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A Review of Heat Transfer Enhancement Parabolic Trough Solar Collector with Pin Fin Arrays Inserting

Mukesh Dhar Dubey[1]* Amit Kumar[2]

[1] Master of Technology Scholar, Department of Mechanical Engineering, Patel College of Science and Technology, Ratibad Bhopal, MP

[2] Assistant Professor, Department of Mechanical Engineering, Patel College of Science and Technology Ratibad Bhopal, MP

Abstract – Parabolic trough collector is one of the dominant emerging solar technologies for producing heat at high temperatures. Parabolic trough collectors are widely used as a solar energy recovery device, with the reflected concentrated solar energy focused mostly to a single cylindrical tube. Improving the performance of solar collectors has been recently a subject of intense research because of its advantages such as a decrease in the size and cost of systems and an increase in the thermal performance. Among solar collectors, parabolic trough collectors (PTCs) are of great importance because of their applicability. PTCs are widely used in Concentrated Solar Power Plants (CSP), which demand high and low-temperature heat, respectively.

Keywords: Solar Energy, Parabolic Trough Collector, Tube Receiver, Heat Transfer Enhancement, Finite Volume Method, Monte Carlo Method

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INTRODUCTION

Over the past years, power was still the most concern of humanity. From the very starting of this world, humans tried to convert power during this universe from one sort to a different. We will think about the discovery of fire because the historic transition. Fire is that the transition that used the energy keeps within the burned material to get new power, for example, to heat food. The problem started once human's population increased. The planet started facing pollution and global warming, mainly due to burning fossil fuels. Fossil fuels are thought-about to be a good example of non-renewable energy supply. Non-renewable energy sources are accessible on earth in limited quantities and can eventually be depleted. Coal, gas and oil are non-renewable because they have specific conditions and lots of years to be produced. So, we will notice the importance of using new sources that may be replenished during a short period of time. Firstly, we tend to typically define CSP system, so we tend to observe its importance and what the best countries for this technology are. After that, we tend to move to call the main parts during this system. At the end, we discover data regarding some technologies and applications additionally to the price of CSP, within the conclusion we tend to summarize all the preceding ideas.

LITERATURE REVIEW

Gong et al. investigated the impact of pin fin arrays inside a PTC. They found small enhancements in Nusselt number up to 5%. Tube receiver with pin fin arrays inserting was introduced because the absorbent material tube of parabolic trough receiver to extend the general heat transfer performance of tube receiver for parabolic trough solar collector system. The Monte Carlo ray tracing technique (MCRT) in addition to Finite Volume methodology (FVM) was adopted to research the heat transfer performance and flow characteristics of tube receiver for parabolic trough solar collector system. To validate the feasibleness of the developed MCRT and FVM combined technique, the numerical results are compared with experimental results conducted within the diss check facility in Spain and also the max relative error is less than 5-hitter. The numerical results indicated that the introduction of absorbent tube with pin fin arrays inserting style for the absorbent tube of the parabolic trough receiver will effectively enhance the heat transfer performance. the common Nusselt variety are often increased up to 9.0% and also the overall heat transfer performance issue are often increased up to 12.0% once the tube receiver with pin fin arrays inserting was used.

Benabderrahmane et. al. examined a similar idea using to greater fins in the low part of the absorber. They found that the Nusselt number can be enhanced up to 80%. Authors also investigated the influence of heat transfer fluid properties and receiver geometries (with and without fins insert) of parabolic trough solar collector.

Wang et. al. studied the use of an asymmetric outward convex corrugated tube in PTC. The achieved Nusselt number was about 1.2 times greater than the smooth case. In this study, the asymmetric outward convex corrugated tube is introduced because the metal tube of PTR (ACPTR) to extend the heat transfers performance and reliableness. AN optical-thermal structural sequential coupled technique was developed to review the heat transfer performance and thermal deformation of tube receiver for parabolic trough solar collector system.

Bellos et. al. examined the use of converging–diverging absorber tube geometry for operation with thermal oil. They found 25% enhancement in the Nusselt number and thermal efficiency enhancement up to 4%. The results showed 4.55% mean efficiency improvement compared to usual tube geometry. It is interesting to state that altogether study cases, with nanofluids, water and wavy surface, the increase within the efficiency is larger for higher fluid temperature levels. More specifically, the most reason for the efficiency improvement in these cases is that the increase in heat transfer constant within the flow, whereas alternative parameters as fluid specific heat capability have positive impact on the collector efficiency.

