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TESTING THE ELECTRIC EQUIPMENTS SUBJECT TO VIBRATIONS AND ANALYSIS OF THE TEMPERATURE UPON THE ELECTRIC RELAY

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ABSTRACT The object of the paper presented hereby is that of achieving a study concerning the effects of heating upon the electric equipments, respectively the electrical relays to vibrations. Starting from the issues related to the appearance of and particularly the negative effects of the vibrations often present in practice, especially in certain domains of using the electric equipments, where it is not to be avoided the presence of vibrations or mechanical schock. The aim of the present paper is that os achieving a vibrating mass, in the three directions X, Y and Z, with the help of which one can simulate the presence of the vibrating movements often occurred in practice and the appearance of the electric arc and of the termic effects upon the contacts of the electrical relays.

KEYWORDS: electric arc, vibrations, current density, contacts electric contacts, electrical relays, thermic effects

1. INTRODUCTION

The thermic effects in the electric devices is one of the most poignant physical processes that take place in the electrical equipments used for disconnecting the electric circuits in electric charge, the electric arc that appears between its contact elements. [6] [4] [5]

The electric arc leads to a supplementary solicitation of the device, by the transfer of energy from the arc column towards parts, the constructive conducting components, solicitation that manifests itself by super-temperatures [6] that can solicit the contact elements to their destruction .

The electric arc can appear also at the switching off of the contacts of an electric device but its destructive effect is more diminished if the speed of switching off the contacts is high enough, so that the thermic effect of this process is negligible.[6]

The high value of the current density in the electric arc, which is approximately 10^4…..10^7 A/cm^2 is based both on the ionization by shock, and on complex physical processes such as the thermic emission, the emission produced by the electric field, the thermic ionization, etc.[6]

The electric arc appearing in the electric equipments is a violent phenomenon of electric discharge in a gas and is strongly influenced by the local conditions in the extinguishing chamber, such as the length of the electric arc, the heat ceding, the intensity of the electric current and the type of current.[6][5]

The technology of interrupting the electric arc aims at limiting the duration of the electric arc with the view of reducing to the minimum the thermic effects in devices and the effects of the short-circuit effects in the protected installations of electric devices.

The thermic conduction represents the remittance of the heat from a region with a higher temperature to a region with a lower temperature in the interior of a medium or different mediums that are in physical contact under the influence of a temperature difference.

The process of extinction of the electrical arc in the electrical equipment is a complex process that depends on a number of factors related to both the type of current, such as alternating current or direct current network parameters in which the device is mounted, and the environment the arc is extinguished.[6]

Usually in alternating current the process of extinguishing arc is favored by passing a current through the value 0. Due to this fact the ionization in the arc column is minimal and the disposal of the majority charge carriers facilitate the extinguishing arc.

We can mention that the time constant of the electric arc is a characteristic size which depends on its geometrical dimensions and have different values depending the current intensity and power dissipation of the arc column.[6] [5]

The fact that electric arc extinction is taking place to the passing of electric current through a zero value, the time constant can be analyzed on an appropriate model for small values of the current order of a few amperes.

An electric equipment is included in a network, the interruption proces of electric arc in extinguishing chamber depends on network parameters namely current short circuit and arc voltage restoration.

Electric arc extinction also depends on device parameters are: arc voltage and withstand voltage signifying restoring electrical stiffness in electric arc column. [6] [7] [5]

From above presented facts it can be concluded that thermal processes which take place in electrical equipment greatly influence its performance. Thermal process control of electrical appliances depends very much on their design parameters and materials used, especially from equipment to equipment.

2. THEORETICAL PROBLEM

The thermic flux associated to a surface represents the quantity of heat Q that crosses a surface on all wave lengths in all directions in the time unit.[1]

$$\phi = \frac{Q}{t}[W] \qquad (1)$$

The density of the thermic flux is the relationship between the thermic flux and the aria of the surface.[1],[2],[3]

$$q = \frac{\phi}{A}\left[\frac{W}{m^2}\right] \qquad (2)$$

The variation of the internal energy of a physical system between two states is equal to the sum between the quantity of heat exchanged by the mechanical work system effected upon the system.

$$dU=\delta Q+\delta L \qquad (3)$$

A homogenous body, having internal sources of heat, setting the temperature field is possibile by solving the differential equation of the thermic conduction.

