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CONTRIBUTIONS REGARDING THE OPTIMIZATION OF THE THERMOMECHANICAL ACTUATORS WITH PARAFFIN

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***Abstract* – The purpose of this work consist in the optimization projection of the thermomechanical actuators with paraffin. In this purpose has been realized an experimental work what contains the following stages:**
- the realization of a paraffin mixtures with different substances with the object of improvementing the paraffin properties;
- for the experimental visualization of the temperature distribution it was used a method based on a thermo-signallizer substance: cobalt chloride;
- for the uniformalize temperature field they were diped in the paraffin volume diverse shapes realized by cooper. The importance of the study of the paraffin actuators is justified by the international tendencies for find and make new models for the actuation and control devices with small dimensions, economical costs and easy for manipulation. In the end of the study are presented the resulted conclusions after the experimental study and are established the future directions of research.
This paper provides an example of the layout and style for the paper submissions for the SIELMEN 2007 conference. Paper submission information is also discussed.

Keywords: *thermomechanical actuator, paraffin, cobalt chloride, mixtures, cooper.*

1. INTRODUCTION

Thermomechanical actuators with paraffin are knowed in technique and are used as part of actuators mechanism tagged of geometric reduced sizes, constructive simplicity and easy operation. As a matter or fact, they can be definite such as little containers with mobile pistons. On heating, the paraffin is melted, the process is accompanied of an importance increase of volume which moves the piston. On cooling, is passed the inverse conversion, but is necessary the presence of an opposing spring for the return of the piston in initial position.
The paraffin actuator uses the volume expansion of paraffin that occurs during the solid to liquid phase change in order to produce mechanical work in the form linear motion of the piston.

The utilization of the paraffin as a working medium for the thermomechanical actuators with paraffin involves some disadvantages, namely:

- the paraffin has only a very small thermal conductivity of about 0.24 W/mK [2]; however the addition of additives such as graphite or copper, could increase the thermal conductivity; it is desirable to increase thermal conductivity of paraffin in thermal actuator applications to facilitate heat transfer and ultimately cycle time of the actuator device;
- a provocative particularity for this type of actuator is sealing of a recipient with paraffin; the utilization of the paraffin for the thermomechanical actuators involves matters in connection with tightness or paraffin leakages from the recipient;
- non-uniformity of the distribution of the temperature pattern in volume of paraffin.

2. PARAFFIN MIXTURES WITH DIFFERENT SUBSTANCES

In the aim of the optimization projection of the actuators with paraffin it was realized a study of paraffin mixtures with different substances. Thus, the paraffin it was mixed with different substances, for the improvement the properties of the paraffin, as follows: aluminum, copper, bronze, zinc, asphalt, ferrofluid, graphite, metallographite, electrographite, electrostatic developer, silica gel, etc. Because, I obtained some interesting results about the paraffin-graphite mixture, in the following part of my project is exposed an experimental study concerning the mixture before mentioned.
In conclusion, I combined paraffin in liquid form with graphite powder (electrographite, metallographite) and I obtained a mixture for which I realized plotting of static characteristics $\Delta\theta(t)$ namely temperature-time variation, presented in figure 1.

To obtain the conclusions has been elaborated a test programme that contains the following mixtures:

- 100% paraffin;
- 60%paraffin and 40% graphite;
- 40% paraffin and 60%graphite;
- 50% paraffin and 50%graphite;
- 80% paraffin and 20% metallographite;
- 70% paraffin and 30%metallographite;
- 80% paraffin and 20% electrographite.

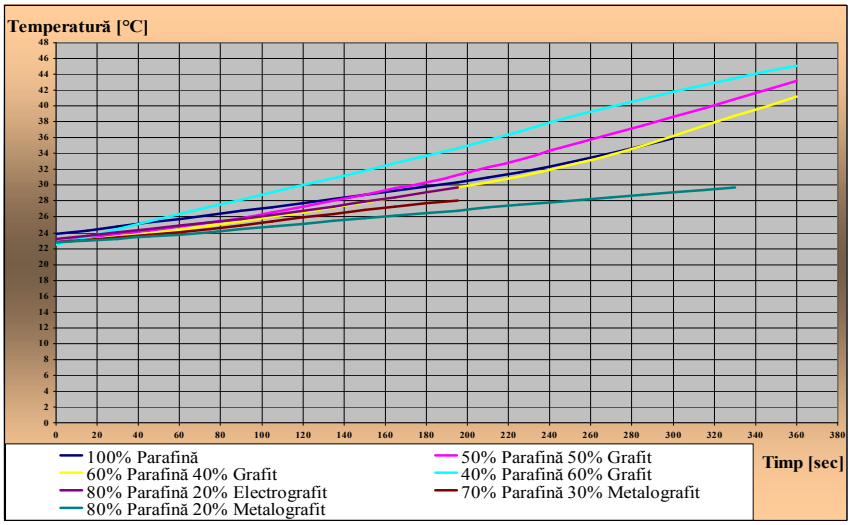


Figure 1: The static characteristics for the mixture paraffin – graphite.

