# Research On the Heat Output of Heliostat Field Based on Microelement Method

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**Abstract.** The optimal arrangement of heliostat field is of great significance to energy utilization, and the rational arrangement of heliostat field is firstly to accurately calculate the heat output of heliostat field. To calculate the heat output of the heliostat field, first calculate the optical efficiency of the heliostat. After geometrical optical analysis, the micro-element method and the cross-product method can be used to determine whether the incident or reflected light on each area of the micro-element is occluded by the shadow of the tower or other heliostats, so that the shadow occlusion efficiency can be calculated. Then using the transformation of the optical cone coordinate system and the mirror field coordinate system and the symmetry of the incident light and reflected light with respect to the normal vector of the heliostat, so as to determine whether the reflected ray falls into the receiving range of the collector. So the truncation efficiency of the collector is solved. Then the optical efficiency of the heliostat is obtained by the formulas of specular reflectance, atmospheric transmittance and cosine efficiency. Finally, using the normal radiation irradiance formula, the heat output of the heliostat field is obtained. The annual average heatoutput obtained by the formula is 38.5MW.

**Keywords:** Heliostat field, Micro-element method, Coordinate transformation, Cross-product discriminant method.

## 1. Introduction

The main component of the tower solar thermal power station is the heliostat, the flat mirror mounted on the horizontal shaft, and the vertical shaft connected to the base. A large number of heliostats are arranged to form a heliostat field, and an absorption tower is installed in the middle of the heliostat field. Besides, a collector is installed on the absorption tower. The heliostat reflects the sunlight incident in the form of a cone beam to the collector for energy conversion. When the heliostat is working, due to the different incidence of sunlight, the control system will adjust the direction of the heliostat, so that the reflected light just shoots onto the center of the collector. It can be seen that the reasonable arrangement of heliostats in the mirror field needs to be optimized, first step of which is to accurately calculate the effective utilization rate of heliostats.

The research on the optimal arrangement of heliostat fields is still in its infancy, and there are few relevant studies [1]. In this paper, geometric optical analysis, the cross-product discriminant method and the micro-element method are used to calculate the shadow occlusion efficiency and the collector truncation efficiency, Then the cosine efficiency, atmospheric transmittance and specular reflectivity are calculated, so that the annual average optical efficiency of the heliostat field is calculated, and finally the annual average heat output is calculated. (Data source: http://www.mcm.edu.cn/html_cn/node/c74d72127066f510a5723a94b5323a26.html).

## 2. Model establishment and solving

### 2.1. Establishment of the model

#### 2.1.1 Calculation model of sun position

The following definitions were obtained by consulting the data [2]: Solar Hour Angle$\omega$:

$$\omega = \frac{\pi}{12}(\mathrm{ST}-12) \tag{1}$$

In the above formula, ST is the local time.Sun declination $\delta$ :

$$\sin\delta = \sin\frac{2\pi D}{365}\sin\left(\frac{2\pi}{360}23.45\right) \tag{2}$$

In the above formula, $D$ is the number of days counted from the vernal equinox.Sun Altitude Angle $\alpha_s$:

$$\sin\alpha_s = \cos\delta\cos\varphi\cos\omega + \sin\delta\sin\varphi \tag{3}$$

In the above formula, $\omega$ is the local latitude (in this paper, the north latitude is positive). Sun Azimuth $\gamma_s$:

$$\cos\gamma_s = \frac{\sin\delta - \sin\alpha_s\sin\varphi}{\cos\alpha_s\cos\varphi} \tag{4}$$

**2.1.2 the calculation model of shadow occlusion efficiency.**

According to the data [3-4], the shadow occlusion loss is mainly divided into three parts: the block of the tower on the incident light, the block of the front heliostat on the incident light of the back heliostat, and the block of the reflected light of the back heliostat by the front heliostat. Therefore, this paper can calculate the shadow occlusion efficiency by the following steps.

(1) Calculation of the angle between the heliostat and the x-y plane

As shown in Fig.1, the center of the circular region is the origin, the east direction is the positive direction of the x-axis, the north direction is the positive direction of y-axis, the direction perpendicular to the ground is the positive direction of z-axis. $O_n$ is the coordinates of the heliostat center, $A_n, B_n, C_n, D_n$ are respectively the coordinates of the four vertices of the heliostat, $E_nO_n$, $MO_n$ respectively represents the incident direction of the sun and the path of the rays reflected to the center point of the collector entrance section. $F_n$ is the midpoint of $ME_n$, $H_n, J_n, I_n$ are respectively the projection of $E_n, M, F_n$ on the horizontal plane with $O_n$, $|E_nO_n| = |MO_n| = l_n$.

