# SEASONAL HEATING CAPACITY AND THERMAL EFFICIENCY OF FLAT SOLAR WATER HEATING COLLECTORS MADE OF TRANSLUCENT PLASTICS WITH BOTTOM ABSORPTION OF RADIATION

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The article presents a method for processing the results of experimental studies of the daily amount of useful heat accumulated in a capacious receiver of flat solar water heating collectors with bottom absorption of solar radiation and insulated with flat bases. The calculated expression and the results of comparative experimental studies in full-scale conditions of the temperature regime and thermal efficiency of the above solar collectors located horizontally in the meridional direction along the cardinal directions, i.e. the long axis of the flat base of the collectors is directed from east to west.

As is known, the methods of thermal testing of solar collectors with flow-through radiation receivers, due to their low inertia compared to collectors with capacious receivers, are not acceptable for their testing.

Due to the fact that it is useful in a solar collector with capacious receivers-absorbed and converted into low potential heat from solar energy radiation accumulates during daylight hours. To process the measurement results of the main experimental data, we have improved and applied an integral method based on the use of average daily (or averaged over a certain period of daylight) values of the measured parameters and the corresponding thermal characteristics.

**Keywords:** seasonal heating capacity, thermal efficiency, capacitive solar radiation absorber, bottom absorption beam

## Introduction

In flat solar water heating collectors (FSWHC) with capacitive solar radiation absorbers (CSRA), unlike those with flowing CSRA, the function of CSRA and the hot water storage tank are combined, and they can be made of heat-resistant non-metallic materials, for example, heat-resistant plastics. Due to the fact that the CSRA functions and the hot water storage tank are combined in the FSWHC of the type under consideration, they are often called accumulative [1, 2].

Based on the complex of scientific studies carried out on the thermal calculation of flat solar water heating collectors with CSRA and with bottom absorption of solar radiation (SR) and thermally insulated flat bases, we have developed and comparatively tested prototypes of solar collectors of the type in question under field conditions. The article presents the results of comparative experimental studies in full-scale conditions of the temperature regime and thermal efficiency of the above solar collectors located horizontally in the meridional direction along the cardinal directions, i.e. the long axis of the flat base of the collectors is directed from east to west.

**The main part**

The experiments were carried out in the conditions of the cities of Tashkent (the heliopolygon of the FTI scientific and production association (SPA) "Physics-Sun" of the Academy of Sciences of Uzbekistan) and Gulistan (at the heliopolygon of Gulistan State University) during the thermal periods of 20017-2021.

**The purpose of field experiments is:**

-verification of the adequacy of the results of computational and experimental studies;

-determination of the amount of evaporated moisture from the FSWHC with a capacitive CSRA with an open surface;

-determination of the degree of dependence of the hot water temperature on the thickness of the water layer in the capacitive CSRA;

-establishment of heating capacity and thermal efficiency of collectors of the type under consideration and rational terms of their operation in seasonal hot water supply systems.

A pilot production sample of a FSWHC with a capacitive CSRA consists of a housing 1 made of concrete in the form of a box, on the bottom of which there is a container 4 made of a polymer material with a light transparent upper part 7, with inlet 5 and outlet 6 nozzles; a layer of thermal insulation material 3 is placed inside the side walls and the bottom of the housing, while the collector housing is equipped with a front light transparent coating 2, and the side and lower parts of the tank are made of black 8,9 (Fig.1)[ 4, 5, 7].

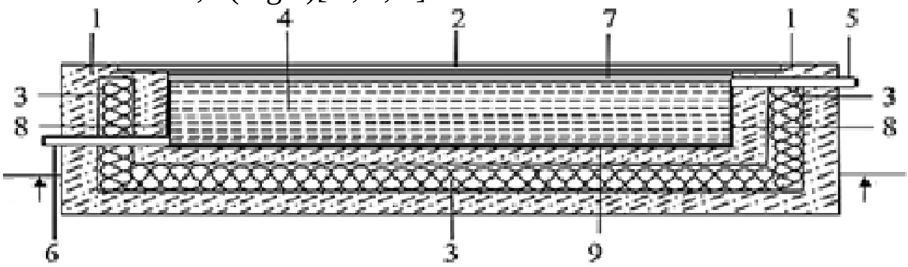


Fig. 1. Schematic vertical section of the proposed FSWHC with capacitive CSRA.

The reduction of the heat losses of the housing achieved, firstly, by the fact that a layer of thermal insulation material placed inside the sidewalls and the bottom of the housing. The internal thermal insulation layer reduces the value of the generalized thermal conductivity coefficient of the three-layer wall in comparison with the thermal conductivity coefficient of the source material. The lower the thermal conductivity of the thermal insulation material, the lower the effective thermal conductivity and, accordingly, less heat loss from the wall surface. For example, the thermal conductivity of normal concrete is 1,5-2,1 W/($m^2$K), the thermal conductivity of reed slabs is 0,06-0,09 W/($m^2$K), depending on the degree of compaction. The average difference in thermal conductivity values is ~20. Secondly, the fact that the collector housing is equipped with a front translucent coating and side thermal insulation, which additionally reduce the heat loss of the housing [8, 9, 10].

Table 1.

