Energy Analysis of Steam Generating Solar Concentrators

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Abstract – Steam generation by using solar energy is not a new thing. In this project we considered the properties of the steam produce by the solar energy. The main purpose of this study is that to find out the various exergy losses at various point in the system and to know the actual exergy available from the setup. By performing exergy analysis, we are able to draw the graphs of how the exergy destruction is taking place. With the help of this study we can use the setup very effectively and system can be udder very effectively to avoid unnecessary exergy losses. This type of information is used in thermodynamic system to work with solar energy very effectively to increase the efficiency of the existing systems.

Keywords - Solar Energy. Exergy analysis, Availability, Scheffler concentrator

I. INTRODUCTION

Parabolic dish collectors are one of the concentrated solar thermal collectors used for energy conversion and power generation in this study consists of a parabolic dish collector and a modified cavity receiver operating in tracking mode. “Exergy is define as the maximum amount of work can be obtain when some matter is brought to a state of thermodynamic equilibrium.The solar collector is one of the key element in a solar thermal energy system. The function of the collector is very simple; it intercepts the incoming solar radition and converts it into a useful form of energy that can be usedas per our requirement. Concentrating solar collectors are used to achieve high temperatures and accomplish this concentration of the solar radiation by reflecting or refracting the flux incident on the aperture area (reflective surface), Ap onto a smaller absorber (receiver) area, Ar. The receiver’s surface area is smaller than that of the reflective surface capturing the energy, thus allowing for the same amount of radiation that would have been spread over a few square meters to be collected and concentrated over a much smaller area, allowing for higher temperatures to be attained. These concentrating solar collectors have the advantage of higher concentration and are capable of more effective utilization of the solar intensity at off-noon hours than other types of solar concentrators. The difficulties for the use of dish type of parabolic collector is that it requires two dimensional tacking system. Most of the concentrating collectors can only concentrate the beam normal insulation (the parallel insulation coming directly from the sun), otherwise, the focal region becomes scattered and off focus, which decreases the performance efficiency of the system, therefore requiring the concentrator to follow the sun throughout the day for maximum solar energy collection. For the parabolic concentrator, continuous tracking is needed; if oriented east-west, the concentrator requires an approximate ± 30°/day shift; if north-south, an approximate 15°/hr shift. This tracking also must accommodate a ±23.5°/yr declination excursion. [1]

II. LITERATURE REVIEW

Lloyd C. Ngo[1] concludes that the exergy analysis was carried out on the parabolic dish solar collector with a modified cavity receiver considering the content of incident solar radiation. By applying a derived expression for exergy efficiency, exergy destruction and losses were generated and the optimum design and operating conditions iare found out.The exergy efficiency increase with increasing receiver temperature until the optimum temperature is reached and then start to decrease. The main values of dimensionless exergy losses in this analysis tends to exergy destructed by absorption heat transfer, exergy loss due to optical and heat leakage loss. The dimensionless exergy loss due to heat increase as the receiver temperature increases whereas the dimensionless exergy destruction decreases. Wolfgang Scheffler[2] describes the idea about how to design the scheffeler reflectors and how it was done. The analysis is done by considering the various parameters like by stopping the sun, by moving the sun, blending and flexing etc.P.Rajamohan,R.V.Jebarajsekhar,N.SankaraSubramanian and K.Ramanathan[3]observed that lower temperature ranges can be achieved by parabolic dish i.e. below 180°C but for higher temperature ranges we could switch over for Scheffler concentrator which gives comparatively good output than that of the parabolic one.

III. PROBLEM DEFINITION, OBJECTIVE

3.1 Problem Definition:

Exegy analysis is the more suitable method for finding out the efficiency of the system, by using the various equations of the exergy we are able to find out the exergy losses by conduction convection, radiation and pressure drop and by using other parameter.

3.2 Objective:

The objectives of this research are:

1. Todo the exergy analysis and accumulation of steam generating solar concentrator.
2. Tocalculate the actual exergy available from the system.

3.3 Exergy Analysis:

Use of the exergy analysis concept is more useful because it relevance directly the system work attainable for ideal processes.as the destruction losses are reducingautomatically the exergy efficiency increases.by applying the exergy balancing to the working system we are able to calculate the magnitude of the various exergy losses at various components of the system.Exergy balance can be generally being expressed as

$$\Sigma \dot{E}in - \Sigma \dot{E}out - \Sigma \dot{E}loss - \Sigma \dot{E}change - \Sigma \dot{E}des = 0$$

3.4 Experimental Setup:

The proposed experimental setup consists of a paraboloid Scheffler Reflector dish fitted with low iron glass mirror as shown in Fig.1 mild steel structure supports the reflector dish and sun tracking system. The tracking system swivels the reflector throughout the day to ensure maximizes solar radiation onto the reflector. A steam generating receiver is installed at the focus of reflector dish to receive the concentrated solar heat flux, which in turn transferred to water present in the receiver.

