Solar water heating collector using CPVC pipe

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***Abstract*— Solar heater is a very useful device for heating the water, for producing the steam for domestic and industrial purposes by utilizing the solar energy. Chlorinated polyvinyl chloride (CPVC) is a thermoplastic pipe and fitting material (produced by the post chlorination of polyvinyl resin) used for potable water distribution, corrosive fluid handling, and fire suppression. There has also been a boost in less-than favorable publicity regarding premature copper-pipe failures manifested as pinhole leaks caused by corrosion arising from aggressive (although still potable) water conditions or aggressive soil. Due to such type of problems, many facilities professionals have sought out other technologies, such as different thermoplastic pipe, nothing but CPVC pipe.**

***IndexTerms*—CPVC pipe, solar water heater, collector, renewable energy.**

I. INTRODUCTION

Solar is the word which describes that we are dealing with some renewable energy source for a hot water system. The solar hot water system has been a vital throughout the world due to its cost effectiveness and easiest maintenance. The solar energy is the most capable of the alternative energy sources [1]. As an increasing Demand for energy and rising cost of fossil type fuels (i.e., gas or oil) solar energy is considered an attractive source of renewable energy that can be used for water hearing in both homes and industry. Heating water consumes nearly 20% of total energy consumption for an average family [2, 3]. Solar water heating systems are the cheapest and most easily affordable clean energy available to homeowners that may provide most of hot water required by a family. Solar heater is a device which is used for heating the water, by utilizing the solar energy for producing the steam for domestic and industrial purposes. Solar energy is the energy which is coming from sun in the form of solar radiations in infinite and abundant amount, when these solar radiations falls on absorbing surface, then that gets converted into the heat and finally this heat is utilized for heating the water [4]. This type of thermal collector suffers from heat losses due to radiation and convection. Such losses increase rapidly because of the temperature of the working fluid increases.

Since 1963, in U.S. building more than 28 billion feet (or about 5.3 million miles) of copper plumbing tube has been installed- that's equivalent to a coil wrapping around the earth more than 200 times [5]. Because copper has been used for mechanical systems since metals were first employed in these types of applications for long-term durability in installations due to it's light, strong, corrosion resistant, and available in rigid and semi-rigid forms. Copper's widespread acceptability ensures compliance with all major building codes due to its proven dependability. In terms of pricing, many copper proponents assert the fact that labor costs oftentimes compensate for the difference in material costs between CPVC and copper. Copper is a very versatile material and used for potable water supply, drain or waste applications, supply of natural-gas, steam having high-pressure applications, etc. The hard well water, soft acidic water, excessive water velocity or aggressive soil conditions are not responsible for copper. Solar hot water system is dominating over the solar heating system as it is easy to maintain, relatively low manufacturing and maintenance cost. Being a part of a developing country having crisis of electricity and for unavailability of natural gas connection in remote places. To reduce the pressure on the power sector where we already have a lot of crisis, we need an alternative water heating system that provides continuous hot water supply without consumption of electricity. The system is always successful when its efficiency level increases [6]. This system efficiency level can be increased by reducing its heat loss A hot water system has been already designed, we need to do further but easy implementation by working on its insulation at variable time, temperature and solar radiation, so there is a minimum temperature drop over night which in turn determined the operating temperature of the system. All the solar systems can be utilized the solar energy and its application depends upon the solar collectors which are flat-plate, compound parabolic, evacuated tube, Fresnel lens, parabolic dish which are used in these systems [4].

Materials or devices to prevent the conduction of heat, the aim of thermal insulation are to reduce the effects of the various processes of heat transfer between objects which have thermal contact. Heat is the transfer of thermal energy between objects of varying temperature. Heat flow is an inevitable consequence of contact of objects of differing temperature. Thermal insulation helps to keep a gradient of temperature. This is the insulation in which heat flow is decreased or thermal radiation is not absorbed but it is reflected. In this work, two Solar Water Heater systems were built using open collectors with the same external area for solar insulation. The first system uses only pipes and the second one uses plates, both with natural circulation of water, called thermosyphony. Its working principle is based on the density difference between the hot water, which is heated by solar radiation incident on the collector, and the cold water that is present in the reservoir. For that purpose, it is necessary that the collectors be positioned with a minimum slope and that the reservoir is installed at a certain height above the collectors. It is important to note that they do not need circulation pumps.

They are economical when taking into account their cost and maintenance, even with efficiency smaller than those using forced circulation, being quite suitable for small systems. For the capitation sub-system it was used the so called "open collectors," since they do not have transparent cover nor thermal insulation. These systems have good performance for low temperatures. Solar Water Heater systems are generally very simple using only sunlight to heat water. A working fluid is come into contact with a dark surface which exposed to sunlight causes increases in the temperature of the water. This water is heated directly, so it is direct system. It may be a heat transfer fluid such as a water mixture that is passed through heat exchanger called as indirect system.

