Study of thermal zones in a heating collector of a traction motor NB-418 K6

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Abstract. The article provides the data about functional dependencies affecting the heating characteristic of the traction electric motor (faulty soldering in the riser winding). Studies have shown the functional dependence of the temperature drop along the length of the riser (with the coefficient 0.95 %) that allows determining the functional dependence of the riser temperature on its length.

1. Introduction

Currently, there is a large number of different methods for diagnosis and control of DC motors technical state. Literature and patents review shows that the most complete research in the field of development of methods of diagnosis and testing of DC motors has been carried out in various fields of transport, which can be explained by the following circumstances:

- a special significance of engines reliability for traffic safety;
- heavy operating conditions of engines, causing intensive degradation processes in the engine (insulation aging, transfers to the collector, etc.)
- long service life of electric locomotives.
- significant economic costs for the restoration of engine performance.

In the field of aviation technology, DC motors are mainly used as actuators of various mechanisms (low-power high-speed motors operating in good conditions at low voltage levels). The most typical failures of such engines are the deterioration of the switching quality, the deterioration of the quality of the current accumulation at the collector node, the defects in bearings, and soldering failure.

In this regard, the development of methods for determining the technical state of the soldering quality is a priority in the development of methods for diagnosis of DC motors in this industry. Nowadays, many methods and techniques have been developed to detect such defects.

The paper presents a study of the temperature drop effect on the functional dependence on the geometry of the riser.

2. Materials and methods

The use of thermal imaging with the approximation of a functional dependency (temperature as a geometry function of the riser winding) and obtaining the equation coefficients a, b, c.

Methods for determining the technical state of various objects depend on the purpose of the study, and they can be divided into methods of diagnosis and control. The tasks of diagnosis and control are formulated in the same way: to determine in which of the pre-established set of states the object is at a determined time interval. The main difference between the diagnosis methods and control is that the
object of study is considered as a whole. In the diagnosis the object is considered as a whole and as a set of elements. In this case, the state of the main elements influencing the overall state of the object as a whole is considered. Thus, technical diagnostics provides the control of both the object as a whole and its separate elements and determines necessary operations and their sequence to establish the state of the object.

The study of defects in traction motors of electric locomotives, their breakdowns during operation makes it possible to conclude that the traction motor (TM) is considered an unreliable node, the research is necessary to reduce the malfunction.

On the practical side applying the methods of technical diagnosis or control involves the search for defects in a test object, taking into account the following requirements. It is necessary to develop new methods for determining a particular type of defects that rarely occur in the operation of engines and which are economically feasible.

Thus, the use of diagnostics will allow reducing the number of unplanned repairs and reduce non-production costs.

In case of the faulty soldering, there is an increase in the transient resistance at the junction and, as a consequence, a significant heating described by the Joule – Lenz law [4, 5, 7]:

\[ Q = I^2 R \, dT \]

where \( Q \) is the amount of heat a measure of the energy of the body, Joule, \( I \) is the current in the conductor, Amperes, \( R \) is the transient resistance characterizing poor contact, Ohm, \( dT \) is the period of time during which heating occurs, seconds.

3. Investigation of the heating effect along the riser length on the defect of faulty soldering of the riser

It allowed identifying the functional dependence represented by Fig. 1.

![Figure 1. The simulated functional dependence of the riser temperature on the geometrical pattern.](image)

Traction motors have a complex structure as a result of complex physical processes occurring in them; both thermal and electro-magnetic, which generally characterize a traction motor as a complex object for study[8].
The research methods of diagnosing traction motors were done at the expense of experts VNIIZHT and different institutes of railway transport, and by experts of locomotive repair plants.

There are various trends in the study of diagnosis methods of traction motors, due to the variety of possible failures and types of different physical damage in a TM.

In this regard, the study of the effect of the TM defects on the working process parameters and the development of methods for determining the type of defect of the traction motor is important.

**Figure 2.** Approximation of the functional dependence.

**Figure 3.** Zones of possible faulty soldering.
4. Conclusion

Based on the analysis of the damage of the TM on the road network, all major faults that occur in TM can be divided into the following groups. Malfunctions caused by the insulation aging of the motor windings inter-turn short circuits in the windings, the failure of the insulation of the windings on the object. Faults leading to the failure of the normal switching engine of substandard soldering in the riser, deterioration of the current collector in the collector-brush unit of the inaccurate setting of the brush engine in neutral, incorrect setting of the magnetic system additional poles, the asymmetry of the magnetic system of the main poles.

Faults can be caused by defects in the starting motor armature.

The results obtained in the work were used to create a control and measuring complex to determine the type of defect of traction motors NB 418K6.

To detect substandard soldering a riser TM can serve as a temperature distribution in zone 1 (Fig. 3) characterizing the defect as a change in the functional dependence of temperature on the geometry function (the number of points distributed lengthwise the riser). If there is a defect, the functional dependence will change the form and parameters of the mathematical equation.

After studying the defect of faulty soldering of the riser affects the temperature distribution lengthwise the riser.

The obtained data of the experiments with a faulty soldering in the engine riser, allow making the following conclusion. The differences between the graphical dependences of the riser thermal diagrams are evident. Thermal processes are analogues to electrical transients \([1, 2, 3, 6]\). The possibility of using the least squares method to approximate the mathematical dependence of the experimental data to find the numerical values of the variables of the equation in order to create methods of thermal imaging control of soldered joints.

![Figure 4. Working state of the collector plate.](image)
Figure 5. Collector plate malfunction.

Infrared imager position at the test facility

1- commutator inspection hole,
2- traction motor (TM 1),
3- infrared imager,
4 – traction motor (TM 2),
5, 6, 7 – tripod legs

Figure 6. The technique of thermal imaging for quality control in riser soldering of the collector.

The method of thermal imaging in quality control of the collector risers soldering (Fig. 6) with the test conditions for the NB-418K6 engine is as follows, the current of the motor is $I_d = 880$ A, the engine speed is $n = 890$ r/pm, the heating time of the collector riser is $t_{\text{initial}} = 20$ Minutes, cooling
time or TM stopping time $= 180$ s (3 minutes), the initial temperature of the collector riser is $T_{\text{initial}} = 21.7^\circ$C.

To automate the processing of thermal images in order to identify a defect in the collector plate, it is necessary to use the software based on the conduct of one single direct first collector plate. The presence of a rigid fastening of the thermal imager (Fig. 6) during stress tests allow application the numerical control of subsequent collector plates for the entire traction motor, since the geometry of the motor collector does not change, therefore, the subsequent coordinates of the remaining collector plates are known. The automated process of processing thermal images allows us to reduce the influence of the human factor, and, therefore, has a positive effect on the diagnosis of the engine.

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