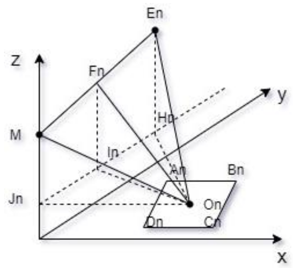


**Fig.1.** Schematic diagram of the mirror field coordinate system

Then calculating the angle between the incident ray (or reflected ray) and the heliostat normal $\theta_n$

$$\cos\theta_n = \frac{|\overrightarrow{O_nF_n}|}{l_n} \tag{5}$$

Here $F_n = \left(x_{hn}/2, y_{hn}/2, l_{OM} + l_n\sin\alpha_s + z_{O_n}/2\right)$, $x_{hn} = x_{O_n} - l_n\cos\alpha_s\sin(\gamma_s - \pi)$, $y_{hn} = y_{O_n} - l_n\cos\alpha_s\cos(\gamma_s - \pi)$, $z_{O_n} = 4m, l_{OM} = 80m$.

Set the angle between the helioscope and the x-y plane as $\mu_n$, then:

$$\mu_n = \frac{\pi}{2} - \angle F_nO_nI_n \tag{6}$$

Therefore,

$$\cos\mu_n = \sin\angle F_n O_n I_n = \frac{l_{OM} + l_n \sin\alpha_s - l_{OJ_n}}{2 l_n \cos\theta_n} \tag{7}$$

(2) Calculation of the angle between the heliostat and the y-z plane

Firstly, the angle between the vertical projection of the normal of the heliostat in the x-y plane and the y-axis is introduced as $\hat{\theta}_n$, then.

$$\cos\hat{\theta}_n = \frac{y_{O_n} - \frac{y_{h_n}}{2}}{l_{O_n I_n}} \tag{8}$$

Here, $I_n = \left(\frac{x_n}{2}, \frac{y_n}{2}, z_{O_n}\right)$.

Then, the angle between the helioscope and the y-z plane is set to be $\beta_n$, and the range of its variation is specified in $(0, \pi)$, so that the following relation is obtained [3]:

When the heliostat is on the east side of the tower, or when the center of the heliostat is on the y-axis and the time is later than noon,

$$\beta_n = \frac{\pi}{2} + \hat{\theta}_n \tag{9}$$

When the heliostat is on the west side of the tower, or when the center of the heliostat is on the y-axis and the time is earlier than noon,

$$\beta_n = \frac{\pi}{2} - \hat{\theta}_n \tag{10}$$

(3) Calculation of the coordinates of the four vertices of the heliostat

For a heliostat, $A_n B_n C_n D_n$, $A_n C_n$ is a diagonal. Set the length of the long side and the short side of the rectangular heliostat as $l_1$ and $l_2$, and set the angle between the long side and the diagonal as $\rho_n$, then:

$$\tan\rho_n = \frac{l_2}{l_1} \tag{11}$$

The expression of the coordinates of $A_n(x_{1n}, y_{1n}, z_{1n})$ is as follows:

$$\begin{cases} x_{1n} = x_{O_n} - \frac{1}{2} l_{A_n C_n} (\sin\rho_n \sin\beta_n + \cos\rho_n \cos\mu_n \cos\beta_n) \\ y_{1n} = y_{O_n} - \frac{1}{2} l_{A_n C_n} (\sin\rho_n \cos\beta_n + \cos\rho_n \cos\mu_n \sin\beta_n) \\ z_{1n} = z_{O_n} + \frac{1}{2} l_{A_n C_n} \cos\rho_n \sin\mu_n \end{cases} \tag{12}$$

The coordinates of $B_n, C_n, D_n$ can be calculated in the same way.

