SOLAR ENERGY COLLECTOR WITH CANAL ABSORBER

Imants Ziemelis, Žanis Jesko, Uldis Iljins, Henriks Putāns
Latvia University of Agriculture
Imants.Ziemelis@llu.lv

Abstract. The article deals with a solar collector which absorber made of a metal sheet with open canals and provided with a heat transfer medium circulation system. When the solar rays are striking the absorber sheet, the heat carrier flowing down along the absorber canals is heated up. There an experimental investigation of the solar collector with open absorber, ass well as covered by a polycarbonate sheet and plastic film has been carried out. The obtained temperatures, consumption of heat transfer medium, obtained amount of heat and other experimental results for each of variants examined are presented.

Key words: solar collector, absorber, canals, temperature.

Introduction

For hot domestic water heating using the solar radiation, large number of solar collectors is known. Different types of collectors such as flat plate, tracking the sun, focusing the solar rays and others are developed [1]. Each of these types has varieties of design, application and efficiency. More often flat plate collectors are used due to its simple construction, installation and operation [2].

Materials and Methods

At the Agency of Latvia University of Agriculture Research Institute of Agricultural Machinery a new construction of a flat plate solar collector with absorber having open canals has been developed [3]. The collector has been made and its experimental investigation carried out (Fig. 1).

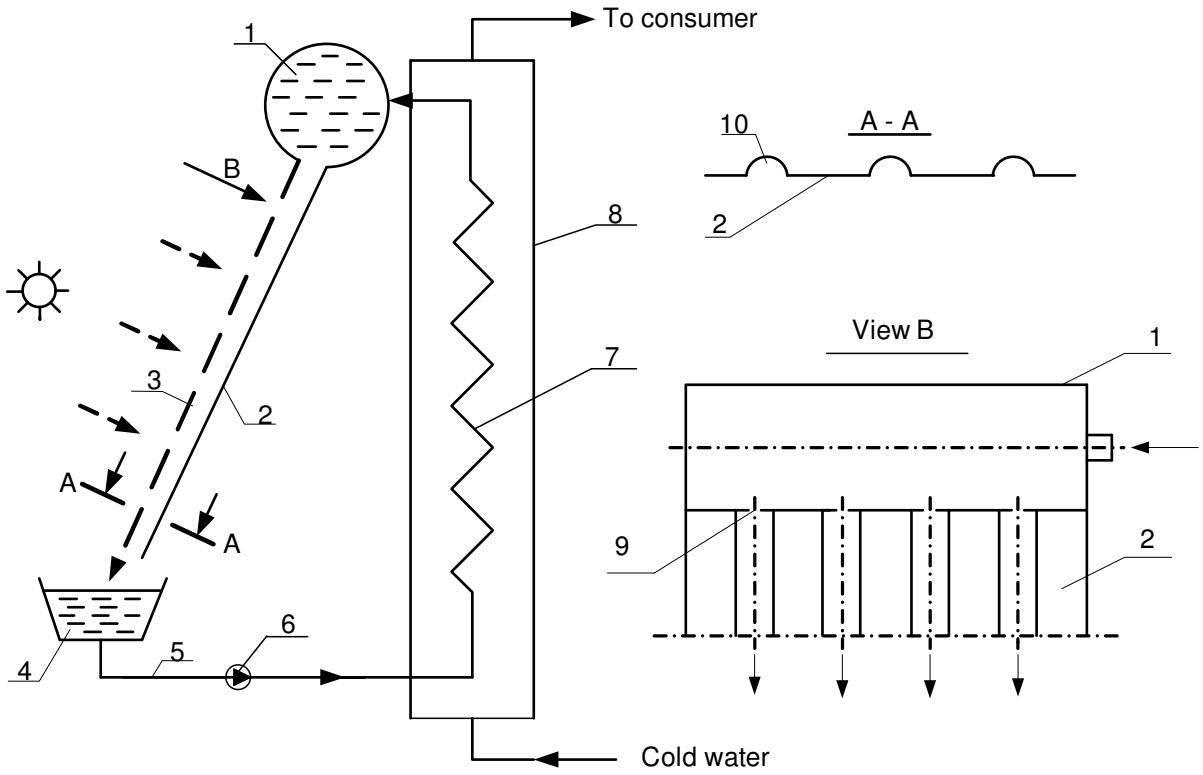

Fig. 1. **Solar collector with canal absorber:** 1 - upper tube; 2 - absorber sheet; 3 - water flow; 4 - hot heat carrier collecting box; 5 - piping; 6 - circulation pump; 7 - heat exchanger; 8 - cold water tank; 9 - bores; 10 - canals

The collector consists of a frame, flat plate absorber 2 with canals 10, upper heat carrier tube 1, a heat carrier collecting tube or box 4 at the bottom part of the absorber, circulation pump 6, heat meter and plastic piping 5.

