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BASIC HELIOSTAT MODEL FOR SMALL SCALE INDUSTRY

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Abstract: The central receiver system (CRS), which comprises of a heliostat field, receiver, and power production unit, is one form of concentrated solar power (CSP) technology. Heliostats are simply mirrors that concentrate sun energy at a single spot on a receiver at the top of a tall tower. Starting with the first heliostat initiatives in the early 1970s and continuing now, there has been a general trend to increase heliostat size from around 12 m2 to around 150-200 m2, with many counter instances of considerably smaller heliostats appearing in recent years.

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I INTRODUCTION

The expense of the tower limits its height. The receiver's weight and wind age area are the two most essential aspects in the tower's design. In some areas, seismic factors are also crucial.

As previously mentioned, the fluid choice has an impact on the weight and size of a receiver. A 380 MW receiver's weight can range from 250,000 kg for an exterior liquid sodium receiver to 2,500,000 kg for a cavity air receiver. If a surrounding heliostat field is employed, these would be positioned at the top of a 140 to 170 m tower. Steel frame structure, utilising oil derrick design procedures, or concrete, employing smokestack design approaches, are the two proposed tower designs. Steel frame towers are less expensive at heights less than 120 metres, whereas concrete towers are less expensive at higher heights, according to cost assessments.

Storage System-

Even during periods of fluctuating insolation (clouds) or after sunset, a storage mechanism allows the steam turbine to function under constant circumstances. It is made up of two primary components: hot and cold storage tanks.

An electric generator turns mechanical energy into electrical energy.

Objectives

1.To design and develope receivers and reflectors for higher efficiencies

2.To select material and manufacture different receivers and reflectors

3.To analyze results obtained from experiment performed

4.TO PROVIDE A BASIC HELIOSTAT MODEL FOR CENTRAL RECEIVING SYSTEM FOR LAB DEVELOPMENT

SCOPE OF PROJECT

1.The receiver should be provided black coating in order to utilize more heat

2.The concept of prism should be utilize to concentrate sun rays at a point to meet the heating need

3.Manufacturing the above stated updated material and enter the market

4.Increasing overall efficiency of the plant by doing so as stated

Explanation

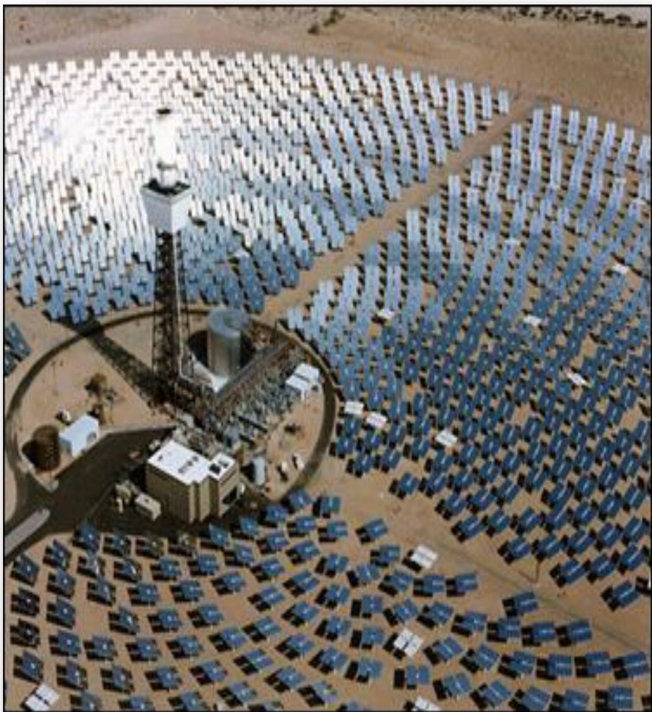
Design of central receiver and heliostat basic model

REFLECTOR AND RECIEVER

A heliostat (from helios, the Greek word for sun, and stat, as in stationary) is a device that comprises a rotating mirror, commonly a plane mirror, that compensates for the sun's apparent movement in the sky by reflecting sunlight toward a set target. The target might be a real item or a direction in space that is far away from the heliostat. To accomplish this, the mirror's reflecting surface is kept perpendicular to the bisector of the angle between the sun's and the target's directions as viewed from the mirror. Because the target is virtually always immobile in relation to the heliostat, the light is reflected in a predictable direction. According to contemporaneous accounts, Willem's Gravesande created the heliostata, as it was originally known (1688-1742). Giovanni Alonso Borelli (1608-1679) and Daniel Gabriel Fahrenheit are two other possibilities (1686-1736).

