Research on Optimal Design of Eccentric Solar Thermal cooker Tracking Device

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ABSTRACT

At present, a research project is being conducted to meet the demand for energy that is insufficient by using natural energy. In the paper, research focused on improving the performance of solar kilns as part of the use of solar energy. In this paper, simulation of the solar cooker follower using the application ADAMS conducted, and the optimal structural coefficients of the solar cooker follower were determined based on this. The optimized solar cooker can widely use as a power source in countryside houses.

1. MAIN CONTENT

Solving the demand for energy to the improvement of people's life by actively developing and using renewable energy is one of the important problems in building a powerful nation. Presently, projects are actively underway to actively use solar energy in the world, and solar cookers have a significant place in solving rural energy problems. One of the important problems in the use of solar cookers is the design and manufacture to increase the heat collection efficiency by focusing on the bottom of the cookers from the light reflector. Then, it is important to install solar cookers and to design and manufacture solar cookers tracking devices that can adjust azimuth and elevation angles smoothly. The paper considered the scientific and technological issues that demand from the optimum design of an eccentric solar cooker follower with a power output of 1 kW.

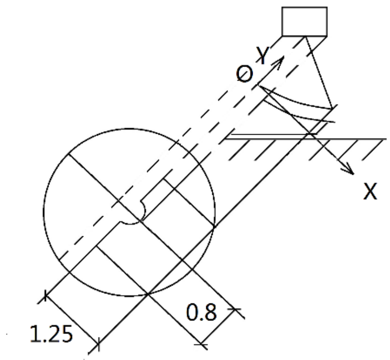

Fig.1. Rotation Parabolic Selection of Eccentric Solar cooker

The eccentric solar cooker uses the part of the revolving paraboloid surface as a reflector to place that the shadow of the cooker lies outside the reflector (Fig.1). Rotational parabolic reflector used, so the condensing ratio is high, and the temperature at the focal surface of the kiln reaches 400 ~ 500 ℃, and the thermal efficiency of the solar cooker is 55 ~ 60%. The tracking method of solar cookers divided into two types, manual and automatic. Solar cookers, which generally used in rural areas, are being followed manually. Currently, an eccentric solar cooker with a heat output of 1kW has been developed and has used for cooking in a rural house. However, the tracking device of the solar cooker was not standardized, and the structure was not optimized. Besides, there are phenomena the thermal efficiency of the solar cooker decreased because of the focus of the solar cooker not concentrated. The mechanism of an eccentric solar cooker tracking device shown below (Fig.2).

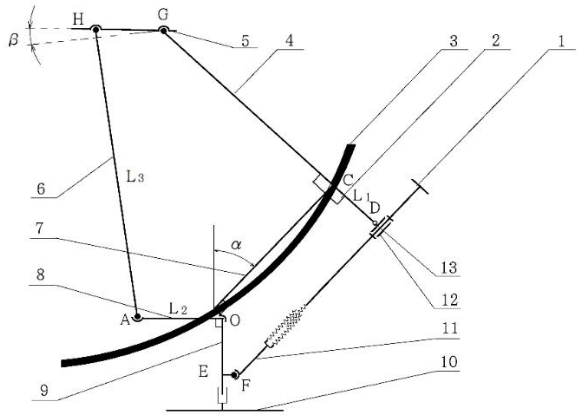

Fig.2. Mechanism of Eccentric Solar cooker Installation Frame

Here

1-high angle adjusting knob and adjusting shaft, 2-fixed arm (1), 3-reflective plate, 4- Cooker support rod (1), 5- Cooker support rod, 6- Cooker support rod (2), 7- Reflective plate fixing frame, 8-fixed arm (2), 9-Vertical Beam 10-support frame, 11-Link, 12-Guide, 13- cylinder pin

As shown in the Fig.2, the solar cooker tracking device consists of eight pieces.

Seven of them use for altitude tracking by the sun. Given the focal height of the eccentric solar kiln, the length GC of the kiln support 1 is fixed. Also, given that the reflector plate size of the solar kiln and the size of the kiln support fixed at a given heat output, the length of the reflector fixing frame BC and the length of the kiln support GH given. Also, because the working elevation of the solar kiln is inconvenient to use, the length OE is to be fixed in a piece consisting of a fixed arm (2) and a vertical beam. The tracking device of the eccentric solar kiln must satisfy the horizontal angle (β) of the kiln holder in the focal point while satisfying the altitude following (α) along with the azimuth following (γ) to ensure the normal working condition of the solar kiln.

2. Optimal Design about the device of tracking of Eccentric Solar Kiln by Using Application Program ADAMS2013

Based on the working conditions described above, an optimization design for the eccentric solar kiln tracking device with minimum tracking power (P) carried out using the application ADAMS2013.

The range of change of azimuth $\gamma = -90^{\circ} \sim 90^{\circ}$

Range of change of altitude $\alpha = 20^{\circ} \sim 70^{\circ}$

Range of inclination angle of hook support $\beta = 0 \sim 5^{\circ}$

Tracking power $\mathrm{P} \Rightarrow \mathrm{Min}$

Simulation calculation is the problem to calculate the optimal length of the fixed arm 1, the length CD (= L1), OA (= L2), and the length AH (= L3) of the kiln support 2 while satisfying the conditions as like this. The calculation results are summarized as follows. First, the effect of length CD and OA of the fixed arm (1) and the fixed arm (2) on the power consumption were considered (Fig.3).

