THE PRINCIPLE OF MEASURING DIFFERENTIAL THERMO EMF IN THE DEVICE "THERMOTEST"

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Rejection of defective products of steel or selection of the material for manufacturing spare parts and nodes is often met problem for enterprises of machine engineering branch. The methods of rejection used nowadays are rather labour-intensive, require highly qualified staff and, besides, performing such operations and the applied equipment are markedly expensive. The simplest method of control is the method of thermoelectromotive force (thermo-emf). It is based on fundamental property of electric thermometry: emf of the circuit consisting of several different conductors is determined exceptionally by the temperature of junctions and does not depend on temperature gradient along the conductors. However when changing junctions temperature th.-emf value changes too. This brings to device reading changes during thermo-emf measurement due to the fact that sensor temperature changes (as a rule it decreases) when taking measurements due to transmitting some energy to the investigated sample possessing significantly less temperature. However this method is not widely used in industry. For eliminating this drawback we used the method of measuring differential thermo-emf (Fig. 1).

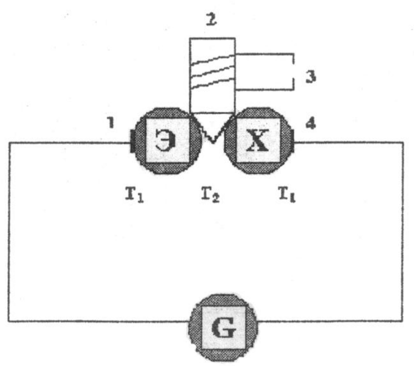

Fig.1. The diagram of measuring differential thermo-emf

The diagram shown in Fig. 1 is functioning in the following way. An electric circuit consisting of tested sample (further the standard) **S**, hot electrode **2**, tested sample **X**, cold electrodes **1,4** and galvanometer **G** is closed by hot electrode **2** prior warmed by the heater **3** up to temperature T_2. In case of similar chemical compositions and standard conditions tested sample thermo-emf of contacts **S-2** and **2-X** will be equal in value but opposite in direction and, consequently, galvanometer does not show emf presence in the circuit. In case of different chemical composition or structural condition of the standard and tested sample surface thermo-emf of contacts **S-2** and **2-X** will be different in absolute value and will be determined by temperature T_2 of hot and T_1 cold electrodes. In this case galvanometer shows presence of emf in the circuit the value of which is equal to algebraic sum of thermo-emf of contacts **S-2** and **2-X** (that is differential thermo-emf) testifying different chemical composition or structural condition of the standard surface and tested sample.

For measuring differential thermo-emf structural diagram shown in Fig. 2 is proposed. Thermo-emf measurement is taken with the help of the sensor consisting of two insulated from each other electrodes, thermocouple to control the temperature of electrodes and the heater (Fig. 3). Differential thermo-emf arrives at amplifier A1 from sensor electrodes. Amplification factor of the amplifier is chosen in such a way that when measuring thermo-emf of tested samples used for device calibration device readings should correspond to calibrated ones. From amplifier output voltage is supplied to analog digitizer and then to digital indicator board showing the results of measurement.

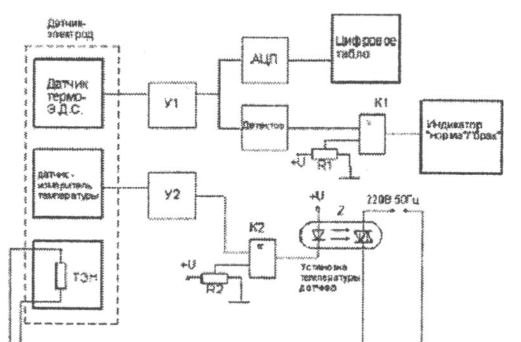

Fig. 2. Structural diagram of device Thermotest

For mass sorting out of articles according to steel types the possibility of thermo-emf control in a certain range is provided. For this purpose comparator C1 with controlled threshold of wearing is used in the diagram. Thermo-emf of detector output for obtaining absolute thermo-emf value is supplied to the straight comparator input and pedestral voltage from alternating resistor R1 is supplied to the comparator inversion input. Changing pedestral voltage one can admit limited waste threshold. The result of comparison is displayed on indicator boards "norm" and "waste". To obtain high sensitivity of the sensor the temperature of its electrodes should be maintained at optimal level. Thermoregulation canal consists of a thermocouple (temperature meter), amplifier A2, comparator C2, resistor R2, optosimistor Z and heater TEH. Current temperature value from the thermocouple enters the amplifier and then to the comparator which compares established temperature value with the current value and controls the heater via optosimistor. The diagram showed high recurrence of measurement results.

