ANNALS of the ORADEA UNIVERSITY.
Fascicle of Management and Technological Engineering, Volume VII (XVII), 2008

ADAPTED STAND FOR TESTING FLAT PLATE SOLAR THERMAL COLLECTORS

Radu VELICU[1], **Raluca LATEŞ**[1]
[1]Transilvania University of Braşov, Department of Product Design and Robotics
e-mail: rvelicu@unitbv.ro, latesr@unitbv.ro

Keywords: Testing rig, flat plate, thermal collectors, embodiment design

Abstract: The Renewable Energy Laboratory from Transilvania University of Brasov has a test rig for solar thermal collectors acquisitioned from G.U.N.T. GmbH, Germany. This paper presents the way that the stand is adapted for two purposes: the possibility of testing different solar collectors and the possibility of automation the much precise adjustment of the solar radiation incidence angle. The testing algoritm is also presented.

1. INTRODUCTION

The Renewable Energy Laboratory of Product Design for Sustainable Development Centre from Transilvania University of Brasov has a test rig for solar thermal collectors acquisitioned from G.U.N.T. GmbH, Germany. Figure 1 presents the scheme of the stand.

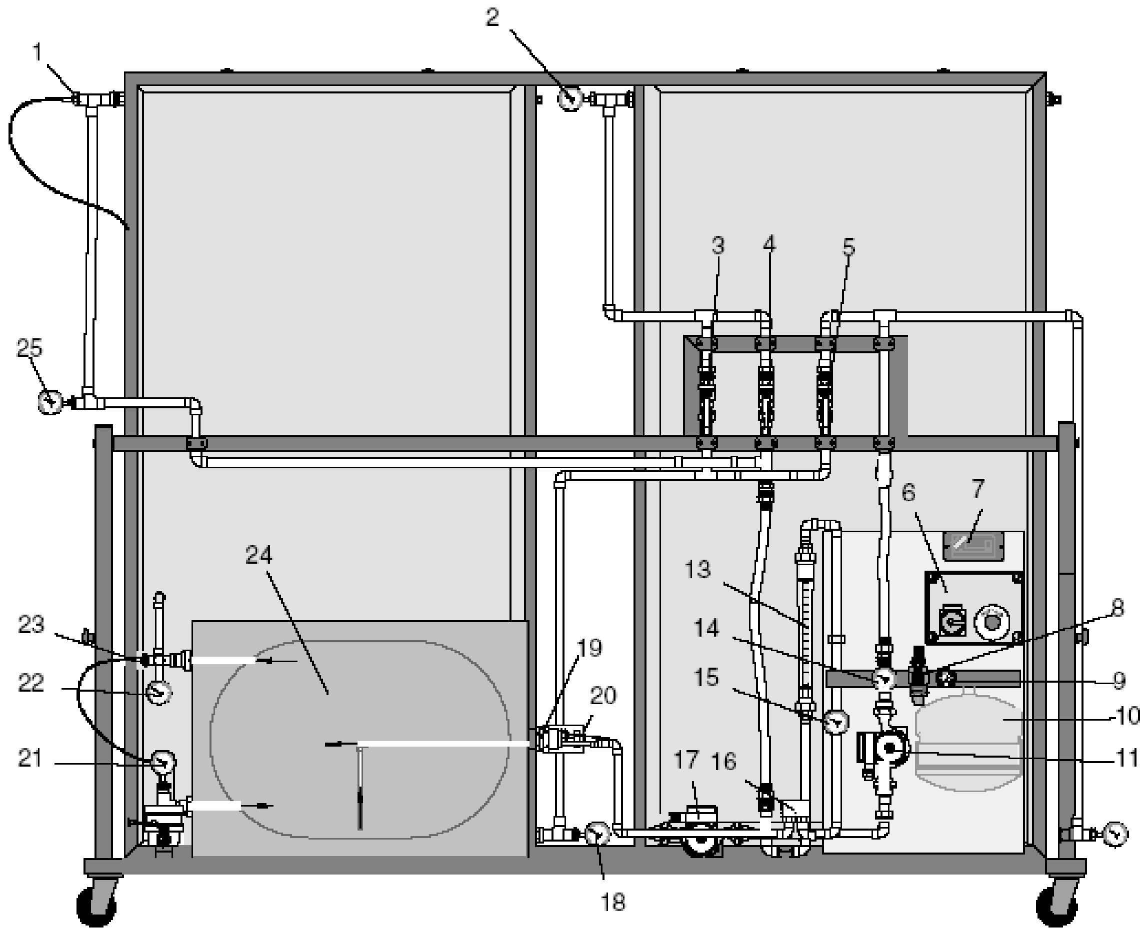


Fig. 1. Test rig for flat plate solar thermal collectors

The components of the stand, in the above figure numbered, are: 1 – collector sensor; 2 – thermometer, TI 1; 3 – ball-cock; 4 – ball-cock; 5 – ball-cock; 6 – switch box; 7

– temperature differential controller; 8 – safety valve; 9 – manometer; 10 – diaphragm expansion tank; 11 – pump for the solar circuit; 12 – thermometer, TI 2; 13 – variable area flow meter; 14 – thermometer for solar advance circuit, TV; 15 – thermometer for solar return circuit, TR; 16 – plate heat exchanger; 17 – pump for hot water circuit; 18 – thermometer, TI 3; 19 – auxiliary heating source; 20 – sensor of storage tank; 21 – thermometer, TI 5; 22 – thermometer, TI 6; 23 – temperature sensor of the auxiliay heating; 24 – storage tank; 25 – thermometer, TI4.