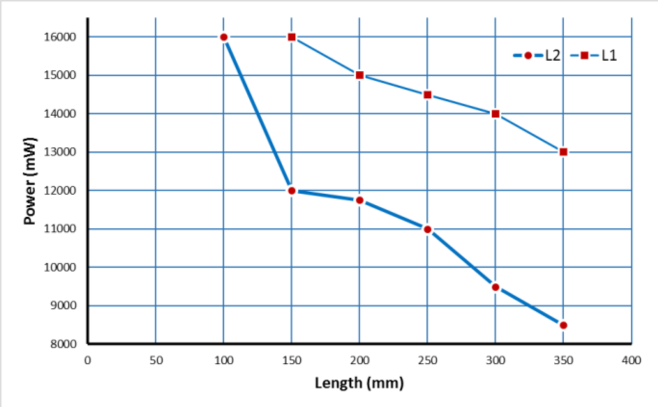

Fig.3. the effect of the length of the chips on power consumption

(L_1-fixed arm (1) length, L_2- fixed arm (2) length)

As shown in Fig.3, the power consumption reduced when the lengths of the fixed arms extended within the given limits. In particular, the influence of the change of the length L_2 (= OA) of the fixed arm 2 on the power consumption is greater than the length L_1 (= CD) of the fixed arm 1. Next, the effect of the length of the fixed arms on the angle of inclination of the kiln support was considered (Fig.4).

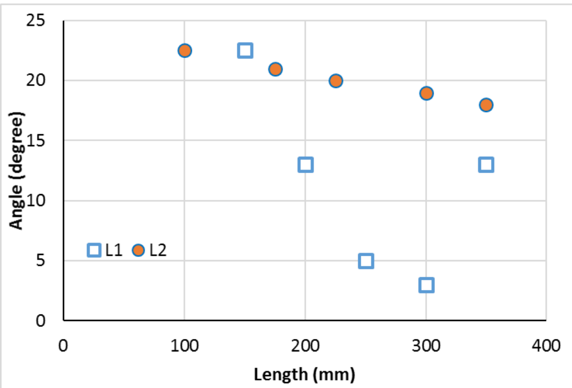

Fig.4. the effect of the length of the chips on the angle of inclination of the kiln support

Where, (L_1-fixed arm (1) length, L_2- fixed arm (2) length)

As can be seen in Fig.4, the change of the inclination angle of the kiln support along the length of the fixing arms is different. When the length L_1 (= CD) of the fixed arm 1 changes from a given limit, the tilt angle of the kiln holder has a minimum. However, the length L_2 (= OA) of the fixing arm 2 tends to decrease when it changes at a given limit. Based on the calculation results, we determined the optimum lengths of the pieces that satisfy the constraints while minimizing power consumption (Fig.5).

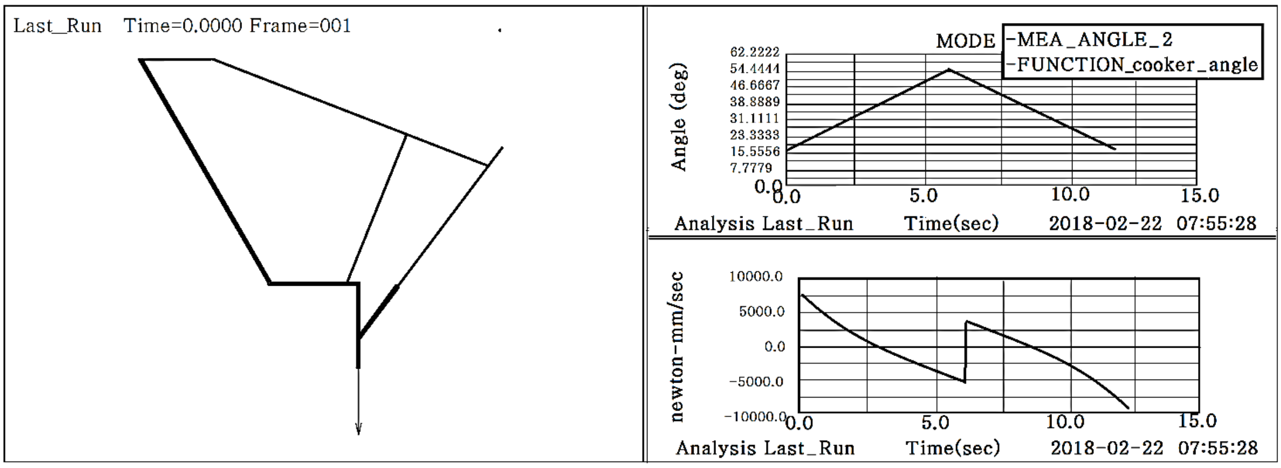

Fig.5. Kinematic Simulation and Optimal Length Determination of Eccentric Solar Kiln Mounting Frame

The optimal length of the chips is as follows.

Optimum length of fixed arm (1) CD, L_1=310mm

Optimum length of fixed arm (2) OA, L_2=320mm

Optimum length of kiln support (2) AH, L_3=1020mm

3. Conclusion

Thus, by optimizing the following structure of the solar kiln, it was possible to prepare the solar kiln smooth and safe working conditions, improve the thermal efficiency, and reduce the steel consumption. Eccentric solar kilns use natural energies, save fossil fuels, and help solve energy problems in rural areas. After optimizing the design of eccentric solar kiln installations, the steel consumption of the installation frame was saved 1kg per unit compared to before the modification, and the thermal efficiency was improved by 5%.

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