(4) Calculation of coordinates at any point $P_n$ in the heliostat $n$

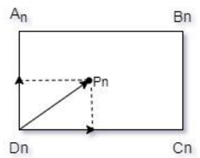


**Fig. 2** coordinates at any point $P_n$ in the heliostat $n$

As shown in Fig.2, $D_n$ is taken as the datum point, and $\overrightarrow{D_nA_n}$, $\overrightarrow{D_nC_n}$ are taken as the bases, so that for any point $P_n$ in the heliostat $n$, there is:

$$\overrightarrow{D_nP} = k_1\overrightarrow{D_nC_n} + k_2\overrightarrow{D_nA_n} \tag{13}$$

In formula (13), $k_1$, $k_2 \in [0,1)$.

Therefore, the expression for the coordinates of any point $P_n$ in the heliostat n is as follows:

$$\begin{cases} x_{Pi} = x_{4n} + k_1(x_{3n} - x_{4n}) + k_2(x_{1n} - x_{4n}) \\ y_{Pi} = y_{4n} + k_1(y_{3n} - y_{4n}) + k_2(y_{1n} - y_{4n}) \\ z_{Pi} = z_{4n} + k_1(z_{3n} - z_{4n}) + k_2(z_{1n} - z_{4n}) \end{cases} \tag{14}$$

(5) Calculation of the coordinates of the intersection of the sun's incident rays and the tower

Set the coordinates of the intersection of the incident solar rays and the tower as $(x_{ti}, y_{ti}, z_{ti})$, then the following expression can be obtained:

$$\begin{cases} x_{ti} = x_{Pi} + y_{Pn}\tan\gamma_s \\ y_{ti} = 0 \\ z_{ti} = z_{Pi} + y_{Pn}\dfrac{\tan\alpha_s}{\cos\gamma_s} \end{cases} \tag{15}$$

(6) Calculation of the coordinates of the intersection of the sun's incident rays on the heliostat and the plane of the other heliostat

To simplify the calculation, two algebraic elements $s_1$, $s_2$ are firstly introduced:

$$s_1 = (z_{O_n} - z_{P_n}) - (y_{O_n} - y_{P_n})\sin\beta_n\tan\mu_n + (x_{O_n} - x_{P_n})\cos\beta_n\tan\mu_n \tag{16}$$

$$s_2 = \tan\alpha_s - \cos\gamma_s\sin\beta_n\tan\mu_n + \sin\gamma_s\cos\beta_n\tan\mu_n. \tag{17}$$

Set the coordinates of the intersection of the incident rays on the heliostat and the plane of the other heliostat as $(x_{mi}, y_{mi}, z_{mi})$, then the following expression is obtained:

$$\begin{cases} x_{mi} = x_{Pi} + \sin\gamma_s s_1/s_2 \\ y_{mi} = y_{Pi} + \cos\gamma_s s_1/s_2 \\ z_{mi} = z_{Pi} + \tan\alpha_s s_1/s_2 \end{cases} \tag{18}$$

(7) Calculation of the coordinates of the intersection of the rays reflected from the heliostat and the plane of the other heliostat

To simplify the calculation, algebraic element is introduced as:

$$s_3 = z_{O_n} - l_{OM} - y_{O_n}\sin\beta_n\tan\mu_n + x_{O_n}\cos\beta_n\tan\mu_n \tag{19}$$

Set the coordinates of the intersection of the rays reflected from the heliostat and the plane of the other heliostat as $(x_{li}, y_{li}, z_{li})$, so that the following expression should be satisfied:

$$\begin{cases} x_{li} = x_{Pi} + x_{O_n} s_1/s_3 \\ y_{li} = y_{Pi} + y_{O_n} s_1/s_3 \\ z_{li} = z_{Pi} + (z_{O_n} - l_{OM}) s_1/s_3 \end{cases} \tag{20}$$

(8) Calculation of shadow occlusion efficiency

Firstly, divide each heliostat, set its area microelement as $ds_n$. Then two counting elements $N_1, N_2$ are introduced to count the microelements that can receive the incident light and the microelements that can receive the reflected light.

