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Intermittent voltage unbalance and its impact on large power asynchronous motor operating modes

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Nowadays low power quality is one of the most significant problems in electric power system of Russia. Systematic violation of power quality regulations leads to additional losses in power transmission and power distribution, and also causes negative influence on consumer operation. Among the most powerful sources of power quality degradation are traction substations of alternating current, which supply railways with electric power. In the recent years in power networks of Syberia and Far East electric motor outages have become more frequent at oil pumping stations situated close to traction substations. Outages occur when vibratory sensors are triggered due to vibrations in bearings, and also due to rotor axis offset. The damage left by these outages is estimated in millions of dollars. Conducted investigations demonstrates that the reason for electric motor outages and vibrations in bearings is electromagnetic interference caused by electrified railway transport. The aim of the research is determination of electromagnetic interference which impact on electric motor outages. Besides there are tasks to estimate possible interference levels and develop protective means.

The first part of research work is related to investigation of possible origins of large power motor vibrations. There is a huge number of works concerning these topic written by Russian and foreign authors. They state that the main reasons for electric power motor vibrations are voltage unbalance and voltage unsinusoidality. It is important to note that traction substations of alternating current degrade voltage balance and sinusoidality in the first place. This is due to numerous current transformations: special-purpose traction substation transformers transform three-phase current to single-phase current, and then AC/DC transformation takes place in the rolling stocks. In 1962 soviet scientists observed that traction substations are source of so-called intermittent voltage unbalance, when the angle between symmetrical components of voltage is not a constant value and varies over time. Research of intermittent voltage unbalance were not conducted. Currently such investigations are very important. Authors estimate as constant and intermittent voltage unbalance impact on electric motor vibration levels and conclude that intermittent voltage unbalance constitutes a more significant danger. This can be explained by the change of magnetic field hodograph in the motor air gap. In case of constant voltage unbalance, hodograph has a shape of ellipse fixed in place. In case of intermittent voltage unbalance it also has an elliptic shape, but ellipse is moving along the circle. Movement of magnetic field ellipse increases resonance probability of magnetic flux density components and enhances probability of rapid magnetic flux density growth in the motor air gap. Such flux density growth increases vibration levels. Authors prove afore-mentioned theoretical study by experiment. The experiment was executed in the Otto-von-Guericke University scientific laboratory in Germany.

The second part of research work is related to the research of intermittent voltage unbalance occurrence at traction substations and its further spread over power network. The research is conducted for a traction substation with a widely used Y/Δ-11 transformer windings connection scheme. Research results help to find out how number, power and power factor of trains passing by the traction substation impact on amplitude of voltage negative sequence component and the angle between the symmetrical components of positive and negative sequences. Also, events are determined

when danger for geographically distributed power motors caused by high vibration levels reaches its maximum.

The third part of research is linked with the development of methods for intermittent voltage unbalance measurement. Modern regulations on the power quality do not involve the measurement of the angle between the symmetrical components. Besides, measurement of the voltage unbalance index is produced on long averaging intervals. This is unacceptable for intermittent voltage unbalance measurement. Therefore it is feasible to develop convenient methods for measurement such voltage unbalance.

In the fourth part of the research work authors develop the methods to protect motors against intermittent voltage unbalance. In conclusion recommendations are given how to use research results for practical purposes.