

CONTRIBUTIONS REGARDING THE DEVELOPMENT OF NEW TYPES OF SOLAR ACTUATORS

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ABSTRACT

The paper presents the authors' contributions to the development of solar actuators with bimetallic band and Bourdon tube in the EMAD Research Centre of "Ștefan cel Mare" University of Suceava. The solutions and the experimental devices are described with their peculiarities and advantages. The paper ends with main conclusions about the testing of the actuators and their practical implementation.

KEYWORDS: bimetallic band, Bourdon tube, actuator

1. General considerations

Within the EMAD Research Center of the USV, a number of solutions have been developed since 1996 in heliothermic actuators and motors area made based on solid heating medium [3].

The solutions relate to rotary actuators and motors as well as linear actuators with limited movement.

This study presents the primary constructive solutions with their peculiarities and the general conclusion regarding the experimentation and practical implementation.

By solid heating medium is obtained a thermo-bimetal or a shape memory material after the action of temperature.

In technical applications, thermo-bimetals are widely used because at temperature variation they can produce:

- movement due to deformation;
- force due to internal stresses that occur if external forces prevent strain production.

Both of these effects can be achieved with thermo-bimetals of different forms, such as: hogging thin bands, U shaped work where the angular aperture varies, twisting contrivance or helical spiral, discs whose bend varies, as it is shown in Figure 1.

Overall technical applications were used for the combined effect of force and motion production by a heated thermo-bimetal. The two effects are applied in sequence or simultaneously. For example, a bimetallic band embedded at one termination can

operate as a pawl. By heating and moving the band hogs at the free point, proportional to the temperature, until the pawl comes in contact with it, the movement ceases in practice. By raising the temperature further, internal stresses occur which increase proportionally to temperature until they achieve the value necessary to operate the pawl. Then the bimetallic piece can close or disclose a contact [3].



a)



b)



c)

Fig. 1. Thermo-bimetallic modules
 a) bimetallic arc modeled after a cylindrical helical path; b) bimetallic arc modeled after a conical helical path; c) bimetallic arc curved – performed in "U" shape [3]

In this way, numerous constructions used in electrotechnics operate to actuate a process when limit temperature is reached, such as: overload protection relay and temperature controller (thermostat for warming pads or chambers, flattening mills with regulators, warmers, baking machines, etc.).

Another one is the operation of a helical band in the form of an arc, made of thermo-bimetal, that must overcome the elastic force of a spring. The thermo-bimetal member, through heating, deforms and acts with a force over the spring, compressing it. Increasing the resistance force of the spring, as it is compressed, proportionally to the extent of deformation, prevents the thermo-bimetal movement. The thermo-bimetal will continuously shift on an increasingly smaller distance, as the spring elastic force does not increase proportionally to the temperature variation.

2. Heliothermic mixed actuator with parabolic concentrator

One of the solutions achieved in the EMAD Research Center is the heliothermic mixed actuator consisting of a mechanical converter with thermo-bimetallic band associated with a thermo-mechanical converter with paraffin, both placed in the solar concentrator focusing point as it is presented in Figures 2 and 3.

The solution is made of a bimetallic band 1, modeled after a spiral arc with several coils, embedded in a paraffin based thermo-conductor agent 2, contained in a flat cylindrical container 3, sealed and placed through a cannular fastening piece 4 in the parabolic concentrator focusing point 5, fixed in turn by an adjusting bolster with toggle joint 6 on a supporting surface 7. The bimetallic band 1 is anchored to the inner wall of the container 3, and the inner end of the axle with pap which is supported in a sliding bearing sealed through an insertion. The axle stub is connected through a mechanical thimble 8 to a flexible axle, positioned within the tubular support 4, which actuates the associated mechanism.

To compensate the volume variations of the agent 2 at the transition from the solid to the liquid phase, under the solar radiation action, it is used an assembly consisting of two Bourdon tubes 10 and 10' positioned coaxially and coplanar. Through the collecting channels 11 and 11', the Bourdon tubes are clamped to the cylindrical surface of the container 3 and are connected at the same time to the thermo-conductor agent 2.

