Thermal Analysis of Process of Steam Generation by Fresnel lens Concentrator

Mr.Amit S.Kharabe[1] Prof.M.R.Dharme[2]
[1]M.E. Scholar [2]Assistant Professor
[1,2]Department of Mechanical Engineering
[1,2]M.E.Thermal Engineering, Dr.Rajendra Gode College of Engineering, Amravati

Abstract— The renewable energy is become growing importance in the world day by day. Every country developing their renewable energies resources. The thermal power plants needed to produce large amount of water, steam for rotating turbine and coal is used for generation of the steam. The concentrator used for generating the steam has a better option in the future of electricity generation. In this research work the different types of solar concentrator studied and the results are collected for Fresnel lens at different days for same place.

Key words: Fresenel Lens Concentrator, Renewable Resources, Steam Generation

I. Introduction

A. General

The development effort in optical components for optimally concentrating solar energy has thus far emphasized reflecting elements, such as cylindrical and compound parabolic mirrors.[1] An optimum convex shaped nonimaging Fresnel lens is designed following the edge ray principle. The lens is evaluated by tracing rays and calculating a projective optical concentration ratio[2]. Kwangsun Ryua asserted about a new arrangement of solar concentration optics utilizing modularly faceted Fresnel lenses to achieve a uniform intensity on the absorber plane with a moderate concentration ratio. The uniform illumination is obtained by the superposition of flux distributions resulted from modularly faceted Fresnel lenses [3]. Daniel Chemisana presented the study on the photo module concentrator using the fresenel lens for building power utilization [4].In this reserch paper we have presented the low pressure steam generation using the fresenel lens concentrator.

B. Different Types of Fresnel Lenses

The Fresnel lenses are used for concentrated the photons of sun on the area of application. The Fresnel lenses are mainly classified as imaging and non imaging type. The following are the types of Fresnel lenses:

1) Imaging Type

a) Spherical

A spherical Fresnel lens is equivalent to a simple spherical lens, using ring-shaped segments having each a portion of a sphere, and capable to all focus light on a single point. This type of lens produces a sharp image, although not quite as clear as the equivalent simple spherical lens due to diffraction at the edges of the ridges.

b) Cylindrical

A cylindrical Fresnel lens is equivalent to a simple cylindrical lens, using straight segments with circular cross-section, focusing light on a single line. This type produces a sharp image, although not quite as clear as the equivalent simple cylindrical lens due to diffraction at the edges of the ridges.

2) Non-Imaging

a) Spot

A non-imaging spot Fresnel lens uses ring-shaped segments with cross sections that are straight lines rather than circular arcs. Such a lens can focus light on a small spot, but does not produce a sharp image. These lenses have application in solar power, such as focusing sunlight on a solar panel.

b) Linear

A non-imaging linear Fresnel lens uses straight segments whose cross sections are straight lines rather than arcs. These types of lenses focus light into a narrow band. It can't produce a sharp image, but can be used in solar power, such as for focusing sunlight on a pipe, to heat the water.

II. Experimental Setup

In this study, the water is circulated with the help of electric pump through copper coil. The flow of water is continuously maintained with the copper tube and copper tube is placed with the parabolic solar collector. The radiation from the sun is attracted towards the parabolic collector by means of used glass reflector and Fresnel lens. The radiation of the sun is trapped by the Fresnel lens and it is transferred to the copper coil. The solar radiation is again reflected on the copper coil. The heated water is then passed into a cool water tank where the evaporator coil is provided within it.

The evaporator coil losses it absorbed heat into the cool water, and steam get collected in the circular type tank chamber which is kept air tight. The air tight chamber serves for steam storage. The steam is then passed to the application area. The flow of water is kept in control with flow control valve. The temperature of inlet and the outlet water is measured by the k-type thermocouple.

