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Research On Solar Based CL-CSP (Cross Linear Concentrating Solar Plant) Systems

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Abstract* - *The study is based on the analysis of heat transfer calculation, heat flux distribution over the front and back surface of pipes and flow analysis of HTF (air) inside the pipes of cavity linear receiver (CLR) installed at CL-CSP site RGPV, BHOPAL. The linear cavity receiver consists of a rectangular cavity containing six pipes of alloy 800H as this material can resist high temperature of over 1000^0C with air as the heat transfer fluid (HTF). The heat transfer fluid (HTF) used is atmospheric air as it has advantages in term of availability and cost compare to other fluids. Air shows drastic change in its properties at high temperature and pressure therefore it is required to inspect the behavior of thermal properties of air inside the receiver pipes.

Keywords: CL-CSP system, cavity linear receiver (CLR,heat transfer fluid (HTF)

I. INTRODUCTION

The framework of the solar structure related with the trough which are parabolic in shapes (called as Trough), including Fresnel reflectors which are linear in shape (considered as LFR), in addition with the power tower (known as PTower), significantly leads to the decreases in optical effectiveness after reaching in the month of the winter with the high degree of the latitude. The optical effectiveness of the plates i.e. troughs and the linear shaped Fresnel reflectors LFR are much lower (less) in the month of winters as compared with the power towers, but they gradually increase in the month of summers. [1] According to the seasonal changes in the months, the variations of increase and decrease takes place from the cosine factor changes in the structure of optical implementations. The rotation of the mirrors horizontal in angle related with the LFR, the optical effectiveness suffers because of the cosine factor which is connected with inclination in the northern and southern direction of the sun. This conditions leads to worse in nature if the mirrors are placed according to the geographic regions related with the high degree of latitude. This kind of state of affair is similar as the trough(reflectors). Moreover, the cosine factor causes the accentuation by the loss of end which is generally, effectedby the reflection of light which is leading ahead of the selection of receivers which is appropriate to the alleviation of the sun related with the direction of axis with the receivers. As a result, the plant with the solar power gives the production radically lesser in the month of winters as compared with the month of summers [1-3]. These kind of effects are referred as " declination penalties", which can be felt correct from the degree of latitude from 20° or so which becomes very significant because of the increase in the nature of latitude[2]. The implementation of the horizontally shaped placed concentrators is not suggested in geographic zones related with latitude over the degree of 40° because of the payment of higher rate of penalties[4]. It is implementations of the solar fields with the large scale are easily installed the countries of the northern Africa, so that the long distanced power transmission lines can be constructed for the supply of power to Europe[5]. The declination penalties are considerable in Northern Africa near the Europe because of the degree of latitude which is near to 35°.

A. Concentration Solar Power (CSP) technologies

The Concentrating solar power (CSP) is a technique which was not utilized in the previous year. for the concentration of the sun rays in the old times(history), Archimedes utilizes the usage of the mirror in 212BC[3]. In the present time, the CSP technique is utilized in 2017, which are related with the 4.815GW operating, and the 2.709GW is under manufacturing and 1.26GW kind of CSPs are under progress[4]. In accordance with the reference [5], related with the 17GW of the CSP concerned projects are still under improvement all over the world, and 8GW kind of CSP projects is leading in the United States. Spain is positioned on the second place related with the 4.46GW in the area of the expansion of solar systems, which is followed by the country of China with the 2.5GW. The announcement which has been announced by India itself related in the Ministry of New and Renewable Energy which leads with the aim of the generation of 20GW solar

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energy powers in connection with the grid phase till the year of 2022, and they claim that the electricity consumption will be increased to 50% related with the CSP electrical energy of solar systems [5].

