EXPERIMENTAL RESEARCH STUDY ON THE USE OF A RESISTIVE TENSOMETRIC SENSOR

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Abstract: *The paper presents a method using the electric tensometry. The electric tensometry is a method for measuring the deformations by using some transducers. These transducers turn the variation of a mechanical size into variations of an electric size. The principle of functioning of the resistance tensometric transducer is the modification of the electric resistance depending on the variation of the specific deformation.*

Keywords*: sensor, transducer,sensitive element.*

1. Introduction

Sensors are used in all kinds of automated systems and actions, regardless of the field of science or engineering, or of the nature of processed they are supposed to analyse and control. They are used on a large scale, ranging from the chemical, food, automotive, aerospace industry, passing through medicine, biology, environment protection, agriculture to the military industry. [1]

One can state that the sensors convert the size to be measured applied at the input into another size able to form the signal of measurement which will be processed and transmitted along the measurement chain. Consequently, the sensor will be considered to be the sensitive element converting the size to be measured applied at the input, and the transducer represents the entire assembly mounted and connected to the sensor. As the technological developments are in a continuous progress, new types of sensors are created and designed and are based on semi-conductive materials, optical fibers as well as new materials (polymers, elastomers) that lead to the improvement of the sensors' importance and to the uses they have in covering new fields of interest.

The transducer can contain in its structure one or more sensors, able to convert the size to measure into another size having the quality of being easily measured. The sensors and the transducers could be considered as the source of a new technical revolution.

2.1 Sensors and tensometric resistive transducers

The tensometric resistive sensors are those resistive sensors where the electrical resistance variation is produced caused by the variation of the conductor's length, as an effect of the elongation or of the contraction. Whether the tensometric sensor is mounted on a certain part of the piece subjected to deformation caused by a stress, then, it will suffer deformations in the same time with the piece supporting it.

Measuring the variation of the sensor's resistance through electrical methods, being proportionally with its elongation, the deformation of the part of the piece subjected to study can be determined on the basis of a previous measurement standard, establishing in the end the non-electric size inducing this deformation. According to the way of manufacturing and mounting of the resistive sensor, one can distinguish the following types of tensometric transducers.

a) **Simple tensometric transducers** – the resistive sensor is mounted directly on the piece and strictly follows its deformations. As the resistive wire has the dimension of a hundred part of a millimeter, the process of mounting these sensors is a difficult operation. Therefore, the method is used only for measuring the deformation fo the pieces operation at very high temperatures.

b) **Tensometric transducers with paper support** – In order to avoid the difficulties caused by the direct mounting of the resistive sensor on a piece, the transducer is previously stuck, by using a glue, on a paper support. As the electric resistance of the sensor must be higher enough as the transducer should have a corresponding sensitivity, the total length of the resistive wire is of about 10^2 mm. To reduce the surface on which the sensor is laid, the wire should be grid-shaped (fig. 1). [2].

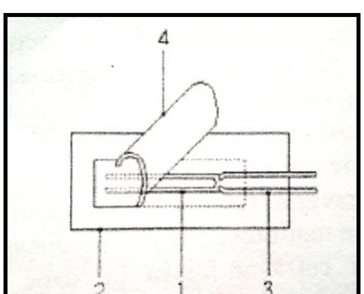

Fig. 1. *Tensometric transducer with paper support*

Grid 1 is mounted on the paper support 2, at both ends two copper conducters 3 are glued to the larger surface, by means of which the transducer is connected in the circuit of measurement. The resistive sensor of the transducer is protected by a thin foil of paper 4 wich is glued above. This type of transducer, well-known, has a series of advantages, among which a relative easy mounting, a possibility of manufacturing transducers of various shapes and configurations, a uniformity of transducers produced simultanously and keeping the quality standard.

c)Tensometric transducers with metallic foil – they are identical to the previous ones, principally, the only difference being given by the fact that the sensor is a thin wire, its place being retaken by a foil made up of a resistiv material, its thickness having the values between 2 and 20 μm applied previously on a support cut by using photo-chemical means. The creation of this type of transducers is due to the progress of the development of the industrial technique.[2]

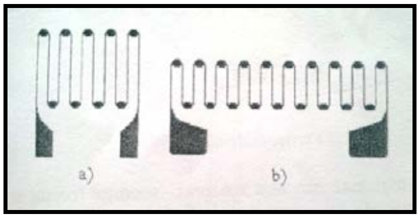

Fig. 2. *Tensometric resistive transducer with metallic a) normal width; b) increased width*

These transducers has the advantage of a mechanical and thermal contact with the piece they are mounted on, and this allows its functioning using a higher measurement current. This is the reason for which a better use of the surface is achieved, these transducers having even smaller dimensions lead to simplify their high series production.