The upper tube 1 has small bores 9 along all its length. The cold heat transfer fluid – heat carrier flows into the tube 1. On the absorber sheet in front of every of bores 9 small canals 10 are made along which the cold heat carrier from the upper tube flows down and gets hot from the solar radiation heat absorbed into the absorber sheet. At the bottom part of the absorber sheet a hot heat carrier collecting tube or box 4 is placed, where the hot heat carrier flows in from the canals 10. By means of a circulation pump 6 it is delivered to a heat consumer or returns into the upper tube 1 for second circle of heating. It is envisaged to use the collector for swimming pool water heating or also as a pre-heater for the heat pump operation, which heightens the heat carrier temperature up to the necessary.

For the laboratory examination instead of solar radiation infra red lamps have been used (Fig. 2). By means of the heat meter the temperature at the inlet and outlet of the absorber and the heat carrier flow has been measured and amount of heat accumulated into the heat carrier has been stated. Interesting results are obtained when the absorber was open, covered by a plastic film and the sheet of polycarbonate.

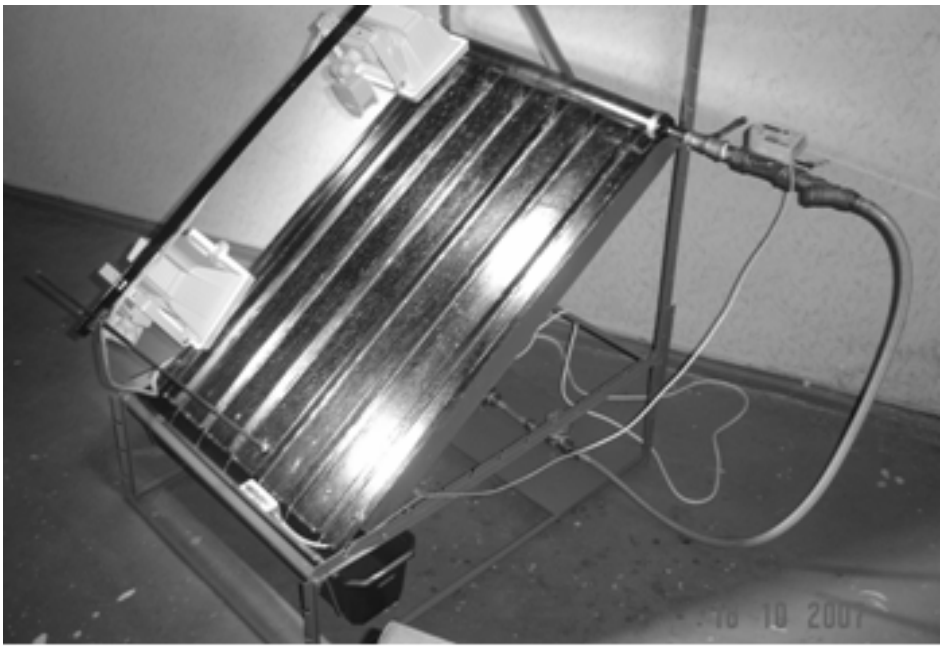

Fig. 2. **Solar collector absorber without a cover**

One of the variants of the invention in Fig. 1 is shown, where at the top part of the absorber sheet 2 the cold heat carrier collector-pipe 1 with several small bores 9 is fastened. In front of the every bore on the absorber sheet 2 small canals (ditches) 10 are made, along which from the bores 9 of the top collector-pipe 1 the heat carrier 3 flows down. As the fluid is in a direct contact with the hot absorber sheet, it gets hot. The canals end in the common box 4 at the bottom part of the absorber sheet.

By means of the circulation pump 6 the hot heat carrier from the collecting box 4 along the piping 5 through the heat exchanger 7 placed in the cold water tank 8 is driven. In the heat exchanger the heat transformation from the hot heat carrier to the cold water is performed. After cooling down the heat carrier returns back to the top collector-pipe 1 for the next outlet and heating.

Such construction of the absorber can be placed into the flat plate solar collector box, covered by the sheet of glass and put on the slope roof of a house.

The objective of the experimental research was to determine the power und efficiency of the collector at the given radiation intensity in stationary regime of work for the absorber:

- without any cover;
- covered by plastic film;
- covered by 6 mm thick polycarbonate sheet.

