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Study of the Mechanism of Voltage Generation in the Order of 12-24 V Potential by Means of Thermo Emf Based on the Seebeck Effect

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Abstract: This article studies the mechanism of generating potential difference in the range of 12-24 V DC using the thermoelectromotive force arising at the boundary of two dissimilar conductors. The experimental conditions are considered, including the choice of materials, temperature conditions, the influence of the conductor cross-section, and the use of transformers to increase the output voltage. An analysis of the feasibility of this economic approach is carried out, taking into account some costs.

Keywords: thermoelectric driving force, voltage converters, thermocouple, temperature differential, Seebeck coefficient, virtual circuit, energy consumption, Fermi level, alternative material.

Introduction. Thermoelectric driving force (thermo EMF) is the voltage that occurs at the boundary of two dissimilar materials in the form of a wire, in the presence of a temperature gradient. This phenomenon, discovered by T. Seebeck in 1821, is widely used in thermocouples for measuring temperatures in automation systems. But under standard conditions, thermocouples generate very low voltage, which limits their use for power generation. This study is aimed at studying only the possibility of increasing the thermo EMF to 12-24 V DC by optimizing the experimental conditions and using additional voltage converters. This effect is based on differences of property of the material thermic conductivity and another aspects or sizes of materials. Processes is very simple but it has not high effect of power generations. We can give more examples of constructs which show it. But all constructions have no great efficiency. The thermoelectric effect is the direct conversion of heat change into electrical voltage and vice versa. A voltage is generated when there are different temperatures on each side of a thermoelectric device through a thermocouple structure. Or, when a voltage is applied to it, a temperature difference is created on one side, and a colder side on the other. The temperature gradient applied at the atomic scale diffuses charge carriers from the hot side to the colder side.

Methods and results. The method is based on the following aspects, which is the basis of the work:

- Determine the experimental conditions in the optimal version, including the choice of materials and conductors.
- Determine the modes, temperature differentials and those necessary to create a significant gradient.
- Study the influence of the parameters and characteristics of the conductors and the output voltage [7,10, 4, 5].

Use transformers or other converters to increase the voltage to 12 - 24 V, which depends on expression 1.1.

$$\mathcal{E} = \int_{T_1}^{T_2} \alpha_{12}(T)\,dT \qquad (1.1).$$

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- Conduct a feasibility study (FS) of the feasibility of the proposed method.

To conduct the experiment, the LabVIEW environment was used, in which the operation of a thermoelectric unit capable of generating voltage due to the temperature gradient between conductors - chromel and alumel - was simulated. Implementation of the algorithm in a virtual environment allowed for a detailed analysis of the system's behavior when changing various parameters.

Materials and equipment used.

Conductors made of two dissimilar materials: Chromel and alumel were chosen as conductors due to their high Seebeck coefficients. Seebeck coefficients: for chromel - 2.5×10^{-5} V/K, for alumel - 1.8×10^{-5} V/K.

Temperature sources: The building's boiler plant was used as a heat source during the heating season, which made it possible to minimize the costs of maintaining a high temperature of the hot end. The cold end was cooled using the atmospheric temperature in winter, which provided cooling down to -25°C.

Simulation software environment: A virtual circuit was developed in LabVIEW, including temperature controllers and Seebeck coefficients for calculating the thermal EMF. To increase the voltage, a Multiply Block with a transformation ratio of 2400 was used, simulating the operation of a transformer.

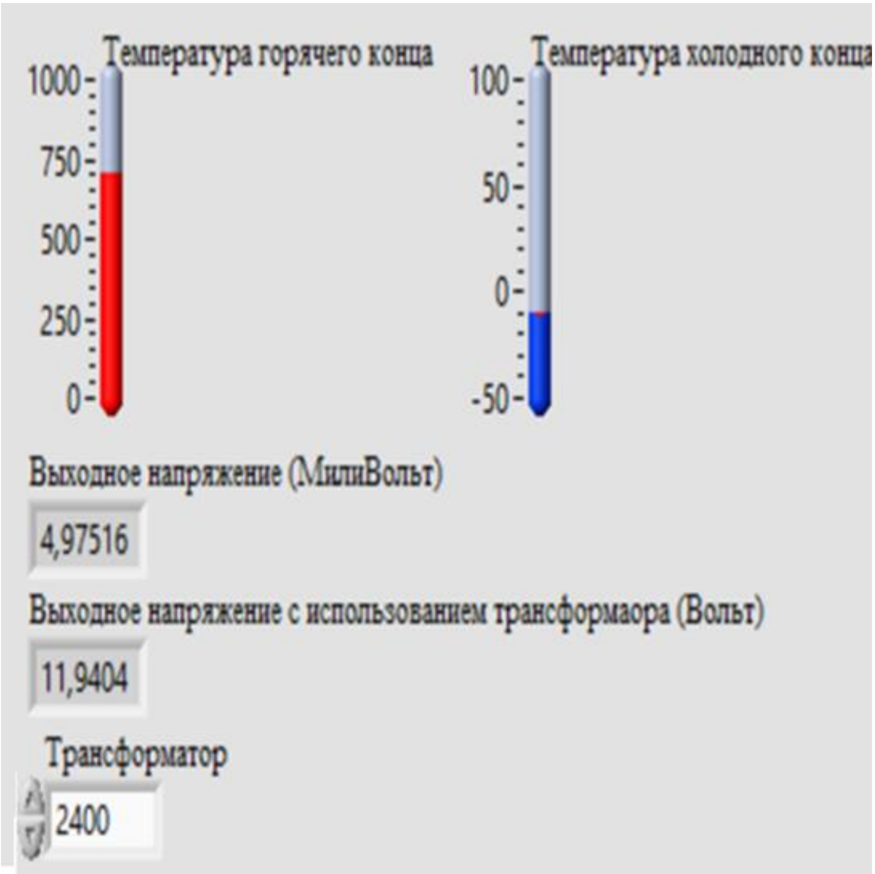

Рис 1. Передный вид интерфейса.

