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FEATURES OF METHODS OF OPTIMISING CALCULATION OF PARAMETERS THE COMBINED SOLAR POWER INSTALLATIONS

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ABSTRACT

In given paper use of solar water heaters for processes of the industrial factories is observed. Besides, the analysis of the results gained on experimental installation is presented. However settlement results showed that in the chosen range of temperature its growth leads to increase in total efficiency of installation, as efficiency a steam power cycle raises more intensively, than decreases к.п.д. Photo batteries. It is known that the least decrease in efficiency with temperature growth is characteristic for photo converters on the basis of gallium arsenide. Thus, essential raise of efficiency of the combined photo thermodynamic solar power installations has a consequence considerable martempering of their technical and economic characteristics.

KEYWORDS: *Solar Power, Mathematical Model, Thermodynamic Transformation, Battery, Temperature.*

INTRODUCTION

Questions of calculation of the combined solar power installations were observed by many authors [1, 2, 3]. Simpl expressions for definition of the basic power parameters of the combined systems have been offered. On the basis of these settlement techniques calculations of parameter's of the combined solar power installations were made, their efficiency, magnitude of specific holdings and a power production were defined. Besides, problems of sampling of optimum sizes of collecting channels, design features of collecting channels, limits of operating temperatures for achievement of peak efficiency were solved, etc.

Let's analyze more simple and exact enough design procedure of key parameters of the combined systems, offered in-process [2].

For the purpose of optimization of parameters of the observed combined solar power installations the mathematical model is developed, allowing to carry out alternative and optimizing calculations at various inducted initial data.

The report volume allows to result only basic used settlement relationships:

The rate of flow of the solar radiation getting on station, is equal

$$q_S = S \cdot F \qquad (1.1)$$

Where: S - density of a stream of a direct solar radiation,

F - The total aperture square parabolic cylindrical concentrators.

Electric power of photo batteries of combined station $_{NE}$ makes:

$$N_Э = q_S \cdot \eta_0 \cdot \varepsilon \cdot \eta_{PV} \qquad (1.2)$$

η_0 - optical EFFICIENCY of concentrators,

η_{PV} - EFFICIENCY of photo batteries taking into account extent of concentration of radiation and an operating temperature,

ε - a stacking factor of a face-to-face surface of the radiation detector photo cells.

Electric power is equal in the steam-turbine part of station:

$$q_T\ \eta_{TH} = q_S\ \eta_0\ (\eta_{hl}^{rec} - \eta_{PV})\ \eta_{TH} \qquad (1.3)$$

η_{TH} - efficiency of thermodynamic transformation taking into account efficiency of the turbine, the oscillator, pumps and losses at a heat transfer.

Thermal losses in the solar radiation receiver develop of actually radiation losses and the convective convective heat exchange in an aerosphere

$$q_{hl}^{rec} = F_{fs}\ [k\sigma\ T_{fs}^4 - k\sigma\ T_a^4 + \alpha^a_{conv}\ (T_{fs} - T_a)] \qquad (1.4)$$

Where F_{fs} - the square free (without the thermal insulation) receiver surfaces, T_{fs} - absolute temperature of this surface, T_a - air temperature, k - receiver radiation coefficient, α^a_{conv} - factor of the convective convective heat exchange in an aerosphere.

Heat transfer calculation in the chilling channel of the receiver of a solar radiation which simultaneously is the steam plant of a thermodynamic part of station, is defined by the equation of thermal balance:

$$q_T = G_{wfc}\ (h_{1c} - h_{2c}) \qquad (1.5)$$

Where G_{wfc} - the working medium charge (or a special cooler in case of the double-circuit circuit design) in the chilling channel, h_{1c} and h_{2c} - a working medium enthalpy on an exit and a channel entry, and also the equation of a heat transfer from photo cells to a working medium:

$$qT = \int_0^\infty K_{ec} \ (t_c - t_{wf})df + \int_{f_{ch}}^{f_{ec}} K_{ev} \ (t_c - t_{wf})df \quad (1.6)$$

Here K_{ec} and K_{ev} - surface-area factors on economizer and evaporative channel sections, t_c and t_{wf} - temperatures of photo cells and a working medium, f_{ec} and f_{ch} - the squares of a flowed about surface economizer a section and the channel as a whole.

In-process [2] it is in more details shut down on dependence of efficiency of the photo battery on concentration of a solar radiation and temperature. It is known that the least decrease in efficiency with temperature growth is characteristic for photo converters on the basis of gallium arsenide. However the literary data about their efficiency over the range temperatures 100-200^{0}C and concentration to 100 is small and are appreciably inconsistent.

In FTI of A.F.Ioffe of the Russian Academy of Sciences experimental researches of efficiency of monocrystal GaAs-elements in the specified range of temperature and concentration are spent. These elements have been specially made for work in the concentrated stream of a solar radiation. The gained experimental data are approximated by the equation expressing dependence efficiency Elements from concentration and temperature to within ± 0,5 absolute processes (fig.1). Apparently from this drawing, efficiency of GaAs-elements over the range temperatures 150-200^{0}C With makes 19 - 17 % [2].