$$\frac{\partial\theta}{\partial t} = a\Delta\theta + \frac{q_v}{\rho c}, \quad \text{where: } a = \frac{\lambda}{\gamma c} \qquad (4)$$

where:

α - represents the thermic disffusion which characterizes the possibility of equalizing the temperature in a non-evenly heated body [unit][m^2/s] [1]

γ - the thermic conductivity of the material [W/mK]

ρ - density of the material [kg/m^3]

c - the mass heat of the material [J/kgK]

q_v - the volume density of the thermic flux (heat) flux [W/m^3]

Δθ - laplacian of temperature.[2]

Fourier's equation for solving practical cases is possible using the unequivocal determination of process conditions, including:[1]

geometric conditions, which determine the geometrical shape and body size, intervening in the expression of laplacian temperature (for three-way conduction) for flat bodies (Cartesian coordinates)

$$\Delta\theta = \frac{\partial^2\theta}{\partial x^2} + \frac{\partial^2\theta}{\partial y^2} + \frac{\partial^2\theta}{\partial z^2} \qquad (5)$$

and cylindrical bodies (cylindrical coordinates)

$$\Delta\theta = \frac{\partial^2\theta}{\partial r^2} + \frac{1}{r}\frac{\partial\theta}{\partial r} + \frac{1}{r^2}\frac{\partial^2\theta}{\partial\varphi^2} + \frac{\partial^2\theta}{\partial z^2} \qquad (6)$$

physical conditions, determine the values of *a*, λ, γ, *c*, and the distribution in space and time variation of interior heat sources;[1] [2]

initial conditions, determine the temperature distribution inside the equipment;

boundary conditions express the distribution and temperature variation or heat flow on the surface of the equipment.[1]

Fourier's equation for plane bodies:

$$\frac{\partial\theta}{\partial t} = a\frac{\partial^2\theta}{\partial x^2} \qquad (7)$$

Fourier's equation for cylindrical bodies:

$$\frac{\partial\theta}{\partial t} = a\left(\frac{\partial^2\theta}{\partial r^2} + \frac{1}{r}\frac{\partial\theta}{\partial r}\right) \qquad (8)$$

The heat remittance represents the exchange of thermic energy between two points or two areas of the same body as a result of a difference of temperature between them [1].

3. EXPERIMENTAL DETERMINATIONS

In the experimental determinings I have compared the effects of the temperature upon two electric relays from different firms, but with almost identical characteristics from the point of view of the functioning parameters.

An electrical relay was from the SCHRACK firm, with the series PT570024, supply tension of the reel 24 [V] continuous current (CC). Respectively the maximum current born of 6 A at the tension of 250 [V] alternative electric current (AC). The second electrical relay, from the Omron firm, with almost identical parameters, the supply tension of the reel 24 [V] continuous electric current (CC). Respectively the maximum electrical curremnt born 5 A at the tension of 250 [V] alternative electric current(AC).

Figure 1. Testing the electrical relays to vibrations. On the left-had side one can see the Omron electircal relay, and on the right-hand side, the Schrach electrical relay

The testings were made in identical conditions in both cases, both relays were placed on the testing table for electric equipments at the t=90 seconds with a rezistive consumer of 1400 [W].

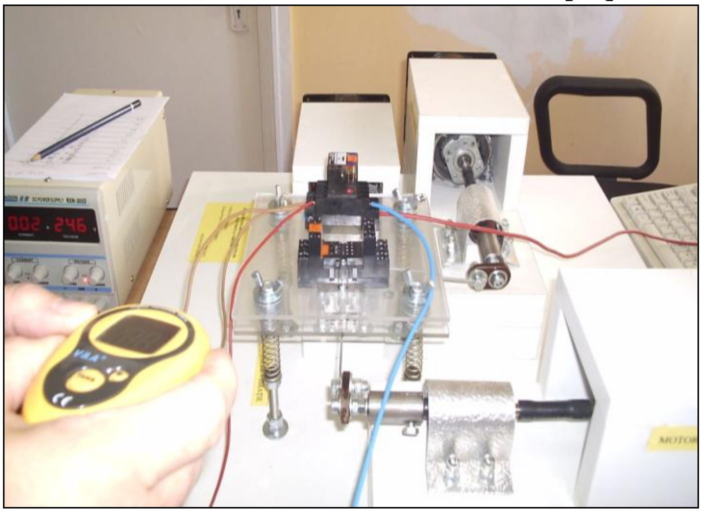

Figure 2. Testing the two types of relays on the system of testing the electric equipments to vibrations

In the present paper I have analysed the variation of temperature measured on the relays frame during the functioning, the temperature of the initial environment is of 27 [°C].