Solar thermal applications with solar concentrators use receivers at focus of the concentrators. These receivers receive concentrated heat from the solar concentrators. Heat flux falling on to these receivers is partly absorbed by working fluid and rest is lost by way of different thermal losses. To receive solar radiation, at least one face of the solar receivers is to be kept exposed to solar collector, while other parts of the receivers can be shielded with good insulation. To analysis the performance of the solar thermal system it is utmost important to recognize the correct estimation of thermal losses from the receiver. If the losses can be accurately measured, then it is possible to establish performance or efficiency of the receiver at different operating conditions.

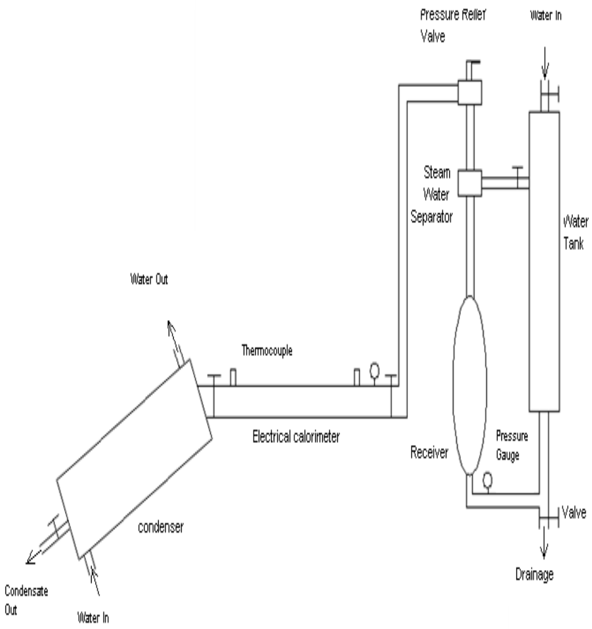


Fig.3.1Schematic representation

Fig. 3.2 Actual photograph of experimental setup

IV. RESULTS AND DISCUSSIONS

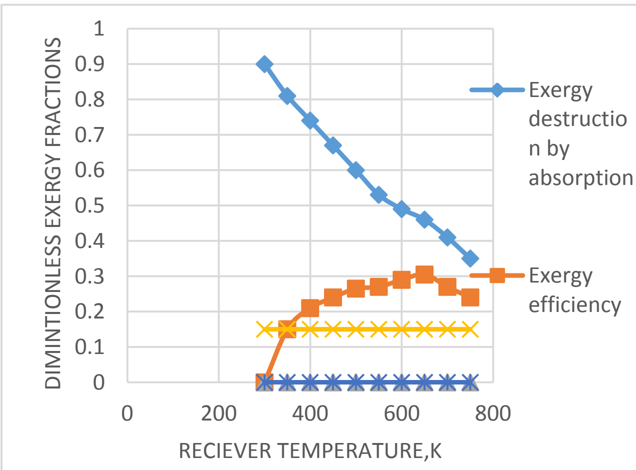
4.1. Balance Sheet For Exergy Analysis

Table 4.1 Heat Balance Sheet for Exergy Analysis

Exergy outflow	KJ/S	Exergy utilized	KJ/S	%
Outflow exergy rate: $\dot{E}_{out,f} = \dot{m}C_p(T_o - T_a - T_a \ln \frac{T_o}{T_a}) + \frac{\dot{m}\Delta P}{\rho}$	2.7689	**1.In flow exergy rate** $\dot{E}_{in,f} = \dot{m}C_p(T_{in} - T_a - T_a \ln \frac{T_{in}}{T_a}) + \frac{\dot{m}\Delta P}{\rho}$	1.3737	49.61
		2.Exergy destruction due to pressure drop $\dot{E}_{des,\Delta P} = T_a \frac{\dot{m}\Delta P}{\rho} \frac{\ln(T_{out}/T_{in})}{T_{out} - T_{in}}$	0.09426	3.41
		3.Exergy destruction due to absorption $\dot{E}_{des,abs} = I_b A_a \eta_o T_a(\frac{1}{T_r} - \frac{1}{T_s})$	0.04914	1.77
		4.Exergy destruction due to conduction $\dot{E}_{des,cond} = \dot{m}C_p T_a(\ln(T_{out}/T_{in}) - \frac{(T_{out} - T_{in})}{T_r})$	0.00285	0.10
		5.optical heatloss $\dot{E}_{l,opt} = (1 - \eta_o) I_b A_a \eta_p$	1.1141	40.24
		6.Other losses $\dot{E}_{out,f} - \dot{E}_{in,f} - \dot{E}_{des,\Delta P} - \dot{E}_{des,abs} - \dot{E}_{des,cond} - \dot{E}_{l,opt}$	0.13485	4.87
Total	2.7689	**Total**	2.7689	**100**

