Improving the temperature resistance of traction electric motors using a microprocessor control system for modern locomotives

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Abstract. Temperature control of traction electric motors running on direct current with the help of a modern microprocessor-based locomotive control system is analyzed in the paper. Development of a methodology for calculating the temperature of the windings of traction electric motors operating on direct current, based on a modern control system has been discussed. To determine the dependence of the temperature of traction motors on the motion profile and weight of the rolling stock.

1 Introduction

Currently, the most frequent malfunctions of modern diesel locomotives operating on the territory of Uzbekistan mainly consist in traction electric motors. That is why the malfunctions of traction motors mainly depend on temperature, and the control of set temperatures is considered very important. This, in turn, reduces the number of failures of the traction motor and leads to efficient operation of locomotives.

Analysis of the malfunctions of traction electric motors for a certain period of time, analysis of the parameters recorded by the microprocessor control system of the diesel locomotive, analysis of methods for calculating the heating temperature of the exhaust electric motors, as well as comparison, temperature values of the traction electric motors during the trip and calculated using the proposed algorithm.

The malfunctions of electric motors operating with direct current of diesel locomotives operated by JSC "Uzbekistan temir yullari" were studied. The indicators recorded by the modern microprocessor control system of the locomotive are compared, a method for calculating the temperature of the electric motor windings is developed, and the values of the temperature of the electric motors during the trip are calculated using the proposed method [1].

A traction electric motor operating with direct current is a unit consisting of several expensive components and parts. Malfunctions of traction electric motors on all diesel locomotives will be possible to be divided into two groups: the first group – the largest malfunctions are damage to electrical components, and the second group includes mechanical failures.

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As practice shows, from the total number of failures of the traction electric motors, the number of damage cases is 5% of the share of generators and two-machine units, and the rest is associated with malfunctions of the traction electric motors. Most often, malfunctions of the traction electric motors occur during the expansion of the diesel locomotive, due to these malfunctions, the traction electric motors are forced to enter an unscheduled repair [2-3].

The conducted studies have shown that traction electric motors running on alternating current moving through the territory of Uzbekistan, due to the occurrence of a malfunction, will be forced to take the locomotive for repair in excess of the planned repair program. Many of these defects consist of faults in the insulation of the conductive part of traction motors operating on alternating current.

The main cause of such malfunctions is high temperature, which leads to a reduction in the service life of machines, insulation wear, the appearance of micro deficiency in insulation and the occurrence of malfunctions. In order to avoid these malfunctions, it is advisable to monitor the thermal state of the conductive parts of the traction electric motor operating on alternating current in real time, that is, during use, if this is done using a modern microprocessor-based locomotive control system.

An effective algorithm for calculating the temperature of the exhaust of the traction electric motors was obtained, on the basis of which it will be possible for The Machinist to show information about the heat status in the display module, the electric motor of the traction, warnings and recommendations about the dangerous operating mode to return it to normal.

To determine the temperature in the parts of traction motors operating on alternating current, an analytical calculation method is applied in the rules of traction calculations. The theoretical foundations of this calculation were laid in connection with the law of conservation of energy and the theory of thermal conductivity of bodies. We know well that the same body has an infinitely high thermal conductivity and had the same energy dissipation over the entire surface and the same temperature at all points of the body [4-8].

2 Objects and methods of research

The method consists in determining the excess temperature of the exhaust of the electric motor according to the current change $I = I(s)$ using the thermal parameters τ_∞ and T, this type of traction characterizes the intensity of heat exchange of electric motors. The calculation is carried out according to the formula

$$\tau = \tau_\infty \frac{\Delta t}{T} + \tau_0 \left(1 - \frac{\Delta t}{T}\right) \quad (1)$$

here τ_∞ is a stable increase in temperature, provided that no heat is transferred to the environment and all heat in the body does not accumulate, °C; T is the thermal time Constant, s; τ_0 is the increase in temperature in the current connection, °C; Δt is the time interval during which the temperature changes, s.

Cooling of traction electric motors is calculated as follows when stopping or when the locomotive is idle:

$$\tau = \tau_0 \left(1 - \frac{\Delta t}{T_0}\right) \quad (2)$$

here T_0 is the heat time constant when the current is off.

