RT&A, Special Issue No 5 (75)
Volume 18, November 2023

DETERMINATION OF THE ENVIRONMENTAL TEMPERATURE DEGREE ON MAGNETIC LEVITATION CORE INDUCTION

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Abstract

The issues on determining the degree of influence of temperature changes caused by climatic features of the area, internal heat generation during the operation of an electronic circuit and other reasons on the value of the magnetic induction of the levitating magnetic core are analyzed in the article. Based on the results of preliminary studies, the model of the Magnetic Levitation System (MLS), the dependence on the temperature of the magnetic induction on the levitating core was obtained. The preliminary investigation results of the MLS show that the magnetic induction of the levitating core is a linear monotonically decreasing function of temperature. The aim of this issue is to study the effect of temperature on the nature of the power characteristics of the MLS, the temperature in the measuring chamber of which has a significant effect, which indicates the violation of the levitation current stability caused by temperature changes in the magnetic induction of the levitating magnetic core (which indicates the violation of the levitation current stability).

Keywords: magnetic induction, magnetic levitation systems, measuring chamber, magnetic core, solenoid

I. Introduction

When the magnetic levitation system (MLS) is operating under conditions different from normal, its accuracy, in addition to the main error, will also be predetermined by additional errors from various disturbing factors of both a systematic and random nature [2].

Among these factors, first of all, are temperature changes caused by climatic features of the area, depending on the time of year and time of day, internal heat generation during the operation of the electronic circuit and other reasons.

II. Discussion

In Fig.1 the basic electric circuit of the MLS using an integrated Hall sensor and a temperature meter is shown. It contains a traction node 1, consisting of a solenoid 2 and a magnetic core 3, a measuring chamber 4, an integrated Hall sensor 5, an analogue block 6 of the solenoid current control.

The electronic unit itself contains an operational amplifier 7 K140UD14, a power transistor 8 of the KT805A type, in the emitter circuit of which the winding of the solenoid 2 and the measuring resistor Ri are connected in series, the output of which in the form of a levitation voltage Ul is fed to the input of the signal shaper, proportional to the measured parameter of the control object.

Temperature sensor 9 - the thermistor is mounted on the lower cheek of the solenoid frame. It is as close as possible to the zone of placement of the levitating magnetic core. The thermistor is turned on according to the voltage divider circuit, the output signal of which is supplied to the direct input of the operational amplifier 10. The circuit is adjusted to its initial state using the adjustment resistance 11 connected to the inverse input circuit of the amplifier 10. The gain of the operational amplifier is set using the adjustment resistance 12. A voltage signal proportional to the temperature of the working area of the levitating magnetic core is fed to the analogue input of the microcontroller.

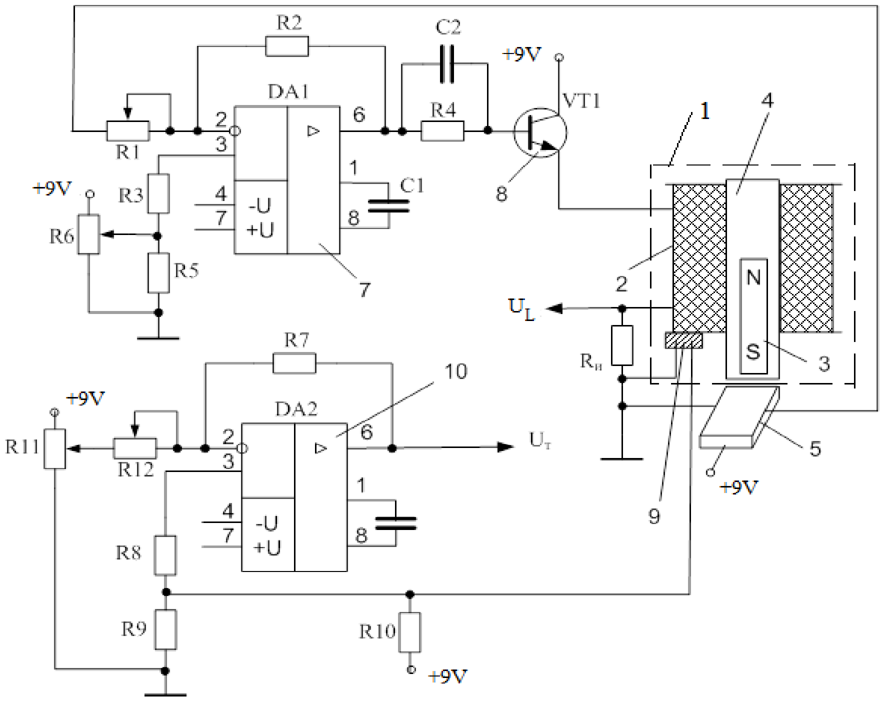

Fig. 1: *Diagram of a magnetic levitation system with a temperature meter*

III. Results

Considering the typical case where the only significant disturbing factor is the change in the ambient temperature in the measuring chamber of the system, caused by both external climatic changes and internal heat generation associated with the consumption of electric energy from the power source, assuming that other factors, such as the change in the resistance of the measuring resistor Ri, change in linear dimensions of individual structural elements, etc. - are not significant.

The temperature in the measuring chamber has a significant effect on the nature of the power characteristic of the MLS, which is manifested in a violation of the stability of the levitation current caused by temperature changes in the magnetic induction B_m of the levitating magnetic core [3].

