OPTIMIZATION OF PARAMETERS AND THE GEOMETRICAL SIZES THE PRECISION STABILIZER OF THE ALTERNATING CURRENT

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ABSTRACT

In work optimization of parameters and the geometrical sizes of the precision stabilizer of an alternating current is considered. The criterion of optimization chooses optimum values of density of currents in windings. On the basis of the received optimum parities recommendations at the choice of parameters of the stabilizer are developed.

Keywords: stabilizer, optimization, magnetic fields, galvanic baths.

I. INTRODUCTION

Test beds, galvanic baths and installations where scientific researches on the stabilized magnetic fields are carried out require precision stabilizers of an alternating current. In the present work optimization of parameters and the geometrical sizes of the stabilizer of an alternating current with short-circuited levitation a winding (LW) [1] is considered. In the given work as criterion of optimization preset values of density of currents in windings are accepted.

II. MAIN PART

According to work [2] for a preset value of density of current J_2 in LW it is possible to write down:

$$\tau_{T2} = A_{T2} J_2 \left(\frac{\mu_o l_{cp2}^3}{\lambda S_{\acute{a}\hat{\imath}\hat{e}\ 2}^2} \right) = J_2 m_{12}^* A_{T2} A_{C2} \sqrt{\frac{C}{n_{e2}}}, \qquad (1)$$

Where are designated:

$$A_{T2} = \frac{b_2 \rho_{20}}{K_T} \sqrt{\frac{2g\gamma_2 K_{32}}{\mu_o}}; A_{C2} = \sqrt{\frac{\sigma_2}{\sigma_{\hat{a}}}}; \frac{l_{cp2}}{\lambda} = \frac{C}{\mu_o} A_{C2};$$

$$\sigma_2 = \frac{2m_a + m_c n_{o2} + m_a m_c n_{o2}}{m_a m_c n_{o2}}$$

If to accept: $\gamma_2 = n_k\ \gamma_M = 1.1 \cdot 8.9 \cdot 10^3 = 9.79 \cdot 10^3$ кг/м³ ; $\rho_{20} = 1.7 \cdot 10^{-8}$ Ом/м ; $g = 9.8$ м/с² ; $K_T = 13$; $K_{32} = 0.6$; $\mu_o = 1.256 \cdot 10^{-6}$ Гн/м ; $b_2 = 0.98$ we shall receive: $A_{T2} = 389 \cdot 10^{-6}$; $A_{C2} = 1.082 \div 1.283$. From (1) it is easy to define size:

$$\tilde{N} = \left(\frac{\tau_{T2}}{A_{T2}} \right)^2 \frac{n_{e2}}{J_2^2 A_{c2}^2 m_{12}^{*2}} \qquad (2)$$

Using (2) it is easy to find other sizes of the core and windings if values J_1 are known, J_2. With this purpose in the beginning we shall consider as density of currents J_1, J_2 depending on temperatures τ_1, τ_2 change.

We Shall present force of weight LW $P_в$ and temperature τ_1 in a following kind:

$$P_{\hat{a}} = 2(g\gamma b_2)^2 \frac{l_{cp2}^2}{\lambda J_2^2};$$

$$\tau_1 = A_1 J_1 \sqrt{\frac{S_{o1} l_{cp1}^2}{\lambda S_{ox1}}} (\Delta_{ok} + \alpha_M \tau_1) = J_1 \frac{K_p}{b_2} A_{C1} A_{T2} \sqrt{\frac{C}{n_{e1}}},$$

where:

$$A_1 = \frac{K_p}{K_T} \rho_{10} \sqrt{2g\gamma K_{31}}; A_{C1} = \sqrt{\frac{\sigma_1}{\sigma_{\hat{a}}}}; A_{T1} = A_{T2} \frac{K_p}{b_2};$$

$$I_1 W_1 = \sqrt{2g\gamma K_{31} S_{o1} \frac{l_{cp1}}{\lambda}}$$

Then

$$\frac{\tau_{T1}}{\tau_{T2}} = \left(\frac{J_1}{J_2} \right) \left(\frac{K_p}{b_2} \right) \left(\frac{A_{C1}}{A_{C2}} \right) \sqrt{\frac{n_{e2}}{n_{e1}}}$$