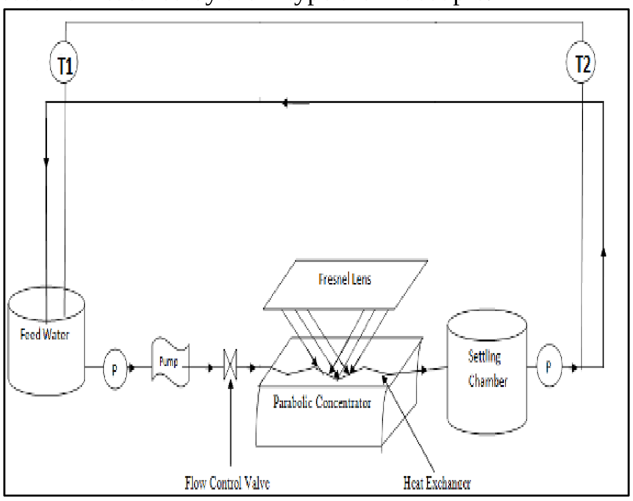

Fig. 1: Experimental Setup

The temperature is recorded for each mass flow of water and the reading for each flow rate is recorded. The pressure of steam is recorded by the pressure gauge and corresponding temperature is recorded by the temperature indicator. The circulation of water is kept continued with used to pump so that the efficiency of steam generation is improved with hot feed water. The global radiation for the experimentation is measured with the help of solar pyranometer and wind velocity is recorded by the anemometer.

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IV. RESULTS & DISCUSSIONS

The experimentation is carried out in such way that the performance of the Fresnel lens is tested for different flow rate of water given for steam generation. The following results were obtained at different flow rates with the used of Fresnel lenses and without using Fresnel lens.

Date:15/04/2016 for Flow Rate of 1.66 Lit/Min						
Time (AM)	Inlet Temp (˚C)	Outlet Temp (˚C)	Temp Diff. (˚C)	Solar Intensity (W/m2)	Wind Speed (m/sec)	Pressure of steam (Psi)
09:30 - 10:00	33	37.95	4.95	728.214	0.5	1.45
10:00 - 10:30	37.98	42.65	4.67	758.759	1.6	1.48
10:30 - 11:00	42.65	48.85	6.2	794.519	0.6	1.56
11:00 - 11:30	48.85	53.55	4.7	813.144	2.7	1.56
11:30 - 12:00	53.55	57.65	4.1	847.414	3.3	1.81
Date:15/04/2016 for Flow Rate of 1.66 Lit/Min						
Time (PM)	Inlet Temp (˚C)	Outlet Temp (˚C)	Temp Diff. (˚C)	Solar Intensity (W/m2)	Wind Speed (m/sec)	Pressure of steam (Psi)
12:00 - 12:30	57.65	61.05	3.4	869.764	1.9	1.82
12:30 -1:00	61.05	64.15	3.1	877.214	0.6	1.82
1:00-1:30	64.15	66.45	2.3	839.219	0.8	1.85
1:30-2:00	66.45	68.15	1.7	786.324	1.6	1.85
2:00-2:30	68.15	69.45	1.3	763.229	1	1.85