Kumar and Reddy examined the insert of porous discs vertical to flow and they proved 64% enhancement in Nusselt number. The numerical model to evaluate the heat transfer characteristics of a porous increased solar parabolic trough receiver is projected. Introduction of the porous discs within the receiver, improves the heat transfer characteristics of the receiver however with a pressure drop as penalty. The heat transfer was increased all told receivers due to increase in heat transfer space, thermal conduction and turbulence. The maximum heat transfer coefficient is achieved in high half porous disc receiver with H = 0.5di, w = di at h = 30 with reasonable drag. The share will increase in Nusselt variety for optimum receiver configuration is 64.2% compared to tubular receiver at Reynolds variety of 31,845 with the pressure drop of 457 Pa. There is a scope to optimize the receiver configuration with different working fluids, materials totally different porosity values of the receiver

Mwesigye et. al. examined the use of wall-detached twisted tape inserts and they found that this method leads to 2.7 time's greater Nusselt number and to 5% increase in thermal efficiency. The study shows considerable increase in heat transfer performance of regarding 169%, reduction in absorbent material tube's circumferential temperature difference up to 68 and increase in thermal efficiency up to 100% over a receiver with a clear absorbent material tube. an entropy generation analysis shows the existence of a painter number that there's minimum entropy generation for every twist ratio and width ratio. The optimum Reynolds range will increase with increasing twist ratio and reducing width ratios. The maximum reduction within the entropy generation rate was regarding 58. Correlations for heat transfer and fluid friction performance for the vary of parameters thought of were additionally derived and presented.

Aditya Khodke et. al. Heat dissipation is one of the main problems which we come across while dealing with high load and high speed machines. Because of the work they perform, some amount of heat is generated inside the machine. This heat has to be transferred outside the system to obtained efficient output. If it is not done, then this heat may cause damage to machine parts. To do this, fins are used. Main purpose of fins is to increase surface area of machine so that heat can be transmitted in atmosphere. In this project, we are trying to increase surface area of fins by providing perforations to it. These perforations may be of any shape and size. Our aim is to find those shapes and size which will increase the efficiency of fin.

D. N. Elton et. al. The heat transfer enhancement in PTC due to twisted tape inserts has been studied. The major objective was to develop Nu connections for plain absorber as well as absorber with twisted tape under accurate non-uniform solar radiation level. This was done by taking good number of data points. From parity plots it has been observed that both the correlations are matching with an error less than 20%. Hence for PTC analysis, the present correlation is more viable than the uniform heat flux based Nu correlations.

PARABOLIC TROUGH SYSTEM

Parabolic Trough Systems use a linear parabolic concentrator with a reflected surface to focus radiation on an absorbent pipe running on the focal line of the parabola. The absorbent pipe contains the heat Transfer Fluid or HTF that is heated and pumped-up to the steam generator. The steam generator is in-turn connected to a turbine. For modification of the daily position of the sun perpendicular to the receiver, the trough tilts east to west so the direct radiation remains targeted on the receiver. However, seasonal changes within the in angle of sunlight parallel to the trough don't need adjustment of the mirrors, since the light is just targeted elsewhere on the receiver. The receiver containing the HTF will reach temperatures of 400 °C and generates live steam to drive the turbine generator of a standard power block.

The receiver is also enclosed in a very glass vacuum chamber. The vacuum considerably reduces convective heat loss.

Full-scale parabolic trough systems carries with it several such troughs laid get into parallel over an oversized area of land. Since 1985 a solar thermal system using this principle has been fully operation in California within the United States. It's referred to as the SEGS system. Alternative CSP styles lack this sort of long experience and so it will presently be said that the parabolic trough style is that the most completely established CSP technology.

Fig. 1: Parabolic Solar Trough System at Kramer Junction, Mojave Desert, California

Technology Constraints:

- The higher method temperature is presently limited by the heat transfer thermal oil to 400°C.
- The heat transfer thermal oil adds additional prices of investment and of in operation and maintenance.
- Depending on national laws, environmental constraints from ground pollution by spillage of thermal oil may occur.
- High winds could break mirror reflectors at field corners.
- Low-cost and economical energy storage systems haven't been demonstrated up to currently.
- Heat losses between the receivers and therefore the central conversion unit are high

Complexity of flexible connections necessary between moving receivers and stationary piping reduces the responsibility of such distributed systems.

CSP

Solar energy is tapped to supply electricity in 2 distinct ways in which. Unique is by means of a photovoltaic system that uses sunlight for the reason that it is and also the different is by means of solar concentrators. The fundamental plan is to translate the sun's energy within the sort of impending photons to usable electricity.

Solar Concentrators, like that employed in CSP, is used to focus sunlight to be used one or the other during a photovoltaic system or a solar thermal system. Although these 2 technologies primarily use centered solar light-weight to supply electricity, they differ within the method sunlight is converted to electricity. within the case of a photo-voltaic device, the centered light-weight is converted to electricity by exploiting the electronic properties of conductive materials, whereas within the case of solar thermal, the centered light-weight heats up a transport fluid that is then accustomed generate steam that drives a turbine using the Rankine cycle generator. Although PV generally uses the visible to UV a part of the spectrum to produce electricity, solar thermal uses the infrared energy to heat the HTF.