To obtain information about the heating temperature of the windings of traction motors, it is necessary to determine the indicators of its operation: the amount of current flowing through the winding from the position of the driver's controller. The above indicators can be obtained with the help of a modern microprocessor-based locomotive control system, since it allows you to more accurately monitor and regulate the operating modes of the main and auxiliary equipment of the locomotive, as well as receive information through the on-board diagnostic system of the locomotive.

Determination of the temperature of traction motors operating on direct current should be calculated analytically based on data provided by a modern microprocessor control system of a locomotive. To build an algorithm, you first need to build its structure (Fig.1).

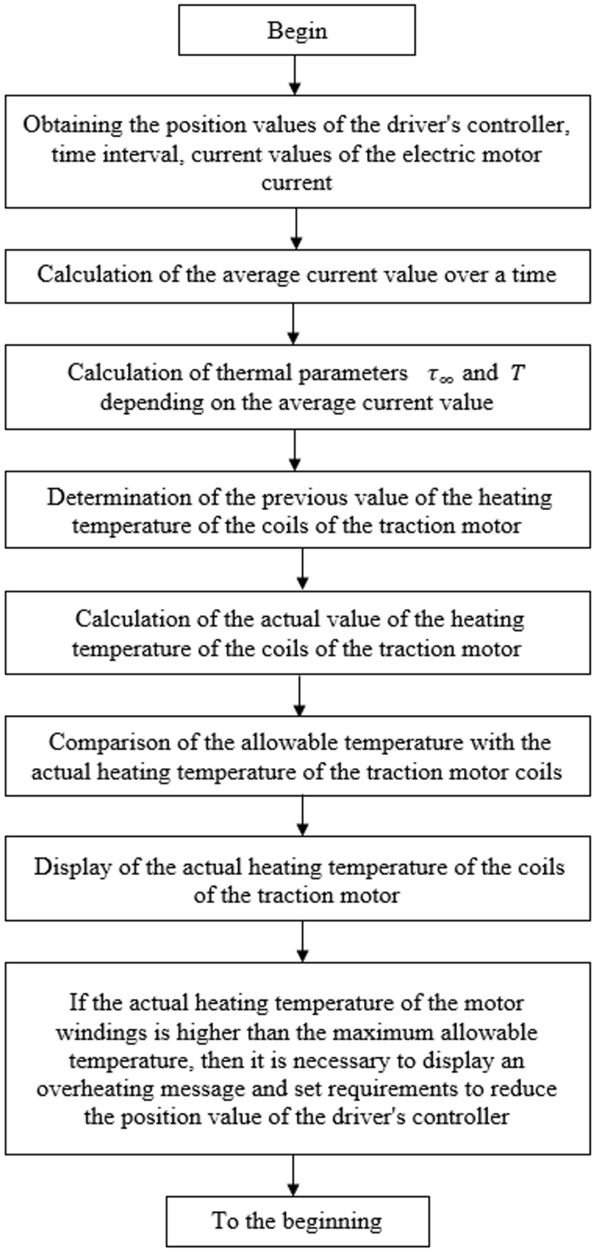

Fig. 1. Structure of the calculation of the heating temperature of traction electric motor chillers

Firstly, the microprocessor control system of the locomotive can take the position of the driver's controller, the current value of the traction motor and the values of the first-time interval, the readings necessary for the diagnosis of the locomotive. The next work done is to sequentially calculate the initial and final current values in the time interval, while the current value changes throughout the time interval. Therefore, in such conditions it is very important to calculate the average value of the current.

We assume that at the beginning of work, the current passing through the windings of the traction motors of the locomotive and their temperature are zero. Then, taking the values of the thermal parameters τ_{∞} and T of the current from the characteristics of the traction motor according to the graphs of the average thermal curve, we determine the limiting temperature of the winding of the traction motor.

Fig. 2. Modeling a trip using the program "traction accounting"

Further, the winding temperature of traction motors is calculated as the actual value of the traction motor according to formulas (1) and (2), depending on the state of traction. This increase in its temperature compared to the maximum permissible leads to damage to the insulating part of traction motors operating on alternating current.

The thrust operating at direct current leads to the appearance of temperature (Fig.1) in the windings of the electric motor, the possibility of constructing an algorithm of which is shown in Fig. 3.