The microelement cannot receive the incident ray in the following two situations:

1)Blocked by a tower, its constraints are:

$$\begin{cases} -3.5 \leqslant x_{ti} \leqslant 3.5 \\ 0 \leqslant z_{ti} \leqslant 84 \end{cases} \tag{21}$$

The corresponding schematic diagram is shown in Fig.3:

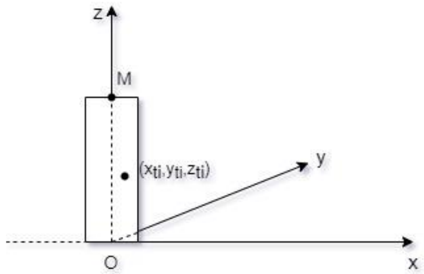


**Fig.3.** Schematic diagram of the intersection of the incident ray and the tower

2)Obscured by the shadow of the helioscope

This paper uses the cross-product discriminant method when calculating whether the incident rays on the heliostat intersects with it, that is:

Calculating the values of the projection coordinates of the theoretical intersection$(x_{mi}, y_{mi})$ on the x-y plane and setting the projections of $A_n, B_n, C_n, D_n, P_n$ as $A_n{}', B_n{}', C_n{}', D_n{}', P_n{}'$. Calculate the signs of $\overrightarrow{A_n{}'B_n{}'} \times \overrightarrow{A_n{}'P_n{}'}$ , $\overrightarrow{C_n{}'D_n{}'} \times \overrightarrow{C_n{}'P_n{}'}$, $\overrightarrow{D_n{}'A_n{}'} \times \overrightarrow{D_n{}'P_n{}'}$, $\overrightarrow{B_n{}'C_n{}'} \times \overrightarrow{B_n{}'P_n{}'}$ respectively to judge whether the theoretical intersection falls on the heliostat.

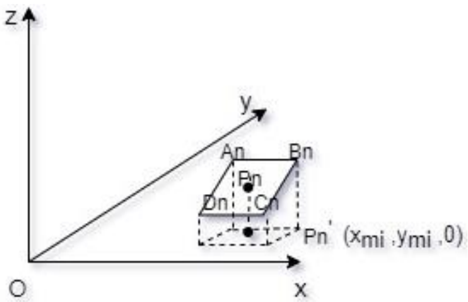


**Fig.4.** Schematic diagram of the intersection of incident rays and other heliostats

As can be seen from Fig.4, the corresponding constraints when falling on the heliostat are:

$$\begin{cases} \left(\overrightarrow{A_n{}'B_n{}'} \times \overrightarrow{A_n{}'P_n{}'}\right) \cdot \left(\overrightarrow{C_n{}'D_n{}'} \times \overrightarrow{C_n{}'P_n{}'}\right) \geqslant 0 \\ \left(\overrightarrow{D_n{}'A_n{}'} \times \overrightarrow{D_n{}'P_n{}'}\right) \cdot \left(\overrightarrow{B_n{}'C_n{}'} \times \overrightarrow{B_n{}'P_n{}'}\right) \geqslant 0 \end{cases} \tag{22}$$

Substituting specific coordinates into it:

$$\begin{cases} [(x_2 - x_1)(x_{mi} - x_1) - (y_2 - y_1)(x_{mi} - x_1)] \cdot [(x_4 - x_3)(x_{mi} - x_3) - (y_4 - y_3)(x_{mi} - x_3)] \geqslant 0 \\ [(x_1 - x_4)(x_{mi} - x_4) - (y_1 - y_4)(x_{mi} - x_4)] \cdot [(x_3 - x_2)(x_{mi} - x_2) - (y_3 - y_2)(x_{mi} - x_2)] \geqslant 0 \end{cases} \tag{23}$$

If $(x_{ti}, y_{ti}, z_{ti})$ corresponding to $\left(x_{P_i}, y_{P_i}, z_{P_i}\right)$ does not satisfy constraint (21), or $(x_{mi}, y_{mi}, z_{mi})$ does not satisfy constraint (23), then let the count element $N_1$ plus 1.

In the same way, the constraints on the microelements that cannot receive the reflected rays can be obtained:

$$\begin{cases} [(x_2 - x_1)(x_{li} - x_1) - (y_2 - y_1)(x_{li} - x_1)] \cdot [(x_4 - x_3)(x_{li} - x_3) - (y_4 - y_3)(x_{li} - x_3)] \geqslant 0 \\ [(x_1 - x_4)(x_{li} - x_4) - (y_1 - y_4)(x_{li} - x_4)] \cdot [(x_3 - x_2)(x_{li} - x_2) - (y_3 - y_2)(x_{li} - x_2)] \geqslant 0 \end{cases} \tag{24}$$

If $(x_{li}, y_{li}, z_{li})$ does not satisfy the constraint (24), then add 1 to $N_2$.