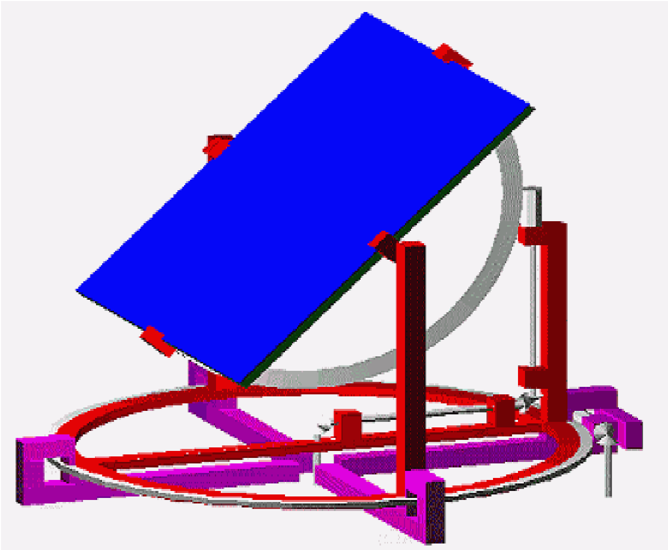
The majority of heliostats are now utilised for day illumination or the generation of concentrated solar power, which is often utilised to create electricity. They're also utilised in solar cooking on occasion. A few are employed for research purposes or to reflect stationary solar rays into solar telescopes. Heliostats were commonly employed to create powerful, steady beams of light for scientific and other uses before lasers and other electric lights became available.

Computers control the majority of contemporary heliostats. The latitude and longitude of the heliostat's position on the planet, as well as the time and date, are sent into the computer. It estimates the direction of the sun as viewed from the mirror, including its compass heading and angle of elevation, using astronomical theory. The computer then calculates the direction of the needed angle-bisector based on the target's orientation and sends control signals to motors, usually stepper motors, to turn the mirror to the right alignment. To maintain the mirror properly positioned, this sequence of procedures is performed several times.The collectors are the receivers.



1. DESIGN OF REFLECTORS

The design of reflectors is primarily determined by criteria such as ground inclination or plane ground, such that the maximum number of rays are reflected towards the receiver. The reflectors are usually optically formed and curved on the inside.



1.1 Assumptions

Assumptions are usually made based on ideal conditions, such as the atmosphere being normal with no dust, the sun being at its highest temperature, which is during the summer, no shadows falling on any reflectors, all rays being reflected towards the receiver, the receiver being heated to its maximum capacity, the turbine being rotated, and the power generation being at its highest.

1.2 SIZE OR DIMENSIONS OF REFLECTOR

The size of the heliostat depends on the kind of receiver used on the tower. The majority of heliostats are composed of iron glass.

The reflectance of heliostats manufactured of low iron float glass is 0.903. Dirt, on the other hand, decreases reflectance to 0.82.

1.3 SIZE OR DIMENSION FOR RECEIVER

• **External type:** These are often made up of panels made up of several tiny (20-56 mm) vertical tubes welded together to form a cylinder. The bottoms and tops of the vertical tubes are linked to headers that feed heat transfer fluid to the tubes' bottoms and collect heated fluid from the tubes' tops [1].

• **Cavity type:** In order to limit heat loss from the receiver, some designs propose placing the flux absorbing surface inside an insulated cavity, minimising the absorber's convective heat losses. The heliostat field's flux is reflected via an aperture onto absorbing surfaces that comprise the cavity's walls. The aperture area of typical designs ranges from one-third to one-half of the interior absorbent surface area. The acceptance angle of cavity receivers is restricted to 60 to 120 degrees (Battleson, 198l). As a result, either numerous cavities are arranged next to one another, or the heliostat field is restricted to the view of the cavity aperture.

1.4 OVERALL HEAT LOSS

The whole heat losses must be included when calculating the plant's overall efficiency. The losses that occur are primarily in the transmitting pipes, and are caused by atmospheric temperature, humidity, and wind while rays travel from the reflector to the receiver. These losses can all be calculated using different formulas, and we can choose the location, material, and where to instal this plant based on all of these factors.