d)**Tensometric transducers of semi-conductor** – they have been created during the recent year, due to the evergrowing progress of the physics of semi-conductors, where the sensor is a semi-conductor (germanium and silica). The main advantage of these types of transducers is their high sensitivity to deformations (approximatively 50-60 times higher than the wire transducers or foil ones) presenting instead the disadvantage of a certain lack of linearity more pronounced and even of the presence of a problem connected to the way they are laid on the measuring surface. The semi-conducting material that is often used (almost exclusively) is silica, the semiconductor-terminals being made of gold, silver or nickel.

e)**Tensiometric transducers obtained out of metallic deposits** – are created directly on the surface subjected to measurement, surface that had been covered by a insulating layer. The sensor is formed by using methods of evaporation or particle bombing. Their main application is on the diaphragm for force transducers and couples, their very small dimensions offering the advantage of supporting high temperatures (1200 ^{0}C).

The tensiomatric transducers with smaller lengths, under 20 mm, are used for measuring the deformation of homogenous materials (steel), instead, the transducers having bigger lengths are used for measuring the deformation of non-homogeneous materials (concrete or wood).

The resistive material the sensor is made of, the insulating support and the glue of the transducers are all chosen according to the maximum working temperature and to the environment’s humidity. For measurements reaching 200 ^{0}C in termperature, any of the materials shown in table 1 can be used, and for termperitures ranging from 200 ^{0}C to 800 ^{0}C, nickel-chrome and karma alloys are used. Generally, for temperatures exceeding 400 ^{0}C, only dynamic measurement can be made by using these materials. [2]

Table 1. Charactaristics of resistive materials

Material	**Sensitivity**	**Reziztivity │Ω·m │**
Constantan	2...2,1	$0{,}47 \cdot 10^{-6}$
Manganine	0,47	$0{,}42 \cdot 10^{-6}$
Nickel-Chrome	2,5	$1 \cdot 10^{-6}$
Isoelastic	3,6	$1{,}05 \cdot 10^{-6}$
Karma	2,1	$1{,}02 \cdot 10^{-6}$
Silica p [111]	100 ... 170	$(0{,}01 \div 10) \cdot 10^{-6}$
Silica n [100]	-90 ... -65	$(0{,}01 \div 10) \cdot 10^{-6}$

2. Experimental research study on sensing a tensometric sensor on paper support

2.1 Description of the probe endowed with ternsometric marks subjected to mechanical traction

The sketch of the probe is shown in Fig. 3. The material used is steel OLC45.

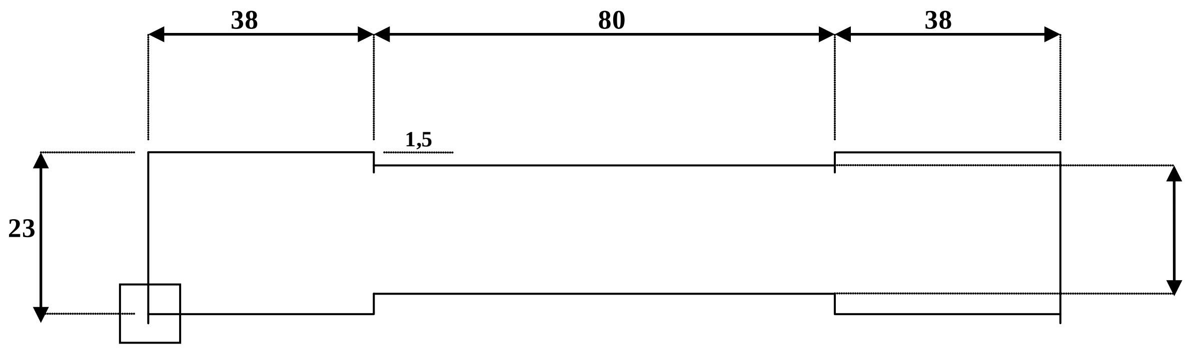

Fig.3 *The sketch of the probe*

2.2 The equipment used for the experimental research study

For testing the traction and determining the relative elongation, a traction device and a Wheanstone bridge are used and are shown in figure 5.

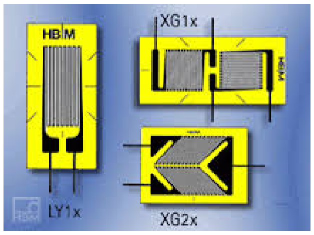

Fig. 4 *Tensometric marks*

Input range: ±24mV DC, accuracy: 0,02% of reading +30µV, impedance:100Mohm, 10 VDC bridge excitation.

