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A Review on CFD Analysis of Tube Receiver for Parabolic Trough Solar Collector with Pin Fin Arrays Towards CSP Technologies

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***Abstract* – Solar thermal systems are advantageous since it is easier to store heat than electricity on a large scale. Investigation on the heat flux distribution on the absorber tube is critical to get detailed knowledge on how to improve efficiency with the aim to enhance the overall heat transfer performance. In this study Tube receiver with pin fin arrays inserting was introduced as the absorber tube of parabolic trough receiver to increase the overall heat transfer performance of tube receiver for parabolic trough solar collector system. The Monte Carlo ray tracing method (MCRT) coupled with Finite Volume Method (FVM) was adopted to investigate the heat transfer performance and flow characteristics of tube receiver for parabolic trough solar collector system.**

***Keywords*– Solar energy parabolic trough collector Tube receiver Heat transfer enhancement Finite volume method Monte Carlo method.**

I. INTRODUCTION

Over the past years, power was still the main concern of humanity. From the very beginning of this world, humans tried to convert power in this universe from one type to another. We can consider the discovery of fire as the historic transition. Fire is the transition that used the chemical energy stored in the burned material to generate new power, for example, to heat food. The problem started when human's population increased.A typical concentrated solar power plant with PTC technology is mainly composed by three modules: PTCs, parabolic trough receivers (PTR) and power generation devices.

The general structure of PTR is an absorber tube (made of metal) surrounded by a glass cover (also named glass envelope), while the annular gap between the absorber tube and glass cover is evacuated. In order to absorb the concentrated solar irradiation and decrease the thermal radiation losses effectively, a selective coating is coated on the outer surface of the absorber tube.

II. HISTORY OF CSP

According to legends, Archimedes used a "burning glass" to concentrate sunlight on the invading Roman fleet and repel them from Syracuse (Sicily). In 1973 a Greek scientist, Dr. IoannisSakkas, curious about whether Archimedes could really have destroyed the Roman fleet in 212 BC, lined up nearly 60 Greek sailors, each holding an oblong mirror tipped to catch the sun's rays and direct them at a tar-covered plywood silhouette 160 feet away. The ship caught fire after a few minutes; however, historians continue to doubt the Archimedes story.

In 1866, Auguste Mouchout used a parabolic trough to produce steam for the first solar steam engine.

The first patent for a solar collector was obtained by the Italian Alessandro Battaglia in Genoa, Italy, in 1886. Over the following years, inventors such as John Ericsson and Frank Shuman developed concentrating solar-powered devices for irrigation, refrigeration, and locomotion.

In 1913 Shuman finished a 55 HP parabolic solar thermal energy station in Meadi, Egypt for irrigation.
The first solar-power system using a mirror dish was built by Dr. R.H. Goddard, who was already well known for his research on liquid-fueled rockets and wrote an article in 1929 in which he asserted that all the previous obstacles had been addressed.

Professor Giovanni Francia (1911–1980) designed and built the first concentrated-solar plant. which entered into operation in Sant'Ilario, near Genoa, Italy in 1968. This plant had the architecture of today's concentrated-solar plants with a solar receiver in the center of a field of solar collectors. The plant was able to produce 1 MW with superheated steam at 100 bar and 500 degrees Celsius.The 10 MW Solar One power tower was developed in Southern California in 1981, but the parabolic-trough technology of the nearby Solar Energy Generating Systems (SEGS), begun in 1984, was more workable. The

354 MW SEGS is still the largest solar power plant in the world.

III. PAST STUDIES

Arun Kumar (2018) investigated the performance of helical coil solar cavity receiver based parabolic trough concentrator (PTC) for the conversion of energy received from the sun into useful heat and finally electricity. D N Elton (2018) in the present study, Nusselt number correlations for plain absorber and absorber with twisted tape (y=3.48, 5.42 and 7.36) are developed under the realistic condition of solar concentration with controlled environment. Gong et al. (2017) investigatedthe impact of pin fin arrays inside a PTC.

They found smallenhancements in Nusselt number up to 5%. S. N. Vijayan (2017)reviewed the contributing factors for the overall performance of parabolic trough collectors. Its performance depends on the operating parameters such as the type of receiver and the collector material, medium of heat transfer, type of application and various climatic conditions.

Pravin P. Gavade (2017) had donethe Modification and Design of Paraboloid Reflector and Receiver to Enhance Heat transfer rate. Belloset al.(2017)investigated the use of internally finned absorbers operatingwith gas working fluids and they finally found 100%enhancement in heat transfer coefficient and consequently inthe Nusselt number.

Huang et al. (2017) examined a dimpled PTC and they foundthat the deeper dimples lead to 1.4 times greater Nusseltratio compared to the respective smooth case. Benabderrahmaneet al.(2016) examined a similar idea using to greater finsin the low part of the absorber. They found that the Nusseltnumber can be enhanced up to 80%. Jaramillo et al. (2016) have worked on the thermal hydraulic performance of a PTC with twisted tape inserts for low enthalpy processes by considering the first and second law of thermodynamics for a temperature range of 70 to 110º C.

IV. PRESENT WORK

This study comes to present with a clear and systematicway the relationship between the Nusselt number enhancementand the thermal efficiency enhancement. The resultsof this study indicate which Nusselt enhancements lead toadequate thermal efficiency enhancement. This knowledgemakes easier the selection of thermal enhancement methodsand clearly proves the need for Nusselt enhancement up to alimit. More specifically, this study makes clear the thermalefficiency enhancement margin for every thermal enhancementmethod if the increase in the Nusselt number is known.

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