The Complex Use of Wave Potential and Flow Energy

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Abstract. A device for automatically adjusting the angle of solar panel is designed by using the temperature difference effect produced by solar energy. The device can automatically sense the angle and intensity of sunlight to form a temperature difference. The temperature difference is converted into a pressure difference by a temperature difference collector, and then the pressure is converted into the power needed to adjust the angle of solar panel by a pneumatic push rod, so as to realize the automatic light alignment of solar panel. The temperature sensing and pressure forming automatic light tracing device designed by this device has better usability and popularization. It can be applied to the automatic light tracing of solar panel, effectively solve the cosine effect caused by the change of solar light angle, and reduce the problem of low power generation efficiency caused by light tilt and short life of traditional electric control light tracing device.

1. Introduction
Solar photovoltaic power generation also has the problems of low density, intermittent, light direction and intensity changing with time, which puts forward higher requirements for solar energy collection and utilization devices. The existing photovoltaic power generation mainly has the following two problems:

(1) In the current solar photovoltaic power generation field, flat stationary power generation units occupy more than 50% of the market share. However, the cosine effect caused by sunlight slanting can not be fully exerted, and the photovoltaic conversion rate decreases with the increase of the incident angle of sunlight.

(2) According to the research, the single axis (double axis) solar tracking system can increase the power output by 15% - 20% (25% - 40%) compared with the fixed system. Although it has good output efficiency, most of the existing light-tracking technologies are based on sensors and turbine worm technology. Such light-tracking products are expensive and have poor reliability, and the light sensor has high environmental requirements and is easy to damage.

Therefore, it is of great significance to study the temperature difference induction solar tracking system to improve the power generation efficiency of solar photovoltaic systems.

2. Principle analysis
The main design idea of the device is: sunlight is irradiated on the isosceles triangle heat collection panel, and due to the difference between the sun position and the angle of the heat collection plate, different temperatures are generated on the heat collection plate. The heat of the heat collecting plate is...
transmitted to the ammonia gas duct. Due to the principle of thermal expansion and contraction, the ammonia gas at the higher temperature has a larger expansion degree and the other end has a smaller expansion degree. The expansion of ammonia gas drives the movement of the gas pole, which changes the angle of the solar panel until the temperature on both sides of the solar panel is the same, that is, the solar panel is facing the solar light source.

The mechanism diagram of the device is shown in the figure. The ammonia gas in the gas pole generates pressure difference through the process of thermal expansion and cold contraction, which drives the rotation of the solar panel, so that the solar panel can face the sun.

Fig. 1 Installation mechanism

Now, ammonia $V_0$ is introduced into both ends respectively. Under the temperature $T$, the volume of ammonia gas is $V_t$, the expansion equation of ammonia gas is as follows:

$$V_t = V_0(1 + \alpha t)$$

Among them, $\alpha$ is the gas expansion coefficient, consult the data and take $\alpha = 3.66 \times 10^{-3}$.

According to the actual gas state equation:

$$\left(p + \frac{a}{V_0^2}\right)(V_0 - b) = RT$$

When the filling gas is ammonia and the gas pressure is 8 atmospheres, take:

$$a=0.242(J \cdot m^3 \cdot mol^{-2})$$

$$b=3.73 \times 10^{-5}(m^3 \cdot mol^{-1})$$

$V_0$ is the molar volume of the gas in this state

$$V_0=22.4L/mol \times 8 = 179.2L/mol$$

Assuming the piston area is $s$, the pressure $p$ can be calculated to meet the requirements.

For solar panel work requirements, the area of the solar panel is $2.2m^2$, and the radiation intensity of the solar panel is 1000W / m$^2$. The measurement of solar panel is carried out under standard conditions (STC). The standard conditions are defined as: atmospheric quality AM1.5, light intensity 1000W / m$^2$, temperature 25 ℃.

Considering the gravity torque and friction damping of solar panel, the air bar needs to overcome 147n. Through calculation, the distance between the air rod and the rotating center is 0.27m, and the pushing distance of the air rod is 300cm.
3. Structural design

3.1. Temperature difference collector module
The temperature difference collector module is used to collect the different temperature difference formed under the sunlight.

