STUDY OF TRANSIENT REGIME AT THE ELECTROMECHANICAL PARAFFIN ACTUATORS

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REZUMAT. Actuatoarele au devenit rapid elemente-cheie pentru îmbunătăţirea performanţelor generale ale sistemelor de acţionare motiv pentru care aceasta lucrare investigează factorii care pot influenţa caracteristicile de performanţă ale actuatoarelor cu parafină în varianta cu piston.

Cuvinte cheie: actuator, funcţie indicială, parafină.

ABSTRACT. Actuators have rapidly becoming key elements for improving the overall performances of drive systems for which reason this paper investigating the factors that can influence the performance characteristics of paraffin actuators with piston

Keywords: actuator, indexical functions, paraffin,

1. INTRODUCTION

Advanced automation and miniaturization, found today in all areas of engineering, require further development of a wide range of safe and compact drives in most modern systems. Speed and precision that control mechanical processes and systems represent parameters of particular importance. Actuators have quickly become key elements that improve overall performance of existing products, thus adding additional features or leading to the emergence of new products that could not have been achieved before.

Thermal actuators are composed of active elements which convert thermal energy into mechanical energy or useful action (in motion). Thermal energy conversion is based on the phenomenon of expansion of active solid, liquid or gaseous elements, or on the passing from one phase to another.

Command and control signal applied to the source determines the heat transfer to the actuator active elements, such as gas, liquid or solid, which either expand or undergo a phase transformation accompanied by limited deformation. The associated mechanical structures allow the deformations and forces / torques developed by the active elements to be amplified and converted into mechanical work.

According to the general theory of systems, the electromechanical paraffin actuator represents technical dynamic systems and these and be studied using mathematical model through indexical functions.

If a dynamic system is represented by a mathematical model, then both its nature and its performance can be known by studying response, in time, at typical inputs such as: step signal, ramp signal or harmonic functions.

Generally, to determine indexical functions, for a given regime, value of input signal must be about 5…15% of its maximum possible value. Not recommended increasing the input signal because it leads to increase influence of object nonlinearity and finally it obtains the important deformations of process.

2. STUDY OF THE HEAT SOURCE INFLUENCE REGARDING THE MATHEMATICAL MODEL CONFIGURATION OF ACTUATOR

The paraffin electromechanical actuator is a dynamic technical system, which, according to general systems theory, can be studied using the mathematical model using unit step functions and frequency characteristics. In this paper, investigations were limited to the unit step functions domain, which have highlighted some key parameters, such as speed of transient regime, delay, response time, amplification coefficient.

For study the heat source influence on mathematical model configuration and transient regime performance were taken into account the following cases: internal heat sources represented by resistors or

PTC heating elements (heating elements with positive temperature coefficient) and external heat sources represented by a heating fluid or a battery with Peltier elements.

The output signal is represented, for both situations by the displacement variation of rod actuator due to dilatation of paraffin stored inside the enclosure actuator.

Model of investigated paraffin actuator is shown in Figure 1, is used in practice in: the washing machine, cooking devices and in ventilation systems and consists mainly of a housing 1, made of a plastic, that has inside a rectangular metal container by steel 2, in which is stored a quantity of paraffin. This container is provided with a rod 3 which as a result of warming paraffin actuator acts with substantial force on a piston 4 which is returned to original position by a return spring 5.

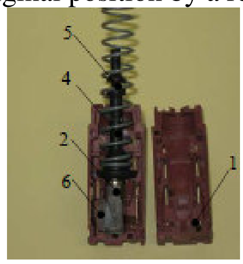
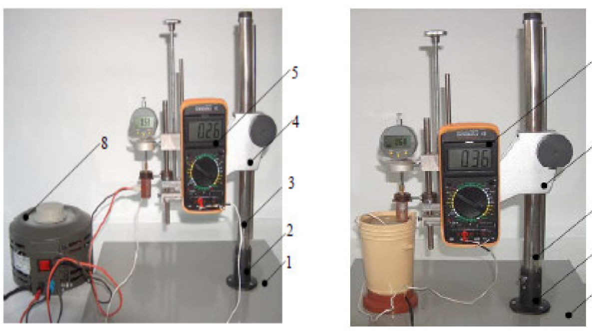


