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SOLAR COLLECTORS AND A HELIOSTAT PLANT ANALYSIS: A REVIEW

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Abstract- Since the greenhouse effect of overconsumption of fossil fuels is thecause of global warming, efforts have been made in recent decades to replace coal, oil and natural gas withsolar energy. Solar cookers, photovoltaic (PV) panels, solarthermal collectors, concentratingsolar power plants, and other methods is applicable to harness the sun's energy and bury it into heat and electrical energy. Focusingprimarily on solar panels, the purpose of this discussion is to introduce various solar panel systems such as: As an example, we study a molten salt cavity receiver's and heliostat collector's energy and exertion. Finally, we present some methods to optimize plant performance by calculating cycle energy and exergy losses.

Keywords: Solar collectors, illumination, Exergy analysis, Cavity receiver.

1. INTRODUCTION

There are two basic kinds of solar panels. After the introduction ofcollectors, two main categories wereclearly named.

- Fixed collector and
- Sun trackingcollector

Fixed collectors are stationary and do not track the sun. This category describes his three different categories of collectors. Sun tracking collectors follow the sun throughout the day to capture more energy than fixed collectors, as the name implies. In this post, four different types of sun tracking collectors will be covered.

- Linear Fresnel reflector
- Parabolic through collector
- Parabolic dish reflector
- Heliostat field collector

2. TYPES OF SOLAR COLLECTORS

2.1 Flat-Plate Collectors

Operation of the collector for flat plates is simple. It only relies about radiation that penetrates a translucent layer before being applied to an absorbing layer that converts solar energy into heat. The absorbed heat is transferredto the medium fluid (water, waterwith antifreeze, air in pipes, etc.) to heat it and make it available for directheat. The interior of the housing and the underside of the absorber plate are both sufficiently insulated to minimize line loss. A large diameter head pipe connects the liquid pipe at its end. Since it doesnot pass long waves, the transparent layer mainly serves to prevent theloss of solar reflection. Since this collector is fixed in its position and isnot tracked. In the northern hemisphere, the sun must face south, while in the southern, it must face north. The optimal collector pitch angle depends on the latitude of the place with an angular variation of 10 to 15 degrees. Prototypes of various translucent insulating plate current collectors. Over the last ten years, developed and tested. Affordable transparent insulation that has high thermal resistance. (TI) Materials have been developed to enable the commercialization of these collectors.

2.2 Compound Parabolic Collectors

Designed by Winston. These types ofcollectors can absorb nearly all of thelight emitted into the mouth. These collectors can absorb most of the diffuse radiation entering the aperture and focus it without trackingthe sun.

Some types of compound parabolic concentrators can track sunlight, but these concentrators are comparableto flat plate concentrators and must be locked at They will adopt a particular angle known as the acceptance angle depending on where they are. The minimum allowable angle for a fixed CPC collector mounted in this mode is 47 degrees. From the summer solstice tothe winter solstice, the sun's declination is captured at this angle. However, creating a synthetic parabola requires some theoretical and numerical calculations andanalysis.

Vacuum tube collector (ETC) Vacuum heat pipe collectors wereinvented because flat panel collectorsdo not perform well in cloudy or coldclimates as a result of moisture condensation on the panel surface. Heat pipes inside vacuum-sealed tubes make up these solar panels even though vacuum envelope collectors may be able to operate at higher temperatures than flat plate collectors due to lower convection and conduction losses. The tube, which isa sealed copper tube, is fastened to the tube's filling of black copper fins. (Absorber plate). Each tube has a metal tip that protrudes from the top and is connected to a sealed tube. (condenser). A little amount of liquid, such as methanol, is present in the heat pipe. That undergoes a cycle of evaporation and condensation. In thiscycle, the heat of the sun vaporizes the liquid, goes to the heat sink area, and then condenses and releases latent heat there. The process is then repeated with the condensed liquid in the solar panel.

