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SOLAR COLLECTOR WITH VARIABLE PARAMETERS USED FOR EXPERIMENTAL TESTS

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Abstract: Solar collectors used for hot water preparation and heating in Romania are produced abroad. This means that in their design, the specific Romanian geographical and meteorological parameters are not considered. Many parameters influence their efficiency in certain ways. The aim of the paper is to present a solar collector with interchangeable components and variable parameters in order to find the best combination which corresponds to maximum efficiency. The collector is designed to be tested on a test rig made for verifying the theoretical optimization made in a previous work [2].

1. INTRODUCTION

Solar collectors used for hot water preparation and heating are produced all over the world. Their construction differs and they are implemented in various regions. In the design process the geometrical and meteorological parameters are not considered. The present work concerns this problem, to find the optimum construction for the climate of Brasov, Romania. The aim is to improve solar collector's efficiency, which can be done in two ways: maintaining the normal incidence angle of solar radiation on collector's surface through a tracking system and optimizing the construction of the collector. The paper refers to the second solution.

In a previous work an optimization using MATLAB was made [2]. The objective function was defined and the restrictions were established. With this collector with variable parameters, the theoretical results will be verified on an experimental stand, where the specific climate conditions of Romania will be simulated.

2. OBJECTIVE FUNCTION

The literature gives information about the way that geometrical parameters of solar collectors' construction influence their efficiency [1, 3, 4]. The aim is to find the optimum combination which corresponds to a maximum value, so the efficiency, the objective function, has to be maximized:

$$\eta \rightarrow \max \tag{1}$$

The parameters which appear in efficiency function are given in Table 1:

Table 1: Parameters from efficiency function

	Parameter	Symbol	Measure units
1.	Mass flow rate	$\dot{m}$	l/h
2.	Specific heat of heat carrier	C_p	J/kg
3.	Collector's area	A_c	m^2
4.	Number of glazing	N	-

5.	Inclination angle of collector	β	^{0}
6.	Absorber temperature	T_p	^{0}C
7.	Ambient temperature	T_a	^{0}C
8.	Wind speed	V	m/s
9.	Thermal emissivity of absorber	ε_p	-
10.	Thermal emissivity of glazing	ε_g	-
11.	Distance between tubes	D	mm
12.	Inner diameter of tube	d_i	mm
13.	Exterior diameter of tube	d_0	mm
14.	Thermal conductivity of absorber	k	W/mK
15.	Absorber thickness	x	mm
16.	Heat transfer coefficient of absorber	h_f	-
17.	Incidence angle of radiation on collector surface	Ψ	^{0}
18.	Refraction index of glazing	n	-
19.	Extinction coefficient of glazing	K	-
20.	Total thickness of all glazing surfaces	X	mm
21.	Absorption coefficient of absorber	α	-
22.	Fluid temperature inside the collector	T_i	^{0}C
23.	Irradiation on collector' surface	H_T	W/m^2
24.	Thermal conductivity of base insulation	k	W/mK
25.	Insulation thickness	L	mm
26.	Thermal conductivity of side insulation	U	W/mK
27.	Side surface area of collector	A_l	m^2

All parameters are influencing the efficiency more or less. In the next stage the most important ones are chosen. The collector, by its construction, should be able to permit the variation of these parameters.

3. REQUIREMENTS

Before starting designing the collector, the requirements list has to be established. In this way the parameters with greater influence are established. Six parameters are chosen, as the most important:

- number of glazing;
- thickness of glazing;
- thermal emissivity of glazing;
- exterior diameter of tubes where the heat carrier flows;
- inner diameter of tubes where the heat carrier flows;
- distance between tubes;

The construction of the collector should permit to use different geometries of circuits flow tubes: harp type (Fig.1a), meander type (Fig.1b), and spire type (rectangular, Fig.1c. either elliptic, Fig.1d) as well as different profiles for absorber plate.