The tested system prepares hot water by transforming the solar radiation into heat. The solar radiation source is a sun simulator. The stand is equipped with two flat plate solar thermal collectors Bluetec (CosmoSOL) which can be connected separately, in series either in parallel.

The paper presents the way that the stand is adapted for two purposes: the possibility of testing different solar collectors and the possibility of automation the much precise adjustment of the solar radiation incidence angle.

2. CONSTRUCTIVE ELEMENTS FOR ADAPTING THE STAND

The design of constructive elements for adapting the stand started from a requirements list [2] which comprises: the changing should not affect the existing structure, which could be remade anytime; the possibility of mounting different solar collectors with surfaces till 2 m^2 should be created; emplacement of an automatic system for rotating the collectors.

In the existing structure, the collectors are mounted on a support made of L 40x40x3 profiles and the Bluetec collectors are assembled with rivets. Many other collectors are assembled on metalic structure in two ways: with clamps, mounted with screws (fig. 2, a), using the flange of the collector; with screws, using specific profiles (fig. 2, b) that can be monted also with clamps or with screws on another beam.

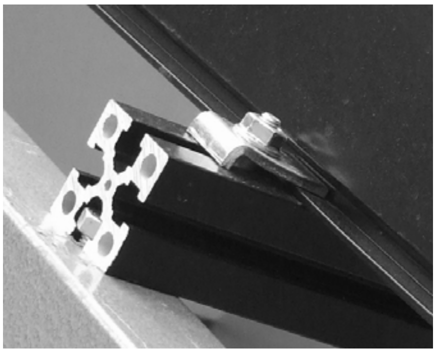
a  b 

Fig. 2. Systems for attaching colectors

The embodiment design of the adaptive structure of the testing stand was developed using 3D modelling with possibility of viewing the mounting and demounting issues and also simulating the movement with emphasise on touching between elements, because the existing space is very small.