Because of the great difference of thermal radiation between the front and the back of the sun, the temperature on the front of the sun is higher than that on the back of the sun. When the sun irradiates the solar panel vertically, the light received by the temperature difference collector module on both sides is the same and the temperature is equal. At this time, the temperature difference is eliminated. Therefore, a cone-shaped collector which can effectively form temperature difference is designed. As shown in Figure 2:

![Temperature difference collector](image)

**Fig. 2** Temperature difference collector

The module is designed as a conical structure, and the length of the left and right waist is longer. According to the triangle theorem, the effect of absorbing solar radiation by the inclined plane is more obvious. When the distance is large, the irradiation area can be enlarged and the temperature can be raised rapidly. The stroke hour can reduce the irradiation area and make it slightly adjusted. The heat insulation layer is designed as a special structure with a middle space and a lower resistance, which minimizes heat transfer and increases the temperature difference, effectively avoiding the effect of heat transfer between the two heat collecting surfaces. At the same time, the module also has a thermal insulation layer to avoid direct contact with the solar panel and avoid damage to the solar panel due to high temperature and temperature difference.

In terms of material selection, in order to realize the real-time tracking of the solar panel, the rapid heating up of the solar panel can be achieved in a short time, thereby changing the angle of the solar panel in real time. In this scheme, the material of iron carbon alloy with low specific heat capacity, high pressure resistance and easy heat absorption is selected, and the surface exposed to sunlight is moderately rough treated, so as to reduce the temperature sensitivity reduction caused by the heat loss phenomenon of light reflection.

3.2. Thermal energy to pressure module
The thermal energy to pressure module transforms the temperature difference into the pressure difference, thus forming the power.

When the solar panel is directly exposed to the sun, due to the different radiation received from the sun, the temperature difference collector absorbs more radiation on the light face, with high temperature, and the average temperature reaches about 58 °C. The backlight surface absorbs less solar radiation and
the temperature is about 38 ℃. Due to the existence of the intermediate heat insulation layer, the temperature at the hot end is prevented from transferring heat to the cold end, which effectively increases the temperature difference between the two heat collection surfaces. In addition, the temperature at the hot end will not input heat to the solar panel and cause waste of energy and damage to the solar panel. As a result, a temperature difference of about 20 ℃ was generated at both ends.

According to the principle of thermal expansion and contraction, when the temperature increases, the gas will expand and the pressure will increase. When the temperatures on the two sides are not equal, the high-pressure ammonia gas filled in the temperature difference collector modules on the two sides will absorb different thermal energy, and the bionic honeycomb-shaped support structure in the temperature difference collector is used. The internal heat conduction module makes the ammonia expand and intensify the pressure under the rapid heat absorption. The pressure difference will be formed when the pressure increases at both ends, and the pressure will be large along the high temperature front.

The structure of structural support, heat exchange and balance pressure in this module is shown in group 3:

![Fig. 3 Internal structure diagram of thermal energy to pressure](image)

### 3.3. Pressure drive module

There is a difference in the pressure between the two ends, and a power is formed at the single end to drive the solar panel to rotate.

When the high-pressure ammonia gas is transmitted to the driving part, it is driven by the gas pressure. In consideration of the power amplification to improve the steering sensitivity of solar panel, an air driving module based on Pascal principle is designed to enhance the power. It can be seen from Pascal's theorem that the pressure of ammonia gas increases with the change of temperature at 8 atmospheric pressures, and the pressure produced by the gas expansion forms at the top of the pneumatic push rod. Using Pascal's principle, after any point in the incompressible stationary fluid generates a pressure increase due to external force, this pressure increase is instantly transmitted to the points of the stationary fluid, that is, the pressure inside and outside the air inlet $P_1 = P_2$, which is $S_1 = S_2$. The pressure passes through the catheter and enters the sealed pneumatic push rod. Because the diameter of the intake pipe, the contraction of the lumen and the cross-sectional area of the catheter are smaller than the cross-
sectional area of the pneumatic push rod, the gas passes from the catheter to the pneumatic push rod. The pressure is multiplied several times, and the power generated is also increased. This part of the pressure pushes the bar to move.