II. EXPERIMENTAL

Our project totally works on the Thermosyphony principle. In the thermosyphony system, water comes from the over head tank and enter in the bottom of solar collector with natural circulation. Water circulates from the collector to storage tank by absorbing the heat from the sunray and so with this water heated in the collector. The cold water at the bottom flow into the collector and replaces the water which is hot, and then forced into the insulated water storage tank. When There is no solar radiation on the collector the process of the circulation stops Thermosyphony system has less maintenance due to absence of controls system. Efficiency of a collector depends on the difference between and ambient temperature and collector temperature. It is inversely proportional to the intensity of solar radiation.. In thermosyphony system, cold water flows into the system due to pressure difference and therefore the cold water tank should placed at least 8 feet or more than that. Thermosyphoning is used for circulation of liquids and volatile gases in heating and cooling applications, such as heat pumps, water heaters, boilers and furnaces.

CPVC (Chlorinated Poly Vinyl Chloride) Pipe

CPVC stands for Chlorinated Polyvinyl Chloride. This yellowish plastic polymer was discovered to handle the higher temperatures CPVC has a few advantages over copper as well. It is generally a stable compound and is corrosion less. CPVC also requires about 25% less time to install than copper does. Chlorinated polyvinyl chloride (CPVC) is a thermoplastic pipe, produced by the post chlorination of polyvinyl resin. It used for potable water distribution, corrosion. Because of these in many facilities it is used over professionals copper. Since CPVC is non-metallic, it will never pit, scale, or corrode and maintain drinking-water quality even if the pH value of the potable water source falls below 6.5 The Ph value measures the relative acidity of water; the pH of natural potable water should be between 6.5 and 8.5. Unlike copper, CPVC offers stable pricing that is unaffected by market fluctuations or international supply and demand. We have a solar water heating collector made from CPVC with aluminum fins. We has taken a whole new look at the CPVC collector and come up with a design that places the risers closer together, and uses a curve tin sheet for the absorber plate. We have to admit that a bit skeptical of the performance of the new design due to the poor thermal connection between the risers and the tin absorber sheet, but We have a go at testing a collector with copper risers and aluminum fins against CPVC design, and the CPVC does quite well -- it is only about 5% short of the performance of the copper/aluminum collector.

Test Setup

There was a planning to test the CPVC collector on the Sun Simulator but still having some problem getting up to the full sun area light levels. We decided to do an outdoor test, for that we have to test the collector without bothering about fluctuations in sun, temperature, wind. A collector's performance is proportional to the temperature rise. By using tank or motor, the water from the reservoir is pumped into the collector which is situated on the top for inserting water into inlet which is below the collector. We are tried to maintain all the conditions as follows- The water from the pump entered the collector on the bottom left corner, and then returned from the collector to the outlet by a tube from the upper right corner of the collector. We selected the relatively warm day to take the data, but the reservoir temperatures maintained at all the way up to 160 F, so there is a good difference between ambient and collector absorber temperatures.

Table 1 Material Requirement And Dimensioning For CPVC Collector

Sr. No.	Item	Dimensions	Quantity
1	Sheet Plywood	8 mm	-
2	CPVC pipes of ¾ inch	50 feet	5 pieces
3	CPVC Tee	20 mm	12
4	CPVC Bend	20 mm	2
5	Valve	20 mm	2
6	5 inch Dia. Parabolic Reflector	4 feet 6 inch	7
7	Galvanized Sheet Box	Length-5 feet | Breadth- 4 feet | Depth- 6 inch	1
8	Glass	Length- 4.94 feet | Breadth - 3.94 feet	1
9	Clamp	-	4
10	Silicon tube	-	1
11	Bedding	1 inch	1
12	Bolt	-	45
13	Fevicol	-	-
14	Stand	Length - 4.98 feet | Breadth – 4 feet | Angle Of Inclination - 30	1

Working Principle

The basic principle of our work is the Thermosyphon principle. In this system, by natural circulation water comes from the over head tank to bottom of solar collector and water circulates from the collector to storage tank and upto that time the absorber keeps absorbing heat from the sun and water gets heated in the collector. After that cold water gets converted into hot water which is placed in an insulated hot water storage tank. If the solar radiations stop falling on the collector then and only then the process of the circulation stopped. Collector's efficiency always varies accordingly with the difference between collector temperature and ambient temperature and also it is inversely proportional to the intensity of solar radiation.

Thermosyphon is based on natural convection, which circulates a fluid without the necessity of a mechanical pump. The above physical effect is used for circulation of liquids as well as volatile gases in heating and cooling applications. This type of circulation may be open-loop or may be a vertical closed-loop circuit. Its purpose to simplify not only the transfer of liquid but also the transfer of gas while avoiding the cost and complexity of a conventional pump.