To assess the economic feasibility, calculations were made using market data: Cost of materials: Chromel and alumel: the cost of conductors is from 15 to 20 dollars per kg, depending on the supplier. For the experiment, several meters of wire were needed, which, converted to weight, cost approximately 50 dollars [6-10].

- Temperature control equipment: The boiler unit of the heating system was used as a heat source. reduce the cost of maintaining high temperatures. Cooling of the cold end was carried out by using atmospheric temperature in winter, which also minimizes costs.

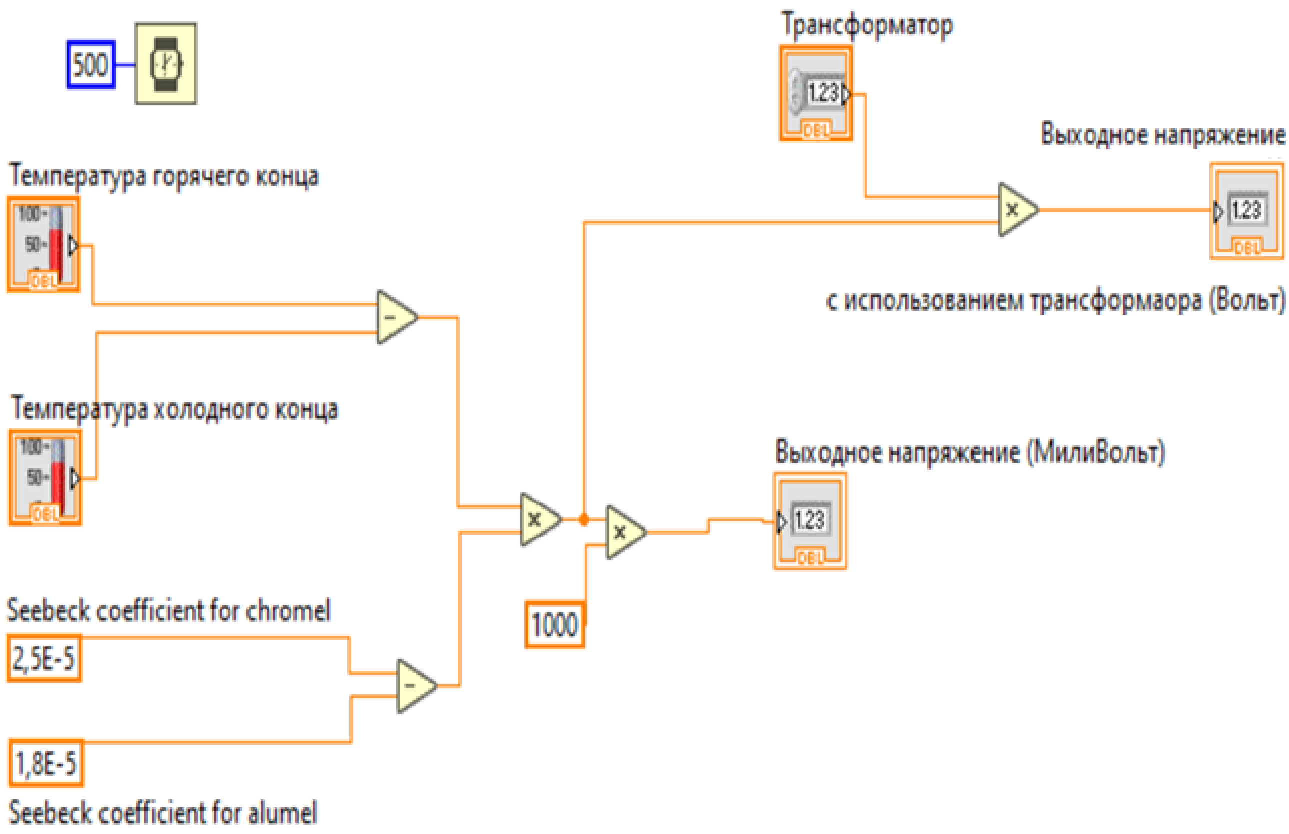

Fig 2. Circuit diagram of the experiment

- Transformers and converters: A transformer with a ratio of about 2x2400 was used to step up the voltage. A real voltage converter, such as the XL6009 DC-DC converter, costs about 12,000 UZS, but requires additional equipment and control [1-5].
- Power costs: Maintaining a temperature gradient between 1000 °C and -25 °C requires significant electricity costs. The estimated electricity costs are about $ 300 per month. Results for temperature difference: At 700 °C for the hot end and -10 °C for the cold end, the output voltage was 4.975 mV, which after transformation resulted in a value of 11.94 V, close to the target level of 12 V (1.1)

$$U = \frac{F_2 - F_1}{e} \quad . 1.1.$$

where, F is the Fermi level, e is the electron charge.

Conclusion. In the course of this study, the possibility of generating voltage up to 12 V using the thermoelectromotive force arising at the boundary of dissimilar conductors was analyzed. Modeling in the LabVIEW environment allowed us to clearly study the process of voltage conversion and increase. Based on the analysis and feasibility study, it can be concluded that generating voltage up to 12 V and higher in this way is not economically justified due to the high costs of materials and maintaining a temperature gradient, as well as the low efficiency of the process. It is recommended to consider the use of other alternative materials and energy conversion methods that will provide higher efficiency and economic feasibility[11].

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