THE PRESSURE CONTROL DEVICES WITH USING OF MAGNETIC FLUID

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REZUMAT. În numeroase procese industriale, parametrii optimi care decid calitatea şi randamentul, precum şi siguranţa în funcţionare a instalaţiilor, depinde de măsurarea corectă a presiunii unor agenţi de lucru (apă, ulei, abur, aer comprimat, gaze). Măsurătorile de presiune se bazează pe proprietăţi fluidice şi magnetice ale fluidelor magnetice, care permit obţinerea de valori sau limitat de presiune într-o incintă. Dispozitivul experimental prezentat se bazează pe poziţionarea fluidului magnetic în interiorul a două bobine cu ajutorul a două membrane din materiale elastice.

Cuvinte cheie: controlul presiunii, senzor cu fluid magnetic.

ABSTRACT. In many industrial processes, the optimum parameters that determine the quality, efficiency and reliability the installations depends on the correct measurement of agents working pressure (water, oil, steam, compressed air, gas). Pressure measurements are based on fluidic and magnetic proprieties on magnetic fluids, which allow obtaining values or limited of pressure in an inside. The experimental device presented is based on magnetic fluids positioned inside of two coils by the help of two membranes of elastic materials.

Keywords: pressure control, sensor with magnetic fluid.

1. INTRODUCTION

In this paper we will present utilization the magnetic fluid in pressure measurement. Pressure measurements are based on fluidic and magnetic proprieties on magnetic fluids, which allow obtaining values or limited of pressure in an inside. The experimental device presented is based on magnetic fluids positioned inside of two coils by the help of two membranes of elastic materials. It consists in a cylindrical vertical nonmagnetic vessel surrounded by two coils filled with the magnetic fluid characterized by magnetic permeability μ_{MF} and density ρ_{MF}. The magnetic fluid is positioned on the membranes of elastic material or immiscible liquids which allow a very large mobility of the magnetic fluid inside of coils.

For the oil pressure measurement from transformers, magnetic fluid positioning is performed using two membranes of elastic material or a liquid immiscible with magnetic fluid (water). Inductance of the coil will be a function of magnetic fluid displacement, displacement due to the change oil pressure.

2. THEORETICAL CONSIDERATIONS

The natures of physical phenomena are usually classified as mechanical, thermical, electrical, magnetical, atomic and nuclear, such of properties of bodies or of physical systems. Taking into account only nature of the information about phenomenon or property to be received by sensor from a physical system or a body, we can classify physical sensors based on this criterion. In this case we will have: mechanical sensors, thermical sensors, electrical sensors, magnetical sensors, atomical sensors and nuclear sensors. These are, of course, physical sensors, because there are, chemical sensors, biological sensors and another type, too.

There is well known that customers of sensors will choose sensor in connection with physical nature of information to be obtained about a phenomenon or a physical system. That is why we have chosen this way for classification of the physical sensors.

The largest numbers of physical sensors achieved and used in our days are mechanical sensors, which are conversion sensitive elements of mechanical information into another one, preferably in electric information, which may be processed on a computer. The theory of this type of sensor is based on laws of mechanical phenomena expressed by mathematical formulae as a connection between various quantities as a measure of mechanical properties of physical systems. Such a law is Newton's law of mechanical movement for example. The main quantities used to express mechanical laws are: length (L), time (T) and mass (m). That is why it is essentially to obtain information about these quantities firstly, and after that about another like: speed, acceleration, impulse or quantity of movement, force, pressure and so on.

Devices for measuring pressure in 10^{-2} -10^{6} mm Hg used as transducers, tensometer inductive, capacitive or piezoelectric transducers. In principle inductive transducers for pressure measurement using displacement transducers, determination of pressure is achieved by measuring the movement of an elastic element which takes the pressure.