Table 1: Reading of Experimental Work

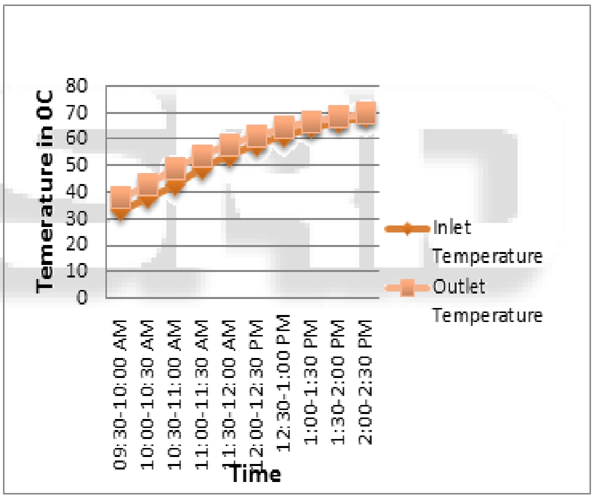

Fig. 2: Variation in Temperature with Time at Flow Rate of 1.66 Ltr/Min

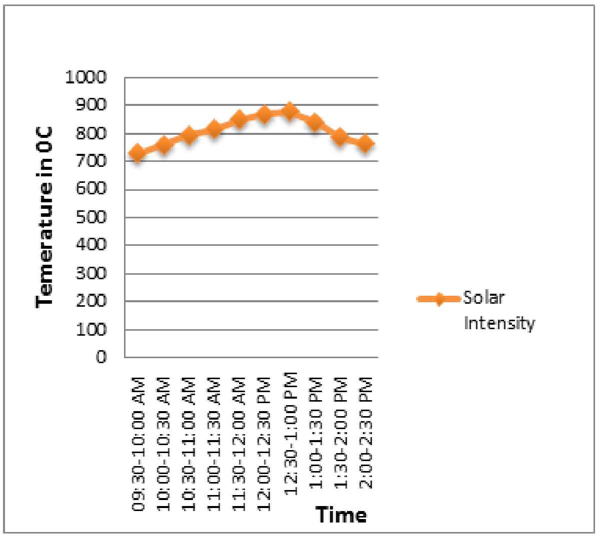

Fig. 3: Variation in Solar Intensity with Time

Date:17/04/2016 for Flow Rate of 2.66 Lit/Min						
Time (AM)	Inlet Temp (˚C)	Outlet Temp (˚C)	Temp Diff. (˚C)	Solar Intensity (W/m2)	Wind Speed (m/sec)	Pressure of steam (Psi)
09:30-10:00	32.5	37.9	5.4	689.47	0.1	2.01
10:00-10:30	37.9	43.1	5.2	731.94	1.5	2.05
10:30-11:00	43.1	49.6	6.5	765.46	0.7	2.10
11:00-11:30	49.6	54.6	5	813.14	0.3	2.11
11:30-12:00	54.6	59.1	4.5	845.18	3.2	2.15
Date:17/04/2016 for Flow Rate of 2.66 Lit/Min						
Time (PM)	Inlet Temp (˚C)	Outlet Temp (˚C)	Temp Diff. (˚C)	Solar Intensity (W/m2)	Wind Speed (m/sec)	Pressure of steam (Psi)
12:00-12:30	59.1	62.7	3.6	863.06	2	2.45
12:30-1:00	62.7	65.9	3.2	848.16	3.5	2.50
1:00-1:30	65.9	68.3	2.4	782.60	0.1	2.65
1:30-2:00	68.3	70.2	1.9	772.91	3	2.70
2:00-2:30	70.2	71.4	1.2	746.84	2	2.80

Table 2: Reading of Experimental Work

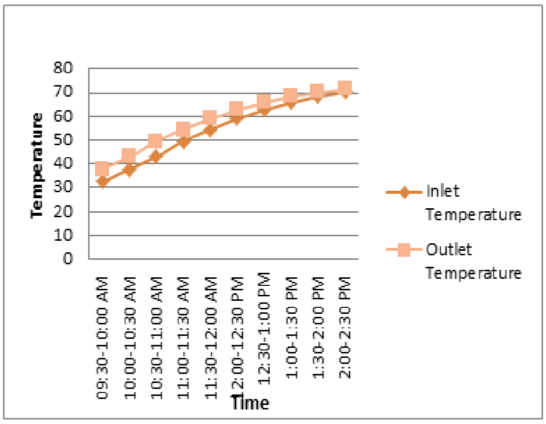

Fig. 4: Variation in Temperature with Time at Flow Rate of 2.66 Ltr/Min

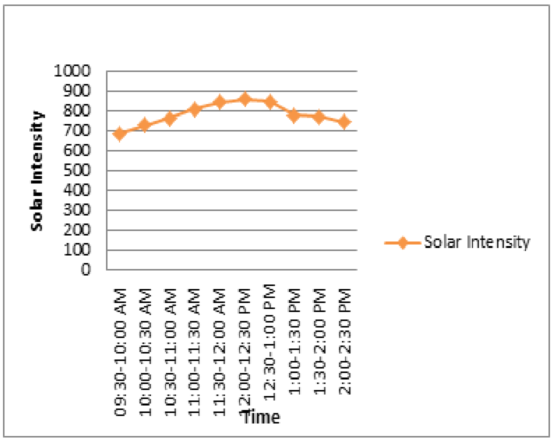

Fig. 5: Variation in Solar Intensity with Time

Variation in Pressure of Steam with Inlet and Outlet Feed Water Temperature:-

The Figures 1.6 & 1.7 shows the variation in the pressure of steam with feed water inlet and outlet temperature at different flow rates. The steam generation is depends on various parameters such as, solar intensity, temperature, mass flow rate and specific heat of the fluid. At 1.66 LPM, specific heat of the feed water is less and higher temperature difference is reported. The pressure of steam is increases with increasing in the heat input and mass flow rate of water. The following figures show the variation in steam. The maximum pressure of steam is obtained at outlet temperature of 70 ºC with the maximum flow rate of 2.66 LPM.

