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Temperature Transducer

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ABSTRACT

The presented paper is based of literary studies and analysis of the author, the device and the principle of operation of temperature transducer are considered. The schematic diagram of a temperature transducer is shown. Some experimental research has been done on some parameters of this kind of transducers.
Keywords: Temperature Transducer, RTD

I. INTRODUCTION

Temperature is a physical quantity proportional to the average kinetic energy of the particles (eg, molecules) composing the substance when it is in thermal equilibrium [2]. Direct measurement of the energy of molecules is difficult to achieve, so the temperature is judged by its relation to different properties of the substances - thermal expansion, radiation intensity, etc. When measuring the temperature it is necessary to adopt a corresponding scale, characterized by the beginning (zero) and unit size (degrees).

Measurement conversion is performed by a transducer. The measuring transducer is a measuring instrument designed to produce a measurement signal suitable for further processing, transmission and storage of measurement information.

Depending on the location in the structural scheme of the measuring circuit, the transducers are primary and intermediate. The measuring transducer, which immediately perceives the measured magnitude, is called a primary transducer. Primary transducers are located directly on the site or in the area of its impact and are remote from the location where the measurement information is processed and recorded [2].

II. DESIGN AND PRINCIPLE OF RTD

Thermal resistors (Resistance Temperature Detector - RTD) are transducers based on the resistance of a conductor or a semiconductor to the temperature. This equation is non-linear and has the following form [2]:

(1) $R = R_0\,[1 + A(T-T_0) + B(T-T_0)^2]$,

where R_0 is resistance by temperature T_0 (It is accepted $T_0 = 0^0C$),

R - Resistance by temperature T,

A and B are temperature coefficients.

In a relatively narrow temperature range, the equation of resistance on temperature can be considered linear [2]:

(2) $R = R_0\,[1+\alpha_R(T-T_0)]= R_0\,(1+\alpha_R\Delta T)$

where α_R is temperature coefficient of resistance, i.e. the variation of the resistance is proportional to the change of temperature.

Figure 1a shows the construction of a temperature transducer without a protective jacket. Sensitive element 1 is wound on insulating mica 2. External insulation 3 is used to protect the sensitive element from mechanical damage.

The temperature transducer depicted in Figure 1b has a spiral-shaped sensing element 1 located in the insulating mica ducts 2 which are filled with powdered aluminum oxide 3. Aluminum oxide appears to be a very good electrical insulator having greater heat resistance and good thermal conductivity.

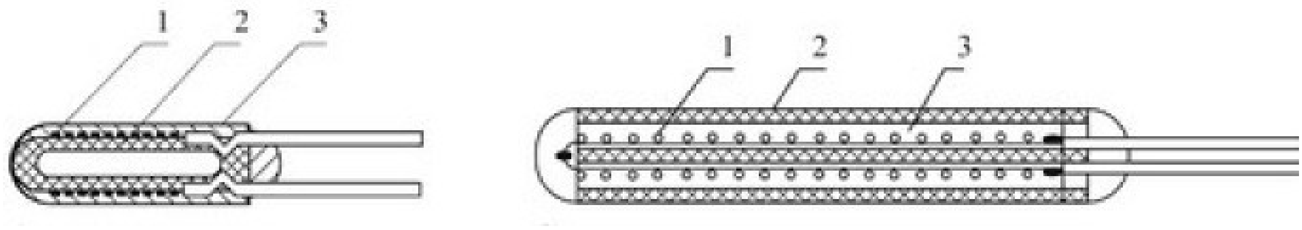

Figure 1. Design of RTD

The most widespread use of platinum, copper and nickel materials for thermal resistors. The temperature coefficient of resistance of platinum is $\alpha_R \approx 0{,}004\ deg^{-1}$ and is used as a thin conductor with a diameter Φ 50 - 100μm or a flat band with a cross section of 0,002 – 0,005mm^2. It is used in the temperature range of –200 to +1000^oC. The initial resistance R_0 (by T=0^oC) of standardized platinum thermoregulators is equal to 1, 5, 10, 46, 50, 100 and 500Ω.

Copper thermoresistors are used for temperatures from –200 to +200^0C. Electrolytic copper has a temperature coefficient $\alpha_R \approx 4{,}2.10^{-3} deg^{-1}$. The conversion function can be assumed to be linear in the range -50 to +180^0C. The small specific resistance of the copper requires the copper thermosensors to be made of a thin coil with many turns. The presence of the varnish insulation of the conductor reduces the upper limit of the range to about 120^0C. The initial resistance R_0 (by T=0^oC) of standardized copper thermistor resistors is 10, 50 and 100Ω [2].

Nickel has a high temperature coefficient of resistance $\alpha_R \approx 6{,}3.10^{-3} deg^{-1}$, but its characteristic is with greater non-linearity. It is used for temperatures below 300^0C.