The daily amount of solar radiation incident on the collector surface and the amount of useful energy received, at = 0,05 m and = 0,07 m, respectively, per season.

| Dates of experiments | Number of days | $Q^{\Sigma}_{fall_{9-15}}$, MDj | $Q_{usef_{9-15}}$, MDj | | $\bar{\eta}_{9-15}$ | |
|---|---|---|---|---|---|---|
| | | | 0,05 m | 0,07 m | 0,05 m | 0,07 m |
| 05.2021 | 15 | 4207,13 | 958,52 | 1257,30 | 0,23 | 0,30 |
| 06.2021 | 21 | 5633,92 | 1293,56 | 1684,82 | 0,23 | 0,30 |
| 07.2021 | 29 | 7905,70 | 2014,90 | 2528,70 | 0,25 | 0,32 |
| 08.2021 | 30 | 8713,34 | 2187,86 | 2664,06 | 0,25 | 0,31 |
| 09.2021 | 21 | 6750,44 | 1782,63 | 2217,96 | 0,26 | 0,33 |
| season | 112 | 33210,53 | 8237,48 | 10352,48 | 0,25 | 0,31 |

Table 2.

The amount of useful hot water received during the season at $\delta_в$ = 0,05 m and $\delta_в$ = 0,07 m, respectively, per season.

| Months | Number of days of collector operation | The volume of water in the collector, (V) l | $t_w$, $^oC$ | $Q_{usef_{9-15}}$, MDj/*mon* |
|---|---|---|---|---|
| | $\delta_в = 0{,}05m$ | | | |

| | | | | |
|---|---|---|---|---|
| May | 15 | 3750 | 42÷ 43 | 958,52 |
| June | 21 | 5250 | 50÷ 53 | 1293,56 |
| July | 29 | 7250 | 53÷55 | 2014,90 |
| August | 30 | 7500 | 53÷55 | 2187,86 |
| September | 21 | 5250 | 47÷48 | 1782,63 |
| **season** | 112 | 29000 | | 8237,48 |
| Months | $\delta_в = 0{,}07\ m$ | | | |
| May | 15 | 5250 | 40 ÷ 42 | 1257,30 |
| June | 21 | 7350 | 47 ÷ 49 | 1684,82 |
| July | 29 | 10150 | 49 ÷ 50 | 2528,70 |
| August | 30 | 10500 | 46 ÷ 47 | 2664,06 |
| September | 21 | 7350 | 41 ÷ 43 | 2217,96 |
| **season** | 112 | **40600** | | 10352,48 |

To increase the efficiency of water heating in the FSWHC, the side and lower parts of its capacious CSRA are made of a black polymer material. In this case, the radiant flow of SR passing through the upper light transparent wall of the container and the water layer will be completely absorbed by the black sides and lower parts of the container. The main part of the absorbed SR energy will be spent, first of all, on heating the water concentrated in the tank. Only a small fraction of it is transmitted by thermal conductivity to the body. The effect of preferential heating of the water, rather than the body, is enhanced by natural thermogravitational convection, as a result of which the side and lower parts of the tank are continuously washed by descending streams of cold water.

Experimental studies of a pilot production sample of the FSWHC were carried out during the warm period of 2017-2021 at the heliopolygons of Gulistan State University.

**Results**

The results of the generalization of experimental data on the determination of water temperature, the sum of the daily heating capacity and the average daily thermal efficiency of FSWHC with capacitive CSRA, during clear and semi-clear days are presented in Tables 1, 2, the amount of incident solar energy, the amount of hot water received per season, the amount of useful energy for $\delta_в$ = 0,05 m and $\delta_в$ =0,07 m, per season, respectively.

The number of working days at which the temperature of the received warm (or hot water) is higher than 40÷ 42°C are: 18 – in the month of May, 19 – in June, 27 - in July, 29-in August and 24 – in September. The total volume of warm (or hot) water received from the collector during the season (V-IX months of the year) was 29,0 liters. at 0,05 m, at water temperatures at the time of intake (14h50m~15h10m) in May - 47÷48$^oC$, in June 45÷53 $^oC$, in July and August -53÷55 $^oC$, in September, 40÷42 $^oC$. At 0,07 m, the total volume of hot water received from the collector during this period left 40,600 liters. with a temperature of 3-4 $^oC$ lower than at 0,05 m. From the database of Tables 1 and 2, we determine the expected technical and economic indicators of the reservoir under consideration. The amount of conventional fuel saved from the use of the collector of the type in question, determined from [3, 6, 11]

$$G_{c.f.}^{\text{spe}} = \frac{Q_{\text{usef}}^{\text{season}}}{\eta_{\text{m1}} \cdot q_{c.f.}} \quad (1)$$

with the efficiency of using low-power traditional heat sources ($\eta_{\text{m1}}$) 0,5, the calorific value of conventional fuel ($q_{c.f.}$) 29,3076 *GJ/t.c.f.* at 0,05 m is. t is 41,46 kg c.f./m$^2$season and at 0.07m is 48,6 kg c.f./m$^2$season.

As the results of measuring the volume of heat water taken from the collectors showed, by the end of the day (18 pm), the loss of water in the collector with an open evaporation surface is 5 liters. Calculations according to the attached methodology converge with data on processing the results of experimental studies of the daily amount of useful heat accumulated in a capacious receiver of flat solar water heating collectors with bottom absorption of solar radiation and thermally insulated flat bases.

Thus, depending on the change in prices for the cost of construction of the collector, the coverage period (coverage period) is from 1 to 3 months, the reduction of greenhouse gas emissions into the environment varies from 67 kg to 235 kg per square meter per year, depending on the type of fuel.

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