Theoretical and Experimental Studies on Piezoelectric Thermal Fire Annunciator

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***Abstract*—** *The paper presents theoretical and experimental studies on testing the possibility of using piezoelectric converters as a signaling device in fire protection systems. The advantage of this process is the absence of the necessity to connect electrical lines, which in most cases they themselves cause fire.*

Keywords*— *Piezoelectric converter, transformer mode, depolarization, signaling device, fire security.

I. INTRODUCTION

The systems, designed for remote registration of occurrence moment of fire situation at oil and gas industry facilities, contain a primary converter (located directly at the facility), a communication channel and a signaling device installed in the control room.

Practice shows that, the reliability of such systems is mainly determined by the primary converter, so that their design is presented by very stringent requirements. Therefore, currently, several types of devices have been developed reacting either to an increase in the ambient temperature caused by it [1,2,3]. The converters used in practice are mainly fusible and ferromagnetic fuses and photoelectric signaling devices.

II. STATEMENT OF THE PROBLEM

The disadvantage of the first two types of converters is that their work is connected with the need of using sufficiently powerful electrical circuits, which in case of fault, they themselves can be sources of an explosion or a fire. Photoelectric converters operation is connected with the need of using special power supplies and amplifiers complicating the signaling scheme, thus, reducing its reliability. These shortcomings can be eliminated if a piezoelectric ceramic, having the ability to be depolarized under the effect of temperature is used as a sensitive element [4,5].

III. SOLUTION

Fig 1. presents the diagram of the device, which can be recommended as a signaling device on the occurrence of a fire situation. The device contains a piezoelectric transformer, the first section *1*being connected to the 220 V network, however, the secondary one-2 is loaded onto gas-discharge indicator 4through the communication channel 3.

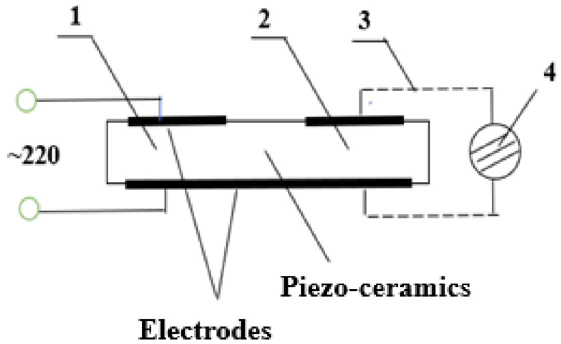


FIG.1: SIGNALING DEVICE ON THE OCCURRENCE OF A FIRE SITUATION

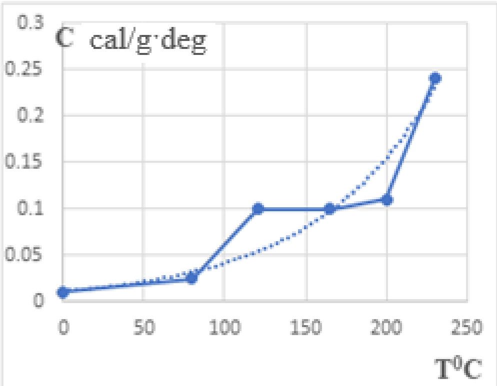
The transformer is installed at the facility; however, the gas-discharge indicator is installed in the control room. Under normal conditions, the transformable voltage in the network maintains luminescence indicator. When the temperature increases on the object, the piezo-ceramics becomes depolarized, the voltage transformation stops to the indicator and it goes down, signaling the occurrence of a fire situation.

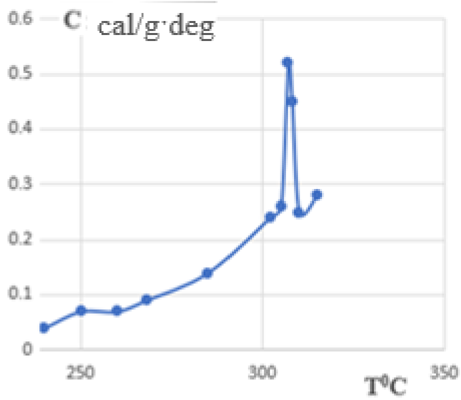
Since the problems, related to the design of piezoelectric transformers, have been sufficiently fully illuminated in [6], the results of the studies on thermal depolarization and piezo-ceramics inertia are of practical interest in constructing signaling schemes. This is due to the fact that depolarization rate and heating time of piezo-ceramics to the point of phase transition determine such an important parameter of the system as its speed.

In accordance with the known thermodynamics dependence, the thermal time constant of the converter can be determined by the following formula [7]:

$$\tau = \frac{Cml_3}{\lambda l_1 l_2} \tag{1}$$

where C- is the heat capacity, cal/g·deg.; λ- is thermal conductivity, cal/s·m deg.; *m*- is the transformer mass, *g; l_1, l_2, l_3*- are length, width and thickness of the transformer, *m.*





a) **b)**

FIG. 2: RESULT OF EXPERIMENTAL STUDIES

As a result of experimental studies (Fig. 2, a, b), it was discovered that the average heat capacity for piezoceramics ZTL-19 (zirconate-titanate-lead) is (0.2-0.4) cal./g·deg.;, while temperature is close to the point of the base transition, its value increases to (0.8-1) cal./g·deg;.

The study of the heat capacity enabled to determine the temperature at which the piezo-ceramics was completely depolarized. This temperature for ceramics, ZTL-19 is $(305 \div 308)^0$C.