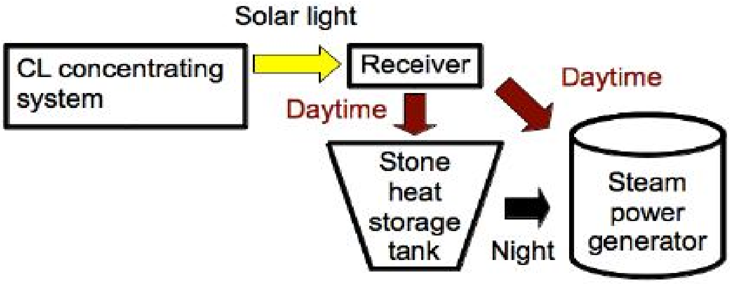

Fig. 1. Flow diagram for a typical CL-CSP-plant

B. Optical Efficiency

- CL is two axial optical control as compared with Trough and linear Fresnel have one axial optical control
- For high concentration of sunlight related with low rate of the cost and lesser optical kind of losses CL technology can easily adjust direction of mirror with respect with the solar powers.
- The usage of tower can provide the axial optical control as well as with the high degree of temperature but with the high amount of cost.
- The results which leads to increased optical loss is because of the distance between receiver as well as mirror which is usually higher in nature.
- The generation of the high efficiency usually depends upon the higher degree of the temperature, steam temperature and the higher efficiency

II. LITERATURE REVIEW

[1]**(Shrivastava *et al.*, 2019)**current study deals with research on CL-CSP plant system carried out analytically. The research also includes CFD based simulations among three models, mainly model 1, model 2, and model 3. Model 1 consists of straight pipe; Model 2 consists of Zig-zag pipes and Model 3 consists of helical pipes. The results were evaluated for heat flux, outlet temperature, velocity gradients, turbulent, eddy viscosity etc. under the conditions for presence of air and in vacuum. The results also showed that model 3 with helical pipes have the best structure as the outlet temperature obtained was least compared to model 1 as well as the model 3.

[2]**(Xinglong, Zheng and Liu, 2019)**concentrator always plays an important role in solar energy collection as it could enhance the energy density effectively. Various structures of solar concentrators have been researched in recent years, among which multi-surface (MS) and multi-element (ME) combinations are the two typical structures. MS concentrator is an improved structure for single surface concentrator. It is usually designed to increase the acceptance angle, enhance the light intercepting efficiency, homogenize the energy distribution, etc.

[3]**(Shrivastava *et al.*, 2019a)** research paper shows the proper usage of the Cl-CSP plant for utilizing the solar energy in the month of the summer as well as winters. We have increased the volume of consumption of the solar energy with the new usage of Technology i.e. Concentrating solar power plants. This paper also gives the overview on the LFR and Solar tower power plants. This paper also displays the type of the receivers by which the solar energy is captured and then send to the different type of generators for the use of solar energy. This paper finally concludes the applications of the CL-CSP technology.

[4]**(Zhai *et al.*, 2018)**CSP-PV hybrid system can be fully integrated with the advantages of the two systems to achieve low cost, stable output, and manageable to generate electricity. In this paper, the operation strategy of the CSP-PV system is proposed for parabolic trough CSP system and PV system which are now commercially operated. Genetic algorithm is used to optimize the design of the system and calculate PV-installed capacity, battery capacity, and storage capacity of CSP system, making the system to achieve the lowest cost of electricity generation.

[5]**(Orosz, Dale and Otanicar, 2017)**potential advantages in hybridizing the two technologies if the low investment cost and higher areal basis yield of PV can be combined with CSP's robust and scalable storage. Under the Advanced Research Projects Agency-Energy (ARPA-E) FOCUS program, our team developed a novel approach to achieve CSP-PV hybridization through an add-on package that can retrofit existing parabolic trough collector (PTC)

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plants with secondary spectrum-splitting optics and a concentrating PV (CPV) receiver.

[6]**(Mishra, Patel and Gaur, 2017)**Double pipe heat exchanger is simplest form of heat exchanger containing two coaxial pipes, one inside another. Hot fluid flows inside the pipe and cold flui d flows in the gap between the two pipes, the surface of the inner pipe is the heat transfer surface which is responsible for the heat transfer between the fluids. This analysis based on the computational fluid dynamics where air to air heat exchanger utilized in cross linear concentrated solar power system CL-CSP. The fol lowing research is under process at RGPV BHOPAL.