For the possibility of attaching different kind of collectors, new elements have been added to the existing structure. The new structure is presented in fig. 3, with an existing Bluetec collector and a *Zenit* collector. There have been added, for each frame, two steel strips LT 70x3 on which the collector can be mounted with clamps on its flange or on another profile attached with screws (fig. 4, a – general, b – detail). The system gives the possibility of assembling, with specific assembling elements, of some solar collectors [8, 9]:

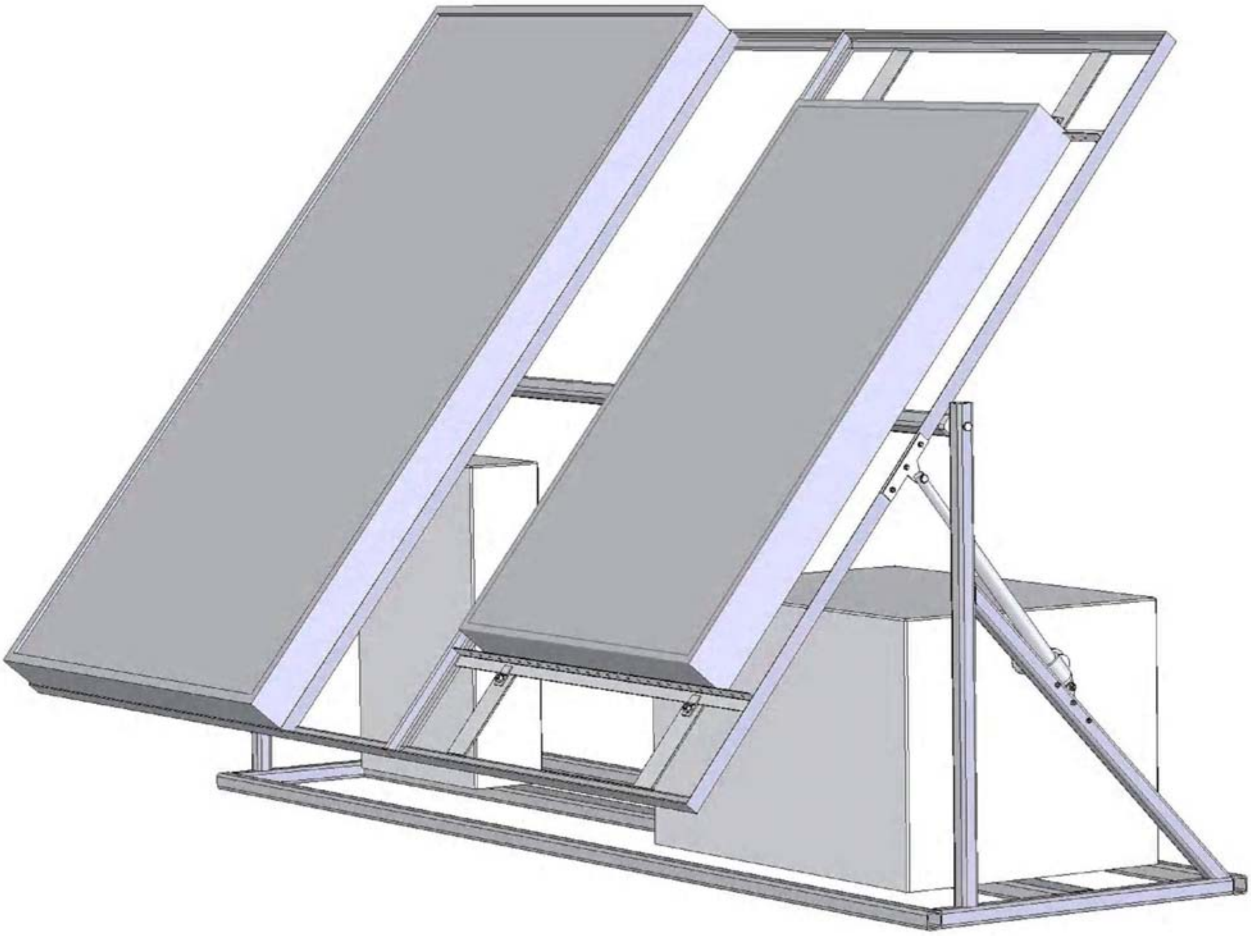


Fig. 3. Adaptive testing stand with two different collectors

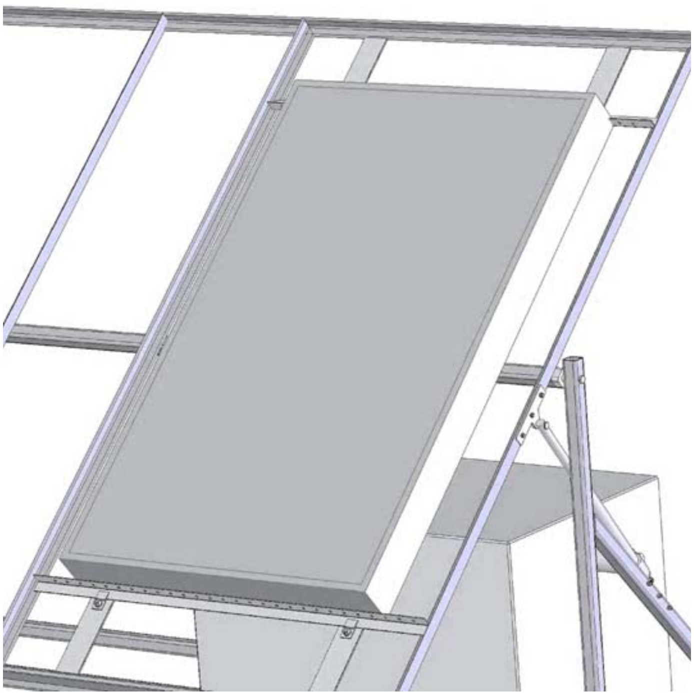
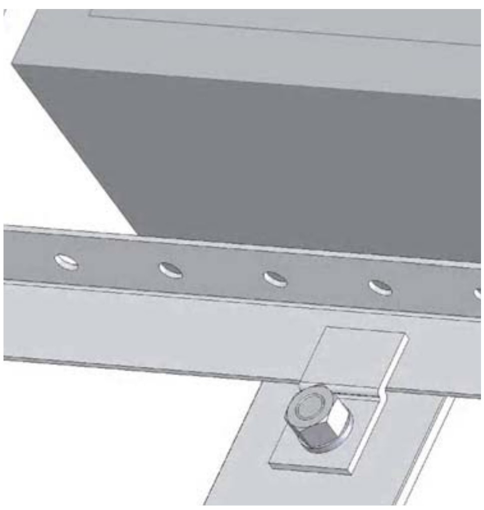
a  b 

Fig. 4. Elements for attaching different collectors (a – general; b – detail)

Zenit, *Wiessmann* (Vitosol 100, 200, 300); *Vaillant* (VFK 900S); *Wolf* (TopSun F3, CFK1, TRK); *ThermoSolar* (MT 180, 250, MagicSun); *Stiebel* (SOL 23, 25,27); *Redring*; *Bluetec*. Having a surface of approximately 5 m^2 the system permits, as far as the space permits, to assemble two identical collectors in horizontal either vertical position (maximum of 2 m^2) or a single one. In case of testing two collectors, the option of series or parallel configuration exists. The connection to the fluid circuit is made through four fixed plugs with the help of flexible tubes.

For the tracking system's automation, a system with linear actuator ATL 05 24 V DC C300 RL1 produced by **Servomech** Italy was designed (see fig. 3). The actuator has a maximum stroke of 280 mm, between minimum position (closed) and the maximum position (opened). The actuator has two joints, one on the stand's abutment and another on the collector's abutment panel. The frame of the solar collectors can make a tracking movement with an angle of the plane with the vertical between 0 and 90° (fig. 5 a and b).

The actuator has two cylindrical joints, one on the support of the structure and another one on the support frame of the collectors. Two identical 3 mm plate elements attached with three screws on the existing structure. The geometry of the linkage bar mechanism has been chosed in order to avoid small pressure angles. The smallest pressure angles are reached at the extreme positions (vertical and horizontal plane of collectors). The active stroke of the actuator is in fact of 240 mm. As it can be seen from fig. 5, a, the vertical position of the collectors is obtained at a 40 mm starting displacement of the actuator. This distance has been choosed, first of all, in order to avoid touching between the cylinder of the actuator and the vertical beam of the structure.