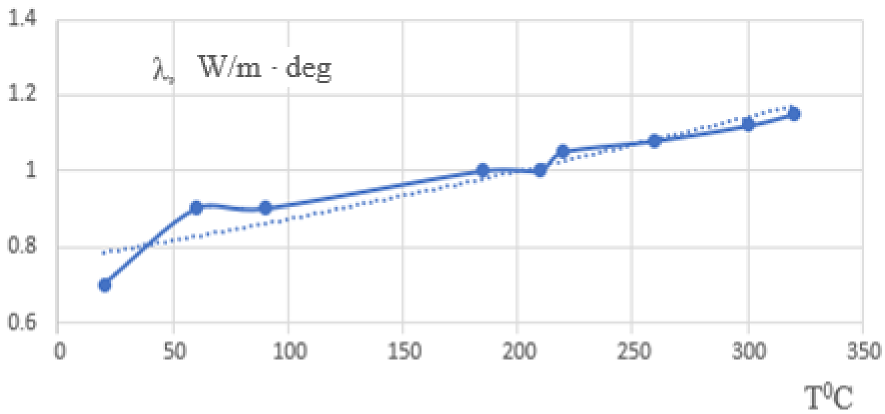


FIG.3: THERMAL CONDUCTIVITY MEASUREMENT OF PIEZO-CERAMICS

The thermal conductivity measurement of piezo-ceramics ZTL-19 (Fig. 3) allows us to conclude that its value, depending on the ambient temperature, varies from 0.7 W/m·deg;. at normal temperature to 1.1 W/m·deg.; at phase transition temperature. The signaling system speed is determined not only by thermal time constant. This is due to the process of depolarization having certain inertia. Currently, there are no sufficiently simple analytical dependencies allowing determining the depolarization inertia, in connection with the fact that this parameter has been determined experimentally.

Fig. 4 defines a curve allowing determining the depolarization degree of ceramics ZTL-19 depending on the exposure time to it of the phase transition temperature.

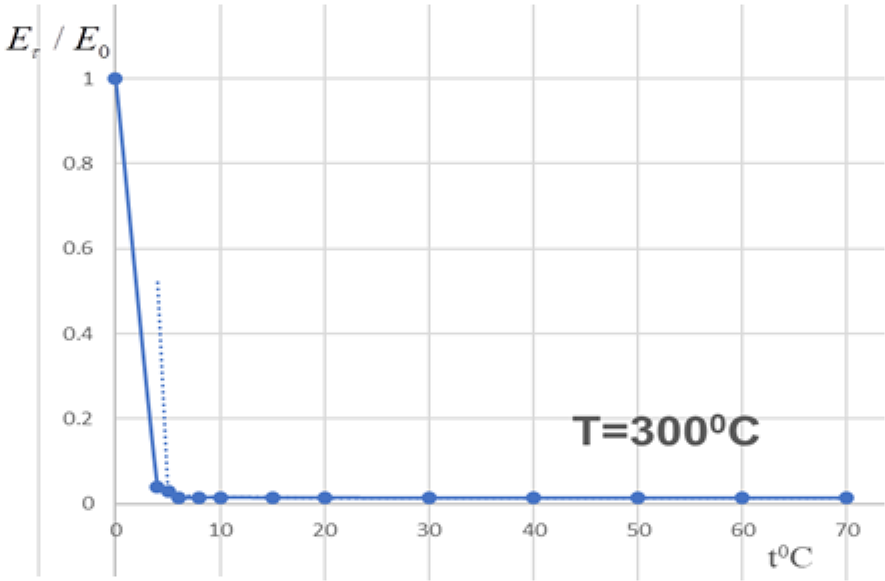


FIG.4: DETERMINE THE DEPOLARIZATION DEGREE OF CERAMICS ZTL-19

In this case it is advisable to use a number of relative values to characterize the depolarization degree [8].

$$K_E = \frac{E_\tau}{E_0} \tag{2}$$

where Eτ- is the current value of permanent polarization in piezoceramics; E_0- is the initial value of permanent polarization. For piezoceramics, ZTL-19 $E_0 = 2 \cdot 106$ V/m.

IV. CONCLUSION

The analysis of the available experimental data allows us to conclude that the duration of depolarization does not exceed 10 c. Thus, taking into account the thermal inertia, the total time required for triggering the signaling system from the occurrence moment of a fire situation does not exceed (10 ÷ 15) s.

REFERENCES

[1] Ilinskaya L.N. Elements of fire-protection automatics. Publish. "Energy", 1969.

[2] Fomenko A.A.Dotty maximum thermal fire annunciator: construction and applicationfeatures. // Security Systems. 2007. - N. 5. P. 85.

[3] EN 54-5: 2000 Fire alarm systems -Part 5: Heat detectors - Point detectors.

[4] Sharovar F.I. Comparative evaluation of the application effectiveness of thermal maximum, differential and smoke fire annunciators//Groteck security systems. 2003. №1. P. 62.

[5] Bakanov V., Neplokhov I. Thermal fire annunciators. Part 2. Application problems. Security Algorithm, 2011, № 6.

[6] A.N. Members. Modern thermal fire signaling: the main characteristics and features of the application. "Security Systems", N. 1 (55), 2004.

[7] R.G. Jagupov, A.A. Erofeev - Piezoelectric elements in instrumentation and automation, L., "Mechanical Engineering", 1988.

[8] V. Sharapov, M. Musienko, E. Sharapova- Piezoelectric sensors, M: "TECHNOSPHERE", 2006.