A COMPREHENSIVE REVIEW ON DIFFERENT EVACUATED GLASS TUBE MATERIAL

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Abstract

the solar energy is the most abundant and eco-friendly source of energy on earth. It is the most readily available source of renewable energy on the earth; the earth receives millions of watt of energy per day which is coming in the form of solar radiation. Solar energy is captured by several conventional and new type of solar collectors of which the evacuated solar collector is the most efficient and suitable collector among all kind of solar collectors. In the present review paper, the existing evacuated tube solar collectors are studied with their applications. The most important feature of renewable energy is that it can be harnessed without the release of harmful pollution.one of most promising renewable energy source is Solar energy, the solar radiation incident on the surface of the earth can be conveniently utilized for the benefit of human society. Solar energy collectors act as heat exchangers that convert the solar radiation energy into internal energy of the transport medium.

Keywords - *Solar energy, evacuated tube, Temperature, heat Pipe.*

I INTRODUCTION

Evacuated tube solar collectors are extensively and widely used because it's good thermal insulation characteristics and insensitivity to the direction of sun light. They are made up of vacuum glass tubes. The absence of air distinctly reduces convection and conduction thermal losses. They additionally have barium getter thing in commonplace, the principle role of getter is to hold the vacuum inside the tube and to provide a visual indicator of the vacuum status. There are three common types of evacuated tube solar collectors, which are (a) Water-in glass evacuated tube solar collector, (b) U-type evacuated tube solar collector and (c) evacuated tube heat pipe solar collector.

The Evacuated tube collector consists of a number of rows of parallel transparent glass tubes connected to a header pipe and which are used in place of the blackened heat absorbing plate we saw in the previous flat plate collector. These glass tubes are cylindrical in shape. Therefore, the angle of the sunlight is always perpendicular to the heat absorbing tubes which enables these collectors to perform well even when sunlight is low such as when it is early in the morning or late in the afternoon, or when shaded by clouds. Evacuated tube collectors are particularly useful in areas with cold, cloudy wintry weathers. Evacuated tube collectors are made up of a single or multiple rows of parallel, transparent glass tubes supported on a frame. Each individual tube varies in diameter from between 1" (25mm) to 3" (75mm) and between 5′ (1500mm) to 8′ (2400mm) in length depending upon the manufacturer. Each tube consists of a thick glass outer tube and a thinner glass inner tube, (called a "twin-glass tube") or a "thermos-flask tube" which is covered with a special coating that absorbs solar energy but inhibits heat loss. The tubes are made of borosilicate or soda lime glass, which is strong, resistant to high temperatures and has a high transmittance for solar irradiation. Unlike flat panel collectors, evacuated tube collectors do not heat the water directly within the tubes. Instead, air is removed or evacuated from the space between the two tubes, forming a vacuum (hence the name evacuated tubes). This vacuum acts as an insulator reducing any heat loss significantly to the surrounding atmosphere either through convection or radiation making the collector much more efficient than the internal insulating that flat plate collectors have to offer. With the assistance of these vacuum, evacuated tube collectors generally produce higher fluid temperatures than they're flat plate counterparts so may become very hot in summer.

II HEAT PIPE EVACUATED TUBE COLLECTORS

Heat pipe evacuated tube collectors, a sealed heat pipe, usually made of copper to increase the collectors efficiency in cold temperatures, is attached to a heat absorbing reflector plate within the vacuum sealed tube. The hollow copper heat pipe within the tube is evacuated of air but contains a small quantity of a low pressure alcohol/water liquid plus some additional additives to prevent corrosion or oxidation. This vacuum enables the liquid to vapourise at very lower temperatures than it would normally at atmospheric pressure. When sunlight in the form of solar radiation hits the surface of the absorber plate inside the tube, the liquid

in the heat pipe quickly turns into a hot **vapour** type gas due to presence of the vacuum. As this gas vapor is now lighter, it rises up to the top portion of the pipe heating it up to a very high temperature. The top part of the heat pipe, and therefore the evacuated tube is connected to a copper heat exchanger called the "manifold". When the hot vapors still inside the sealed heat tube enters the manifold, the heat energy of the vapor is transferred to the water or glycol fluid flowing through the connecting manifold. As the hot vapour looses energy and cools, it condenses back from a gas to a liquid flowing back down the heat pipe to be reheated.

