HYDRAULIC AND THERMOTECHNICAL MEASUREMENTS TO DETERMINE THE EFFICIENCY OF AN INNOVATIVE SOLAR THERMAL COLLECTOR

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Abstract: *There are many variants of solar collectors on the market with their advantages and disadvantages. The innovative solution of solar thermal collector has been done to increase efficiency and improve design. The new constructive solution presents good combination of an attractive design and appropriate constructive materials with special geometric shapes. Hydraulic and thermotechnical tests of this collector showed high hydraulic and structural stability. The main disadvantage is selective electrochemical coat and further development of the solar collector will be in order to improve observed disadvantages.*

Keywords: SOLAR THERMAL PANEL, EFFICIENCY, HEAT CONVERSION, ABSORPTION SURFACE

1. Introduction

The popularity of solar heating systems is increasing for several reasons. These systems are reliable, adaptable and pollution-free, because the renewable solar energy is used. The solar thermal panels have been used in solar installations for preparing hot water, for supplementary heating of the different facilities, as a support to classic heating system, for heating of water in swimming pools, etc.

The reason why solar energy has not been exploited sufficiently so far can certainly be found in its relatively low density compared to conventional sources, and in the fact that for its "capturing" and conversion relatively big solar surface should be installed which requires significant investment. This is why this investment is a privilege of richer individuals and countries, which however, after a relatively short repayment period, provides free of charge and clean energy throughout its useful life. The ways of "capturing" solar energy are diverse. This paper focuses on an innovated technical solution of a solar collector designed for heat conversion, that is to say, primarily for hot water preparation. Photovoltage collectors that perform conversion of solar into electric energy also have a significant role as far as application is concerned.

2. Technical and geometric characteristics of the absorber

There are many variants of Solar Thermal Panels in the market mainly constructed with copper pipes and flat absorbers with different quality of absorption surface. Taking into account advantages and disadvantages of existing solutions, in order to increase efficiency and improve the design, the innovative solution of solar thermal panel has been produced.

This new solar thermal panel presents integration of attractive design and appropriate constructive materials with special geometric shapes. Panel is made of special aluminum lamellas in series connection, placed in aluminum thermal-insulated box. The aluminum was chosen for making the absorber because it is significantly lighter than copper. Weight of system is certainly something that should be taken into account, primarily because of the load on the roof structure, which can be significant, especially if a considerable number of panels are placed on the roof. Aluminum also has good technical characteristics in the sense of heat conducting and the possibility of applying appropriate long-term surface protection. The shape and the profile of lamella make the original absorber, and its design has a number of advantages compared to the usual technical solutions. A significant effort has been made to find the geometric profile of ribbed lamella. The surface protection was made by way of special procedure of electrochemical protection, thus obtaining a high quality selective surface of absorber.
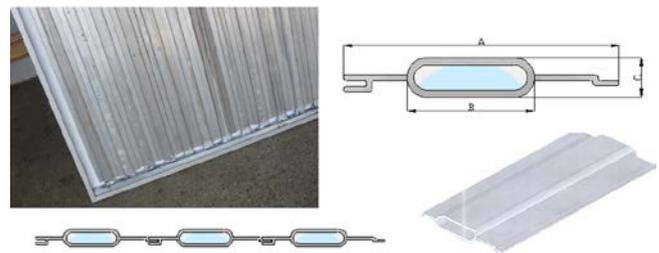

Fig. 1 *Absorber surface of solar panel with a schematic connection of absorber lamellae (cross-section).*

3. Hydraulic and thermotechnical tests of solar thermal panel

In order to determine the hydraulic and thermal characteristics of this new solution the solar panel was required to perform appropriate tests. Hydraulic and thermotechnical tests of solar thermal panel were made on Mechanical Engineering Faculty, University of Nis according to standard SRPS M.F5.110, SRPS M.F5.001 and SRPS M.F5.050, with regard to EN 12975 and EN 12976.