The first step in the algorithm values [6-10] can be started by specifying the following indicators:

1) $x \coloneqq x_1$, where x is the average value of the flowing current in a traction motor running on direct current, and x_1 is the value of the current of the traction motor at the time of starting the algorithm, measured in;

2) $t \coloneqq t_1$, where t is the value of the heating temperature of the electric motor chucks of traction and t_1 is the value of the heating temperature of the electric motor chucks when the algorithm starts to work, measured at °C;

3) $r \coloneqq 0$, where r is the operating value of the microprocessor control system of the diesel locomotive at the current time, in the range of $0 \leq r \leq 3600$, after reaching the value of 3600, it is returned to zero and begins to grow again;

4) $k \coloneqq 0$, where k is the indicator required for the time counter to work.

The indicators x_1 and t_1 are zero when the locomotive is parked for a long time. If the locomotive is in motion during the transition from one hour of operation to another, then these indicators are taken from the constant memory of the devices of the control system with the microprocessor of the diesel locomotive [14-16].

The next task in the algorithm is to organize a query interval for all diagnostic tracts through a control system with a diesel microprocessor. This interval z is the module difference of the Time 0 or any two adjacent values registered in the system after the first.

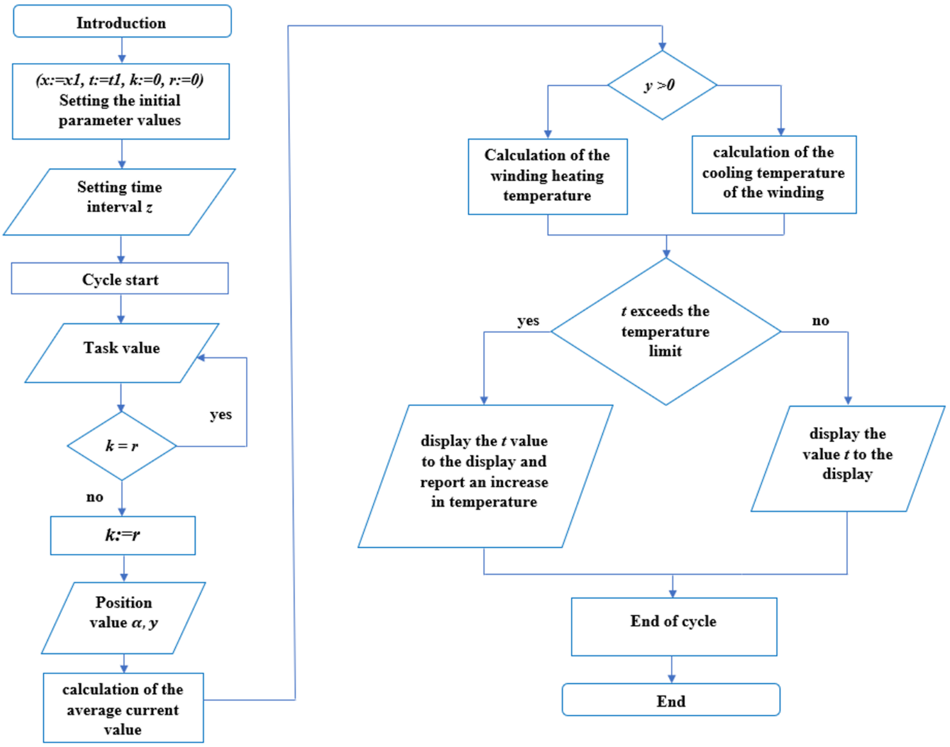

Fig. 3. Algorithm for calculating the heating temperature of traction electric motors

The next step of the algorithm is to determine the current current indicators for calculating the temperature of traction motors operating on direct current. To do this, we carried out the calculation of the trip in the "traction calculation" software, using the actual data about the trip. An example of a simulated travel program is shown in Figure 2.

According to the calculation algorithm, first of all, in this example, the parameter registration interval (Δt), the difference between adjacent times, is determined. Then in this range, the drawstring is the average value of the current in the electric motor [15-16].

Next, the position of The Machinist controller is assessed. Because if its value is zero at the end of the interval, then the diesel locomotive will be in the traction mode, the heating of the electric motor of the traction will indicate the process.

Indication of the possibility control of the thermal state of the pulsed electric motor based on the readings of the microprocessor control system, pulsed electric motors, as well as changing the actual temperature of the pulsed electric motors according to the cooling control method, will make it possible to develop an automatic protection system in the future.