III DIRECT FLOW EVACUATED TUBE COLLECTOR

Direct flow evacuated tube collectors also known as "U" pipe collectors, are different from the previous ones in that they have two heat pipes running through the centre of the tube. One pipe acts as the flow pipe while the other acts as the return pipe. Both pipes are connected together at the bottom of the tube with a "U-bend", hence the name. The heat absorbing reflective plate acts like a dividing strip which separates the flow and the return pipes through the solar collector tubes. The absorber plate and the heat transfer tube are also vacuum sealed inside a glass tube providing exceptional insulation properties.

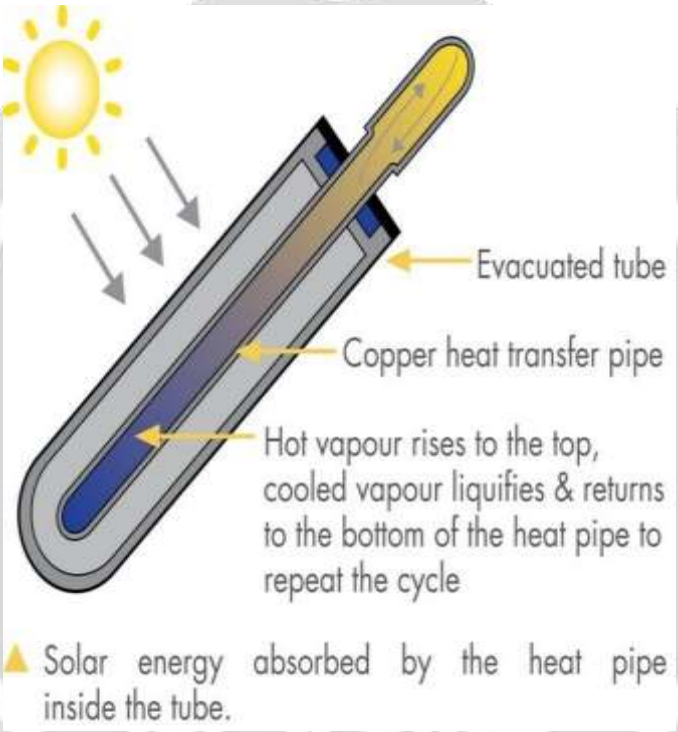

Fig 3.1 – Heat pipe Configuration.

Direct flow evacuated tubes can collect both direct and diffuse radiation and do not require solar tracking. However, various reflector shapes placed behind the tubes are sometimes used to usefully collect some of the solar energy, which may otherwise be lost, thus providing a small amount of solar concentration

IV LITERATURE REVIEW

M.S. Abd-Elhady et.al [1] - the investigation improves the heating capability of evacuated tubes that comprises heat pipes. Thermal oil is inserted in the evacuated tube in order to improve the rate of heat transfer, such that the mode of heat transfer from the inner surface of the evacuated tube to the heat pipe becomes convection via the oil, as well as conduction through the installed fin. The finned surface has been replaced by a foamed-copper. An experimental setup has been developed to study the influence of oil and foamed metals on the performance of evacuated tubes with heat pipes. It has been found that the bulb temperature as well as the heating efficiency of the evacuated tube heat pipe has increased in case of inserting oil in the evacuated tube and replacing the finned surface with foamed copper. Also, the thermal oil acts as a heat storage.

Sarvenaz Sobhansarbandi et.al [2]-this investigation to Solar water heaters (SWHs) are a well-established renewable energy technology that have been widely adopted around the world. In this study we have significantly improved the Evacuated Tube solar Collectors (ETCs) by utilizing the ''dry-drawable" Carbon Nanotube (CNT) sheet coatings to increase the solar energy absorption and Phase Change Materials (PCMs) to increase the heat accumulation for application in solar water heaters.

