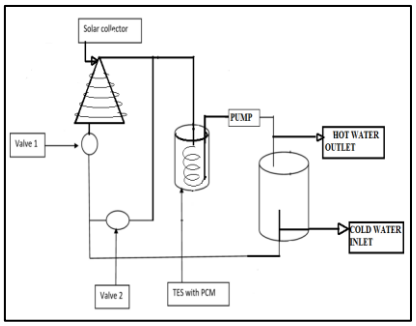

Fig. 3: Layout of water Heater

Fig. 4: Fabricated model

III. RESULT AND DISCUSSION

Major experiments conducted was solar survey, solar intensity analysis, Solar water heater with and without thermal storage material in day and night operation, Solar water heating with salt water as thermal storage material.

From the survey conducted Highest solar irradiance obtained was in the ground with solar irradiance 850 W/m² and placed the experimental setup in the location selected inside the college campus.

From the solar intensity analysis it is noted that the average solar intensity of each day was between 700W/m² and 950W/m^2.From the water heating setup with PCM ,the highest outlet temperature obtained was 78^0c.It is found that water heating with thermal storage material is more beneficial since it can be used whenever the sunlight goes to lower intensity. So that the water heater could operate with out any interruption.

IV. CONCLUSION

The main aim of the project is to develop an efficient solar conical collector to increase the performance of solar based systems and also to make use of the system during non sunshine hours ,using proper thermal storage system. In order to evaluate the performance of collector and thermal storage unit the system is used for solar water heating application. With the fabricated solar water heater system the performance of collector and thermal storage system were evaluated with PCM and sensible heat storage material. The results obtained where satisfactory. These type of solar based applications can easily be used to heat water especially domestic needs .By combining this collector and storage system in any solar application better yield can be obtained.

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