A specific position of the mechanism is presented in figure 6, when the pressure angle of the mechanism is 90°. At this position, the cylinder of the actuator is closing with its upper part to the vertical beam of the structure (fig. 6, b) and also closing with its inner part to the inclined beam of the support (fig. 6, c). Even if the axis of the actuator's cylinder is not in the same plane with the the axes of the two beams of the support, the details from figure 6 show that there is enough space between elements.

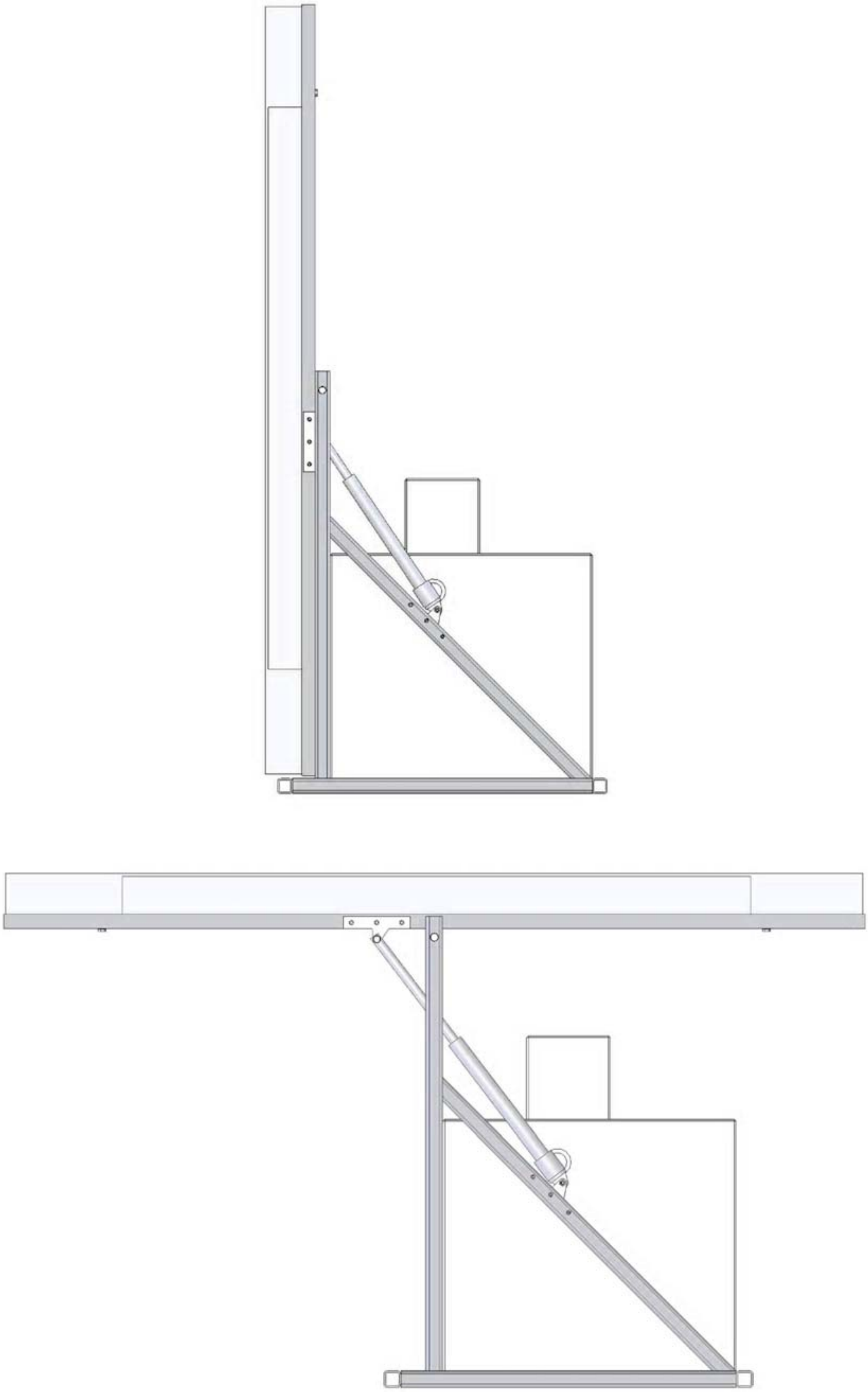
The bolts from joints have a diameter of 10 mm and the diameter of the moving bar of the actuator, joining with the frame of collectors is 22 mm. There is a space problem since the moving bar of the actuator must work, between the vertical beam of the support and the frame of the collectors, on a space of aprox. 30 mm.