1.5 USEFUL HEAT GAIN

Considering all the above losses factors useful heat gain is calculated it is the ratio of actual heat received and consumed by the receiver to the heat received by the reflector from the sun

1.6 INSTANTANEOUS EFFICIENCY

Considering all the losses calculated the overall plant efficiency is calculated by a separate formula which is the instantaneous efficiency of the plant

II MATERIAL SELECTION

The material for heliostat is selected on following basis –

1. Low cost
2. Maximum reflection
3. No absorption and transmission
4. The material basically used is aluminum foil, bright, steel galvanized ,aluminum plate, glass,etc

The material used for receiver is based on following points-

1. low cost
2. Maximum absorption
3. No reflection

Formula:-

Following assumptions are made for the model:-

1. Square shaped mirrors
2. The pedestal area is neglected
3. Forces in the trusses are neglected
4. Equal spacing between heliostats in a field situation, arranged in a regular pattern.

Consequently, the azimuth angular spacing for the i" zone can be determined by

$$\Delta az_i = \frac{\Delta az_1}{2^{i-1}}$$

where Δaz_i is the azimuth angular spacing for the i zone in rad,

The radial distance from the tower to the first row of the zone is calculated such that

$$R_i = 2^{i-1}\frac{DM}{\Delta az_1}$$

where R_i is the radius of the first row for the i zone in m.

Using equations 2 through 6, the radial and azimuth angular spacing for different zones from the tower can be calculated.

Number of Rows and Heliostats

The number of rows for the i zone is determined by

$$\text{Nrow}_i = \frac{R_{i+1} - R_i}{\Delta R_{min}}$$

where Nrow, is the number of rows of heliostats for the zone of the field.

The number of heliostats for each row within the i zone is calculated as

$$\text{Nhel}_i = \frac{2\pi}{\Delta az_i}$$

where Nhel, is the number of heliostats in each within the i zone.

Model of the optical efficiency

The optical efficiency. measures the energy loss of the heliostat field. In general, the optical efficiency is calculated by

$$\eta_{opt} = \eta_{at} \times \eta_{ref} \times \eta_{s\&b} \times \eta_{cos}$$

The Cosine Efficiency

The most significant loss in the heliostat field is due to the angle between the incident solar beam radiation, and a vector normal to the surface of the heliostat which is called the cosine effect. Therefore, It depends on both sun and heliostat positions.

a.Solar position

The solar position is very important because the sun is changing hourly during a day and daily during the year, so it is necessary to model the solar coordinate systems during the year through solar angles. The solar declination is calculated by

$$\delta_s = 23.45 \sin(\frac{360}{365}(284 + N))$$

The surface azimuth angle (9) can be obtained by

$$\text{If } \varphi_s - \varphi' > 0, \quad \varphi_{surf} = \varphi' + 90^\circ$$

$$\text{Else } \varphi_s - \varphi' < 0, \quad \varphi_{surf} = \varphi' - 90^\circ$$

Using both the equations through the solar declination, the solar altitude angle (a,), the solar hour angle (h,), the solar azimuth angle (o,) and the solar zenith angle (0,) can be calculated to find the cosine efficiency.

b**. Heliostat position**

The solar altitude angle of the tower receiver for heliostat (a) which is defined by the tower he (H), the height of each heliostat (H) and the distance of each heliostat from the tower base (R) is calculated and illustrated.

$$\alpha_{tr} = \tan^{-1}(\frac{H_t - H_h}{R})$$

The solar incidence angle on each heliostat (0,) is calculated by

$$\theta_s = \cos^{-1}[(\sin\phi_{lat}.\sin\delta_s.\cos\beta_{hs}) - (\cos\phi_{lat}.\sin\delta_s.\sin\beta_{hs}.\cos\varphi_{surf}) + (\cos\phi_{lat}.\cos\delta_s.\cos h_s.\cos\beta_{hs}) + (\sin\phi_{lat}.\cos\delta_s.\cos h_s.\sin\beta_{hs}\cos\varphi_{surf}) + (\cos\delta_s.\sin h_s.\sin\beta_h\sin\varphi_{surf})] \quad (24)$$

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