Ammonia has an irritating odor, which can burn skin and eyes after leaking, and burn internal organs after inhalation, so it is important to seal ammonia. When sealing, use polytetrafluoroethylene to seal the ammonia gas to prevent leakage of ammonia gas.

3.4. Follow angle module

The power generated by the temperature difference rotates the solar panel vertically to radiate sunlight, and the rotation direction is dynamic and stable.

The pressure difference is realized to drive the solar panel to rotate. As the temperature changes, the pressure on the gas push rod is constantly changed, and the resulting power is also continuously changed. Thus real-time tracking of the solar panel is achieved. The solar panel is directed towards the sun, and the panel is perpendicular to the sun’s rays. When the solar panel rotates to face the sun, the heating situation of the temperature difference collector module on both sides is gradually the same, and the pressure difference generated by the internal ammonia gas will gradually reduce to zero. When the pressure on both sides is equal, the solar panel will have a weak turning trend. If rotation occurs, the temperature difference module on both sides will generate a pressure difference, so that it continues to face the sun. The whole module will always be in such a dynamic balance.

4. Calculation and analysis

Take a place for experimental verification, and measure the light intensity at a place. According to the data collection, the light intensity changes with time as follows:

| Time  | 8:00 | 9:00 | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 | 16:00 |
|-------|------|------|-------|-------|-------|-------|-------|-------|-------|
| Light solar radiation (w·m²) | 340  | 605  | 730  | 812  | 890  | 875  | 610  | 480  | 280  |

By using the least square method, the equation is established between time t and 8:00-9:00. The relationship between solar radiation intensity and time can be approximately as follows:

\[ w = -34.9t^2 + 335.7t + 50.9 \]

If the angle between the heat absorption module and the sun is \( \alpha \) at this time, the area receiving the sun at this time is:

\[ S = 2dl \cos \theta \]

In general, the difference between the heating surfaces at both ends is 60 °, and the difference in heating conversion efficiency is 30%. Then the difference energy \( \Delta W \) can be calculated as

\[ \Delta W = w \times s \times t \times \Delta \eta \]

Because the black area is made of PC, according to the specific heat capacity formula:

\[ W = \eta \cdot m \cdot (T - T_0) \]

Known gas state equation:
Based on the above formula, the pressure difference $\Delta p$ at both ends of the gas rod can be calculated as:

$$\Delta p = \frac{2nRT\Delta \eta \cos \theta}{vcm\eta}$$

The weight of the solar panel is about 15kg, and its moment of inertia is:

$$J = \frac{1}{12}ml^2 = 12.5kg \cdot m^2$$

The average pressure generated is:

$$F = PS/t$$

Since the force position is 0.27m at the rotation center, the moment is:

$$M = Fl = 0.27F$$

Then its initial rotational acceleration is:

$$\beta = \frac{M}{J} = \frac{12\Delta ps}{mlt}$$

If the requirements can be met, the $\beta$ should be greater than 0. At 8 in the morning, the solar radiation intensity is 340 w · m2, and the light intensity is low at this time. When the formula is calculated, the angular acceleration at this time is 0.173 $rad/s^2$, which meets the requirements for use. Through calculation and analysis, most of the time, the device can meet the requirements and can achieve the effect of automatic light tracking.

5. Conclusion
In this device, the principle of transforming temperature difference into pressure difference to generate power is applied to realize the automatic tracking of solar panel. Through the design of cone-shaped heat collecting panel, hydraulic push rod and other mechanisms, the traditional automatic tracking of solar panel by sensors is changed. The design of pure mechanical mechanism reduces the cost and prolongs the service life. It only needs to install tracking module on the traditional solar panel, which has the characteristics of convenient disassembly and assembly. Therefore, the project has a broad application prospect.

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