Figure 7 presents a view from the back of the testing stand and also a detail view with the remaining space. The final solution leaves an aprox. 2 mm space between the bolt of the joint and the vertical beam of the support.

3. TESTING ALGORITHM

The stand's parameters, used as input data in the testing algorithm are:

- total area of collectors, A_G,
- area of absorbers A_A and active surface of the collectors A_a;
- fluid heat capacity;
- the radiation of sun simulator on the active surface of the collector;
- inclination angle of the collector;
- the wind speed which is parallel with the surface of the collector;
- ambient temperature;
- liquid heat carrier temperature at collector input.



a

b

Fig. 5. Extremal positions for collectors (a – vertical; b – horizontal)

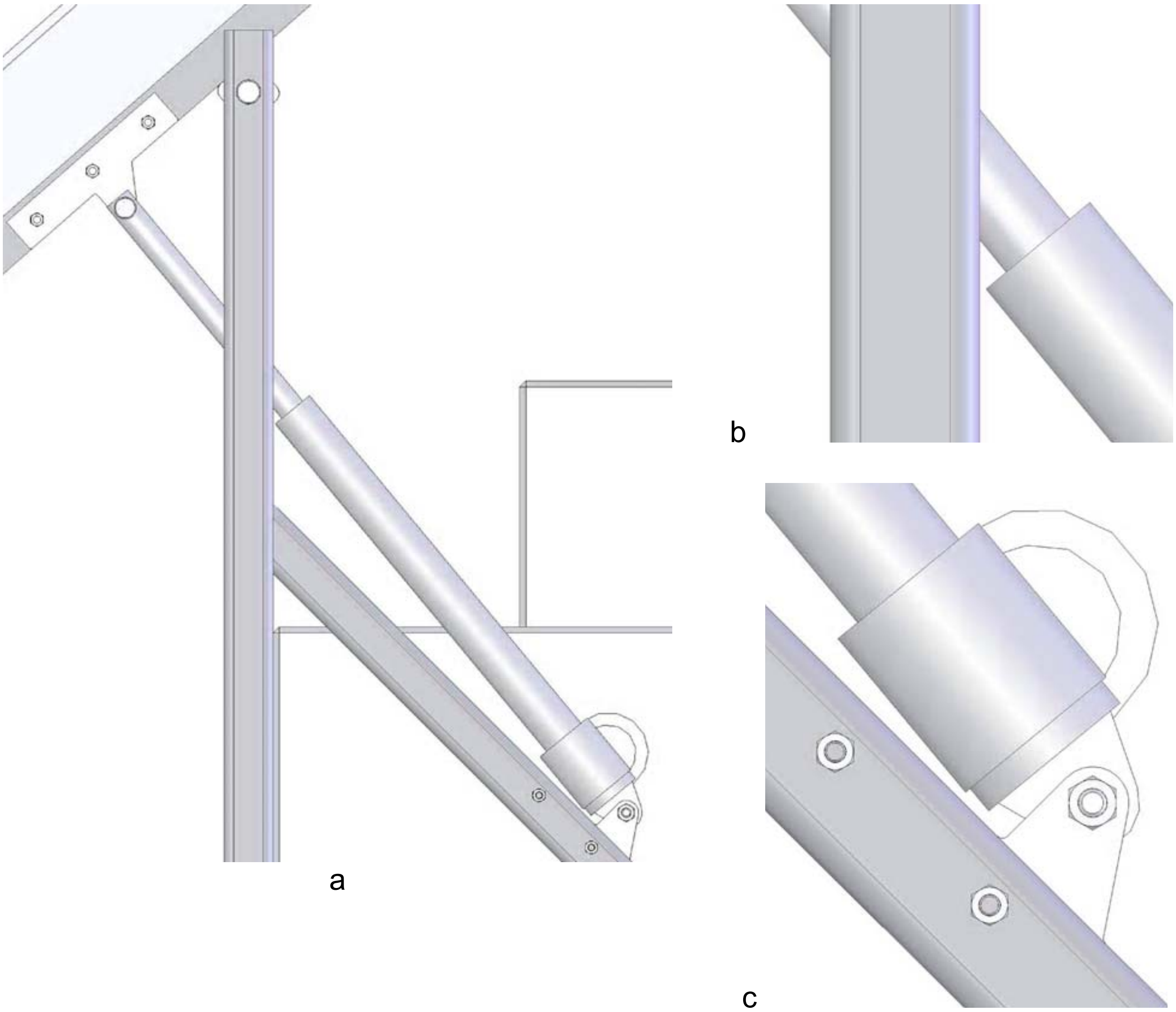


Fig. 6. Space problems of the actuator's cylinder, solved for a specific position (a – general; b, c – details)

The output data which can be measured are:

- temperature of heat carrier at output of collectors;
- liquid heat carrier flow rate.

The testing algorithm for obtaining performance criteria of collectors was elaborated in order to determine:

- the collectors' efficiency;
- the absorbed heat of the heat exchanger;
- the stocked energy
- tracking system testing.

The following lines present the general stages of the testing algorithm for the efficiency of collectors:

1. assembling the panels;
2. inspecting and preparing the panels;
3. configuring the collectors' circuit; the configuration is established, series either parallel, through the ball cocks 3, 4, 5, (see figure 1);

