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Research Article

REVIEW STUDY ON SOLAR POWER TOWER

Navneet Rawat and Rahul Bahuguna

Faculty of Technology, Uttarakhand Technical University Dehradun, Uttarakhand, India

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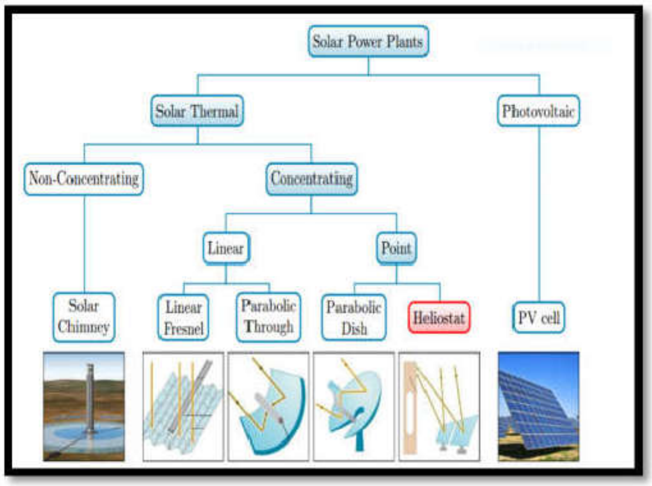
ABSTRACT

Regarding the energy storage concentrated solar power plants (CSP) are gaining interest as in Parabolic Trough Collectors (PTC) or Solar Tower Collectors (STC). In INDIA electricity generated by CSP is increasing with high rate in every year. On cloudy days CSP's having short term variations and also at night they can't provide energy and hence Thermal Energy Storage (TES) or Backup System (BS) is used to operate continuously. For optimum design and operation of CSP throughout year, an accurate estimation of solar irradiation is needed as well as defining the required TES or BS. INDIA has solar radiation of 1700 – 1900 kWh per kilowatt peak with more than 300 clear sky days therefore INDIA has higher potential for solar electricity generation per watt setup, The paper reviews Concentrated Solar Power technology and design, PTC design, STC advantages, adopted model approach and equations.

INTRODUCTION

The energy demand is growing rapidly. To provide humanity with its increased need for energy, energy technology efficiency must be improved; furthermore, renewable resources must be explored and must be aggressively studied. One of the most promising resource is the solar energy. Our sun produces a huge amount of energy, it is about 400,000,000,000,000,000,000,000,000 watts that is 4x1026 watts of energy every second and it will continue emitting energy for a very long while; which makes it the mostreliable and abundant source of energy that available at earth . One hour of sun power emitted to earth provides the energy needed for everyone in our planet for an whole year. There are many technologies developed to collect energy from sun to provide energy for different applications like residence water heating, process heat, water treatment, solar power plants, etc. The main technologies used in solar power plants could be classified . as shown in Figure-1. Among them Concentrated Solar Power systems recently has additional focus of researchers.



Brief History

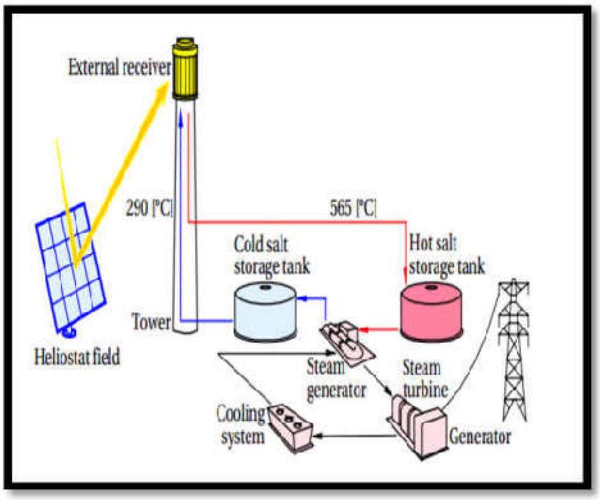
The use of solar energy is not a recent invent, engineers had started to harvest from sun since middle 1800s. Exactly at 1866

*Corresponding author: **Navneet Rawat**
Faculty of Technology, Uttarakhand Technical University Dehradun, Uttarakhand, India

in France, Augustin Mouchot had developed the first parabolic trough solar collector, and at 1878 he built the first large-scale solar steam engines, he actually produced ice using concentrated solar heat. It was a parabolic dish. That machine could generate enough steam to drive a 1⁄2 horsepower engine at 80 strokes per minute. The machine Influenced by Mouchot, Frank Shuman who was an American inventor built the world's first solar thermal power station in Maadi, Egypt (1912-1913). Shuman's plant, used parabolic to power a 60-70 horsepower engine which pumped 6,000 gallons of water per minute from the Nile River to adjacent cotton fields.