III. WORKING

In the beginning, the Air cycle starts from the compressor where the air is compressed and then transferred to the air drum (E7) which is utilized for purpose of storage having the capacity of 2000 liters in the air drum. Afterwards, the Compressed air is transferred to air preheated from the air drum where the procedure of preheating of air is processed by the utilization of the heat of waste air which is impending from the economizer (E5). later than, the preheated air is transferred to air exchanger (E2) where the air is to be converted into heated form with around over 100^0C. By utilizing the heat of hot air impending from the receiver it is again transferred to air related with the electrical heater (E1), where the air is getting heated to around 300^0C. After all the above process, now the air is entering into the cavity linear receiver whose framework consist of6 equal pipes of which are having equal diameter. The Air which is passing through these pipes are crossing 4 type of apertures where the sun radiations are purely focused using different kind of reflecting mirrors. Afterwards, the hot air in the receivers which is around 600^0C enters into the air exchanger and then it goes to the super heater where the saturated steam which is dehydrated is now getting superheated after that, the air enters the steam generator usually to generate the steam(vapor) by increasing the latent related with the heat of water. Afterwards, it is transferred to economizer to preheat the level of water and then it enters the pre heater to preheat the air which is impendent from air drum then it is getting exhausted to the atmosphere. This procedure is the complete sequence/cycle of air which is utilized at HTF in CL-CSP system.

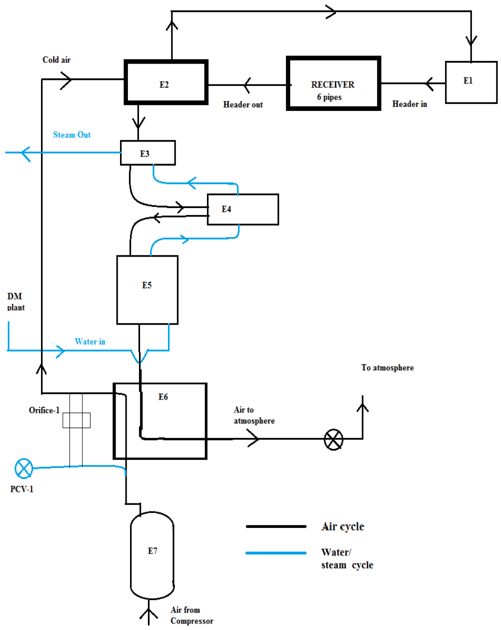

Fig. 2. Block diagram of CL-CSP 30kW$_{th}$

PCV-1 = Pressurized control valve-1
FCV-1 = Feed control valve -1
E1 = Air electric heater
E2 = Air exchanger
E3 = Super heater
E4 = Steam generator
E5 = Economizer
E6 = Air pre heater
E7 = Air Drum

IV. WORKING PROCEDURE OF CL-CSP

1. The Sun light is falling on the heliostat boards which usually have facets over it.
2. As the reflectivity of the facets is extremely high in nature that helps in making very high intense point on the type of receiver which is pointed out in the figure 3[7]

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Fig. 3. Solar concentrator on "C" receiver

3 The concentration of heliostat on receiver point is increasing from A1 to A15 in a very frequent type of manner, that the receiving line are getting more intense in the reflecting sun light at receiver point in a technique of the degree of heat is gradually increasing.

Fig. 4. Concentrator on "A" receiver

4 The comparable course of action has been just followed for B1 to B15, C1 towards C15 as well as D1 in the direction of D15 lines as it has a very high reflectivity power which gets on the receiver target B, C in addition with the D Receiver point.

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Fig. 5. Focus on "B" part receiver

Fig. 6. Focus on "D" part receiver

5 Throughout this process the observation impendent that the skin temperature of the pipes/tubes passes from the A, B, C and D Receiver points. For taking the measurement of the temperature utilizing the resistance temperature detector (RTD's). So, the degree of heat is found out the skin temperature as 645^{0}C by the use of the only 15 heliostat mirror board.