An such transducer is made of a coil with N turns which, by acting on one of the parameters, size to determine the inductance variation cause. The value of this inductance is given by relation:

$$L = N^2 / R_m \qquad (1)$$

where L – the inductance, N – the number of turns and R –the reluctance of magnetic circuit.

In simple traductoarelor magnetic betweennessiron variable reluctance is expressed as:

$$R_m = \sum \frac{l_{MF}}{\mu_{MF} A_{MF}} + 2\frac{\delta \pm x}{\mu_0 A_0} \qquad (2)$$

where the indices refer to parts of iron or betweennessiron, while l - the length, A - the cross-section and μ – the magnetic permeabiltatea.

Differential inductive transducers together into a single unitary construction, two simple transducers identical inductance variations are of opposite sign, the two coils forming two neighboring slops the two coils forming two neighboring slops into a bridgemeter under unbalanced AC. Bridgemeter imbalance is given by the difference in inductance, in the form:

$$L_1 - L_2 = 2\Delta L \cong 2L_0 \frac{x}{\delta} \qquad (3)$$

If transducers with variable bridgemeter (in which $L_0 = \frac{N^2 \mu_0 A_0}{2\delta}$ if $\sum \frac{l_{MF}}{\mu_{MF} A_{MF}} \langle\langle 2\frac{\delta \pm x}{\mu_0 A_0}$).

3. CONSTRUCTIVE DATA AND EXPERIMENTAL PROCEDURE

The differential pressure Δp can be measured with the use of an inductive magnetic fluid transducer, that links, in a single structure, two simple, identical transducers; the induction variations are opposite figures; the two coils 1 and 2 (figure 1) form two adjacent sides of an alternating current bond, with an unbalanced functioning. The unbalance of the bond is given by the induction difference, a differential generated by the change in the magnetic permeability of the magnet core.

The transducer presented in figure 1 shows a vertical cylinder 3, surrounded by coils 1 and 2, the magnetic fluid 4 positioned with the use of diaphragms 5 and 6, so that the induction Lo of coils 1 and 2 must be equal when pressure p_1 is equal to pressure p_2.

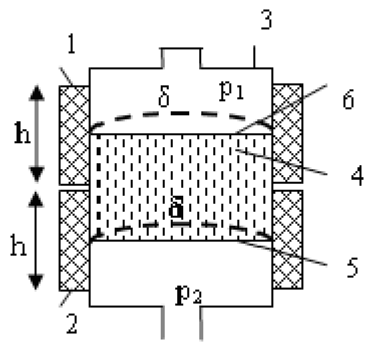

Fig. 1. Magnetofluidic sensor for pressure measurement

The change in pressure, p_2, causes the coil inductance change due to changes the position of the magnetic fluid 4 inside the container 3, which lead to changes in magnetic permeability μ_1 and μ_2 in the two coils, as follows:

$$\mu_1 = \left(\frac{h}{2} - \delta\right)\mu_{fmag} + \left(\frac{h}{2} + \delta\right)\mu_l \qquad (4)$$

$$\mu_2 = \left(\frac{h}{2} + \delta\right)\mu_{fmag} + \left(\frac{h}{2} - \delta\right)\mu_l \qquad (5)$$

where: δ – is the fluid shifting due to the differential pressure given by the baffling device. δ is the membrane deflection at the center taking into account its static deflection.

The unbalance of the bond is given by the induction difference, and takes the following form:

$$\Delta L = L_1 - L_2 \cong 2L_0 \cdot \frac{\delta}{h} \qquad (6)$$

where: L_o can be found in the formula:

$$L_0 = \frac{N^2 \mu_0 S}{2h} \qquad (7)$$

N – the number of coil curls, S – the section, h– the length, μ_0 – vacuum magnetic permeability.
The movement of the fluid is the result of the pressure variation in device, variation is in direct ratio to the coil induction variation.

$$\Delta p = k_1 \cdot \frac{\Delta L \cdot h}{2L_0} \qquad (8)$$

k_1 is a constant coefficient which depends on the parameters of the magnetic fluid (density, viscosity) and on the resistance force of the elastic diaphragm.