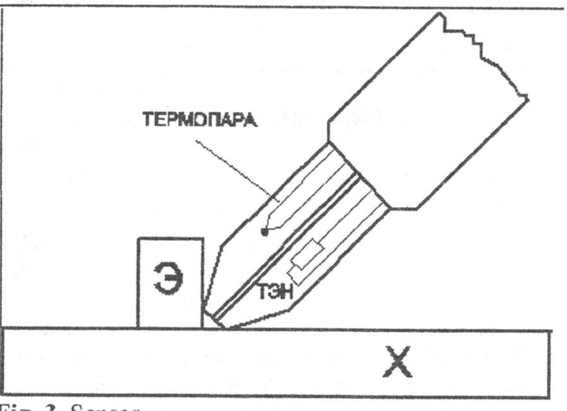

Fig. 3. Sensor

REFERENCES

1. Livshits B.G., Kraposhin V.S., Linetsky Ja.L. Physical properties of metal and alloys. – M.: Metallurgy, 1980. – p. 320.

METAL AND ALLOY MONITORING BY THERMOELECTROMOTIVE MEASURING METHOD

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"Termotest" is a new device developed for nondestructive control, where thermal electromotive force method is used (illustrated in Figure 1). Functioning of a circuit is based on the fundamental property of electrical thermometry: "Electromotive force of a circuit, consisting of several different conductors, depends only on the temperature of soldered joints and doesn't depend on thermal gradient along conductors"/1/.

The scheme, illustrated in Figure 1, operates the following way. The electrical circuit, consisting of reference template (standard hereinafter) **E**, hot electrode **2**, test model **X**, cold electrodes **1,4** and galvanometer **G**, is locked by hot electrode **2**, which is heated by heater **3** to temperature $\mathbf{T_2}$ previously. If chemistry and state of standard and test model are the same, thermoelectromotives of contacts **E-2** and **2-X** will be equal to each other, but opposite by the sign. Consequently, the galvanometer will not register electromotive force in the circuit. If chemistry or surface state of the standard and test model is different, thermoelectromotives of contacts **E-2** and **2-X** will differ from each other and will be characterized by difference between temperature $\mathbf{T_2}$ of a hot electrode and temperature $\mathbf{T_1}$ of cold electrodes. In this case the galvanometer will register electromotive force in the circuit. Value of electromotive force is equal to algebraic sum of thermoelectromotives of contacts **E-2** and **2-X** (or to differential thermal electromotive force). It marks that the standard and test model have different chemistry or different surface structure. Sizes of the standard and test model will not influence on the value of differential thermoelectromotive force, if temperatures between contacts of models and cold electrodes are equal to each other. The possibility of rising of parasitical thermoelectromotives because of different temperatures of the standard and test model are excluded in the device "Termotest" due to the original design of sensor.

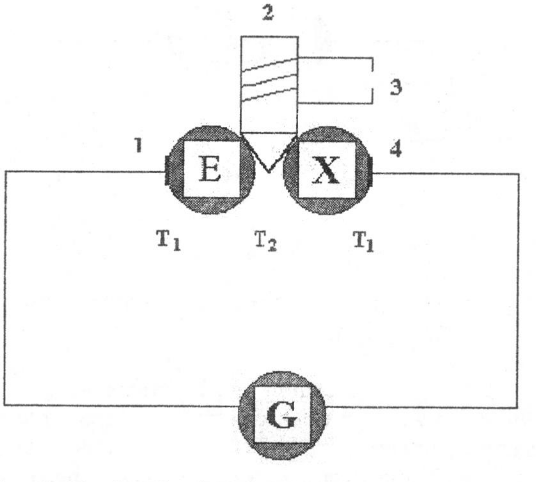

Fig. 1. Basic circuit of measuring of differential thermoelectromotive in the device "Termotest"