In summary, the effective utilization rate of the incident solar light on the heliostat $i$ is:

$$\eta_{si} = N_1 ds_n / l_1 \times l_2 \tag{25}$$

The effective utilization rate of the reflected solar light on the heliostat $i$ is:

$$\eta_{si} = N_2 ds_n / l_1 \times l_2 \tag{26}$$

The shadow occlusion efficiency of heliostats $i$ is:

$$\eta_{\mathrm{sb}i} = \eta_{si} \times \eta_{bi} \tag{27}$$

### 2.1.3 Computational models of cosine efficiency and atmospheric transmittance

According to the data [5], the cosine efficiency $\eta_{\cos}$ is the cosine value of the angle $\theta_n$ between the incident ray and the normal of the heliostat in the previous model:

$$\eta_{\cos n} = \cos\theta_n = \frac{|\overrightarrow{O_n F_n}|}{l_n} \tag{28}$$

According to the formula for atmospheric transmittance [6], the atmospheric transmittance is obtained as $\eta_{\mathrm{at}}$ follows:

$$\eta_{\mathrm{at}} = 0.99321\text{-}0.0001176 d_{HR} + 1.97 \times 10^{-8} \times d_{HR} \tag{29}$$

Where $d_{HR} = \sqrt{(x_{O_n} - 0)^2 + (y_{O_n} - 0)^2 + (z_{O_n} - l_{OM})^2}$ .

### 2.1.4 Calculation model of collector cut-off efficiency

(1) Establishment of the optical cone coordinate system

Firstly, in order to calculate the direction vector of a certain ray in the light cone, a light cone coordinate system $O_S - X_S Y_S Z_S$ as shown in Fig.5 is established. In a cone beam, along the direction of the main ray, $Z_S$ is towards the center of the solar disk. The $X_S$ axis is always parallel to the ground, and the $Y_S$ axis is perpendicular to $X_S$, and $Z_S$. The positive direction of $X_S, Y_S, Z_S$ satisfies the right-hand rule.

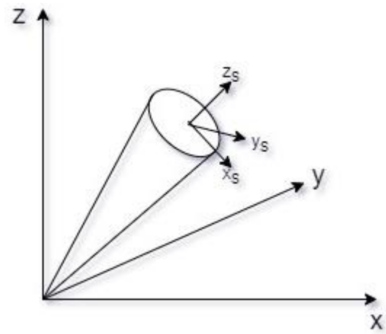


**Fig.5.** Schematic diagram of the optical cone coordinate system

In this coordinate system, assuming that the angle between a ray in the light cone and the $Z_S$ axis is $\sigma$, and the angle between a ray in the light cone and the $X_S$ axis is $\tau$, then the direction vector of the ray is: $\vec{v} = (\sin\sigma\cos\tau \;\; \sin\sigma\sin\tau \;\; \cos\sigma)$.

(2) The transformation from the optical cone coordinate system to the mirror field coordinate system

In order to carry out the subsequent calculation, any ray direction vector $\vec{v}$ in the light cone coordinate system needs to be converted into the mirror field coordinate system, and the direction vector of any ray in the incident light cone in the mirror field coordinate system can be obtained through the following coordinate transformation:

$$\overrightarrow{V_{RS}} = \vec{v} \cdot \mathrm{T} \tag{30}$$

The transformation matrix $\mathrm{T}$ is as follows:

$$\mathrm{T}=\begin{pmatrix} ccc\sin\gamma_s & -\sin\alpha_s\cos\gamma_s & \cos\alpha_s \\ -\cos\gamma_s & -\sin\alpha_s\sin\gamma_s & 0 \\ \cos\alpha_s\sin\gamma_s & \cos\alpha_s\cos\gamma_s & \sin\alpha_s \end{pmatrix} \tag{31}$$

(3) Solving the equation of arbitrary reflected rays in the incident cone

The unit normal vector of the mirror is:

$$\vec{n}=\frac{\overrightarrow{O_nF_n}}{|\overrightarrow{O_nF_n}|} \tag{32}$$

From the geometric relations and the parallelogram rule, the direction vector of the reflected rays can be calculated:

$$\overrightarrow{V_{CS}}=2\left(\overrightarrow{V_{RS}}\cdot\vec{n}\right)\vec{n}-\overrightarrow{V_{RS}}=(m,n,l) \tag{33}$$