Experimental data have been obtained using the device shown in figure 1, having the characteristics: volume inside the coil V_0=48·10^{-4}m^3, diameter of copper wire used for a number of turns N=48000 was d=5·10^{-4} m, and the magnetic fluid used was based on magnetite particles dispersed in kerosene and coated with oleic acid. The best results were obtained for a magnetic fluid with the characteristics: ρ_{MF}=1080kg/m^3, χ_{MF} =0.1 $\mu_{mf} = \mu_0(1+\chi_{mf})$.

Measurements were made using the experimental device what consists of sensor from, figure 1 and the circuit electrical and for the variation of pressure of 50 in 50 mbar I used an air compressor.

In figure 2 are presented experimental dates for electric tension as a function of pressures, for a standard frequency of 50 Hz.

Using a magnetic fluid with higher magnetic susceptibility can be obtained improved electrical signal given by the sensor for same construction and same pressure.

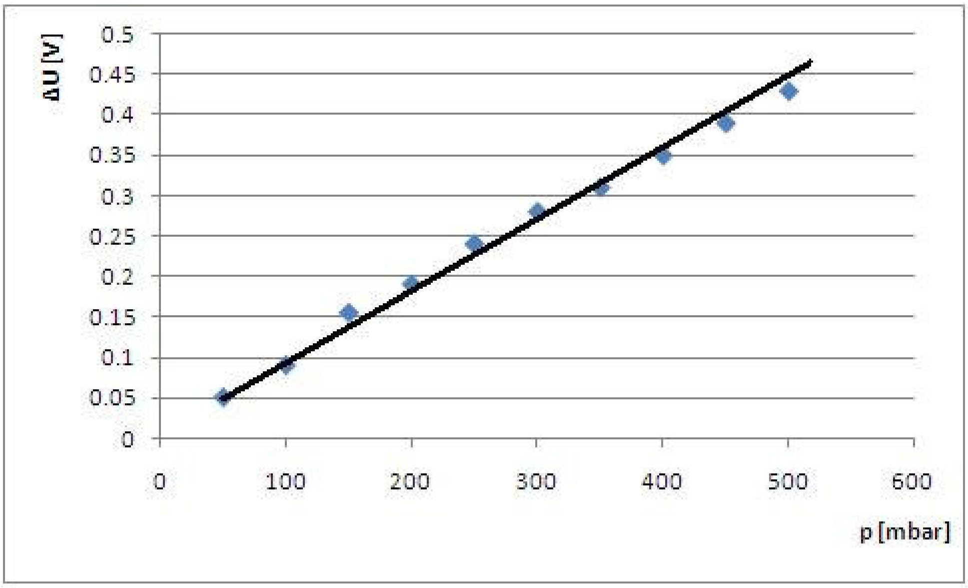

Fig. 2. The dependence of the electric tension on the pressure.

4. CONCLUSIONS

✓ Pressure measurements are based on fluidic and magnetic proprieties on magnetic fluids, which allow obtaining values or limited of pressure in an inside.

✓ The experimental device presented is based on magnetic fluids positioned inside of two coils by the help of two membranes of elastic materials. It consists in a cylindrical vertical nonmagnetic vessel surrounded by two coils filled with the magnetic fluid characterized by magnetic permeability μ_{MF} and density ρ_{MF}.

✓ For the oil pressure measurement from transformers, magnetic fluid positioning is performed using two membranes of elastic material or a liquid immiscible with magnetic fluid (water).

✓ An increasing or a decrease of the pressure of transformer oil will be received by the electronic device which contains the coils as circuit elements because of variation of magnetic permeability inside of the coils. It can be mounted on the pipe connecting transformer and the conservator and can warn oil pressure increase, accumulation of gas or can disconnection the circuit.

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