S. SivaKumar et.al. [3] - the investigation the Renewable source of energy is the future energy source that meets out our demand for energy. In this solar energy is one of the prime sources. The harnessing of the solar energy can be done in both ways Solar (PV), Solar Thermal. Solar thermal finds more suitable for domestic needs such as Space Heating, Cooling, Hot water systems, drying. Hence the need for producing thermal energy from the collectors is important. Out of all the thermal collectors the evacuated tube solar collector (ETSC) is found to have the best efficiency with low solar insolation. In this paper the evacuated tube is modelled with heat pipe for the enhancement of the heat generated from the collector. The objective of this research is to design and investigate the heat transfer analysis of Heat Pipe Evacuated Tube solar collector is made of Borosilicate glass with length 1.8m and 0.058m and 0.049m diameter of outside and inside tubes for the Coimbatore location.

A.E. Kabeel et.al [4] - the investigation Modified coaxial heat pipes have been designed and manufactured to improve the thermal performance of the glass vacated solar collectors. Heat pipes were made up of two concentric copper tubes so that the annulus volume space between the concentric tubes was charged with refrigerant. In addition, the air as the working fluid at four different mass flow rates 0.0051, 0.0062, 0.007 and 0.009 kg/s flows through the inner tube of the heat pipe to the flow through the annulus between the heat pipe and glass evacuated solar tubes. The effect of the tilt angle of the evacuated tube on thermal performance of the evacuated solar tube collector was examined to obtain the optimum tilt angle during the experiments period. The influence of filling ratio for the two types of refrigerant R22 and R 134a on the thermal efficiency of the coaxial heat pipe solar collector at filing ratio range from 30% to 60% was conducted experimentally. Results show that the maximum increased in the thermal efficiency reached 67% corresponding to without heat pipes at mass flow rate 0.009 kg/s. The experiment results showed similarity between the two refrigerants.

Piotr Felinski and Robert Sekret [5] - this investigation a novel concept of using a phase change material (PCM) to store thermal energy directly within a heat pipe evacuated tube collector equipped with a compound parabolic concentrator (CPC). The excellent insulating properties of evacuated tubes and the use of latent heat are significant advantages of a PCM integrated evacuated tube collector/storage (ETC/S) over traditional solar water heaters. However, during the charge cycle of the ETC/S, direct solar radiation only reaches the exposed area of the evacuated tubes, which results in uneven heating of the PCM due to a lower energy input in the shaded area. This can be prevented by using a CPC to concentrate the solar radiation on the shaded area of the evacuated tubes, thereby raising the temperature of the PCM and quantity of stored heat.

V CONCLUSION

Evacuated tube solar collectors are more efficient than flat plate collector in the temperature range of 50-200 ℃ in the application of high temperature used domestic and industrial application. Because advantage of vacuum created between tube is type of collector very common and effective in cooled climate. Since it can harvest both beam and diffuse radiations more efficient than concentric types of solar collector. Since the tube is independent in case of damage only system efficiency is decrease but the other types of collector totally system damage.

References

1. M.S. Abd-Elhady M. Nasreldin, M.N. Elsheikh, “Improving the performance of evacuated tube heat pipe collectors using oil and foamed metals,” Ain Shams Engineering Journal xxx (2017) xxx–xxx.

2. Sarvenaz Sobhansarbandi, Patricia M. Martinez, Alexios Papadimitratos, Anvar Zakhidov, Fatemeh Hassanipour, “Evacuated tube solar collector with multifunctional absorber layers,” Solar Energy 146 (2017) 342–350.

3. S. Siva Kumara, K. Mohan Kumarb, S. R Sanjeev Kumarc, “Design of Evacuated Tube Solar Collector with Heat Pipe” Materials Today: Proceedings 4 (2017) 12641–12646.

4. A.E. Kabeel, Mohamed M. Khairat Dawood, Ali I. Shehata, “Augmentation of thermal efficiency of the glass evacuated solar tube collector with coaxial heat pipe with different refrigerants and filling ratio,” Energy Conversion and Management 138 (2017) 286–298.

5. Piotr Felinski and Robert Sekret, “Effect of a low cost parabolic reflector on the charging efficiency of an evacuated tube collector/storage system with a PCM,” Solar Energy 144 (2017) 758–766.

6. Meysam Faegh, Mohammad Behshad Shafii, “Experimental investigation of a solar still equipped with an external heat storage system using phase change materials and heat pipes,” Desalination 409 (2017) 128–135

7. Mohamed Hany Abokersh, Mohamed El-Morsi, Osama Sharaf, Wael Abdelrahman "On-demand operation of a compact solar water heater based on U-pipe evacuated tube solar collector combined with phase change material," Solar Energy 155 (2017) 1130–1147.