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Once these pieces are assembled, Heat exchanger is scraped by sagging metal (manifold). Either water or glycol is poured into the manifold. Absorbing heatfrom the tubes. The hot liquid is circulated using a different heat exchanger. Transferring its heat to thewater to be sorted in the process or solar storage tanks.

Parabolic flow can efficiently produce heat up to a 400C temperature. The components of this heat-recovery collector are a parabolic mirror and a black metal tube covered in glass. Along the mirror's focal line, this tube extends.

If Parallel rays that hit the reflector and head to the receiving tube will be reflected when the parabola is pointed at the sun. Sun tracking on a single axis is sufficient. As in traditionallymanufactured long concentratormodules. Collectors can either be orientated north-south to track the sun from east to west or east-west to track the sun from north to south. North-south collectors collect more energy throughout the year, while west-east collectors' superior in the summer. The largest application for a system of this kind is a power plant inSouthern California known as a solarpower system (SEGS) with a total installed capacity of 354 MW.

He has two main systems for trackingthe sun. The first is based on a motorthat is electronically controlled by a sensor that measures the intensity of the sun's rays, the second is based ona computer-controlled motor thatreceives feedback from a sensor that measures solar flux at the receiver. Iran's first solar collector system is the Parabolic Solar Collector in Shiraz in the south of the country.

2.3 Linear-Fresnel Reflector

Parabolic flow can effectively generate heat up to temperatures of about 400C. This collector consists of a parabolic mirror and a black metal tube covered with a glass tube to reduce heat loss. This tube extendsalong the focal line of the mirror.

When the parabola points to it If the parabola points to the sun. If the parabola is pointed at the sun, parallel rays' incident on the reflectorwill be reflected to the receiving tube.It is sufficient to use single axis tracking of the sun, as in traditionallymanufactured long concentratormodules. Collectors can be oriented east-west to track the sun from northto south, or oriented north-south to track the sun from east to west. North-south collectors collect more energy throughout the year, while west-east collectors are better in the summer. The largest application for this type of system is a power plant inSouthern California known as a solarpower system (SEGS) with a total installed capacity of 354 MW.

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2.4 Helliostat-Field Collector

Heliostat field. The main point in this is the type of photovoltaic plant. Heliostats are viewing mirrors placed around the tower with their receivers at the top.

Substantial solar energy is concentrated in the facility's receivercavity before being fed to a steam generator in order to produce steam that is both hot and under pressure. The thermal energy captured by the receiver is converted into a flowing liquid, stored and used to generate electricity at night. The concentrationratio range for this collector is 300 to1500. Such plants operate on an areaof 50-150 square meters and sometimes use heat storage systems. Hybrid systems may be created that use both solar and fossil fuels as partof the heat storage system. Normal solar radiation to the receiver is 200-1000 kW/m2.

Thanks to this high flow rate, it can operate at almost high temperatures above 1500 C. Rankin and Brayton cycles are commonly used in heliostat systems, the latter at higher temperatures. In terms of location,the heliostats can be arranged in a circle around the receiver tower due north (northern hemisphere) or due south (southern hemisphere). In moredemanding systems, the heat transferfluid is either water or steam, liquid sodium, molten nitrate (potassium nitrate or sodium nitrate), or even air.In advanced systems, the heat storagemedium liquid must be crushed stone, molten nitrate, liquid sodium, or oil mixed with ceramic bricks 4 ICESE2016, 5-6. September 2016.

Early tower power plants, known as Solar One plants, used steam as the heat transfer medium, which presented many challenges such as storage and continuous turbine operation. Solar One has been updated to Solar Two, which uses molten salt and air as media to solve these problems.

3. THERMAL ANALYSIS OF A HELIOSTAT PLANT

The next article will show the calculations for plant energy and exercise measurement. These considerations will be presented first:

- Rankine cycle steam tower
- Tower's receivers are hollow.
- The liquid medium is a molten salt containing 60% $NaNO_3$ and 40% KNO_3.
- The receiver has four heat sinks. Radiative, reflective, forced and natural convective heat loss. The reductions in energy consumption are too small to be ignored.
- Reflective factor and emissive factor do not change with the receiversurface temperature.