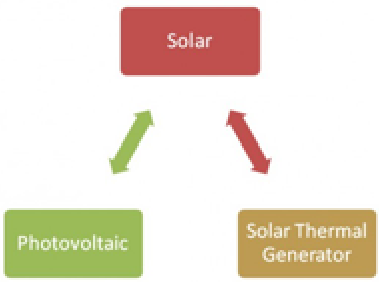

Fig. 1: Solar energy using photovoltaic system and solar concentrators

Concentrated Solar Power is used to produce electricity called solar thermoelectricity, usually generated through steam. Principally CSP technology uses glasses with tracking systems to concentration an enormous space of sunlight onto a small zone. The dedicated light then reasons a thermal storage material like oil, salt or water to heat. This heat is then used as a heat supply for a normal power plant. The solar concentrators employed in CSP systems will usually even be used to give process heating or cooling, like in solar air-conditioning.

To search the energy storage that's possible using dedicated solar collector technology, it's required to briefly visit the a number of solar harnessing skills success used these days. CSP is seen as a holistic technology with different advantages furthermore involving the utilization of the waste heat from power generation.

CSP PRINCIPLE

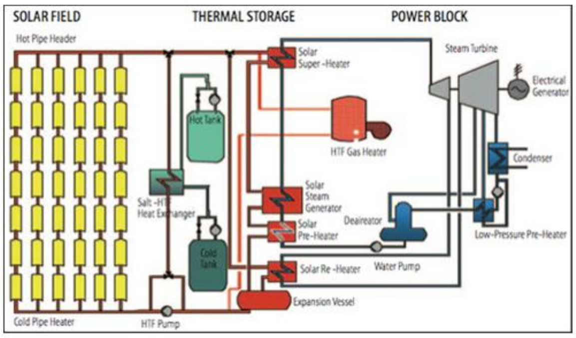

Fig. 2: CSP principles

Fig.2 illustrations the scheme by that a classic parabolic trough solar-to-electricity transformation takings place during a solar thermal system. The whole system will be classified into 3 different parts:

Solar Field — the solar field comprises of rows of parabolic-shaped glasses. An array of tracking parabolic dishes will be organized during a so-called distributed system so the working fluid from every dish is piped to a central power conversion station. The mirrors follow the sun to catch as much energy as potential. The curve of those mirrors centres the sunlight on a significant receiver tube that runs the length of the glass. The central receiver tubes are hollow and filled with a heat transfer fluid (HTF). The HTF, warm by the sunlight to over 400°C, then flows to the power block or the thermal energy storage system, counting on the mode of operation.

Thermal Energy Storage System — Hot HTF is additionally transported to thermal storage tanks. The heat from the HTF is transferred to the molten salts wherever it's keep for later use e.g., once clouds pass by, once sunset, or before sunrise.

Power Block — Hot heat transfer fluid is conveyed to the power block where it's used to boil water to acquire steam to be used all through a standard steam generator to supply current.

Solar thermal conversion scheme of solar power depend on well-known occurrences of heat transfer. All told thermal transformation processes, solar radiation is absorbed at the surface of a receiver that comprises or is attached with flow passages through that an operating fluid passes. For the reason that the receiver high temperature up, heat is conveyed to the operating fluid which can be air, water, oil, or molten salt. The higher temperature which will be achieved in solar thermal conversion depends on

- The insolation
- The degree to that the sunlight is focused,
- And the measures taken to reduce heat losses from the operating fluid.

The temperature level of the operating fluid are often controlled by the speed at that it's circulated. It is possible to match solar energy to the load requirements according to the amount of heat and temperature level. In this manner, it is possible to design conversion systems that are optimized according to both the first and the second laws of thermodynamics. High temperature heat is needed by industry for process heat and by utilities for electricity. The assortment and translation of the radiation to thermal energy relies on the collector style and thus the relative amounts of direct beam and diffuse radiation absorbed by the collector.

By incorporating following devices, the collectors will deliver intensities within the order of 50 suns and temperatures concerning 450 deg C. Trackers will be single axis or dual axis supported the standard of following needed. An alternate approach, additionally using following parabolic dishes, is to find an engine which will generate electricity at the focus of every dish and to move electric current instead of a hot fluid.

CONCLUSION

This paper reviews the methods and experimental and numerical investigations on heat transfer enhancement of PTCs. There are high demands of providing PTCs, which have a higher rate of heat transfer and lower pressure drop. The use of enhanced surfaces such as discs, wire coil, and twisted tape can enhance heat transfer with the increase in turbulence, heat transfer area, and secondary flows. The important parameter on the thermal performance of the PTCs is the choice of the type of working fluids with different advantages and the different operating temperature. It is essential to make the right choice of working fluids for solar systems due to their applicability and temperature demands.

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Corresponding Author

Mukesh Dhar Dubey*

Master of Technology Scholar, Department of Mechanical Engineering, Patel College of Science and Technology, Ratibad Bhopal, MP