Fig. 5 Device for the traction test

2.3 Experimental test

On the basis of the calculation of the unbalanced tension of the bridge, the following equation results, as it can be shown below:

$$\varepsilon^2(K^2 \cdot \Delta U + K^2\gamma^2 \cdot \Delta U + 2K^2\gamma\Delta U - K^2 \cdot U_{alim} + K^2\gamma^2 U_{alim}) + \varepsilon(4K \cdot \Delta U - 4K\gamma\Delta U - 2KU_{alim} - 2K\gamma U_{alim}) + 4\Delta U = 0$$

The data for the 13 tests one can obtain, are recorded in Table 2

The obtained graph F=f(ε) is shown in fig 6.
The method used allows the rising of the characteristic F=f(ε) on the elastic and linear segment.

***Table 2** Experimental data*

Δu	b_0	h_0	R_0	K	γ	E	L	ε[10^{-5}]	Δl	ν	F
m v	mm	mm	Ω			N/ mm2	mm			N/mm2	N
1	16	1	121,1	1,98	0,3	2,1 ·105	143	1,4	0,02678	8,61	1226
4								2,2	0,03211	12,4	1538
5								25,3	0,04244	53,13	1840
6								36,5	0,05422	76,65	2045
7								45,8	0,06320	96,18	2157
8								54,9	0,07850	115,29	3216
9								64,2	0,09180	134,82	4126
10								121	173,03	173,03	5142
11								132	188,76	188,76	6342
12								146	208,78	248,43	7014
13								162	231,66	486,48	7783
14								188	268,56	564,56	9012
15								208	297,44	634,62	9993

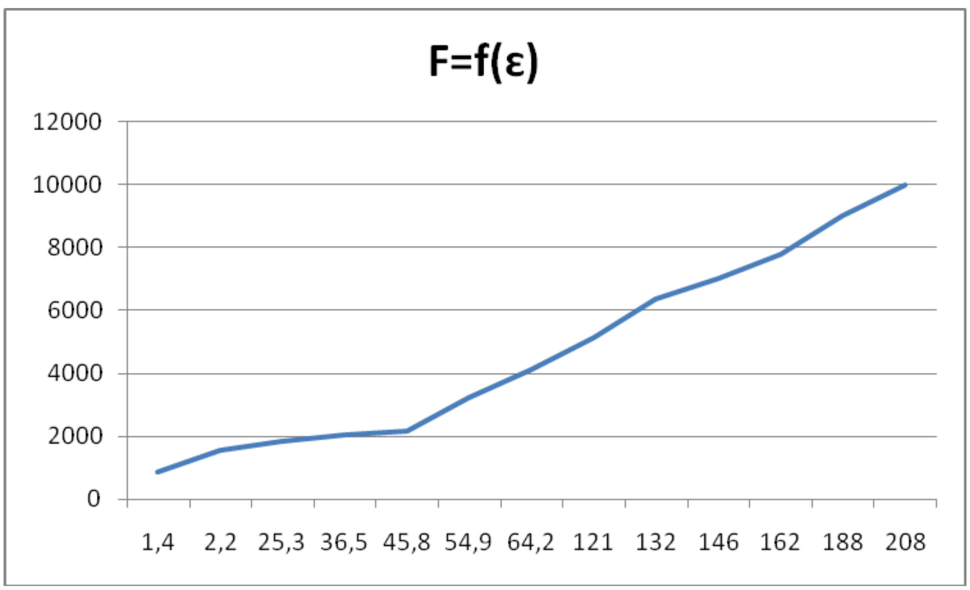

***Fig 6.** The characteristic F=f(ε)*

3. Conclusions

The experimental research study we made shows the importance of using tensometric marks in determining the mechanical tensions occuring in the used probe. One can determine through calculation the values of the force acting on a probe and the elongations corresponding to it. At the same time, the method permit the determination of the values of the force, of the tensions of elongations applied to different materials and then, by comparing these values, the best material can be chosen, responding to technological requests. The method used in this experiment can determine the valued mentioned above on a place of the probe where the tensometric marks are mounted.

4.References

[1]. Ciobanu L. , Senzors and transducers, Ed.Matrix Rom, Bucharest, 2006;
[2]. Chiţă M. , Senzors and transducers, Ed.Matrix. Rom, Bucharest, 2006;
[3]. Atanasiu C., Material's testing, Technical Publishing House, Bucharest, 1982;
[4]. Gutt G., Testing and characterizing metallic materials, Technical Publishing House, Bucharest, 1985;
[5]. Nicolau Th., The electronics measurements in industry, Technical Publishing House, Bucharest, 1964.