To determine the temperature of such heating, it is necessary to set the values of thermal parameters (T and τ_∞) for the average value of the current obtained according to the scheme of thermal characteristics of the traction motor. For the operation of the microprocessor control system of the diesel locomotive, these curves are described in the form of polynomial functions.

$$T = 4.085 \cdot 10^{-17} \cdot I_{average}^{6} - 2.027 \cdot 10^{-13} \cdot I_{average}^{5} + 3.1193 \cdot 10^{-10} \cdot I_{average}^{4} - 1.726 \times 10^{-7} \cdot I_{average}^{3} + 5.108 \cdot 10^{-5} \cdot I_{average}^{2} + 5.468 \cdot 10^{-3} \cdot I_{average} + 26.012 \quad (3)$$

$$\tau_\infty = -2.851 \cdot 10^{-15} \cdot I_{average}^{6} + 29.435 \cdot 10^{-12} \cdot I_{average}^{5} - 1.169 \cdot 10^{-8} \cdot I_{average}^{4} + +7.045 \cdot 10^{-6} \cdot I_{average}^{3} - 2.111 \cdot 10^{-3} \cdot I_{average}^{2} + 0.354 \cdot 10^{-2} \cdot I_{average} + 0.126 \quad (4)$$

3 Results and their discussion

As a result of using the above algorithm (see (1) - (4)), we have compiled a diagram of the temperature change based on the actual trip data. The diagram takes the calculation of the control system with the microprocessor of the diesel locomotive (fig.4).

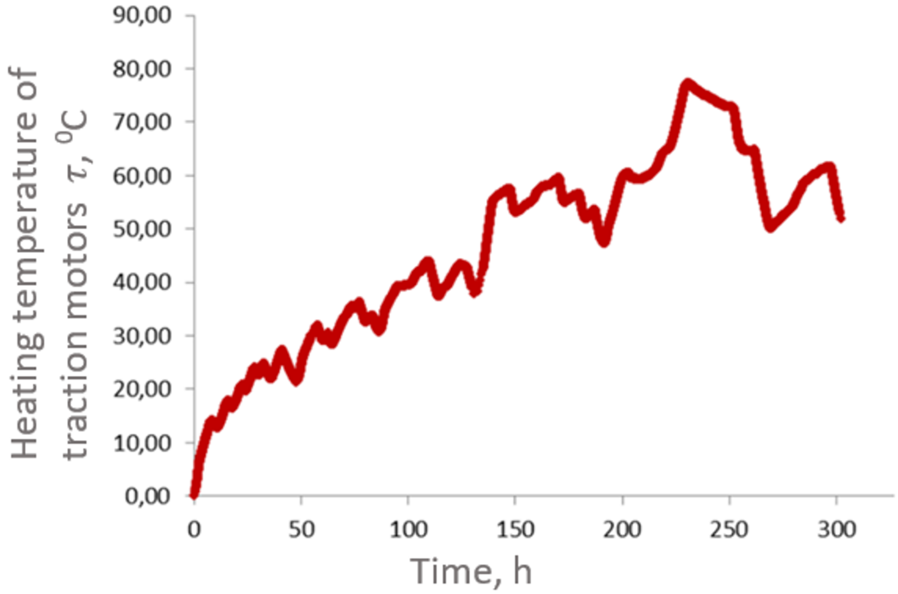

Fig. 4. Chart of heating of the electric motor of gravity.

As can be seen, the curve taken from the figure corresponds to the heating curve of traction motors presented in the simulated trip to determine which the heating temperature of traction motors during the trip determination using this algorithm allows you to get more accurate data.

4 Conclusions

The article discusses the malfunctions of traction electric motors running on direct current moving through the territory of Uzbekistan, based on the data studied, it can be said that with an increase in the weight of the train, the excess of the current flowing through traction electric motors running on direct current leads to heating and subsequent failure. This makes it possible to carry out a diesel locomotive based on the selected time indicators of a modern microprocessor control system by recalculating the values of currents flowing through the seats of traction motors and their overheating temperatures.

Based on the proposed methodology, the current winding temperature allows the driver to display messages about temperature excess and instructions for cooling traction motors running on direct current. This made it possible to develop an automatic control system for increasing the temperature of traction electric motors running on direct current in excess of a given norm, which, in turn, would allow a traction electric motor running on direct current to operate without failures during operation, increase the weight of the train, allowing you to transport as much cargo and passengers as possible.

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