Table 1: *Technical data of solar panel "Solarmont"*

Product	Unit	Receiver of solar energy "Solarmont"
Dimension	mm	910x1980x72
Cover		pamplex glass one sided
Frame and sealing		extruded Al- profile, EPDM rubber
Working medium		water-glycol
Absorber		Al- profile with electrochemical layer
Absorber surface, net	m^2	1,75
Weight of empty receiver	kg	40,0
Water quantity	L	5,0
Nominal flow	kg/h	124
Maximum working pressure	bar	6
Maximum working temperature	°C	100

On the Figure 2 is showed scheme of the measuring line with next elements: 1, 2 Solarimeter, 3 Thermometer at the entrance, 4 Flowmeter, 5 Transparent tube, 6 Filter, 7 Temperature controller, 8 Valve, 9 Pump, 10 Expansion vessel, 11 Safety valve, 12 Venting valve, 13 Thermometer at the exit, 14 Insulation, 15 Gate valve, 16 Anemometer, 17 Ambient temperature.
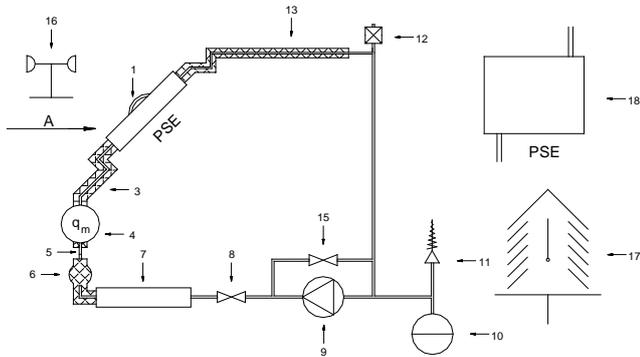
Fig. 2 *Scheme of the measuring line.*

Fig. 3 *Part of the measuring line for hydraulic and thermotechnical tests of solar thermal panel.*

Table 3: *Results of solar panel thermotechnical tests"*

No.	(Tm-Ta)/G	η
1	0,00	0,731
2	0,01	0,651
3	0,02	0,581
4	0,03	0,492
5	0,04	0,493
6	0,05	0,351
7	0,06	0,282
8	0,07	0,211
9	0,08	0,128
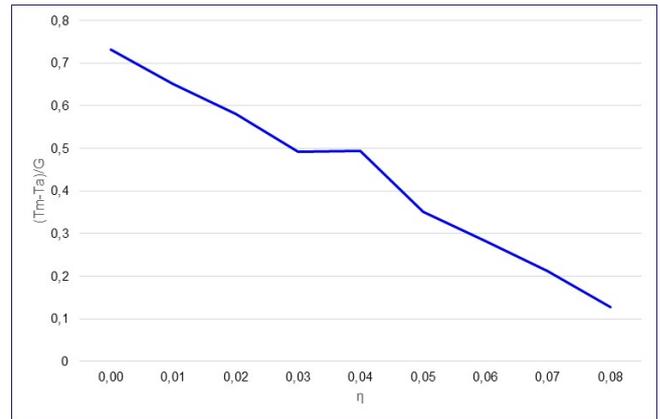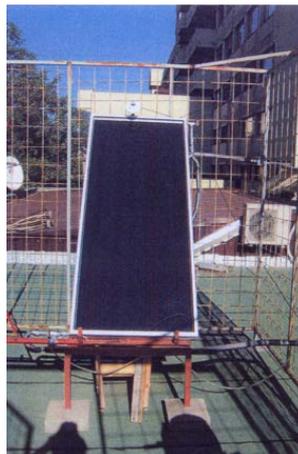
Fig. 4 *Diagram of the current heat utilization.*

4. Results of thermal performance

In order to determine the efficiency of the solar panel it is necessary to calculate the following:

Table 2: *Parameters to determine the efficiency*

Mass flow, kg/s	$q_m = 0.03$
Temperature difference	$\Delta T = T_i - T_e$
Average temperature	$T_m = T_i + \dfrac{\Delta T}{2}$
Arithmetic average temperature difference	$\Delta T_{sr} = \dfrac{T_i - T_e}{2} - T_a$
Reduced temperature difference	$T^* = U_o \dfrac{T_m - T_a}{G}$
Heat transfer coefficient	$U_o = 10 \dfrac{W}{m^2 K}$
Useful heat	$P_T = q_m c_f \Delta T$
Current heat utilization	$\eta = \dfrac{P_T}{A_a \cdot G}$

The efficiency of the receiver is determined according to

$$\eta = \eta_s - a_1\left(T_m - T_s\right)/G^* - a_2\left(T_m - T_s\right)^2/G^* \qquad (1)$$

5. Conclusion

Conducted hydraulic and thermotechnical measurements showed the following:

- Hydraulic and thermotechnical tests that have been performed on this panel showed high hydraulic and structural stability;
- The main disadvantage of the panel is selected electrochemical coating;
- Further development of the solar panel will be done in the future in order to improve some noticed disadvantages.

6. References

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