IV. Result and Discussion

The table below shows the temperature at different time intervals.

Table 2 Temperature Vs Time Of CPVC Collector (on dated 11-03-2015)

Sr No.	Time	Inlet Temp (T1) in F	Outlet Temp (T2) in F	(T2 – T1) in F
1	10 a.m.	82.4	116.2	33.8
2	11 a.m.	86	145.4	59.4
3	12 a.m.	89.6	149	59.4
4	1 p.m.	96.8	156.2	59.4
5	2 p.m.	96.8	152.6	55.8
6	3 p.m.	95	140	45
7	4 p.m.	89.6	127.4	37.8
8	5 p.m.	89.6	122	32.4

Table 3 Temperature Vs Time Of Copper Collector

Sr No.	Time	Inlet Temp (T1) in F	Outlet Temp (T2) in F	(T2 – T1) in F
1	10 a.m.	86	120	34
2	11 a.m.	89	135.75	46.75
3	12 p.m.	96	151.5	55.55
4	1p.m	96	159.45	57.45
5	2p.m	94	153.4	61.4

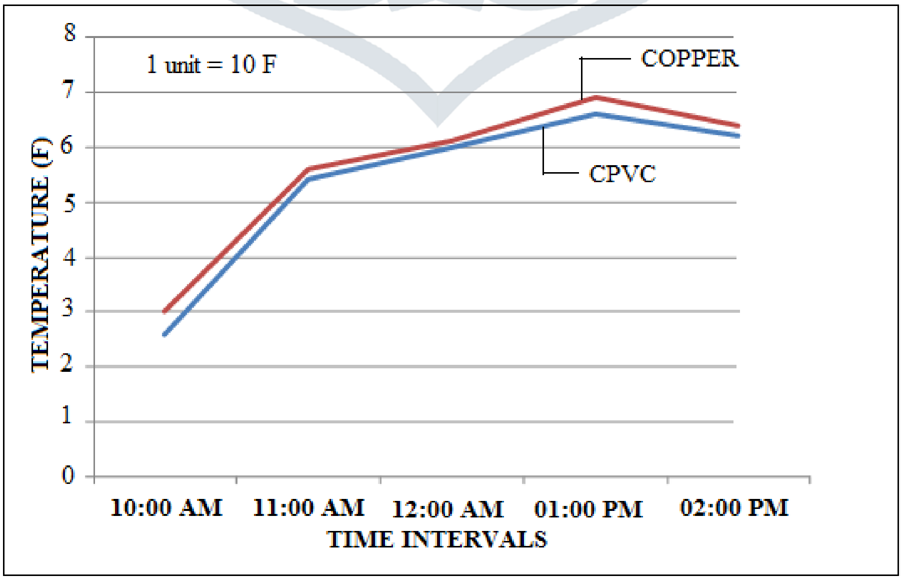

Figure 1 Temperature at different time intervals

The jog in the two curves at about 12:50 pm was a stop to take of the glazing of each collector. By putting the glazing back on and again test will start for more time. At that stage, the two collectors were reoriented to face closer to the sun, which explains the greater rate of temperature increase in the reservoirs for both collectors in the range of 1:00 pm to about 2:00 pm. It looks like the reservoir temperatures would have made it up to about 170 F have we continued the test longer. The following table shows over the 7 hours of the test.

Table 4 Start and end temperatures of the reservoirs and relative performance

Collector	Start Temp (F)	End Temp (F)	Temp Rise (F)	Performance Relative to Base
Copper	70.9	159.3	88.4	Base
CPVC	80	156.2	76.2	0.955

Again, we are surprised by how well the CPVC collector performs relative to the copper collector. We thought that the line contact between the CPVC tube and the tin curve, but apparently very nearer spacing of the risers allows the CPVC collector to come within 5% of the copper collector which is having relatively small gain. As explained above we fabricate the CPVC solar water heating collector for that we analyzed the entire necessary working principal and select the correct principal for our flat plate collector. We have successfully tested this model and compared with the existing copper solar water heating collector.

V. Conclusion

In this project we have mostly focused on the CPVC pipes instant of copper pipes and also parallel study of both the collector. After studying and comparing all the data of both collectors it is found that the cost of our collector is 40-50% less than that of copper collector. The used collector's efficiency is approximately 95% as compare to copper collector and it is portable than the copper collector. So from this we can conclude that the temperature of both the collector is near about same at different time of interval from the different experimental test. But the cost of solar water heating collector is less as compared to the copper from reported data. The only drawback is that the thermal conductivity of the CPVC is less than copper and future work will be going on to improve that efficiency.

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