As

$$J_1 K_p = J_1 + b_2 j_2 K_c K_\tau; \qquad \frac{A_{C1}}{A_{C2}} = \sqrt{\frac{\sigma_1}{\sigma_2}} = \frac{1}{\sqrt{K_c}},$$

That we write down:

$$\frac{\tau_{T1}}{\tau_{T2}} = \left(\frac{\varepsilon_{12}}{b_2} + K_c K_\tau \right) \sqrt{\frac{n_{e2}}{n_{e1} K_c}}, \qquad \left(\text{where} \qquad \varepsilon_{12} = \frac{J_1}{J_2} \right)$$

From here we shall receive:

$$\varepsilon_{12} = b_2 \left(\frac{\tau_{T1}}{\tau_{T2}} \right) \sqrt{K_c \frac{n_{e1}}{n_{e2}}} - b_2 K_c K_\tau$$

Under condition of $\tau_1 = \tau_2 = \tau_a$ for direct cores we shall receive:

$$\left(\frac{\varepsilon_{12}}{b_2} + 1 \right) \sqrt{\frac{n_{e2}}{n_{e1}}} - 1; \qquad \text{If} \qquad \hat{E}_{\tilde{n}} = \hat{E}_\tau = 1$$

Then:

$$\varepsilon_{12} = b_2\left(\sqrt{\frac{n_{e1}}{n_{e2}}} - 1\right) = b_2\left(\sqrt{\frac{h_1}{h_2}} - 1\right); \quad \text{where} \quad \frac{n_{e1}}{n_{e2}} = \frac{S_{o1}}{S_{o2}} = \frac{h_1}{h_2}$$

Thus, for direct cores under condition of $\tau_1 = \tau_2 = \tau_a$ attitude J_1 / J_2 depends only on the attitude of height of windings h_1 / h_2, and always we take place $J_1 < J_2$. On fig.1 dependence $J_1/J_2 = f(h_1 / h_2)$ is resulted.

For step cores under condition of $\tau_{T1} = \tau_{T2} = \tau_a$ we shall receive:

$$\varepsilon_{12} = b_2\left(\sqrt{\frac{n_{e1}}{n_{e2}} K_c} - K_c\right)$$

On figure.2 and 3 dependences $|J_1/J_2| = f(n_{e1}/n_{e2})$ are resulted, $|J_1/J_2| == f(K_c)$. On the basis of these dependences it is possible to draw following conclusions:

1. Because of performance of conditions of levitation $P_в = F_э$ the density of a current in a motionless winding turns out less, than density of a current in LW.
2. For step cores $n_{e1} < n_{e2}$, therefore attitude J_1/J_2 at $n_{e1}/n_{e2} = 0.3 - 0.8$ makes 0.1 - 0.45. With increase in factor of frequency rate LW: $n_{e2} = h_2/C_2$ the density of a current in motionless winding J_1 decreases.

With the purpose of definition of density of a current in LW from expressions:

$$F_2 = K_{32} n_{e2} J_2 C_2^2; \quad F_2 = b_2\sqrt{\frac{2P_{\hat{a}}}{\lambda}} = b_2 F_1,$$

We find thickness of winding:

$$C_2 = \sqrt{\frac{b_2 F_1}{K_{32} n_{e2} J_2}} = C_2'$$

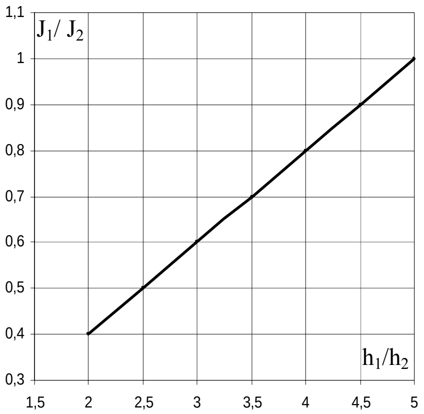

Fig.1. Dependence $\frac{J_1}{J_2} = f\left(\frac{h_1}{h_2}\right)$

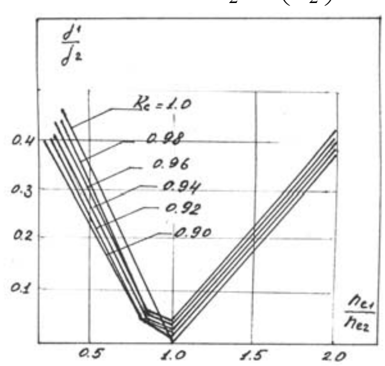

Fig.2 Dependence at $\frac{J_1}{J_2} = f\left(\frac{n_{e1}}{n_{e2}}\right)$ various values K_c (K_c=0.9-1.0)