The equation of the reflected rays in the incident cone is:

$$\frac{x-x_{O_n}}{m}=\frac{y-y_{O_n}}{n}=\frac{z-z_{O_n}}{l} \tag{34}$$

(4) Calculating the coordinates of the intersection point between the light cone reflected light and the heat absorber

The equation for the cylindrical heat absorber is:

$$\begin{cases} x^2+y^2=R^2 \\ \qquad\qquad z\in[76,84] \end{cases} \tag{35}$$

Considering equation (34) and (35), if there is a solution, it means that the energy reflected by the corresponding light is absorbed by the absorption tower, if there is no solution, it means that the energy reflected by the corresponding light is not absorbed by the absorption tower.

(5) Solving the cut-off efficiency of the collector

The formula for the cut-off efficiency of the collector is:

$$\eta_{\text{trunc}}=\frac{E_{js}}{E_{fs}-E_{ss}} \tag{36}$$

Among it, $E_{js}$, $E_{fs}$, $E_{ss}$ respectively describes the energy received by the collector, the energy of total reflection of the specular surface, and the energy lost by shadow occlusion.

### 2.1.5 Calculation of the optical efficiency of heliostats

From the reference data [7], it can be seen that in the absence of ash accumulation, the specular reflectivity $\eta_{\text{ref}}=0.934$.

The optical efficiency of heliostats $\eta$ is [8]:

$$\eta=\eta_{\text{sb}}\eta_{\cos}\eta_{\text{at}}\eta_{\text{trunc}}\eta_{\text{ref}} \tag{37}$$

### 2.1.6 Calculation model of the heat output $E_{field}$ of the heliostat mirror field

According to the data [9], the formula for calculating the DNI of normal direct irradiance is as follows:

$$\begin{aligned}\text{DNI} &= G_0\left[a+b\exp\left(-\frac{c}{\sin\alpha_s}\right)\right],\\ a&=0.4237-0.00821(6-H)^2,\\ b&=0.5055+0.00595(6.5-H)^2,\\ c&=0.2711+0.01858(2.5-H)^2,\end{aligned} \tag{38}$$

Where $G_0$ is the solar constant, and its value is taken as $1.366\mathrm{kW/m^2}$,$H$ is the altitude (unit: $\mathrm{km}$ ).

The heat output $E_{\text{field}}$ of the heliostat field can be calculated as follows:

$$E_{\text{field}} = \text{DNI}\cdot\sum_{i}^{N} A_i\eta_i, \tag{39}$$

where DNI is the normal direct radiation irradiance; $N$ is the number of heliostats; $A_i$ is the lighting area of the heliostat $i$ ( unit: $\mathrm{m^2}$); $\eta_i$ is the optical efficiency of the heliostat $i$.

### 2.2. Calculation of optical efficiency and heat output

#### 2.2.1 Solving the efficiency of shadow occlusion

Firstly, MATLAB is used to read the coordinates of the center position of the heliostat in the consulted data, so that the schematic diagram of the distribution of the heliostat is drawn as shown in Fig.6.

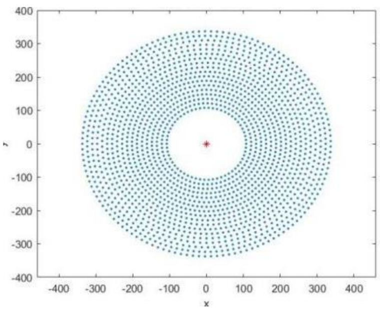

**Fig. 6** Schematic diagram of heliostat distribution

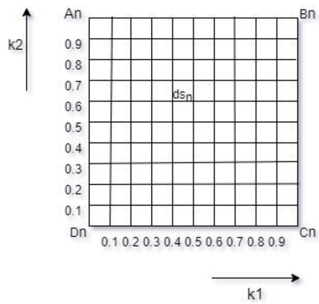


**Fig. 7** Schematic diagram of sectioning

Then the heliostat mirror is segmented as shown in Fig.7. Therefore, the effective utilization rate of heliostat n to receive the incident solar light is:

$$\eta_{s_n} = N_1/100 \tag{40}$$

where $N_1$ is the total number of microelements that are able to receive incident light.