In accordance with the worked out methodology it was envisaged to read the obtained heat power P (W), produced by the collector, from a display of the heat meter (Delta tech compact II Nr 24671701). There amount of heat carrier (water) running through the absorber canals Q (l min^{-1}), as well as the ambient air and heat carrier temperature at the inlet T_{in} (°C) and outlet T_{out} (°C) of the absorber has been measured and fixed into the memory of a computer. The absorber was irradiated by two infrared lamps with power of 500 W each, feed by electric power of voltage U (V).

Results and discussion

The experimental investigation of the solar collector with canal absorber, which absorber was without any cover (Fig. 2) according to the accepted methodology was carried out during two hours. At this time a stationary regime of the collector work has been reached. The obtained values of the parameters in question in Table 1 are presented.

Table 1

Experimental results of the open absorber without a cover

Time, min	Q, l min^{-1}	T_{in}, °C	T_{out}, °C	P, W	T_a, °C	U, V
10:00	114	17.1	17.1	3	19	215
10:05	112	19.6	21.1	179	19	216
10:15	112	25.7	27.5	206	19.5	215
10:30	102	31.4	33.1	185	19.8	218
10:45	105	34.1	35.6	176	19.9	215
11:00	103	35.2	36.6	173	19.9	215
11:15	103	35.8	37.2	171	19.9	217
11:30	103	35.8	37.3	163	20	216
11:45	124	35.8	37.2	193	20	217
12:00	113	35.8	37.2	177	20	215

The results of experimental investigation of the solar collector with canal absorber, covered by a polycarbonate sheet (Fig. 3), according to the accepted methodology in Table 2 are seen.

The thickness of the polycarbonate sheet was 6 mm, the distance between the absorber and polycarbonate sheet – 20 mm. The stationary regime of heating was reached in 2 hours and 45 minutes. The sheet was supported on both sides. The space at the top and bottom of the sheet was open.

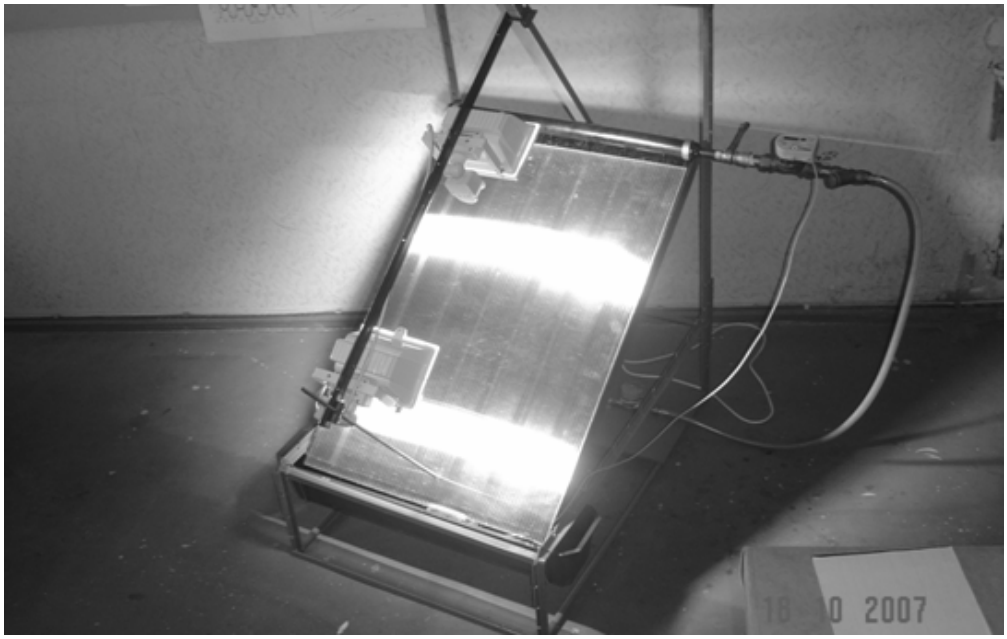

Fig. 3. **Absorber of the collector covered by a polycarbonate sheet**

At the third experiment the absorber of the collector by a plastic film has been covered (Fig. 4). There was no distance between the film and absorber, and the film had close contact with the absorber surface. The obtained results of the measured parameters in Table 3 are collected. As it is seen from the table, the constant temperature of the heat carrier in two hours and 45 minutes has been established.