Solar Thermal Tower Power Plants

In solar thermal tower power plants, hundreds or thousands of large multi-axis tracked mirrors are installed around a tower. These curved mirrors are also called heliostats a computer calculates the ideal position for each heliostat, and a motor drive moves them into the direction of the sun. The system must be very precise in order to ensure that sunlight is really focused on the top of the tower. It is there that the absorber is located, and this is heated up to temperatures of 1000°C or more. Hot air or molten salt then transports the heat from the absorber to a gas turbine or to steam generator produces superheated water steam which drives a turbine and electrical generator



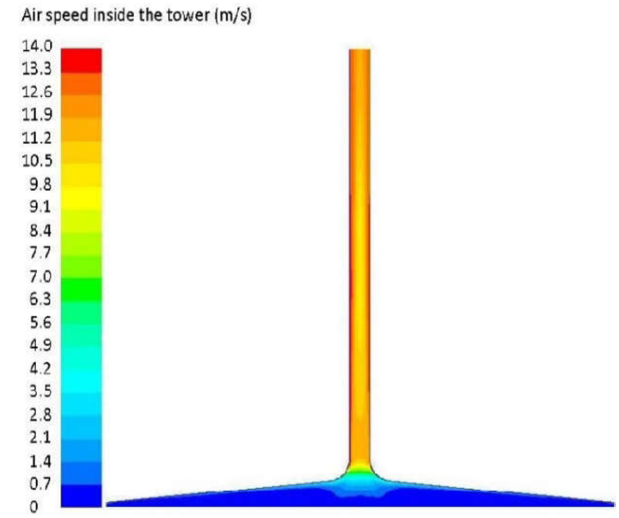
Naeimeh Jafarifar *et al* investigated solar updraft tower (SUT) is a simple power plant in which ventilation of heated air inside a channel drives a turbine. This system is recognised as suitable for areas with abundant solar radiation. As a result, there is no extensive research on the performance of SUTs under mild solar radiation. Studies show that strong ambient crosswinds can affect the performance of a SUT. In this paper, the efficiency of SUTs in areas which benefit from strong winds, despite low solar radiation, is investigated through numerical modelling. Comparison is made between the efficiency of a commercial-scale SUT in Manzanares (Spain) with intensive solar radiation, and one of the same size potentially located in the windy and mild climate of Orkney Islands in Scotland. The results show that ambient crosswinds can increase internal air speed and efficiency of a SUT by more than 15% and 50%, respectively. Consequently, such a SUT in Orkney can offer more than 70% of the efficiency of the one in Manzanares. The results show that, for a given power capacity, a wind turbine enclosed in a SUT can be considered as an alternative to a number of conventional wind turbines installed at height in the open air.

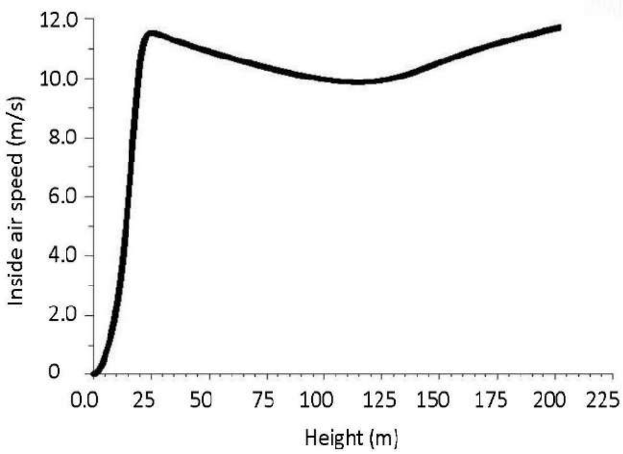
The problem is Solved for two Different Conditions

It is solely the solar heat flux affecting the air velocity inside the tower. In this condition, the expected air speed inside the tower for the numerical model in Orkney is lower than the model of Manzanares, as the solar heat flux is lower in Orkney.