As a result of the effectuated study it has been found that:

- the heat transfer rate of the paraffin-graphite composite was obviously higher than that of the paraffin due to the combination with the graphite which had a high thermal conductivity;
- the mixture prevents leakage of the melted paraffin through its porous structure of the graphite which presents an excellent absorbability;
- the characteristics of the mixture which contains 50% paraffin and 50% graphite, respective 40% paraffin and 60% graphite are higher of the paraffin characteristic;
- the characteristic of the mixture which contains 60% paraffin and 40% graphite, is lower than the paraffin characteristic;

In conclusions, with how much the percent graphite is higher the paraffin-graphite mixture presents a greater heat-transfer rate.

3. THE EXPERIMENTAL VISUALITION OF THE DISTRIBUTION OF THE TEMPERATURE FIELD

In the aim of the optimization design of the actuators with paraffin it was realized an experimental study in connection with the evolution of the thermal process inside the actuator which highlighted that the evolution is realized non-uniform, being registered, among the issues, a superior temperature in the high side of the actuator and an inferior temperature at its lower part.

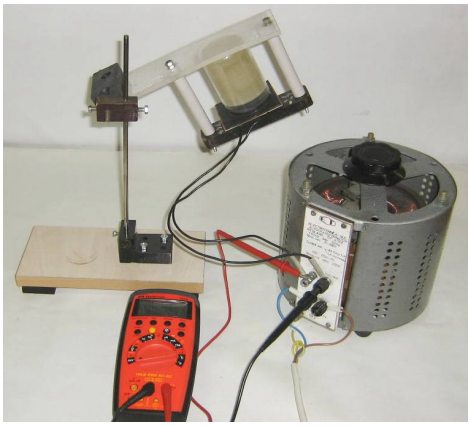
For the experimental visualization of the distribution of the temperature field it was used a method based on thermo-indicator substance, made from solution of cobalt chloride. Practically, it's used the chloride cobalt property modifies the color depending on water amount contained.

The support which is obtained the distribution of the temperature field is constituted from a impregnated solution of chloride cobalt on a textile support made of paper or linen.

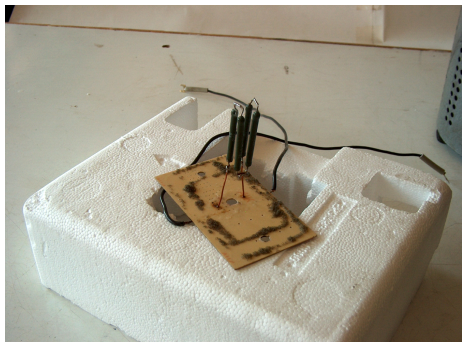
Concerning the type of the paper, it was studious the following variants:

- ✓ impregnated absorbent paper with solution of chloride cobalt;
- ✓ impregnated calking paper with solution of chloride cobalt;
- ✓ impregnated writing paper with solution of chloride cobalt.

Considering the experimental study, it has been conceived a test stand (figure 2), mainly made up of an adjustable source of alternating current, a voltameter and a miliampermeter.



a)



b)

Figure 2: a) Contributions regarding the realization of an experimental stand for the study of the distribution of temperature field in volume of paraffin; b) heating resistors.

The adjustable source has been connected through the mentioned measurement group, at the test platform, mainly constituted of a cylindrical glass recipient, heat resistant, in which is introduced the melted paraffin and in which is immersed the heating group constituted of four heating resistances (presented in figure 2).

The glass recipient is covered by an electroinsulating cap, fixed on two vertical supports, that also sustain the two terminals used to make the connection with the power unit. The paper support impregnated with solution of chloride cobalt, it was convolute on surface of the recipient who contains paraffin. The best results were obtained for variant with impregnated absorbent paper with solution of the cobalt chloride.

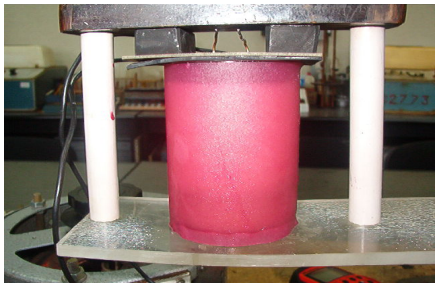


Figure 3: The evolution of the thermal process.

Because of the heating effect or of the melting paraffin, the water from de chloride cobalt will evaporated, permiting thus, the visualization of distribution of the temperature field.

Under the action of the emitted heat due to melting of the paraffin, the water contained of the

signallizer support, it's evaporated, which conducts to the modification color of the layer from pink-violet in blue.

THE UNIFORMALIZE OF THE TEMPERATURE FIELD

For the uniformalization of the temperature field and for the increase of thermal conductivity, were immersed, in paraffin volume, two forms made of copper, like in the following images:

Figure 4: Different forms realized from cooper.

After the effectuation of experimental study, has been observed the fact that the necessary time for the melting of the paraffin it was reduced, which means that we could realize a variant of an actuator with a smaller operating time.

CONCLUSIONS

- The addition of conductive material make increase the thermal conductivity of the paraffin-based medium; however, like any heterogeneous system, non-uniformities can arise through particle segregation or stratification; this leads to erratic performance which is likely to become more severe as the amount of filler is increased or density difference become more pronounced. We could add from 10 up to 30 and even 50 weight percent of a conductive filler;
- The method based on the utilization of a thermo-signalizer substance, for the experimental visualization of distribution of the temperature field, presents the disadvantage as the image obtained do not keeps the quality a pretty long while, the color of the thermo-signalizer layer becoming again rose-violet on measure of the absorption of humidity of the air.

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