The effective utilization rate of the heliostat $n$ to receive the reflected light from the sun is:

$$\eta_{b_n} = N_2/100 \tag{41}$$

where $N_2$ is the total number of microelements that are able to receive the reflected light.

In summary, the occlusion efficiency of heliostat n is.

$$\eta_{\text{sb}_n} = \eta_{s_n}\times\eta_{b_n} \tag{42}$$

The average shadow occlusion efficiency is $\frac{\sum_{n=1}^{1745}\eta_{\text{sb}_n}}{1745}$.

### 2.2.2 Solving the truncation efficiency

We use ray tracing [10]to solve the problem. Firstly, the light rays in a light cone are divided into 96 microelements by using the angular mean division method as shown in Fig.8, and the $\Delta\tau=\frac{\pi}{3},\Delta\sigma=0.3mrad$.

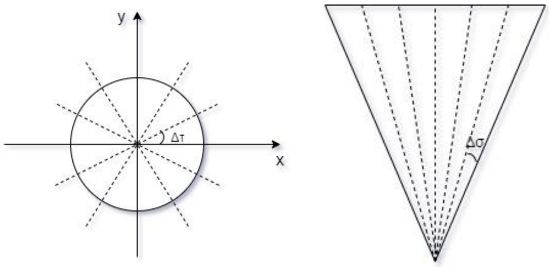


**Fig. 8** Schematic diagram of angular equalization

Then write the equation of the reflected ray as a parametric equation:

$$\begin{cases}x=x_{O_n}+mt\\y=y_{O_n}+nt\\z=zO_n+lt\end{cases}\tag{43}$$

Combining the above equation with the first equation of (34) gives the quadratic equation about $t$:

$$(m^2+n^2)t^2+\left(2mx_{O_n}+2ny_{O_n}\right)t+x_{O_n}^2+y_{O_n}^2-R^2=0\tag{44}$$

When $\Delta<0$, the reflected light will not hit the absorption tower, and the energy of the light will not be absorbed.

When $\Delta\geqslant 0$, set the solution of equation (44) as $t_1,t_2$, and the corresponding intersection points of the reflected light and the absorption tower are $z_1=zO_n+lt_1$, $z_2=zO_n+lt_2$ .Obviously only $z=\min\{z_1,z_2\}$ has practical significance.

As shown in Fig.9, if $z\in[76,84]$ the energy of the light will be absorbed, otherwise it will not.

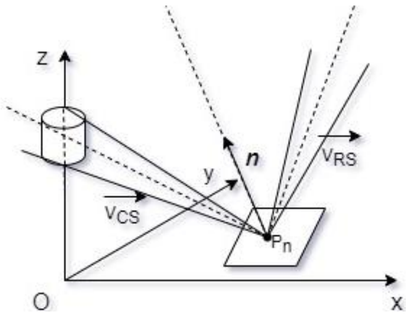


**Fig. 9** Schematic diagram of the reflected light that can be absorbed.

Finally, the collector cut-off efficiency is:

$$\eta_{\text{trunc}}=\frac{E_{js}}{E_{fs}-E_{ss}}\tag{45}$$

### 2.2.3 Solving the optical efficiency and heat output of the heliostat

The specular reflectivity, shadow occlusion efficiency, cosine efficiency, atmospheric transmittance, and truncation efficiency has been calculated, so that we can calculate the optical efficiency of the heliostat at a certain time. In order to simplify the calculation, take the five representatives of the day (9:00. 10:30. 12:00. 13:30. 15:00) to calculate the optical efficiency and heat output of the heliostat and take the optical efficiency and heat output of the heliostat on the 21st of each month to calculate the annual average optical efficiency. The final annual average optical efficiency is 0.6329, and the final annual average output heat power is 38.5149MW.

## 3. Conclusion

In this paper, the calculation formula of the annual average optical efficiency and annual average heat output of the heliostat of the solar tower thermal power station is established, and the microelement method is used to subdivide the heliostat and the cone ray, and the cross-product discriminant method is innovatively used to justify whether the ray falls into the specified rectangle, which avoids the redundant calculation. Accurate calculation of heliostat output heat power is the basic work in the early stage of the reasonable layout and design of the mirror field of the tower power station, and the accuracy of the calculation results will directly affect the project investment or the power generation benefit of the power station. So, the calculation model of the heat output of the heliostat field established in this paper has important promotion and application value for design of the layout of heliostat field.

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