8. Saıf ed-Dın Fertahi, T. Bouhal A. Arid, T. Kousksou , A. Jamil , N. Moujibi, A. Benbassou, "Thermo-mechanical strength analysis for energy storage improvement of horizontal storage tanks integrating evacuated tube collectors," i n t e r n a t i o n a l journal of hydrogen energy xxx (2 0 1 7) 1 -11.

9. Vahit Corumlu, Ahmet Ozsoy, Murat Ozturk, "Thermodynamic studies of a novel heat pipe evacuated tube solar collectors based integrated process for hydrogen production," i n t e r n a t i o n a l journal of hydrogen energy xxx (2 0 1 7) 1 -11.

10. C. A. Papadopoulos and A. D. Dimarogonas, "Coupling of bending and torsional vibration of a cracked Timoshenko shaft," Ingenieur-Archiv, vol. 57, no. 4, pp. 257–266, 1987.

11. S. Sekhar and B. S. Prabhu, "Vibration and stress fluctuation in cracked shafts," Journal of Sound and Vibration, vol. 169, no. 5, pp. 655–667, 1994.

12. O. Dirr, K. Popp, and W. Rothkegel, "Detection and simulation of small transverse cracks in rotating shafts," Archive of Applied Mechanics, vol. 64, no. 3, pp. 206–222, 1994.

13. M. A. Mohiuddin and Y. A. Khulief, "Modal characteristics of cracked rotors using a conical shaft finite element," Computer Methods in Applied Mechanics and Engineering, vol. 162, no. 1–4, pp. 223–247, 1998.

14. S. Sekhar and P. Balaji Prasad, "Dynamic analysis of a rotor system considering a slant crack in the shaft," Journal of Sound and Vibration, vol. 208, no. 3, pp. 457–473, 1997.

15. S. Sekhar, "Vibration characteristics of a cracked rotor with two open cracks," Journal of Sound and Vibration, vol. 223, no. 4, pp. 497–512, 1999.

16. Nandi, "Reduction of finite element equations for a rotor model on non-isotropic spring support in a rotating frame," Finite Elements in Analysis and Design, vol. 40, no. 9-10, pp. 935–952, 2004.

17. Ghoneim, A., 1989. Comparison of theoretical models of phase-change and sensible heat storage for air and water-based solar heating systems. Solar Energy 42, 209–220.

18. Hassan, M.M., Beliveau, Y., 2008. Modeling of an integrated solar system. Build. Environ. 43, 804–810.

19. Himran, S., Suwono, A., Mansoori, G.A., 1994. Characterization of alkanes and paraffin waxes for application as phase change energy storage medium. Energy Sources 16, 117–128.

20. Kakiuchi, H., Yamazaki, M., Yabe, M., Chihara, S., Terunuma, Y., Sakata, Y., Usami, T., 1998. A study of erythritol as phase change material. Iea Annex 10, 11–13.

21. Kaygusuz, K., 1995. Experimental and theoretical investigation of latent heat storage for water based solar heating systems. Energy Convers. Manage. 36, 315–323.

22. Ku¨rklu¨ , A., O¨ zmerzi, A., Bilgin, S., 2002. Thermal performance of a water-phase change material solar collector. Renew. Energy 26, 391– 399.

23. Lee, W.S., Chen, B.R., Chen, S.L., 2006. Latent heat storage in a twophase thermosyphon solar water heater. J. Solar Energy Eng. 128, 69–76.

24. Mehling, H., Cabeza, L., Hippeli, S., Hiebler, S., 2003. Pcm-module to improve hot water heat stores with stratification. Renew. Energy 28, 699–711.

25. Mettawee, E.B.S., Assassa, G.M., 2006. Experimental study of a compact pcm solar collector. Energy 31, 2958–2968.

26. Munro, I., Bernt, W., Borzelleca, J., Flamm, G., Lynch, B., Kennepohl, E., Ba¨r, E., Modderman, J., 1998. Erythritol: an interpretive summary of biochemical, metabolic, toxicological and clinical data. Food Chem. Toxicol. 36, 1139–1174.