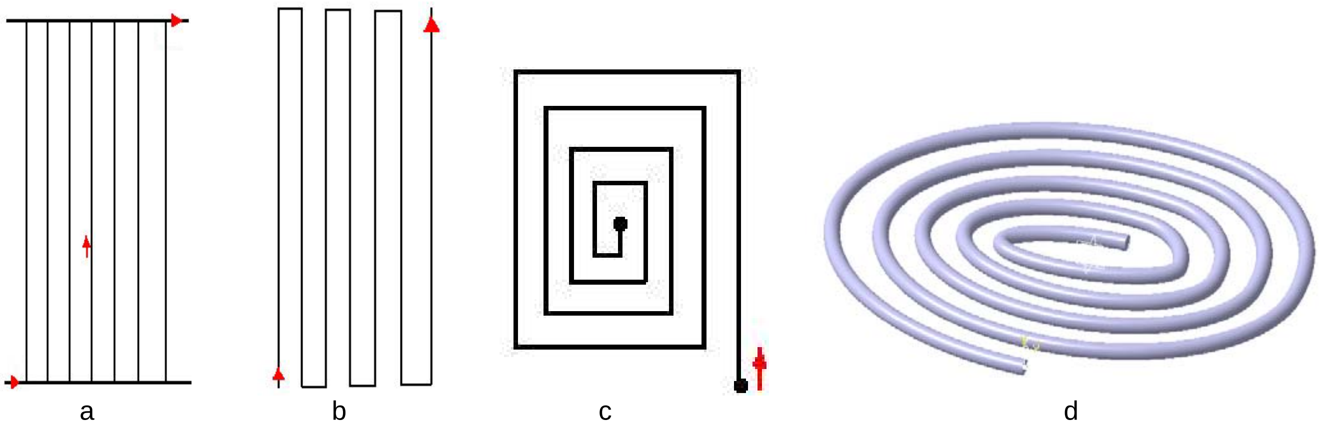

Fig.1. Flow tube circuit types

4. THE COLLECTOR

The number of glazing (transparent plates) and their thickness can be varied by using at the top side of the collector an angle bar on which the glass plates are mounted. Their thickness can be varied by using distance pieces. The drawing of the top part is shown in Figure 2. The thermal emissivity of glazing can be varied by using different materials for the transparent plates.

Fig.2. Glazing support

The collector can use flow tube circuits with different inner and exterior diameters with various distance between tubes, because the components are introduced in the collector through its top. In this way the dimensions can vary. Also, the input and output of flow tubes are designed to be on side walls of collector and also on the back side, see Figure 3. In this way, meander and harp type circuits can be used, but also spire type.

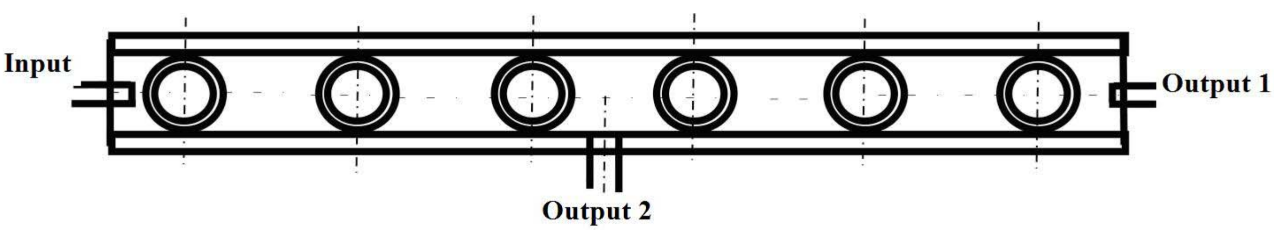

Fig.3. Input and outputs for flow tubes

Above the tubes, the absorber plate can have any desired profile. This plate is laid on the circuit.

Figure 4 shows the drawing of the collector where the components can be seen. The components numbered in the figure are:

1 – Basis plate

2 – Absorber ansamble
3 – Exterior wall
4 – Insulation
5 – Rail support
6 – Guiding plate
7 – Support frame for transparent plates
8 – Transparent plates
9 – Absorber plate
10 – Back absorber plate
11 – Flow tubes
12 – Input
13 – Output
14 – Insulation
15, 16 – Screw

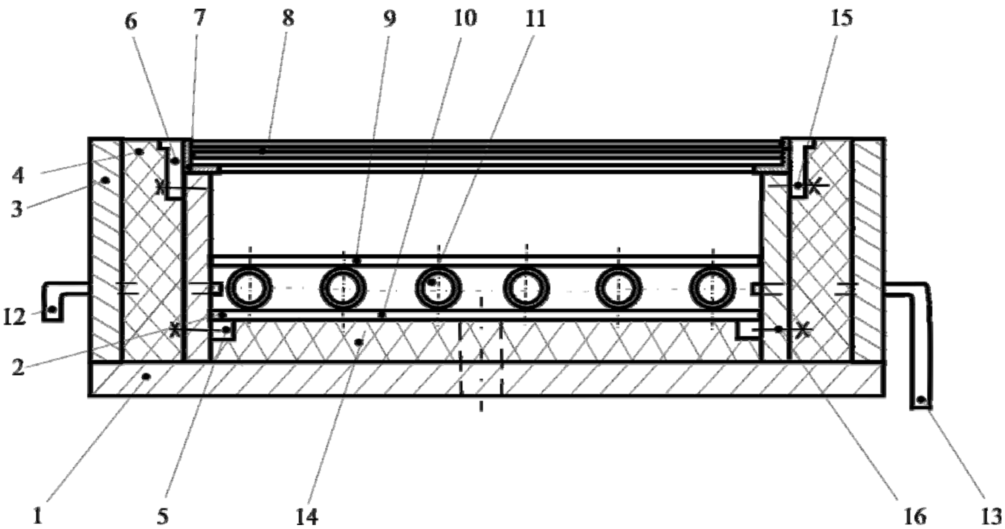

Fig.4. Drawing of collector

5. CONCLUSION

In order to verify the theoretical optimization made in previous work, a collector is designed to be tested. Its construction permits to vary some parameters, chosen in the requirements list. The next step is to make the experiments on a test rig and to compare the results with the theoretical ones, where the climate conditions will be simulated, in order to find the optimum construction for Brasov region.

References

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