4.2 Effects of receiver temperature and solar intensity

Following figure shows the variation of dimensionless exergy ratios with receiver temperature by keeping other variables at optimum values. From the figure it seems that the exergy efficiency increase with increasing receiver temperature until the optimum temperature is reached and then start to decrease.



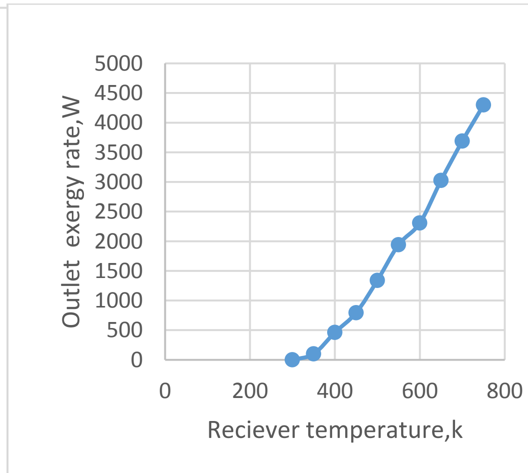


Fig.4.1 variation of dimensionless exergy ratios Fig.4.2The variation of outlet exergy rate versus versus receiver temperaturereceiver temperature.

Exergy destruction due tothe absorption is considerably large as compared to the other processes.as the receiver temperature increases the destruction losses are decreases therefore the high temperature of the receiver must be preferring to get maximum efficiency. the exergy destruction due to the pressure loss is neglected because as compared to the other processes it is very negligible. From figure it is observed that the as the receiver temperature increases outlet exergy rate is also increases.

4.3Effects of Mass Flow Rate:

In case of mass flow rates, the main values of dimensionless exergy losses belong to the exergy destructed by absorption heat transfer and heat leakage loss. As the mass flow rates increases Exergy destruction due to absorption is also increases but in case of heat leakage loss it decreases with increase in mass flow rate.

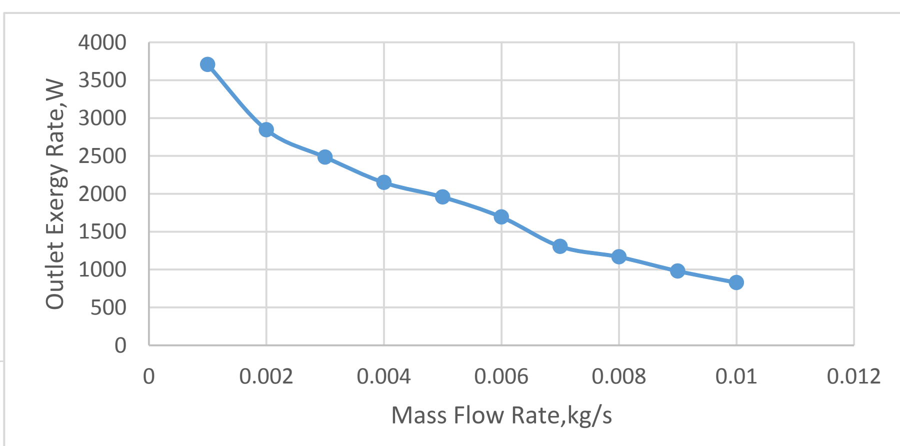


Fig.4.3 The variation of outlet exergy rate versus mass flow rate.

The exergy efficiency increases with increase in mass flow rate up to the optimum value is reached and then start to decrease. It is observed from the figure that the outlet exergy rate is a decreasing function of mass flow rate. As the mass flow rate is increased the heat transfer time reduces and thereforethe exergy output is reducing.

V. CONCLUSION

From the above result it is conclude that, efficiency of the Scheffler concentrator is increased by using insulation to the cavity receiver. Cavity receiver gives better efficiency than that of the plain cylindrical receiver. Exergy efficiency increases as the receiver temperature increase till the optimum temperature. As the mass flow rate increases the exergy efficiency increases. By using exergy analysis, we able to use solar energy more effectively and able to find out magnitude of various exergy losses.

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