The effect of wind is also considered. In this condition, the pressure change at the outlet of the tower in the existence of wind is obtained by solving the momentum equation in the 3D model. The calculations show that a pressure of -60Pa is caused by wind at the outlet of the SUT. The effect of this negative pressure (suction) is added to the effect of solar heat flux in the 2D model.

Figure 11(a) shows the contours of inside air speed obtained from the numerical 2D model of a potential SUT located in Orkney in the absence of wind, and Figure 11(b) shows the variation of air speed on the axis of symmetry along the tower. This figure shows that, in Orkney model if the effect of ambient wind is ignored, an air speed of 11.5m/s is developed on the axis of the tower at the inlet section (23m above the ground).





The efficiency of a commercial-scale SUT in an area which benefits from strong winds, despite low solar radiation, was investigated through numerical modelling in ANSYS Fluent software. A prototype SUT in Manzanares, exposed to rather intensive solar radiation, was used as a benchmark. Comparison was made between the efficiency of Manzanares's SUT and one of the same size in the windy climate of Orkney Islands, in which the radiation intensity is less than half of Manzanares's. The criterion for this comparison was the air velocity developed inside the SUT. Based on the findings of this numerical study, strong and steady ambient crosswinds increase the efficiency of a large-scale SUT by more than 50%. Consequently, a large-scale SUT in the windy climate of Orkney can offer more than 70% of the efficiency of one of the same size located in Spain, where the solar radiation is doubled.

The results of this study are based on numerical simulations. Future research is recommended to validate these result using experimental approaches. It would be also valuable to conduct further analysis to determine the effect of various ambient wind speeds combined with the effect of solar heat flux towards the performance of SUTs.

Jia-Qi Guoa *et al* investigated the potential to improve the performance of molten salt solar power tower system (SPT) is explored through the proposal of CO2-based binary mixture cycle in the present study. The feasibility of using xenon and butane as the additives to the S-CO2 cycle are discussed from the perspective of thermodynamic analysis. The detail parametric study is performed to reveal the effects of crucial parameters on the performance of 4 system configurations. Furthermore, the systematic comparison is conducted for 4 cycle layouts adopting CO2/xenon, CO2 and CO2/butane separately to illustrate the mechanism of performance improvement of SPT system coupled to CO2-based binary mixture cycle. The optimal performance of the SPT system is also demonstrated. Finally, the best performance system layout and suitable additives are recommended. The results indicate the following issues.

Adding xenon into S-CO2 cycle can obviously improve the overall thermal efficiency and exergy efficiency. While the effects of butane as an additive are converse. The inter-cooling CO2/xenon cycle is recommended as the most suitable layout coupled to the SPT system, and the exergy efficiency is 1.18%～1.32% higher than that of the SPT system with S-CO2 inter-cooling cycle. Detail exergy loss fraction distribution illustrates that the receiver is the highest exergy loss part and followed by the heliostat field, and butane as an additive is beneficial to reduce the receiver exergy loss for its smaller temperature difference. The study can provide a novel way to improve the SPT system performance and give a clue to the addition of CO2-based binary mixture in power cycles particularly for the application of SPT system.

Qiang Zhang *et al* investigatedconcentrated solar power (CSP) plant with thermal energy storage can be operated as peak load regulation plant. The steam generation system (SGS) is the central hub between the heat transfer fluid and the working fluid, of which the dynamic characteristics need to be further investigated. The SGS of Solar Two power tower plant was selected as the object. The mathematical model with lumped parameter method was developed and verified to analyze its dynamic characteristics. Five simulation tests were carried out under the disturbances that the solar tower power plant may encounter under various solar irradiations and output electrical loads. Both dynamic and static characteristics of SGS were analyzed with the response curves of the system state parameters. The dynamic response and time constants of the working fluids out of SGS was obtained when the step disturbances is imposed. It was indicated that the disturbances imposed to both working fluids lead to heat load reassignment to the preheater, evaporator and superheater. The proposed step-by-step disturbance method could reduce the fluid temperature and pressure fluctuations by 1.5 °C and 0.03 MPa, respectively. The results could be references for control strategies as well as the safe operation of and SGS.