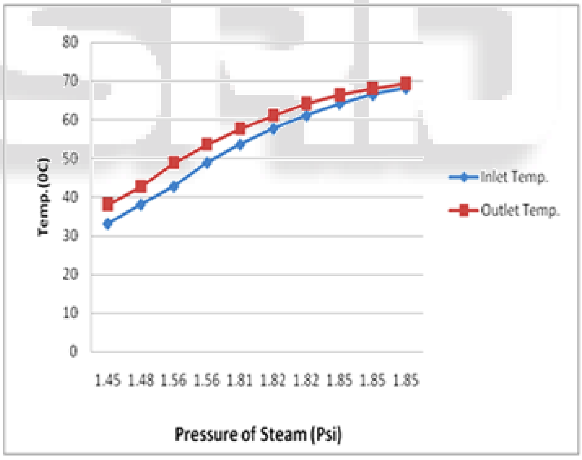

Fig. 6: Variation in Steam Pressure with Inlet and Outlet Temperature at 1.66 LPM

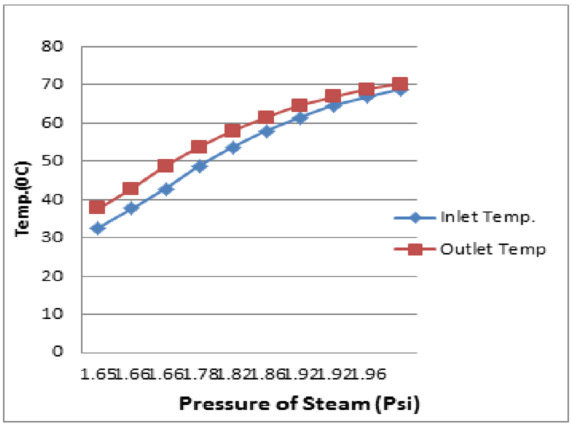

Fig. 7: Variation in Steam Pressure with Inlet and Outlet Temperature at 2.66 LPM

V. Conclusion

The renewable energy utilization for steam generation is can be necessity in order to save the fossil fuel. The following are the conclusion made on the basis of presented study.

- The maximum temperature attained from feed water is 68.3, 70.2 and 71.4 ºC respectively in between 1.00 pm to 2:30 pm.
- The maximum pressure obtained from the experimental results is 2.80 Psi with 2.66 LPM mass flow rate.
- Temperature difference is maximum at the 2.66 LPM mass flow rate and minimum at 1.66 LPM.
- Initially, Temperature difference increases because heat flux is maximum from 9:30 am to 12:30 pm and afterwards, temperature difference goes on decreasing.