Preliminary laboratory studies have shown that a change in the magnetic induction of B_m in the temperature range from $+10^0$ to + 35°C is about 1%. Naturally, with a change in the temperature of the medium in the measuring chamber in the climatic range from -10^0 to $+ 50^0$C, it will be even greater, i.e. amount to about 3%.

Therefore, taking into account the effect of temperature on the traction characteristic of the solenoid is clearly necessary, given the fact that the expected error of magneto-gravity devices is, as a rule, of the order of 0.1 - 0.2% and, in any case, should not exceed 0.5%.

To take into account the influence of temperature on the accuracy of the system, we consider the basic dependence $(F_d = \frac{\pi}{8} \cdot \frac{d_m^2}{d_n^2} . \mu_0 . j_z(b) . h . K(\bar{z}) . I_s)$ of the levitation current on the magnetic and structural parameters of the MLS given in [1]:

$$F_d = \frac{\pi}{8} \cdot \frac{d_m^2}{d_n^2} . B_m . h . K(\bar{z}) . I_s$$

where,

I_s - is the current of the solenoid, A;

d_m - diameter of the magnetic core;

d_n - is the diameter of the wire of the solenoid winding, m;

h- is the height of the winding, m;

d - is the distance from the upper end of the core to the upper edge of the solenoid winding, m;

R and d - are the outer and inner radii of the coil of the solenoid.

According to the results of preliminary studies of the MLS prototype, the magnetic induction B_m of the levitating core can be represented as a linear monotonically decreasing dependence:

$$B_m = B_{mo} . (1 - \alpha_m . \Delta T), \tag{1}$$

where,

B_{mo} is the magnetic induction of the levitating core at a graduation temperature $T_0 = 25$ °C, Tl;

$\Delta T = T - T_0$ - deviation of fuel temperature from calibration temperature T_0, ^0C;

T - is the actual core temperature, ^0C;

α_m - temperature coefficient of influence on the magnitude of the magnetic induction, 1 / deg.

According to the experimental data, it was found that when the temperature changes by $\Delta T_э = 25^0C$, the levitation current increases to the value of $I_s = 316$mA, i.e. by approximately $\Delta I_s = 4$mA, which is:

$$\delta_L = \frac{\Delta I_s}{I_{co}} = \frac{4мА}{312м1} = 0.013, \text{ т.е. } 1.3\%$$

where, I_{co} – is the levitation current at $\Delta T = 0$.

Then we can write that $\alpha_m \cdot \Delta T_э = 0.013$, whence

$$\alpha_m = \frac{0.013}{25} \approx 0.52.10^{-3}, 1 / \deg \tag{2}$$

Substituting (2) in (1), we obtain:

$$B_m = B_{mo} \cdot (1 - 0.52 \cdot 10^{-3} \cdot \Delta T) \tag{3}$$

Then from (2) we obtain an expression that determines the traction force of the solenoid depending on the temperature of the medium in the measuring chamber in the following form:

$$F_s = \frac{\pi}{8} \cdot \frac{d_m^2}{d_n^2} . B_{mo} . (1 - 0.52 - 10^{-3} . \Delta T) . h . K_{o.\mathbf{max}}(\bar{z}) . I_s \tag{4}$$

Now the task is to introduce, in expression (4), instead of ΔT, the voltage $\Delta U_T = U_T - U_{TO}$, which is proportional to the temperature change, where U_{TO} is the voltage at the output of the temperature meter at the initial calibration temperature $T_0 = 25^0C$), мВ; U_T- voltage at the output of the temperature meter at the actual temperature in the measuring chamber, V.

It is obvious that the dependence of the voltage at the output of the temperature meter on its value can be represented in the following form:

$$T = K_u \cdot U_T, \tag{5}$$

where K_u – is the proportionality coefficient, the value of which, in principle, can be set arbitrarily by adjusting the gain of the electronic amplifier of the temperature meter, deg / V.

In this case, it is necessary to choose a value of the coefficient K_u so that at a temperature T_0 = 25^0C the voltage at the output of the temperature meter would be $U_{\text{т}}$ = 0.25V. Then, subject to a linear relationship between voltage and temperature, the proportionality coefficient will be equal to:

$$K_u = \frac{T_0}{U_{\text{т}}} = \frac{25}{0.25} = 100^0\text{C/V} \tag{6}$$

Substituting (5) and (6) in (4) and assuming $I_s = \frac{U_L}{R_u}$ we get:

$$F_s = \frac{\pi}{8} \cdot \frac{d_m^2}{d_n^2} \cdot B_{mo} \cdot \left(1 - 0.052 \cdot \left(U_{\text{т}} - U_{\text{т}o}\right)\right) \cdot h \cdot K_{0.\mathbf{max}}(\bar{z}) \cdot \frac{U_L}{R_u}, \tag{7}$$

where U_L is the voltage at the output of the core weight meter in the state of levitation, V;
R_u – is the measuring resistance of the circuit, Om.

IV. Conclusion

The temperature in the measuring chamber has a significant effect on the nature of the power characteristic of the MLS, which is manifested in a violation of the stability of the levitation current caused by temperature changes in the magnetic induction of the levitating magnetic core.

The dependence is obtained according to the results of preliminary studies of the MLS model of the magnetic induction of the levitating core.

According to the results of preliminary studies of the MLS model, the magnetic induction of the levitating core is a linear monotonically decreasing dependence.

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