Table 2

Experimental results of the absorber covered by polycarbonate sheet

Time, min	Q, l min^{-1}	T_{in}, °C	T_{ou}, °C	P, W	T_a, °C	U, V
10:00	124	16.6	16.6	1	19	213
10:05	121	18.9	20.1	153	19.1	213
10:10	122	21.5	22.6	156	19.2	213.5
10:15	121	23.5	24.6	156	19.4	213
10:30	122	28	29.1	150	19.6	212
10:45	122	30.3	31.4	140	19.7	210
11:00	120	31.5	32.5	140	19.8	212.5
11:15	118	32.1	33	131	19.9	211
11:30	114	32.3	33.3	136	20	210
11:45	116	32.6	33.6	128	19.9	212
12:00	120	32.8	33.9	140	20	214
12:45	125	32.8	33.8	138	20	210

In comparison with the experimental results obtained for open absorber, and covered by polycarbonate sheet and plastic film, from Tables 1, 2 and 3 it follows, that the biggest power was developed in the case, when the absorber by plastic film has been covered – 201 W. The smallest power was observed when the polycarbonate sheet has been used – only 132 W on heat energy.

The higher difference between the average heat carrier temperature T_{av} in the absorber and ambient air temperature T_a has been obtained, and it was 18.3 °C. If the temperature diference $\Delta T = T_{av} - T_a$ was relatively low, the efficiency of the collector η was relatively high. For example, at ΔT = 16.5 °C for the collector without a cover on the absorber, the efficiency was equal to 0.53.

Fig. 4. **Solar collector covered by a plastic film**

Table 3

Experimental results of the absorber covered by plastic film

Time, min	Q, l min^{-1}	T_{in}, °C	T_{out}, °C	P, W	T_a, °C	U, V
10:00	124	16.6	16.6	1	19.0	213.0
10:05	121	18.9	20.1	153	19.1	213.0
10:10	122	21.5	22.6	156	19.2	213.5
10:15	121	23.5	24.6	156	19.4	213.0
10:30	122	28.0	29.1	150	19.6	212.0
10:45	122	30.3	31.4	140	19.7	210.0
11:00	120	31.5	32.5	140	19.8	212.5
11:15	118	32.1	33.0	131	19.9	211.0
11:30	114	32.3	33.3	136	20.0	210.0
11:45	116	32.6	33.6	128	19.9	212.0
12:00	120	32.8	33.9	140	20.0	214.0
12:45	125	32.8	33.8	138	20.0	210.0

In comparison with the experimental results obtained by open absorber, and covered by polycarbonate sheet and plastic film, from Tables 1, 2 and 3 it follows, that the biggest power was developed in the case, when the absorber by plastic film has been covered – 201 W. The smallest power was observed when the polycarbonate sheet has been used – only 132 W of heat energy. The higher difference between the average heat carrier temperature T_{av} in the absorber and ambient air temperature T_a has been obtained, and it was 18.3 °C. If the temperature diference $\Delta T = T_{av} - T_a$ was relatively low, the efficiency of the collector η was relatively high. For example, at ΔT = 16.5 °C for the collector without a cover on the absorber, it was equal to 0.53.

As an important factor the evaporation of the heat transfer medium (water) in the collector with open absorber has to be considered. The greater evaporation during the experiment for the absorber without a cover has been stated, and it was 538 cm^3 during 2 hours of work, but the smallest one, for the absorber covered by the plastic film has been observed. It made only 83 cm^3 during 2.6 hours of the absorbers work.

The total heat losses for the collector in question were about 10 W °C^{-1}. It was stated that the circulation pump with its own power of 18 W, had produced about 2 % of the total heat power produced by the collector.

When the plastic film was put on the absorber canals, it was observed that under the film above the canals there water vapor condensation took place.

Conclusions

1. The examined type of solar collector can be recommended for water heating of swimming pools, where not high temperatures are needed.
2. In order to increase the temperature of the heat transfer medium, the heat pump has to be used.

References

1. Peuser F.A., Remmers K.H., Schnauss M. Solar Thermal Systems. – Berlin: Solarpraxis, 2002. - p. 364.
2. Харченко Н.В. Индивидуальные солнечные установки. – Москва: Энергоиздат, 1991. - 208 стр.
3. Ziemelis I., Kanceviča L., Jesko Ž., Ziemelis Ē., Putāns A. Saules enerģijas plakanā kolektora absorbers ar kanāliem. Latvijas patents LV 13516 izgudrojumam // Patenti un preču zīmes. Latvijas Republikas Patentu valdes oficiālais vēstnesis, Rīga, Latvijas Republikas Patentu valde, Nr. 3, 2007.