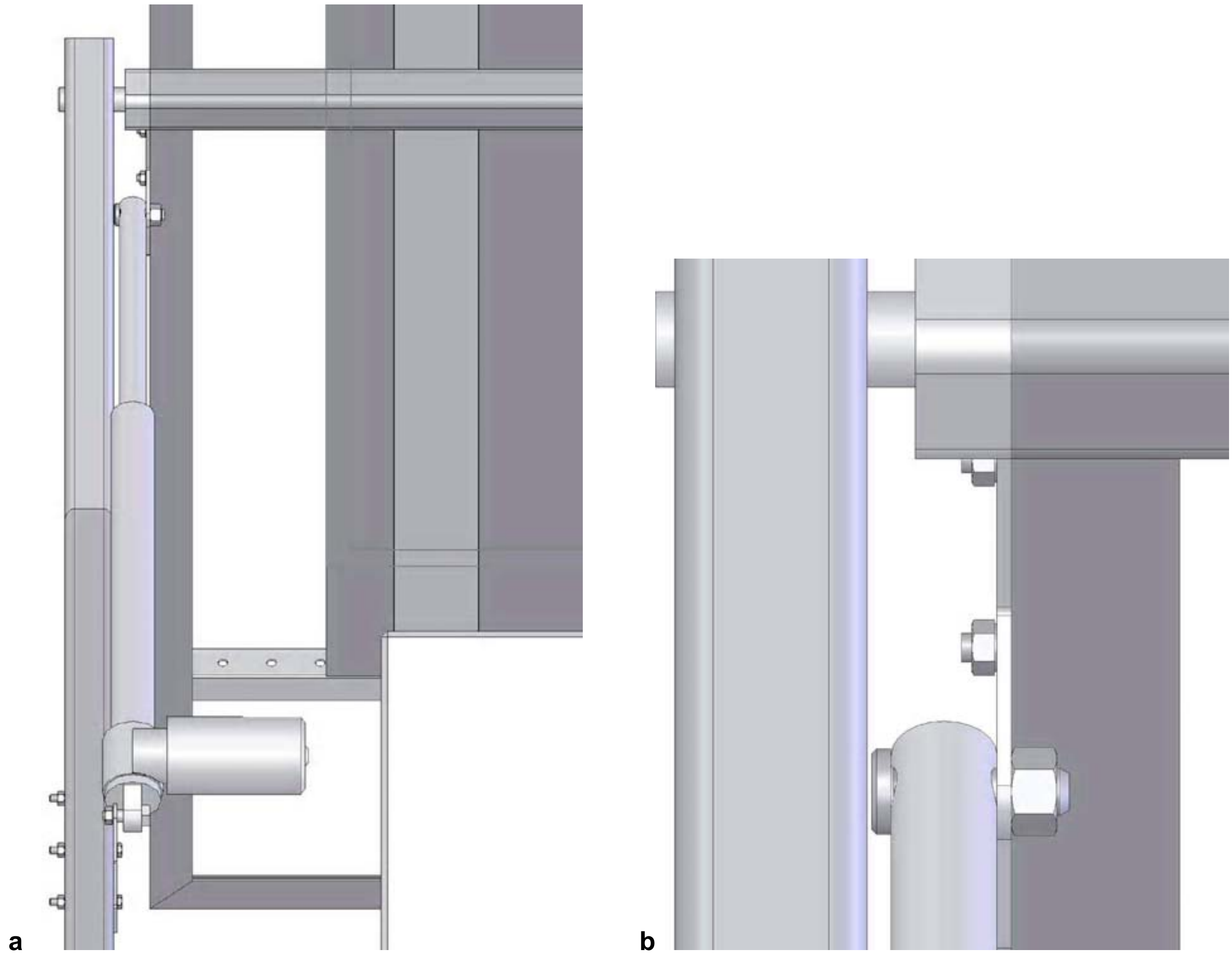


Fig. 7. Space problems of the actuator's cylinder, solved for a specific position (a – general; b, c – details)

4. setting the incidence angle of sun simulator radiation angle on the collector's surface $\alpha = 0^0...90^0$.
5. measuring the sun simulator irradiance;
6. measuring the characteristic temperatures: at collector 1 entrance (12); at collector 1 output (2); at collector 2 entrance (18); at collector 2 output (25); at output from storage tank (22), at even time gaps, for an initially established period;
7. measuring the flow rate (13);
8. collectors' efficiency determination;
9. measurement of input and output temperatures from the heat exchanger;
10. determining the storage heat of heat exchanger;
11. determining the water quantity;
12. determining the temperatures from the storage tank;
13. determining of stored energy.

In order to test the efficiency of a tracking system, the stages from the algorithm of collector's efficiency testing, for the normal incidence of the radiation on the collectors' surface (corresponding to the tracking movement of the sun) are followed. For comparison, the testing for different incidence angles of the radiation on collectors' surface, modified at certain