Rui Chen *et al* investigated the optimal sizing of the solar tower power plant with thermal energy storage is critical for increasing the system reliability and reducing the investment cost. However, the total effects of specific design parameters fofsizing the SPT plants, including design direct normal irradiance, solar multiple and thermal storagehours, on the thermo-economic system performance under different solar resources are still not clear. In this study, a thermo-economic model of 50MW solar tower power plant based on steam Rankine cycle which usesmolten salt storage has been developed to explore the minimal combinations of these parameters at four sites inChina. The relationship between these parameters and their annual effects electricity generation, solar-to-electricity efficiency and levelized cost of energy have been identified. The results show that the optimal design direct normal irradiance for minimal levelized cost of energy depends on both the annual irradiation level and the distribution of solar irradiance, which differs from the recommended values obtained from the traditional methods. It is found that the irradiation received by heliostats at the optimal design condition accounts for a specific percentage (i.e., 72–75%) of the annual irradiation for the cases in this study. The sensitive analysis by varying the main financial parameters indicates that the optimal design direct normal irradiance and the corresponding percentage slightly vary with the heliostat cost. The results can provide a theoretical reference for determining the optimal size of the heliostat field and thermal energy storage for solar tower power systems under different solar resources.

Jonathan E. Reaa *et al* investigatedIn this paper, we present performance simulations and techno-economic analysis of a modular dispatchable solar power tower. Using a heliostat field and power block three orders of magnitude smaller than conventional solar power towers, our unique configuration locates thermal storage and a power block directly on a tower receiver.

To make the system dispatchable, a valved thermosyphon controls heat flow from a latent heat thermal storage tank to a Stirling engine. The modular design results in minimal balance of system costs and enables high deployment rates with a rapid realization of economies of scale. In this new analysis, we combine performance simulations with techno-economic analysis to evaluate levelized cost of electricity, and find that the system has potential for cost-competitiveness with natural gas peaking plants and alternative dispatchable renewables.

Saeed Shafiei Kaleibari *et al* investigated Hydrogen production can be achieved via combined concentrated photovoltaic (CPV) and concentrated solar power (CSP) in which concentrated radiation is spectrally split and then converted in a photovoltaic receiver and a thermal absorber. This study thus proposes an innovative solar process design integrating both thermal and quantum components of solar energy while providing a complete assessment of its global performance to demonstrate its practical interest. A stand-alone solar-to-hydrogen path was modeled and numerically simulated, which was both electrically and thermally supplied by a solar power generation unit to feed the electrolyzer power utilization unit with enhanced solarto- hydrogen conversion efficiency. Following balance of plant (BoP), the heliostat field and cavity receiver were designed to match the entire system in which the receiver only intercepts a definite range of infrared wavelength while the rest is converted by separately insulated PV cells. Moreover, dichroic reflectors and optimum cutoff wavelength were applied to fulfill separate optimization and heat load reduction of each solar cell. Finally, the solid oxide electrolysis cell (SOEC) was designed to utilize the generated thermal and electrical power appropriately. In best case scenario, a solar-to-hydrogen conversion efficiency of 36.5% was achieved under 899 W/m2 direct normal irradiance (DNI) and 1000 sunsconcentration. The solar plant outputs at this operating point were 850 g/h H2 and 6754 g/h O2. Further improvement in efficiency can be achieved through alignment in regard to the site location and annual insolation variation.

CONCLUSION

To resolve the excellent design and operation of the CSP throughout the year, although defining the required TES and/or BS, an accurate estimation of the absolute daily solar irradiation is needed Results of the model approach is given for 8 selected locations, in both Northern and Southern hemisphere In India, there is a rapid progress in the field of concentrated solar power. India has capacity of 1000 GW for the establishment of the CSP. The Indian government has establishment of JNNSM by MNRE to promote various application of the CSP and others solar applications. Indian government regularly revises the policies to promote the CSP applications. Conclusion To resolve the excellent design and operation of the Concentrated Solar Power throughout the year, although defining the required TES and/or BS, an accurate estimation of the absolute daily solar irradiation is needed Results of the model approach is given for 8 selected locations, in both hemisphere In India (Northern and Southern), there is a rapid growth in the field of concentrated solar power. India has capacity up to 1000 GW for the establishment of the CSP. The Indian government has established JNNSM by MNRE to promote various application of the CSPand others solar applications. Indian government regularly revises the policies to promote the CSP applications.

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