THERMAL MODEL OF AN INDUCTION TRACTION MOTOR

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Abstract: Evaluation of the temperature conditions of the windings of the squirrel-cage rotor (ATEM) asynchronous traction electric motor of the DAT-350 type of the 2TE25A locomotive using the developed thermal model.

Key words: traction motor, modeling, heating

Introduction: Current trends in the development of the local locomotive industry suggest increasing the use of energy-intensive technologies and introducing advanced technical solutions.

This in the article electricity 2TE25A thermal model of the ATED type DAT-350 was developed to study heat flows inside the machine . Modeling of the thermal condition was carried out using the SolidWorks application to calculate stable temperature areas . This application allows you to simulate the 2D or 3D steady state temperature field of ATED using the finite element method (Figure 1).

The following assumptions were made to solve the problem :

1) in ATED with an axial ventilation system, the cooling air moves along the rotor axis along two parallel branches - in the rotor ventilation channels and in the air gap;

2) the stator and rotor of ATED are presented as a system of multi-layer bodies, the connections between them are determined by the type and conditions of heat exchange;

3) heat removal from the surfaces of the ATED housing and bearing shields can be neglected due to their insignificant size;

4) the temperature of the cooling air changes linearly along the length of the rotor ;

5) heat removal through the end surfaces of the stator and rotor plates can be neglected due to its small value;

6) stator and rotor construction sectors to volumes are divided , they inside of materials thermophysicist features one different and the heat which keeps connections there is ;

7) stator in the yellow power losses are expressed as distributed sources of thermal energy.

Thermal conductivity. The phenomenon of heat conduction is the process of heat dissipation through direct contact with individual parts of an electric machine or its individual sections, characterized by temperature.

The partial differential equation related to heat transfer has the form [9].

$$c\frac{\partial T}{\partial t} - \propto \cdot T = Q, \qquad (1)$$

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Borderline conditions account taking , the model of the traction electric machine is built in the form of a grid, and the differential equation (1) in the form of a matrix can be given as:

$$CT+CT=Q,$$

In (2) , T is the vector of the node temperature of the finite element grid, K is the finite element matrix corresponding to the heat transfer, C is the finite element matrix corresponding to the specific heat capacity, Q is the internal heat vector. release K and C matrices symmetrical matrices size n × n, generated V process meetings models , where n is a number nodes V three dimensional of course elementary lattice Vector Q is possible be divided enabled to follow components :

$$\mathbf{Q} = \sum_k \mathbf{P}_k + \sum_m \boldsymbol{\alpha}_m, \qquad (3)$$

where **Pk** - loss vector in an electric machine; a $_{m}$ is a heat transfer vector.

Heat exchange in the air space. Both heat transfer and convective heat exchange occur between the moving medium in the air gap and the surfaces of the rotor and stator.

To obtain effective heat transfer, the stator and rotor are modeled as concentric rotating cylinders. Convective heat transfer between two rotating cylinders can be calculated using dimensionless Reynolds number (Re), Taylor number (Te) and Nusselt number (Nu). Expressions for determining Reynolds number and Taylor number are given in [11]:

$$\mathrm{Re} = \frac{lnr_{\mathrm{p}}}{\nu}, \ \mathrm{Te} = \mathrm{Re}\sqrt{\frac{l}{r_{\mathrm{p}}}},$$

where l is the length of the air gap; n - rotation frequency of the rotor; p $_{\mathrm{p}}$ – rotor radius; n is the kinematic viscosity of air.

The convective heat transfer determined by the Nusselt number can be combined with the conductive heat transfer in the heat transfer equation and form the effective heat transfer for both conductive and convective heat transfer [12]:

$$\propto_{\text{э}}(n) = \frac{\mathrm{Nu}\propto_{\text{в}}}{2},$$

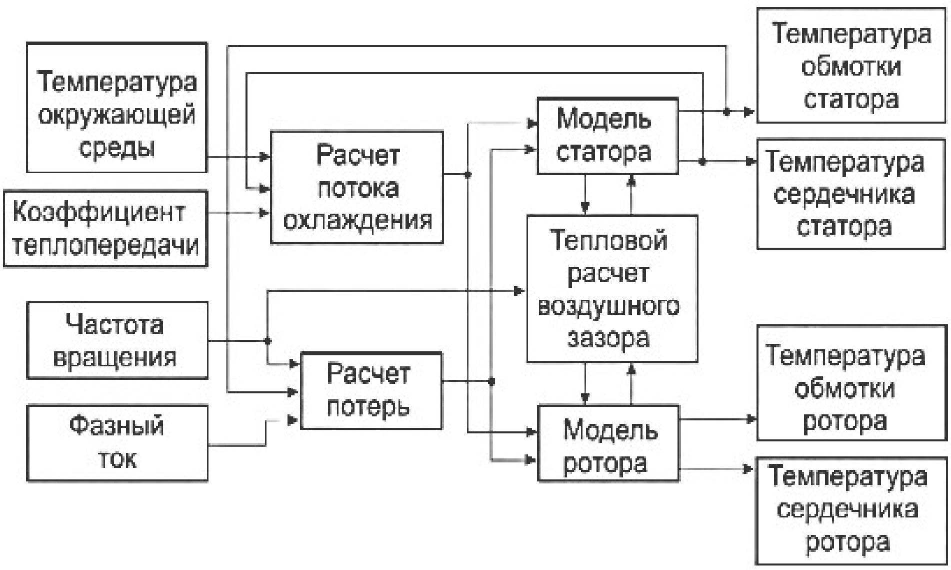
Solving the Laplace equation and assuming the same normal heat flux density q and temperature T at the air gap boundaries of the stator and rotor, we obtain the following relationship of heat flux and temperature between the stator and rotor [13] :

$$q_c = \frac{\propto_э (n)}{r_c \ln\left(\frac{r_c}{r_p}\right)} (T_p - T_c),$$

$$q_p = \frac{\propto_э (n)}{r_p \ln\left(\frac{r_c}{r_p}\right)} (T_p - T_c),$$

where q_c, q_p heat flow of stator and rotor surfaces, respectively; T_c, T_p - the temperature of the stator and rotor surfaces, respectively; r_c, r_p - stator and rotor radii.

The input data for the model are cooling air temperature, heat transfer coefficients, rotor speed and stator winding phase current. Rotational speed and phase current determine the initial data for calculating losses. Losses and cooling conditions are used in the thermal models of the stator and rotor, which are then related to each other using the air-gap heat transfer relation. The output of the model is the temperature at different locations of the winding and core of the ATED stator and rotor.



Rice. 3. Block diagram of the ATED thermal model of the locomotive

Temperature calculation results. In the form. Figure 4 shows the temperature field of the rotor section after 1 hour of nominal phase current flow through the stator winding. In the calculations, it was assumed that the insulation is of high quality, with uniform impregnation of air and non-impregnated layers without foreign additives.

In this case, the heat is removed from the rotor winding mainly to the core, which leads to an uneven distribution of temperature in height. The temperature of the lower layers of the winding is 12 ○ C lower than the upper ones, where the heat is removed by closing the tube with a greater thickness and a lower value of the heat transfer coefficient to the cooling air ·

As in the previous case, the temperature distribution along the length of the stator winding is uneven. The temperature on the side of the air gap is 8-10 ° C higher than on the side of the core. This is also explained by the difference in heat transfer coefficients to the cooling air and the stator core.

Summary. The ATED thermal model presented for calculating the temperature distribution of the stator and rotor windings adequately reflects the physical processes occurring in a closed electric motor with forced cooling and can be used to quickly determine its temperature. groove part of the winding

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