The mirror at the bottom of the steps reflects the sun's rays to the top of the tower where the receivers are located.

Power and energy balance:

$$\dot{Q} = \dot{Q}_{receiver} + \dot{Q}_0 \qquad (1)$$

$$\dot{X} = \dot{X}_{receiver} + \dot{X}_0 \quad (2)$$

Which X' is the total energy inserted into the heliostat field by sun, resulted from the Equation (3).

$$\dot{X} = \dot{Q} * (1 - T^o/T^*) \quad (3)$$

While the T' is the equal sun temperature about 4500 K. The second phase shows the result of the thermal calculations of energy and exergy inside the receiver.

Accordingly, Eq. (4) and indicate that the energy that the energy and exertion sent to the receiver are (5).

$$\dot{Q}_{receiver} = \dot{Q}_{receiver,abs} + \dot{Q}_{receiver,loss} \quad (4)$$

$$\dot{X}_{receiver} = \dot{X}_{receiver,abs} + \dot{X}_{receiver,loss} \quad (5)$$

These phase would be explained in equations (6), (7), and (8).

$$\dot{X}_{receiver,loss} = \dot{Q}_{receiver,loss} * (1 - T_0/T^*) \quad (6)$$

$$(\dot{Q}_{receiver,abs}) = \dot{m}_{msalt} * (h_{msalt,o} - h_{msalt,i}) \quad (7)$$

$$(\dot{X}_{receiver,abs}) = \dot{m}_{msalt} * (x_{msalt,o} - x_{msalt,i}) + \dot{X}_D \quad (8)$$

To determine the power and power loss of the receiver, the receiver needs to measure the temperature. This is calculated from eq. (9)

$$\dot{Q}_{receiver} = \frac{T_{rec,surf} - \frac{T_{msalt,i} + T_{msalt,o}}{2}}{\frac{d_o}{d_i * h_{msalt}} + \frac{d_o}{2k_{tube}} \ln(do/di)} A_{rec,surf} \quad (9)$$

Also $\dot{Q}_{receiver,loss}$ would be calculated separately:

3.1 Emissive Heat Loss

Transmission loss occurs between the receiving port and the source and is estimated using equation (10).

$$Q_{loss,em} = \varepsilon_{eq} * \sigma * (T_{rec,surf}^4 - T_o^4) * A_{rec,surf} * F_r \quad (10)$$

$$\varepsilon_{eq} = \varepsilon_{wall} / (\varepsilon_{wall} - (1 - \varepsilon_{wall}) * F_r) \quad (11)$$

In the Equation (10) and (11) Fr is the view factor, which is calculated as mouth area divided by receiver surface Area. ($F_r = A_{mouth}/A_{rec,surf}$) And σ is the Stephan Boltzmann factor which equals 5.67*10-8 (W/m2*K4). Also, ε_{eq} is the emissivity of the receiver inner body.

3.2 Reflective Heat Loss

The heat reflected to the surrounding is resulted by this Equation (12).

While ρ is the reflection ratio.

$$Q_{loss,ref} = Q_{in} * F_r * \rho \quad (12)$$

$$Q_{loss,fc,cnv} = h_{air,fc} * (T_{rec,surf} - T_o) * A_{rec,mouth} \quad (13)$$

Where $h_{air,fc}$ is the forced convective factor and is obtained from Nusselt number:

$$Nu_{air,fc} = 0.0287 * Re_{air,insi}^{0.8} * Pr_{air,insi}^{(1/3)} \quad (14)$$

In the Equation (14) the Reynolds number and Prandtl number are concluded of thermodynamic formulas, based on reference temperature which is equal to $T_{air,ins} = T_{rec,surf} + T_o/2$ and the reference length is the height of the receiver aperture.