time ranges, determined through the control device of the tracking system with linear actuator and the corresponding software, which simulates the sun trace on the sky, versus the fixed collectors, are repeated. In this way, the tracking system's efficiency of solar collectors with comparative analysis with the results of tests in the reference situation (without tracking system), are made.

References

[1]. GALLOWAY, T. *Solar House – A guide for the solar designer*, Architectural Press – Elsevier, UK, 2005
[2]. PAHL, G., BEITZ,W., *Engineering Design*, Springer, London, 1995.
[3]. PEUSER, F. A. a.o. *Solar Thermal Systems – Successful Planning and Construction*, Solarpraxis AG, Berlin, 2002.
[4]. TIWARI, G. N. *Solar Energy – Fundamentals, Design, Modelling and Applications.* Alpha Science International Ltd., India, 2002.
[5]. UBERTINI, S.; DESIDERI, U. *Design of a solar collector for year-round climatization*. In: Renewable Energy Journal, Vol.28 Issue.4, 2003.
[6]. VELICU, R. *Organe de maşini*. Editura Universităţii "Transilvania" din Braşov, 2003
[7]. WEISS, W. a.o. *Solar Heating Systems for Houses – A Design Handbook For Solar Combisystems.* The Cromwell Press, UK, 2003.
[8]. www.zenit.fr
[9]. www.viessmann.com
[10]. www.solara.ro