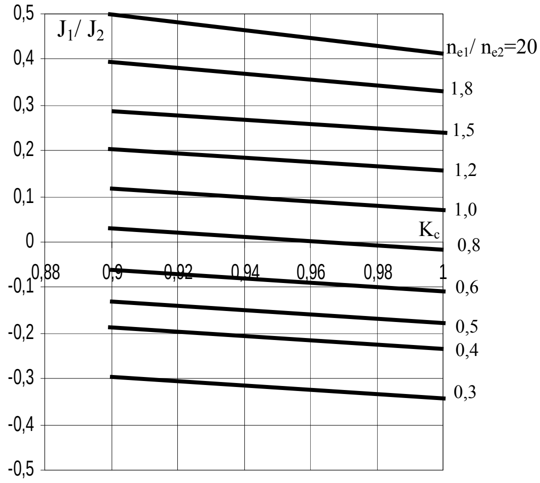

Fig.3 Dependence $\frac{J_1}{J_2} = f(K_c)$

This formula considers a condition of a levitation, but does not consider overheat LW. In view of an overheat, we shall receive:

$$C_2 = \frac{A_{o2}}{J_2^2\left(\alpha_M + \frac{\Delta_{ok}}{\tau_{\ddot{a}2}}\right)} = C_2'', \quad \text{Here} \quad A_{o2} = \frac{K_T}{K_{32}\rho_{2o}K_{c2}} \qquad (3)$$

3. More effective way of increase in density of current J_2 is reduction of a backlash With or thickness of winding C_2. Thus factor $n_{e2} = h_2/C_2$ and conductivity l increase.

$$\tau_{T2} = \left(\frac{\rho_{20}}{K_T}\right)\left(\frac{J_2}{J_1}\right)(I_2 W_2)$$

From here we find sizes ЛО:

$$C_2 = \frac{K_T \tau_{T2}}{K_{32}\rho_{20}J_2^2} = \frac{K_T}{K_{32}\rho_{20}J_2^2}\left(\frac{\tau_{\ddot{a}}}{\Delta_{ok} + \alpha\tau_{\ddot{a}\hat{i}\ddot{i}}}\right) \qquad (4)$$

$$h_2 = \frac{\rho_{20}J_2}{K_T \tau_{T2}}(I_2 W_2) = \frac{\rho_{20}J_2}{K_T \tau_{\ddot{a}\hat{i}\ddot{i}}}(\Delta_{ok} + \alpha\tau_{\ddot{a}\hat{i}\ddot{i}})(I_2 W_2) \qquad (5)$$

As ampere coils are defined as:

$$I_2 W_2 = b_2 I_1 W_1 = b_2\sqrt{\frac{K_u I_i \Delta U}{\omega X_M \lambda}},$$

That parity (5) can be written down as:

$$h_2 = \frac{b_2\rho_{20}J_2}{K_T \tau_{\ddot{a}\hat{i}\ddot{i}}}(\Delta_{ok} + \alpha\tau_{\ddot{a}\hat{i}\ddot{i}})\sqrt{\frac{K_u I_i \Delta U}{\omega X_M \lambda}}$$

Then the attitude of height of a winding to its thickness will be equal:

$$n_{e2} = \frac{h_2}{C_2} = \frac{J_2^3}{\tau_{T2}^2}\left(\frac{K_{32}\rho_{20}}{K_T}\right)^2 (I_2 W_2)$$

The received parities (4) - (5) show:

1. For essential reduction of thickness of winding C_2 and a working backlash With it is necessary to increase density of current J_2 and to reduce temperature of overheat τ_{adm}.

