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Performance Study of Latest Technology in Parabolic Trough Collector for Maximum Energy Utilization from the Solar Energy

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***Abstract* - For the past few decades, solar energy considered as one of the renewable energy resources, has now became a best alternative for fossil fuels used in thermal power plants. This has come true due to the advancement of the solar technologies and to reduce the polluting fossil fuels, hence recently the whole world has its focus on solar power plant. This research paper deals with the innovative researches done on the concentrating collector's specifically solar Parabolic Trough Collector (PTC) which has proven as the best solar energy tracking device. The present study embraces two effects on the collector, one is optimization of receiver tube and the other is the change of heat transfer fluid in receiver tube such as superheated steam, thermic oil, molten salts and Nano particles etc. are appraised. The modification on PTC has been analyzed for improving the collector efficiency, better solar radiation absorption and to improve the thermal efficiency of power plant. The solar thermal power plant which is in successful working condition and under constructional level is also reviewed.**

Keywords* - *Parabolic trough collector, superheated steam, thermic oil, Nano particles, solar power plant

I. INTRODUCTION

Energy is one of the inevitable issues in the day to day life. Recently most of the developing countries are focusing their research on the advancement for the alternative energy which will be a better reliable and abundantly existing source. Since the direct utilization of solar energy is not possible, many technologies have been developed to bridge the gap between the renewable source and power development. Currently many developed countries have started the renewable energy power plant and the developing countries are also on the way with research on innovative technologies for maximum power utilization. The most commonly implementing technologies include solar collectors and solar photovoltaic system. The solar collectors broadly classified into flat plat collector, parabolic trough collector (PTC), compound parabolic collector and Fresnel lens concentrating collectors. The collectors are utilized based on the temperature requirement such as heating, thermal energy generation, refrigeration and desalination etc.

Generally photovoltaic cells method of solar tracking is almost one of the promising technologies but it requires high storage batteries which require huge investment and high maintenance cost. Many researchers have proven experimentally that the parabolic trough collector has the ability to generate electricity considerably. Since the collector should be rigid with good operating efficiency and should have high performance parabolic trough collector is preferred over other collectors and this type collectors can operate an operating temperature range of about 50^{o}C to 400^{o}C [1].

II. PERFORMANCE OF PARABOLIC TROUGH COLLECTOR

Many modifications have been done on the collectors to improve the operating efficiency of the collectors. The Rankine cycle using supercritical CO_2 has been utilized for production of electric power from solar energy using collector and found that the power generation efficiency is about 0.25 and the heat recovery efficiency is about 0.65 [2]. The study also focused on the sun tracking mechanism in the PTC for the improvement in the efficiency [3]. A new modification of two-axis sun tracking system have been developed and constructed to improve the efficiency and reported that the normalized solar radiation values has increased with respect to time and showed 46.46% improvement than the fixed surface collectors [4]. The study has also been done on the working fluid including water, thermic oil, inorganic salts etc. Various studies on thermal analysis has been reported on the solar receiver pipe using superheated steam, thermic oil, inorganic salts and Nano particles etc. for improving the thermal conductivity and for increasing the heat absorption parameter. The thermal analysis on direct steam generation process (DSG) in PTC has been carried out and obtained the result using a Computational Fluid Dynamics (CFD) model as shown in figure below,

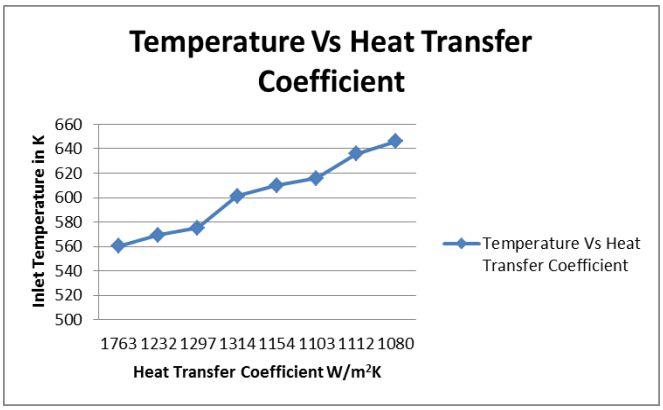

Fig. 1a Fluid inlet temperature Vs Heat transfer coefficient [5]