Fig. 7. View on temperature sensors

6 The analysis which can be bought up by this process that the inlet end of the receiver is usually highly compressed air (333kg/h) out from the air pre – heater which is passing from 6 Nos. tubes go to each receiver point like A,B,C and D, then outlet end of the receiver get 600 ^{0}C(approx.) air temperature.

Fig. 8. View of receiver pipes

7 When the highly compressed air (333kg/h) is transferred from the compressor to air receiver pipes, the observed temperature is dropping between the D Receiver point to the direction of the A Receiver point, there was a lot of heat losses, so the problems which are found are like air is not dehydrated at some moisture content with the air which is utilizing the air electrical heater for raising the temperature of the air. Afterwards, it is again transfers the air in the Air- Receiver pipes and putting the solar power

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concentrated system on the A,B,C and D Receiver point for reducing the level of the losses of the air heat.

8 After getting the 600 ^{o}C (approx.) air temperatures, the air is transferred in the air heat exchanger, and in this heat exchanger, the low air temperature is transferred from air pre heater and in addition with the another high temperature with air heat exchange from each other.

9 After the transmission of the air from the heat exchanger, the air goes to the steam generator and then finally becomes steam (dehydrated). Before getting a steam (vapor) an additional cycle works like water streams from the economizer and after reaching at the one end as well as the another end is converted into high degree of the temperature air, including the water which takes heat from the air and subsequently goes to the steam generator, and after that the air is turned into the saturated type of steam and lastly this saturated steam is processed to the super heater and now, finally becomes super-heated steam.

V. CONCLUSION

The study is conducted only in two countries i.e. Japan (Tokyo) and In India(Bhopal) at RGPV college. By the use of this CL-CSP plant we can consume more solar energy which can be further used in the generation of electricity and other forms. It is a new technology which still needs to be researched and studied in depth, so that more and more scopes can be identified in the CL-CSP systems. Thus, CL system is suitable for collecting solar energy at high latitudes. On differentiating between CL-CSP and Trough systems, the CL system can collect the maximum amount of solar energy even in winter seasons by keeping the cosine factor at a high level.

VI. REFERENCES

[1] P. Shrivastava, S. Chourasiya, M. Pandey, and A. Gour, "CFD Based Simulations on CL-CSP System," *J. Therm. Eng. Appl.*, vol. 6, no. 2, pp. 24–33, 2019.

[2] Xinglong, H. Zheng, and S. Liu, "A Review on Solar Concentrators with Multi-surface and Multi-element Combinations," *J. Daylighting*, vol. 6, no. 2, pp. 80–96, 2019.

[3] P. Shrivastava, S. Chourasiya, M. Pandey, and A. Gour, "A review oncfd simulations on cl-csp system," *Int. J. Adv. Prod. Mech. Eng.*, vol. 5, no. 3, pp. 11–15, 2019.

[4] R. Zhai, Y. Chen, H. Liu, H. Wu, Y. Yang, and M. O. Hamdan, "Optimal Design Method of a Hybrid CSP-PV Plant Based on Genetic Algorithm Considering the Operation Strategy," *Int. J. Photoenergy*, vol. 2018, 2018.

[5] M. Orosz, J. Dale, and T. Otanicar, "Experimental validation of a novel light-splitting technique for retrofitting CSP plants by hybridizing with CPV," *ISES Sol. World Congr. 2017 - IEA SHC Int. Conf. Sol. Heat. Cool. Build. Ind. 2017, Proc.*, pp. 158–167, 2017.

[6] S. Mishra, A. Patel, and A. Gaur, "Thermal Analysis of Heat Exchanger used in 30 kW CL-CSP plant with the help of CFD (Fluent)," *Int. J. Creat. Res. Thoughts*, vol. 5, no. 3, pp. 507–515, 2017.

[7] R. Singh and M. Pandey, "Analytical Analysis for Receiver and Its Processing for A 30 Kw CL-CSP System at RGPV Bhopal," *IJSRD - Int. J. Sci. Res. Dev.*, vol. 4, no. 03, pp. 1859–1864, 2016.