For evaluating the electric and non-electric measures of the heating process, a series of adequate devices were used.

Measuring the temperature is achieved with a distance measuring device, without contact, in infrared, made by FLUKE, model M103HT.

The measuring device enables measuring the temperatures at a distance comprised between 5 cm and 20 m.

The device has the possibility of measuring the temperature up to 900° C, with a precision of 1° C. It also has the possibility of automatic correcting of temperature according to the imposed emissivity.

The temperature measured is displayed on the device display unit, the values measured being memorised in the memory of the device. Also, the device presents an analogical and a nummerical output, which enables its connecting to a computer.

Figure 3. Measuring the temperature on the contacts of the relays without vibrations

A very important aspect is that each relay was tested for the first time without being subject to vibrations, both electric relays at 90 seconds, with the 1400 [W] consumer.

It is to be underlined the fact that during the determinings I have observed the presence of the electric arc, formed between the contacts of the electric relay, which has actually contributed to the heating of the relays.

Table 1. Testing the electric relays without vibrations

SCHRACH Relay		Releu OMRON Relay	
Time [s]	Temperature [ºC]	Time [s]	Temperature [ºC]
0	27	0	27
30	27	30	27
60	27	60	27,1
90	27	90	27,2

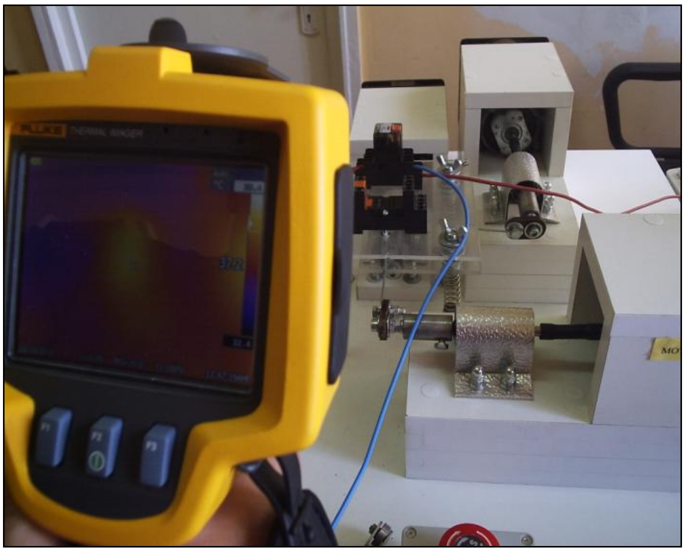

Figure 4. Measuring the temperature on the contacts of the relays during the functioning of the system of testing to vibrations

Table 2. Testing the electric relays to vibrations for the two types of relays

SCHRACH Relay		Releu OMRON Relay	
Time [s]	Temperature [ºC]	Time [s]	Temperature [ºC]
0	27	0	27
20	27,19	20	28,3
40	27,35	40	29,4
60	27,61	60	31
80	27,72	80	32,2
90	28,1	90	33,6

The data obtained further to the experimental determinings have been processed in the Matlab program for both electric equipments.

From the table there can be clearly seen the difference between the functioning parameters of the two electrical relays. The Omron electrical relay represents a more noticeable increase comparative with the Schrack electrical relay.

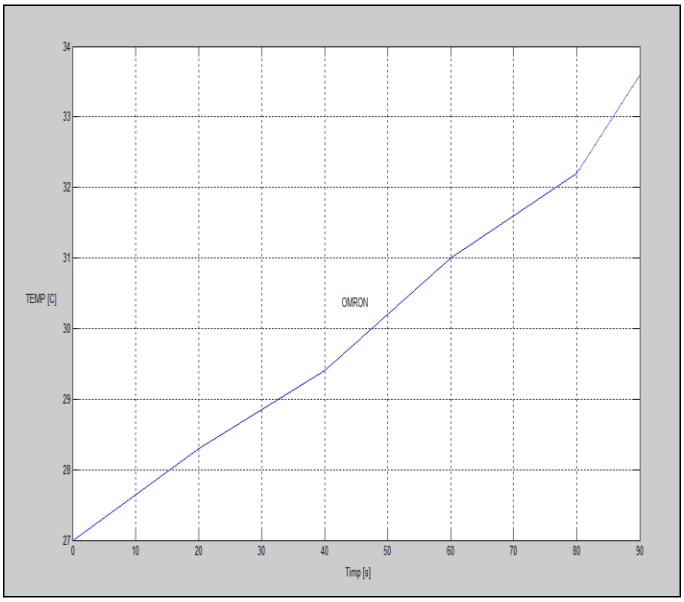

Figure 5. Evolution of the temperature comparative with the time for the Omron electrical relay