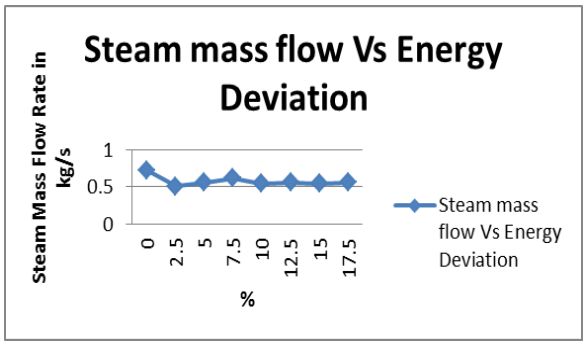

Fig. 1b Steam mass flow rate Vs Energy deviation

From figure 1a and 1b it is found that heat transfer coefficient increases for different fluid inlet temperature and the energy obtained is more when steam mass flow rate reduced. Here the thermal behavior of absorber tube has been studied using water and steam and found better variation with the use of steam as working fluid [5]. The absorber tube is also modified using a single-sided and double-sided absorbing technique for improving the performance [6]. The performance improvement has also been proved by making an internal helically finned tube in absorber tube of parabolic trough collector using CFD model [7]. A U-type solar heat pipe receiver has designed and experimentally tested for heat losses in PTC using natural circulation steam generation system and shown the improvement in thermal efficiency from 0.791 to 0.792 and 0.472 to 0.663 during calm and windy days while considering the receiver in account[8]. Solar aided Power Generation (SAPG) technique in utilizing Medium or low temperature solar heat for power generation effectively by bridging conventional coal-fired power plant of 200MW station with the solar plant using thermal oil for absorbing the solar energy resulted in better solar power efficiency, specific fuel and steam consumption rates which leads to power generation[9]. Risi et al. [10] made a modeling and optimization on the PTC with gas-phase Nano fluids, habitually the heat transfer fluid is synthetic oil, molten salt or water/Steam but here Nano particles (0.25% CuO and 0.05% Ni) are used which have high total surface for solar radiation absorption. They reported that the simulated result shows maximum thermal efficiency of 62.5% for Nano fluid outlet temperature of 650^{o}C in absorber tube.

III. ASSESSMENT ON FULL FUNCTIONAL SOLAR POWER PLANTS

The effective abstraction of electricity from the solar power plant has already been started before a decade by many countries for improving their green environment and to reduce the usage of fossil fuels. Presently USA holds the world's high capacity solar power plant with 392 MW handling capacity [11] and the spain remains next in the solar energy power plant competition. USA recently utilized the SPTC technology for constructing the high electricity generation solar power plant in San Bernardino- California (Ivanpah Solar Power Facility [11] with 392MW and Completed in February 13th 2014) , Mojave Desert-California(Solar Energy Generating System [12] with 354MW and Completed in December 3rd 2013) , Gila Bend-Arizona (Solana Generating Station [13] with 280MW Completed in October 23rd 2013) . Spain is also using the PTC technology for electricity generation in Logrosan (Solaben Solar Power Station (1-6) [14] with 200MW and Completed in September 2013), Sanlucar la Mayor (Solnova Solar Power Station [15] with 150MW and Completed in August 2010), Guadix (Andasol Solar Power Station (1-3) [16] with 150MW and Completed in 2011), and Torre da Miguel Sesmero (Extresol Solar Power Station (1-3) [17] with 150 MW and Completed in August 2012). India being a developing country and due to the shortage of electricity has started utilizing the solar power using PTC technology and constructed at Nokh, Rajhastan (Godawari Solar Project [18]) in 2013 with a generation of 50MW power and also in Bikaner, Rajhastan (ACME Solar Tower [19]) in 2011 with a 2.5MW electricity plant.

IV. FUTURE SOLAR POWER PLANT WITH COLLECTOR TECHNOLOGY

Many countries have already started utilizing solar energy for electric power generation using various technologies still they surge with newly constructing plants. USA currently is in progress with two plants at California 280 MW and 250 MW plant to complete in 2014 with the PTC technology (Mojave Solar plant [20]) at Barstow and (Genesis Solar Energy Project [21]) at Blythe. Using the PTC technology Morrocco have planned for generating 160MW plant named as (NOOR I) Ouarzazate, Soalr Power Station [22] at Ouarzazate. Israel is also constructing a 121MW power plant named as Ashalim Power Station (1,2) [23] at Negev Desert using solar power tower technology and expected to complete before 2017.

India has already started construction of solar power plant targeting 100MW, 50MW and 25MW within 2014. In India three 100 MW power plant is under construction at Rajasthan with the name Dhursur [24] using linear Fresnel reflector technology, Diwakar [25] and KVK Energy Solar Project [26] using PTC technology. Also a 50MW and 25MW SPTC plant is under construction in Anantapur (Megha Solar Plant [27]) and Gujarat (Gujarat Solar One [28])

Hence it is clear that major countries such as United States, Spain, China, Australia, India and South Africa have started the operational solar power plants successfully. Other few countries such as Algeria, Canada, Chile, Egypt, France, Germany, Isreal, Italy, Mexico, Morocco, Thailand and United Arab Emirates are also in the track of electricity generation using solar power plant [29]. From the datas of solar electric power generating countries it is found that 85% of solar power plant adopts SPTC technology which is a most successful technology for electricity generation.

V. CONCLUSIONS

This research paper has focused the importance of renewable solar energy which is a perfect alternative for the fossil fuels such as coal and petroleum products for thermal power plant. In recent times the concentrated Solar Parabolic Trough Collector has been engrossed, with the advancement in solar energy absorption techniques which leads to various results,

- The absorber tube in the PTC plays a vital role in handling various temperature range and absorption of solar radiation. The heat transfer fluid in the receiver tube makes a remarkable improvement in the thermal efficiency of the collector. Many studies shows the change of heat transfer fluid such as water to thermic oil or to superheated steam shows steep increase in collector efficiency. The usage of molten salt for storing high temperature and also the treatment of Nano particles makes the PTC a best operational thermal power plant.
- The optimization on the absorber such as the addition of helically finned tube in receiver tubes and also the double side heat absorption techniques shows a superior result which leads to a various branches for research on absorber.
- Almost 85 % of the operational and under constructional solar thermal power plant in the world uses SPTC. Hence further researches on the PTC make a more economical and ecofriendly thermal power plants.

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