The molten paraffin discharged to the 10 and 10' Bourdon tubes determines, through the pressure created, their outwards deformation. In the manner described, the deformation is converted, through a bar

with spool and spring 12 and 12', in linear drive, and transmitted to other two mechanisms.

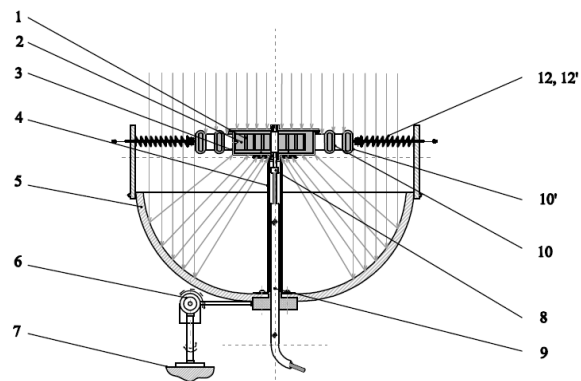


Fig. 2. Longitudinal section through the heliothermic mixed actuator with parabolic concentrator [1]

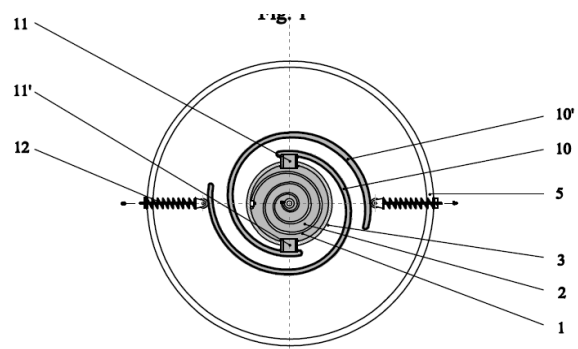


Fig. 3. Transverse section through the heliothermic mixed actuator with parabolic concentrator [1]

The advantages of the solution are:

- increased number of operable elements;
- reduced size;
- construction simplicity.

3. Heliothermic mixed actuator with a cylindrical – parabolic concentrator

Another solution is shown in Figure 4 and is made through a thermo-bimetallic converter associated with a thermo-mechanical converter with paraffin and piston together with a thermo-mechanical converter with paraffin and Bourdon tube.

The heliothermic mixed actuator consists of a bimetallic band 1, shaped as a coiled layout and placed within a tubular container 2 made of brass and closed by a bonnet 2', sealed through an insertion 2''. Inside the tubular container 2, a thermo-mechanical converter with paraffin and piston 3 is placed

coaxially with the bimetallic band 1, fixed to the mentioned bonnet and sealed with another insertion 3'. The container 2 is filled with a thermo-conductor agent 4 consisting of paraffin, which facilitates the heat transmission from the container metallic wall to the two converter elements represented by the thermo-bimetallic band and the thermo-mechanical converter with paraffin and Bourdon tube. At the container free tip, it is placed another thermo-mechanical actuator, with bilateral action, that consists of two Bourdon tubes 5 and 5', connected to the container by means of the collecting canals 6 and 6'.

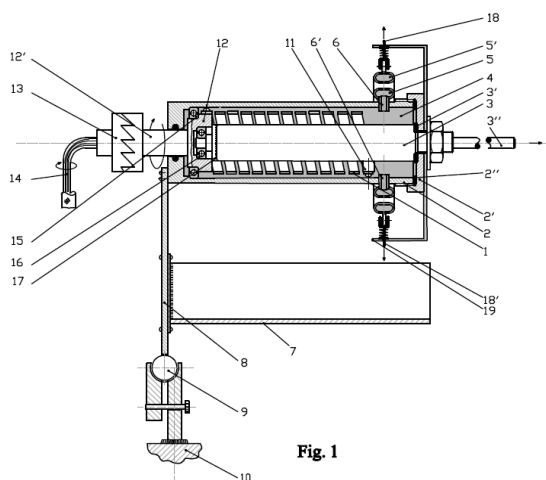


Fig. 1

Fig. 4. Longitudinal section through the heliothermic mixed actuator with cylindrical-parabolic concentrator [2]