References

[1] John H. Reif, Design and Analysis of a High-Efficiency, Cost-Effective Solar Concentrator, Report on Solar Energy.
[2] E.M. Kritchman A. Friesem G. Yekutieli, Efficient Fresnel lens for solar concentration Int.Journal of Solar Energy (Elsevier) 1979, Vol.22(2):119–123, doi:10.1016/0038-092X(79)90095-1.
[3] Ralf Leutzakio,Suzukitakao Kashiwagi, Design Of A Non imaging Fresnel Lens For Solar Concentrators, Int.Journal of Solar Energy(Elsevier) April 1999, Vol.65(6):379–387, doi:10.1016/S0038-092X(98)00143-1.
[4] Kwangsun Ryua,Jin-Geun Rheea,Kang- Min Parkc, Jeong Kimd, Concept and design of modular Fresnel lenses for concentration solar PV system, Int.Journal of Solar Energy(Elsevier) April 1979, Vol.23(6):220–227,doi:10.1016/S0038-2X(79)90095-1.
[5] Daniel Chemisana, Manuel Ibanez , Jerome Barrau, Comparison of Fresnel concentrators for building integrated photovoltaics, Int.Journal of Solar Energy(Elsevier) April 1979, Vol.23(6):290–297, doi:10.1016/S0038-092X(79)90095-1.
[6] Daniel Chemisana, Linear Fresnel concentrators for building integrated applications, Int.Journal of Solar Energy(Elsevier) Jan 1978, Vol.24(7):280–297.
[7] D. Chemisana, Characterization of a photovoltaic-thermal module for Fresnel linear concentrator, Int.j.enconman (Elsevier).2011.04.008, doi: 10.1016.
[8] W.T. Xiea, Y.J. Daia,R.Z. Wanga and K. Sumathy Concentrated solar energy applications using Fresnel lenses: A review,Int. j.rser. (Elsevier) 2011.03.031, doi: 10.1016
[9] David C. Miller and Sarah R. Kurtz, Durability of Fresnel lenses: A review specific to the concentrating photovoltaic application, Solar Energy Materials and Solar Cells, Volume 95, Issue 8, August 2011, Pages 2037–2068,Photovoltaics, Solar Energy Materials & Thin Films, IMRC 2009-Cancun.
[10] H. Zhai, Y.J. Dai, J.Y. Wu, R.Z. Wang, L.Y. Zhang, Experimental investigation and analysis on a concentrating solar collector using linear Fresnel lens, Energy Conversion and Management. Volume 51, Issue 1, January 2010, Pages 48–55.
[11] Naichia Yeh, Analysis of spectrum distribution and optical losses under Fresnel lenses, Renewable and Sustainable Energy Reviews, Volume 14, Issue 9, December 2010, Pages 2926–2935.
[12] W.T. Xie, Y.J. Dai and R.Z. Wang,Numerical and experimental analysis of a point focus solar collector using high concentration imaging PMMA Fresnel lens,9th International Conference on Sustainable Energy Technologies (SET 2010)Energy Conversion and Management, Volume 52, Issue 6, June 2011, Pages 2417–2426
[13] M.M. Valmiki, Peiwen Li, Javier Heyer, Matthew Morgan, Abdulla Albinali, Kamal Alhamidi, Jeremy Wagoner, Technical Notes on ,A novel application of a Fresnel lens for a solar stove and solar heating, Renewable Energy,Volume 36, Issue 5, May 2011, Pages 1614–1620.
[14] Chung-Feng Jeffrey Kuoa, Feriyonikaa, Chung-Ching Huangb, Yong-Lin Kuoa, Analysis of processing parameters in fabrication of Fresnel lens solar collector Energy Conversion and Management Volume 57, May 2012, Pages 33–41.
[15] P.J. Sonneveld, , G.L.A.M. Swinkels, B.A.J. van Tuij H.J.J. Janssen, J. Campen, G.P.A. Bot, Performance of a concentrated photovoltaic energy system with static linear Fresnel lenses,Solar Energy,Volume 85, Issue 3, March 2011, Pages 432–442.
[16] Atsushi Akisawaa,Masao Hiramatsub, Kouki Ozaki, Design of dome-shaped non-imaging Fresnel lenses taking chromatic aberration into account,Solar Energy,Volume 86, Issue 3, March 2012, Pages 877–885.
[17] D.T. Nelson, D.L. Evans, R.K. Bansal Linear Fresnel lens concentrators, Solar Energy,Volume 17, Issue 5, November 1975, Pages 285–289.
[18] Vinod Kumara,R.L. Shrivastavaa,S.P. Untawale, Fresnel lens: A promising alternative of reflectors in concentrated solar power, Renewable and Sustainable Energy Reviews,Volume 44, April 2015, Pages 376–390.
[19] Khalil E.J. Al-Jumaily, MunadhilA.K.A. Al-Kaysi, The study of the performance and efficiency of flat linear Fresnel lens collector with sun tracking system in Iraq, 6th Arab International Solar Energy Conference: Bringing Solar Energy into the Daylight Renewable Energy,Volume 14, Issues 1–4, May–August 1998, Pages 41–48.
[20] David R. Mills, Graham L. Morrison Compact Linear Fresnel Reflector solar thermal power plants, Volume 68, Issue 3, 3 March 2000, Pages 263–283.