2. For reduction of height of a winding h_2 it is necessary to increase temperature of an overheat of winding τ_{adm} and to reduce density of current J_2 and ampere coils I_2W_2.
3. The height of a winding h_2 is directly proportional ampere coils which in turn with increase in conductivity λ and course X_M decrease, and with increase in an increment of pressure ΔU increase.
4. For elimination of harmony LW it is necessary to reduce density of current J_2 and to increase temperature τ_T, that is first of all it is necessary to affect value of factor n_{e2}.

Considering $\rho_{20}=1.7\cdot10^{-8}$ Ом м ; $K_{32}=0.4$ - 0.8 ; $K_T=10$ - 13; $\alpha_M=0.0043$; $n_{e2}=5$ - 10; $\tau_2=50$ -100^0C, it is easy to define factors A_{02}; Δ_{ok} and thickness of winding $C_2=C''_2$. But thus it is necessary to know value of density of current J_2, satisfying as to a condition of a levitation, and set overheat τ_2. Therefore all over again from conditions $C'_2=C''_2$ we find density of current LW:

$$J_2 = \sqrt[3]{\left(\frac{K_{32} n_{e2} A_{o2}^2}{b_2 F_l}\right) \frac{1}{\left(\alpha_M + \frac{\Delta_{ok}}{\tau_2}\right)^2}}\ , \qquad (6)$$

Which satisfies formulas (3) and (6).

As $F_l = \sqrt{\frac{2P_{\hat{a}}}{\lambda}} = \sqrt{\frac{2K_u I_1(\Delta U_1)}{\omega X_M \lambda}}$,

That value (6) can be written down as:

$$J_2 = \acute{A}_0 \sqrt[3]{\frac{n_{e2}}{\left(\alpha_M + \frac{\Delta_{ok}}{\tau_2}\right)^2} \sqrt{\frac{\lambda X_M}{I_1 \Delta U_1}}}\ , \qquad (7)$$

Where it is designated:

$$\acute{A}_0 = \sqrt[3]{A_{o2}^2 \frac{K_{32}}{b_2} \sqrt{\frac{\omega}{2K_u}}}$$

The formula (7) allows to establish dependence:

$$J_2 = f\,(I_1; X_M; \lambda; \tau_2\ ; n_{e2})$$

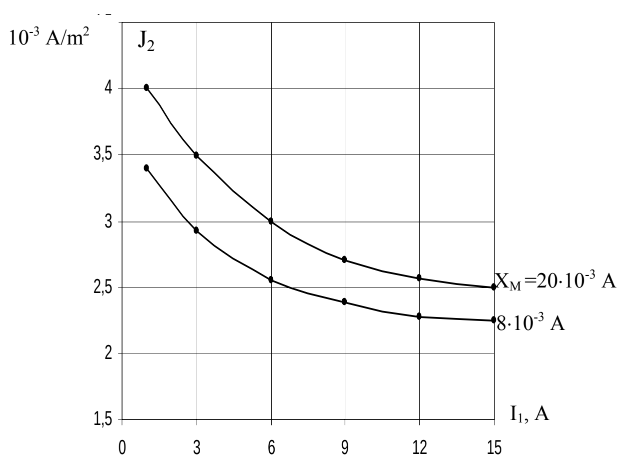

Fig.4 Dependence of density of a current on a current at values of a course of mobile part

On fig. 4 dependence is resulted: $J_2 = f(I_1, X_M)$. The analysis of this dependence shows:
1. Density of a current in LW with increase in parameters X_M; λ; τ_2 ; n_{e2} increases.
2. With increase in rating values of stabilized current I_1 the density of a current in LW J_2 falls.

III. CONCLUSIONS

Analytical expressions of optimum values of parameters and the geometrical sizes of the precision stabilizer of an alternating current with use criterion of density of currents in windings Are received. The received expressions consider temperatures of an overheat of windings and course LW. Thus received following important conclusions:

1. The density of a current in LW turns out less, than density of a current in a winding of excitation (WE). For this reason the height appears less, than height LW.

2. The density of current LW is influenced essentially with values of height, a course and temperatures of overheat LW, and also specific conductivity of a working backlash. At increase in these parameters the density of a current in LW increases. However the increase in stabilizers of a current in WE leads to reduction of a current in LW. With reduction of thickness of a working backlash the density of a current in LW increases. Thus the increase in the attitude of height LW to its thickness is required.

3. At reduction of density of a current and increase in temperature of overheat LW the principle of harmony LW is carried out.

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