Fig. 1 Paraffin actuator

1 - housing; 2 - metal container; 3 - rod;4 - piston;
5 - return spring; 6 - heating source

In the first case (figure 2.a), heater source of paraffin actuator is located inside the housing on surface of the metal container and is represented by a PTC resistor powered by an alternative power source. Experimental tests were performed for the following values of the input signal applied to actuator: 90V, 105V, 120V, 145V and 170V.



a) **b)**

Fig. 2 Experimental stand of the actuator

a) internal heat sources represented by resistors or PTC heating elements; b) external heat sources represented by a heating fluid

Identifying of equations analyzed processes was based on the following equation:

$$T\frac{dx_e(t)}{dt} + x_e(t) = kx_i(t - T_m)$$

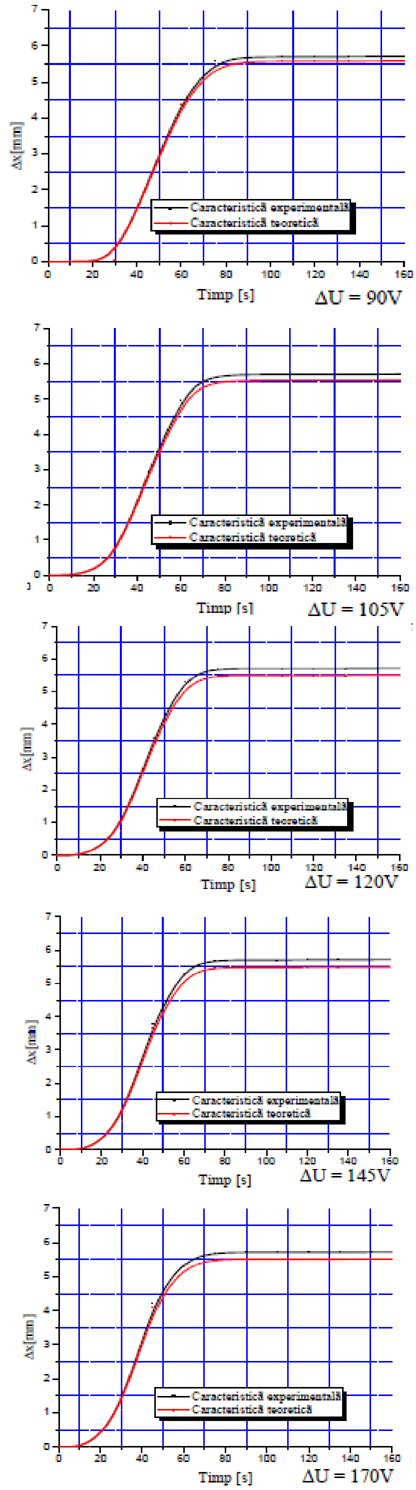
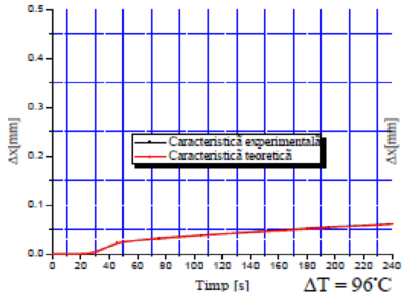


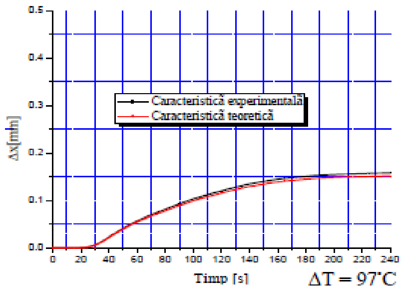
Fig. 3 Experimental and theoretical dynamic characteristics for paraffin actuator in case of the internal heat source is represented by heating elements with positive temperature coefficient

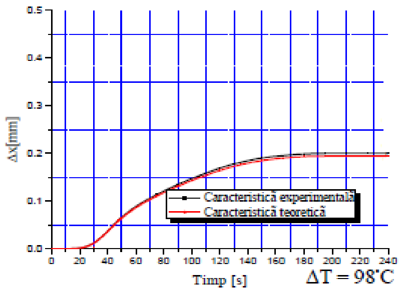
In Figure 3 are presented the experimental indexical functions of paraffin actuator, due to heating of paraffin actuator for the five values of voltage PTC heating element, compared with the theoretical characteristics resulted by identifying the process equation.