3.3 Convective Heat Loss

Convective heat loss typically made up a significant portion of the total heat loss and included both forced and natural convective heat loss. Separate calculations would be madefor forced and natural heat loss:

3.4 Forced Connective Heat Loss

The average temperature of the receiver surface is used to determineforced convection heat loss, which isbelieved to occur from a flat plate at the receiver's mouth size.

3.5 Natural Connective Heat Loss

The natural convection cavity was quite like the flat plate. The natural convective heat loss and natural convective heat transfer coefficient were given by Equations (15) and (16), respectively:

$$Q_{loss,nt,cnv} = h_{air,nt} * (T_{rec,surf} - T_o) * A_{rec,surf} \quad (15)$$

$$h_{air,nt} = 0.81 * (T_{rec,surf} - T_o)^{0.426} \quad (16)$$

3.6 Total Heat Loss

As written in assumptions the conductive heat loss is negligible;

Therefore, the total heat loss is equal to:

$$\dot{Q}_{loss,tot} = \dot{Q}_{loss,em} + \dot{Q}_{loss,ref} + \dot{Q}_{loss,fc,cnv} + \dot{Q}_{loss,nc,cnv} \quad (17)$$

3.7 Steam Generator and Power Cycle

The third section occurs in the steam generator which is a kind of heat exchanger. Rankine cycle is assumed that it's utilized for the power generation (19), (20).

$$\dot{Q}_{rec,abs} = \dot{Q}_{st,abs} = \dot{m}_{steam} * (h_{steam,o} - h_{steam,i}) \quad (18)$$

$$\dot{X}_{rec,abs} = \dot{X}_{st,abs} + \dot{X}_{das} \quad (19)$$

The Equations (18) and (19) are used for calculating the energy and exergy of the steam-generator:

It is easy to calculate $X_{st,abs}$ as the exergy absorbed by the power water from the molten salt. So, the Equation

(20) shows the total exergy absorbed inside the receiver

$$\dot{X}_{(rec,abs)}=\dot{m}_{steam}*(x_{(steam,o)}-x_{(steam,i)})+\dot{X}_{des} \qquad (20)$$

After that, a heat exchanger or steam generator would be used to transmit the heated molten salt's energy to the water in the Rankine cycle. The tower's overall power and power cycle in its entirety.

Inside the various parts of the power cycle the overall energy and exergy equations would be, respectively:

$$\dot{Q}_{(st,abs)}=\dot{W}_{net}+\dot{Q}_{(ps,loss)} \qquad (21)$$

$$\dot{X}_{(st,abs)}=\dot{W}_{net}+\dot{X}_{(ps,loss)}+\dot{X}_{(ps,des)} \qquad (22)$$

In formulas (21) and (22), Qst, abs and Xst, abs are the energy produced and exergy absorbed by the ambient water, respectively. Also, Qps, loss and Xps, loss is the total energy loss and exergy loss during energy transfer in the combined cycle, and Xps is the total exergy loss at different steps of the cycle calculated from des, entropy. production in cycle on all components.

CONCLUSION

This article introduced different types of solar panels built experimentally and commercially. Next, we calculated the energy and exergy of a so-called power tower heliostat system and explained themethods of energy and exergy loss. Related calculations show thatincreasing the size of the heliostat field improves overall efficiency, while decreasing the size of the receiver mouth prevents heat loss.Also, the receiver structure should beoptimized for the number and size oftubes. In many countries, including the United States, Spain, Iran, etc., several companies are focusing onsolar tower energy to test different stages of development and construction of this kind of facility. However, most of the work in this context is still in the experimental stage and these facilities are not in commercial use. In addition to power generation, these plants can also be used to produce hydrogen on a large scale without adverse environmental impacts, in contrast to conventional steam methane reformingtechnology. Additionally, hybrid heliostat systems can be planned andbuilt that use, for example, fossil fuels for heat storage.

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