III. EXPERIMENTAL STAND

The technical resources are:

1. Samples of different types of RTD (platinum Pt100, copper Cu100 and nickel Ni100);
2. Mercure thermometer
    - measuring range: -30 ^oC - +50 ^oC;
    - value of devision: 1 ^oC;
    - accuracy: 1;
    - submerged part: 160 *mm*.
3. Thermostat with known temperature (UT1):
    - volume of liquid: 15 *l*;
    - temperature range: -60 ^oC - +260 ^oC;
    - temperature inertia: $\Delta T = \pm 0.05\ K$ ($\Delta\theta = \pm 0.05\ ^oC$);

The experimental stand is shown schematically in Figure 2. The UT1 is equipped with a heater adjustable to the indications of an electrocontact thermometer and capable of stirring the liquid. The set temperature θ_I is controlled by the thermometer T, which together with the test RTD 1 is immersed in the water. The thermal resistor is connected to the electronic unit 2 which outputs the display 3.

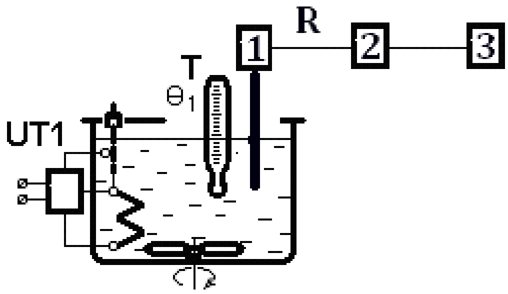

Figure 2. Scheme of experimental stand

IV. EXPERIMENTAL RESULTS

The tests were performed 10 times and the results given in Table 1 for each type of thermoregulator (platinum Pt100, copper Cu100 and nickel Ni100) are averaged. The graphical representation of the characteristics is shown in Figure 3.

Table 1. Results from experiments

№	θ_I, ^oC	R_{Pt100}, Ω	R_T, Ω	ΔR, Ω
1	20	107,23	107,79	-0,56
2	25	109,15	109,73	-0,58
3	30	111,19	111,67	-0,48
4	35	113,24	113,61	-0,37
5	40	115,16	115,54	-0,38
6	45	117,09	117,47	-0,38
7	50	119,01	119,4	-0,39
№	θ_I, ^oC	R_{Cu100}, Ω	R_T, Ω	ΔR, Ω
1	20	108,11	108,56	-0,45
2	25	110,18	110,69	-0,51
3	30	112,08	112,83	-0,75
4	35	114,65	114,97	-0,32
5	40	117,51	117,11	0,4
6	45	119,45	119,25	0,2
7	50	121,02	121,39	-0,37
№	θ_I, ^oC	R_{Ni100}, Ω	R_T, Ω	ΔR, Ω
1	20	110,89	111,26	-0,37
2	25	113,76	114,16	-0,4
3	30	116,61	117,1	-0,49
4	35	119,76	120,06	-0,3
5	40	122,87	123,07	-0,2
6	45	125,51	126,1	-0,59
7	50	128,77	129,17	-0,4

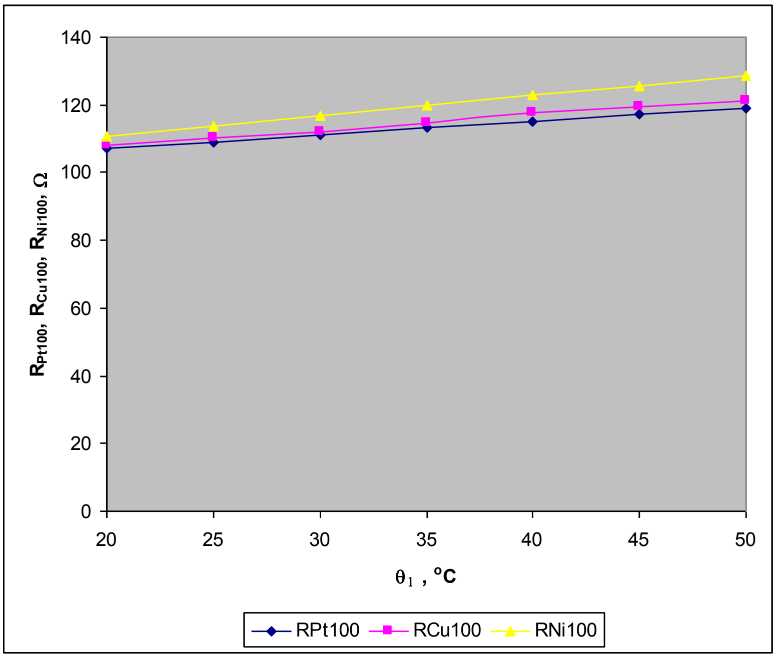

Figure 5. Graphical representation of the characteristics of RTD

V. CONCLUSION

The results of the conducted experiments show that the resistance of the RTD are directly proportional to the temperature of the measured substance. The difference between the measured resistance and the calibration resistance does not pass 1Ω absolute error.

VI. REFERENCES

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