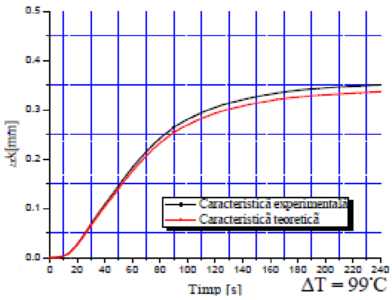
Experimental tests performed by the authors show that the mathematical model associated of the electromechanical paraffin actuators with piston activated by a PTC heating element is represented by an element of PT1Tm type.

In the second case of the experiments, actuator activation was achieved by using an external heat source, represented by heating fluid. Thus, paraffin actuator structure was modified by removing the PTC heating element and the housing of actuator so that it is allowed to enter the heating fluid. Experimental tests were performed for the following values of the input signal applied to actuator: 96ºC, 97 ºC, 98ºC, 99ºC and 100ºC.









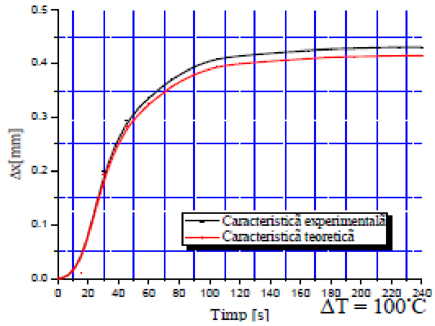


Fig. 4 Experimental and theoretical dynamic characteristics for paraffin actuator in case of the external heat source is represented by heating fluid

The indexical responses obtained by heating process of the actuator, for all values of input signal indicates, as with actuator activated by a heating resistor PTC, PT1Tm type element.

In Figure 4 are presented the experimental indexical functions of paraffin actuator, due to heating of paraffin actuator for the five values of heating fluid, compared with the theoretical characteristics resulted by identifying the process equation.

As a result, analysis of the characteristics was concluded that there is a relationship of dependence between the value of input signal applied to actuator and duration of this transient regime.

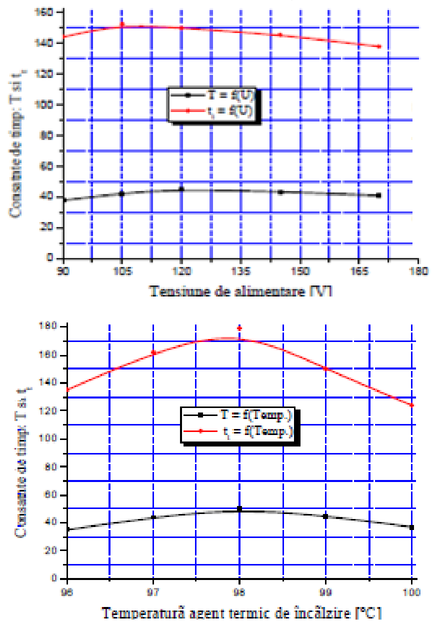


Fig.5 Variation curves of constants ***T*** and t_t

In figure 5 are presented compared, evolutions of the time constants in depending on the size the input for all studied paraffin actuators and above and was concluded that the variation curves of constants T and t_t show a continuous decreasing trend with increasing of the input signal applied.

3. CONCLUSIONS

The study led to the following conclusions:

- in the case of heating resistance, the heating fluid and Peltier elements battery, we recorded an increase in system speed, accompanied by amplitude increase of the input level;
- in the above cases, the variation curves of constants T and t_t show a continuous decreasing trend with increasing of the input signal applied;
- in the case of heating resistance and Peltier elements battery, the evolution of time constants T and t_t has the same trend;
- time constant T and t_t during transient regime for the PTC heating element recorded (heating element with positive temperature coefficient) a particular development, due to the nonlinearity of these elements.

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