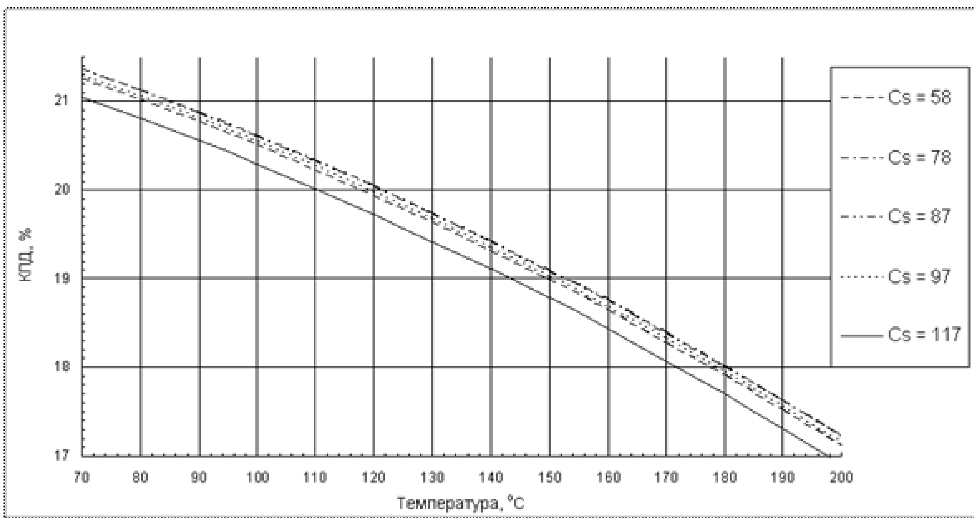

Fig.1. Dependence efficiency Elements from concentration and temperature to within ± 0,5 absolute processes [2]

Optimizing calculations are spent over the range working medium temperatures in front of the turbine 150-200^{0}C and concentration of a solar radiation 80-100. As with growth of temperature efficiency of the photo battery decreases, and a steam power cycle, on the contrary, increases, it is natural to expect some optimum providing peak efficiency of combined installation. However settlement results showed that in the chosen range of temperature its growth leads to increase in total efficiency of installation, as efficiency a steam power cycle raises more intensively, than decreases к.п.д. Photo batteries. Hence, the required optimum is at the temperature exceeding 200^{0}C, however for this area there are no experimental data by efficiency of GaAs-elements. Extrapolation in this area would be unreliable.

Total к.п.д. Gross the one-circuit combined installation in the observed range of temperature and concentration makes from 0,276 to 0,295, and efficiency Net taking into account an auxiliary power requirements, including transformation of a direct current in variable, from 0,256 to 0,277. For double-circuit installation efficiency Gross makes from 0,256 to 0,274, and efficiency Net from 0,230 to 0,245. As appears from this data, efficiency of the combined photo thermodynamic solar power installation in 1,5-2 times exceeds efficiency of the photo-electric and steam-power solar installations applied separately.

Results of calculations show also that for one-circuit installation at temperature in front of the turbine 150, 175 and 200^{0}C the share of the steam-turbine part of installation in its total power makes accordingly 0,45; 0,49 and 0,53, and for double-circuit 0,42; 0,47 and 0,51.

Higher efficiency of the combined solar power installation cannot in itself testify is univocal to its advantage without conducting of a technical and economic estimation. The spent estimation of specific capital outlays showed that they make for one-circuit installation from 1700 to 1850 dollars/kw, and for double-circuit installation from 2050 to 2200 dollars/kw in the observed range of temperature and concentration.

As many aspects of the equipment necessary for creation of combined solar installations, by the industry it is not made, the estimation of capital outlays, naturally, is connected with a row of assumptions. So for example, us it is accepted that cost of unit of the square of the GaAs-photo battery in 10 times exceeds cost of unit of the square of the silicic photo batteries which price is known. Cost of concentrating system develops of cost of mirrors, the oporno-rotary device on which mirrors, the electric drive and an automatic-control system fasten. Cost of the glass polished mirrors according to industrial glass Institute at their order not less than 5 thousand м2 makes 100 dollars for 1 м2. Cost of the oporno-rotary device (OPU) is sized up on materials of the outline sketch of the module параболоцилиндрического the concentrator custom-made ENIN by one of project institutes in the early nineties. At specific metal consumption OPU of 43,4 kg on 1 ^{м2} the aperture square of the module its specific cost in the modern prices makes 86,8 dollars/m2. Analogous assumptions are accepted on a control system of twirl of the module, on system of transformation of a direct current in variable, etc.

Certainly, the data cited above on specific holdings is rough. Their real value can be defined only under the design-budget documentation at design engineering. However, it is possible to consider that our estimation specific investment has an error no more ±20 %. We assume that on the average specific capital outlays in the combined solar power installation make 2000 dollars/kw. It in 4-5 times is less than, for example, for photo-electric installation on the basis of flat photo-electric modules with Si-elements and in 2,25 less, than for the steam-turbine solar power stations of firm of the Billiard pockets built in the USA. Thus, essential raise of efficiency of the combined photo thermodynamic solar power installations has a consequence considerable martempering of their technical and economic characteristics.

It is necessary to note that despite the numerous approved and recommended methods of calculation of the combined systems, sampling of effective alternative it is represented enough challenge as system effectiveness depends on numerous factors. More simpl and economic solutions of this point in question allow to use solar energy effectively. For this purpose conducting of comparative calculations and the analysis of efficiency of various circuit designs, and also optimization of parameters and modelling of regimes of their work is necessary. On this basis it is possible to choose and recommend the most rational, technological and economic system, and also a technique of their calculation.

The combined systems count by an union of methods of calculation of separate subsystems in the general model and the subsequent optimization of the general criterion function. We observe power balance and an engineering design procedure of the main subsystem - flat and параболоцилиндрического a collecting channel more low.

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