GOSPODARKA I INNOWACJE

LABORATORIUM WIEDZY Artur Borcuch

Volume: 22 | 2022

ISSN: 2545-0573

SURFACE CONTROL OF HELIOSTATS

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ARTICLEINFO.

Keywords:
Heliostat, orienter, pore generator, facet, autocollimation, theodolite, surface, longitudinal axis, deformation.

Abstract

In this paper, we consider the mirror surface of heliostats used at the SES solar power plant. At the same time, in order to determine the deformation of the reflecting surface of the mirrors of gelishstats, experimental studies were carried out on the accuracy of assembling heliostats by the autocollimation method, using autocollimation theodolites.

I. INTRODUCTION

The geometric basis of a solar power plant (SPS) is a quasi-focusing system consisting of a discrete set of mirrors (heliostats) located concentrically around an energy receiver (steam generator).

It is obvious that the energy parameters of the SES largely depend on the retransmission properties of the heliostats, which are determined by the geometric dimensions A and B, orientation to the direction of the incident radiant energy flux γ, the distance along the receiving screen of the steam generator R and its own reflectivity.

For an approximate determination of the accuracy requirements for the assembly of heliostats, from a rather formal point of view, we will analyze the scheme for relaying the light flux incident on the surface of a properly oriented heliostat. After reflection from the mirrors of the heliostat, the flow with cross-sectional area $AB\cos\alpha$ highlights a regular place on the screen of the steam generator, which has almost the same area. With some error Δγ orientation of the heliostat, the flow highlights a different area on the screen, shifted relative to the standard one by RΔγ . The consequence of this is the negative effect of double action. Firstly, the flow did not illuminate some area of the regular place on the screen of the steam generator, and secondly, it went beyond the limits of the regular place to the same area. Approximately this "lost" area can be represented as.

$$2R(A+B)\Delta\gamma cos^2\gamma\ , \qquad (1)$$

We express the relative losses as

$\frac{\Delta S}{S} = \frac{2\Delta\gamma R\,(A+B)cos\gamma}{A\cdot B}$, (2)

or, assuming simplifications, A=B.

$\frac{\Delta S}{S} = \frac{2R\Delta\gamma}{A} cos\gamma$, (3)

With a flow loss of 10%, we have

$$\frac{2R\Delta\gamma cos\gamma}{A} = 0.1$$

Where

$$\Delta\gamma = \frac{A}{2Rcos\gamma} \cdot 0.1\rho$$

At *A=1, R = 100м,* $\gamma = 45°$, $\Delta\gamma = 7 \cdot 10^{-4}$ = *2,6*′.

Assuming that the obtained value is the limiting error of heliostat orientation, we proceed to the root mean square error

$$M = \frac{\Delta\gamma}{2.6} \text{ i.e } M = 1'$$

The reflecting surface of the heliostat, in turn, also represents a set of individual flat mirrors (bevels), to which the above reasoning is also applicable. Represent the value of M as the root mean square error of the arithmetic mean, calculate the root mean square error of the position of an individual facet, based on their number in the heliostat - 45:

$$m = M \cdot \sqrt{n} \text{ i.e } m \approx 7'$$

To ensure the calculated accuracy of fixing the position of the facet, geodetic measurements are required with an accuracy of 1-2.

Experimental studies of the assembly accuracy of heliostats were carried out by the autocollimation method, as the most appropriate for the specifics of the problem. The accuracy of the method is quite high (1-2), which made it possible to carry out a fairly wide range of studies.

An autocollimating theodolite (2T2A) was installed opposite the surface of some initial facet and was carried out to guide the theodolite tube to its own display, in which the image of the grid of threads reflected from the mirror of the facet was combined with its own. In this case, the sighting axis of the pipe coincided with the normal to the facet surface at the observed point. This position was fixed by readings along the horizontal and vertical limbs at two positions of the vertical circle. This direction was taken as the initial one, and all subsequent measurements on the remaining facets were relative to the original facet. The second - the working theodolite was sequentially installed in front of the studied facets and similar alignments of the sighting axis with the normal to the surface of the facet were performed, which was fixed by the corresponding readings. alignment of its grid of threads with the visible grid of threads of the base theodolite (in this case, the same combination of grids of threads in the field of view of the base theodolite occurs automatically). When the grids are aligned, the sighting axes of both theodolites are parallel to each other.

Obviously, if the surfaces of all facets are strictly parallel (if their normals are parallel), the condition is met.

$$\alpha_0 = \beta_1 = \beta_2 = \cdots\ \beta_n$$

$$z_0 = Z_1 = Z_2 = \cdots\ Z_n$$

With inconsistencies $\Delta\beta_i = \alpha_0 - \beta_i, \Delta Z_i = Z_0 - Z_i$ it can be concluded that the facet planes turn in the vertical and horizontal planes relative to the original facet.

The overall slope of the facet is defined as

$$\Delta\gamma_i = \sqrt{\Delta\beta_i^2 + \Delta Z_i^2}$$

and the direction of inclination relative to the longitudinal axis of the facet is calculated by the formula

$$\theta_i = arctg\frac{\Delta\beta_i}{\Delta Z_i}$$

An example of processing materials for measurements of heliostat facet positions is shown in Fig. 2, for a surface characterized by a mean square error

M = 8.5.

The scheme allows an objective analysis of the state of the heliostat surface.

The orientation of the upper and lower parts of the heliostats is determined and indicates a tendency for the heliostat structure to twist and sag in the peripheral areas of the structure, where the load-bearing frame is not rigid enough.

In the central region, the position of the facets contrasts in the general deterministic picture, and indicates the presence of additional deformations, probably caused by the system of fastening the reflecting surface of the heliostat to the turntable just in the specified area of the mirror.

It is obvious that rigorous conclusions and recommendations for improving the power frame of a heliostat can be developed only on the basis of an analysis of experimental data from measurements of a sufficiently large number of heliostats, for the study of which the autocollimation method of measurements can be recommended.

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