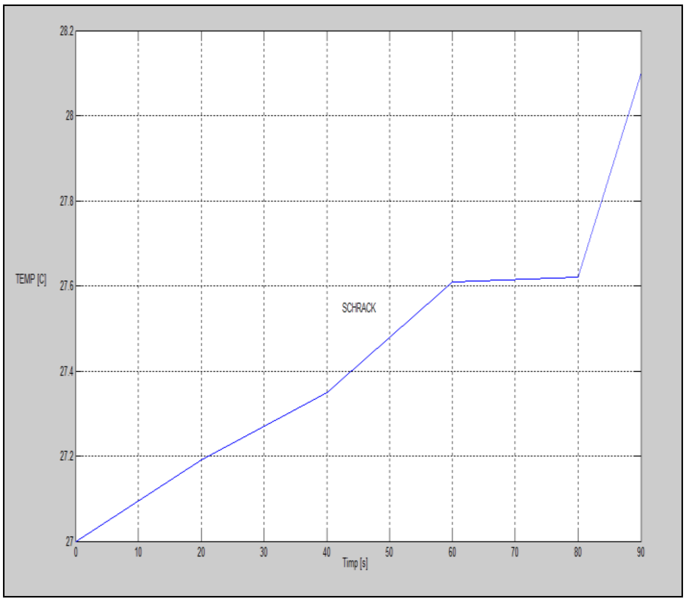

Figure 6. Evolution of the temperature comparative with the time for the Schrack electrical relay

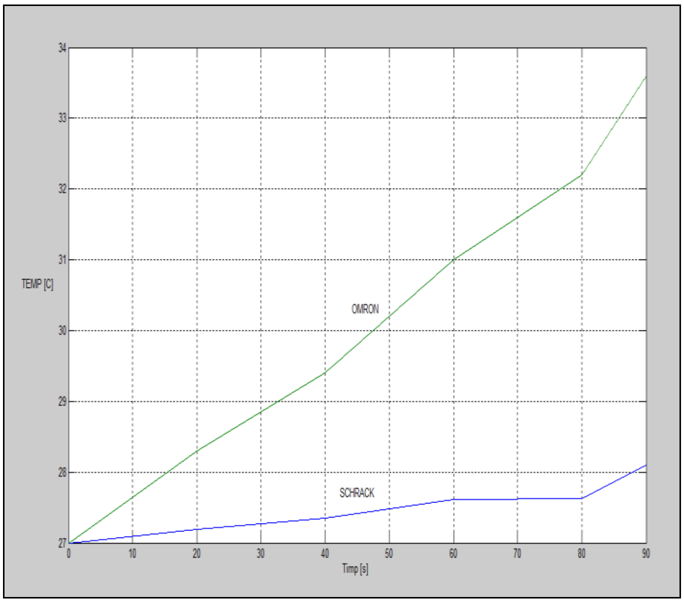

Figure 7. Evolution of the temperature comparative with the time for the two electrical relays

4. CONCLUSIONS

In the present paper I have studied the theoretical and practical aspects of the vibration effects subject to the electrical relays.

The aim of the paper is that os enabling the performing of real simulations of the vibrations mediums, after performing the testing systems and in this way researching into the way of functioning of electrical equipments subject to vibrations, particularly to the electrical relays.

Conclusively, one must take into account the heating of the electrical and electronic equipments during the functioning and the necessity of their corresponding, whereas in projecting, it is very important the oldness (seniority), the technical sense, knowledge about the theory and knowing the electric parameters and the mechanics of the materials used.[6]

The vibrations represent a major danger in the well functioning of the electric equipments and the effects of the vibrations are completely unknown, such as the appearance of the electric discharge between the electric contacts during the functioning which determines an enhanced heating of the contacts, that disengages the heat around, determining the welding of the contacts and the destruction of the electric equipment.

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