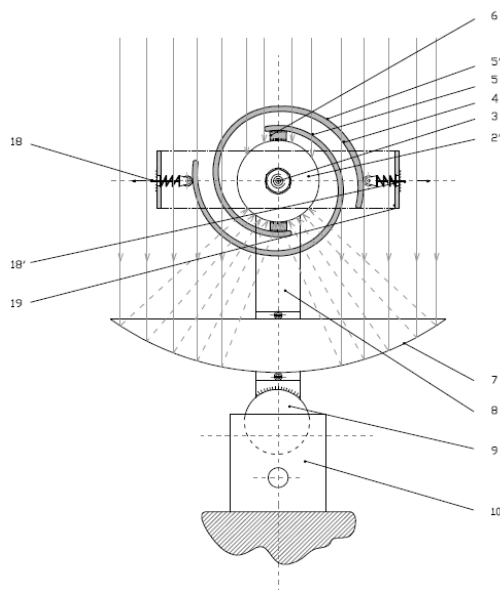


Fig. 5. Transverse section through the heliothermic mixed actuator with cylindrical-parabolic concentrator [2]

The cylindrical container is exposed to direct and reflected solar radiation through a cylindricalparabolic concentrator 7.

As previously mentioned, the thermo-bimetallic converter and the thermo-mechanical converter with paraffin and piston are placed within the container. One of the thermo-bimetallic band tips is fixed to the inner wall of the container 2 by means of a screw support 11. The other tip is fixed of a pap 12, which is integral with a rigid axle 12' provided in its extension with a flexible axle 14 which connects the thermo-bimetallic converter to the driven element, that is not represented in the figure.

The pap 12 is fixed in regard to the container 2 through a ball bearing 15, and in relation to the thermo-mechanical converter through the ball bearing 16 and the pap 17. The Bourdon tube deformation is transmitted to a bar with spool and spring 18 and 18' mounted in a support frame 19.

The system has the advantage of complete capitalization of the effects generated by changing the paraffin state of aggregation: using it as heat-transfer agent to a complete and fast excitation of the thermo-bimetallic converter and the thermo-mechanical converter placed coaxially within the first; the agent volume compensation and production of power and drive through the thermo-mechanical converter with Bourdon tubes.

4. Conclusions

1. The paper presents the authors' contributions to the development of solar actuators with bimetallic band and Bourdon tube in the EMAD Research Centre of "Ștefan cel Mare" University of Suceava.

2. One of the solutions achieved in the EMAD Research Center is the heliothermic mixed actuator made of a mechanical converter with thermo-bimetallic band associated with a thermo-mechanical converter with paraffin, both placed in a solar concentrator focusing point.

3. Another solution is the heliothermic mixed actuator with cylindrical parabolic concentrator that is made of a thermo-bimetallic converter associated with a thermo-mechanical converter with paraffin and piston together with a thermo-mechanical converter with paraffin and Bourdon tube.

4. The solutions present a series of advantages, such as: an increased number of operable elements, construction simplicity, reduced gauge.

References

[1]. Cernomazu D., Poienar M., Romanescu A. N., Țanța O. M., Prodan C., Georgescu D. Ș., Nițan I., Olariu E. D., Ungureanu C., Rață M., *Actuator heliothermic mixt*, Cerere de brevet de invenție nr A/00619 din 13.08.2014.



- [2]. **Cernomazu D., Poienar M., Romanescu A. N., Ţanţa O. M., Prodan C., Georgescu D. Ş., Niţan I., Olariu E. D., Ungureanu C., Raţă M.**, *Actuator heliotermic mixt cu concentrator parabolic*, Cerere de brevet de invenţie nr A/00620 din 13.08.2014.
- [3]. **Romanescu A. N, Ţanţa O. M, Poienar M., Niţan I., Ungureanu C., Mandici L., Cernomazu D.**, *Current state of*

research at the EMAD Research Center from „Ştefan cel Mare” University in connection with actuators and solar motors with solid heating medium, In: Analele Universităţii „Eftimie Murgu” Reşiţa, Fascicula de Inginerie, anul XXI, nr. 2, 2014, p. 123 – 134, ISSN: 1453-7397.