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Әртүрлі көлік түрлерінің өзара іс-қимылы кезіндегі тасымалдарды басқару

Түйіндеме. Мақалада көліктің әртүрлі түрлерінің (автомобиль және темір жол көлігі мысалында) өзара әрекеттесуін оңтайлы жедел басқару принциптері қарастырылған, сондай-ақ үш негізгі бағыт бойынша жүргізілетін тасымалдаудың кешенді жүйесіне талдау жүргізілді, вагондарды түсіруді басқаруды оңтайландыру міндеті шешілді.

Түйінді сөздер: көлік, басқару, өзара іс-қимылы, жоспарлау, көліктік жүйе, басқару әдістері.

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THERMOGRAPHIC RESEARCH METHODS AND FACTORS INFLUENCING THE EFFICIENCY OF THERMAL VISION MONITORING

Abstract. In this paper, the method of remote monitoring and diagnosis of electrical equipment using thermal imaging surveys are considered. Thermal vision diagnostics is based directly on the results of a study of a particular object of electrical equipment based on an assessment of heating temperatures. Inspection of the electrical equipment of intersystem electrical networks is conducted in two stages without interference in the technological cycle of production. Identification and elimination of excessive heating of electrical equipment, i.e. a local defect at an early stage of its development makes it possible to avoid accidental defects. Studies conducted in this direction contribute to improving the technical and economic indicators of electrical equipment of intersystem electrical networks, reliability and safety of operation and can reduce damage from emergency situations.

Key words: thermography, diagnostics, intersystem networks, thermal vision monitoring

The arising malfunctions of the electrical equipment lead to large material and time costs, both in the repair process and in the restoration of the normal production cycle. In this case, the cost of diagnosing a defect can be a significant amount (up to half) of the total cost of equipment. The most costly, including in time, is the diagnosis of defects in electrical equipment, due to the need to analyze a large number of tightly located contact groups, assemblies, current-carrying circuits. Ensuring high-quality and uninterrupted operation of electrical equipment depends on a large number of parameters, among which one can distinguish the influence of the external environment, the regularity and types of loads, the influence of random factors (human factor), etc. [1].

Therefore, the clarification of the technical condition of the electrical equipment of the intersystem electrical networks based on thermal imaging surveys will allow, at the minimum financial cost, in the shortest possible time, without removing the electrical equipment from work, to check the reliability of the monitored object, identify defects at an early stage of their development, reduce maintenance costs by predicting the timing and volume of repair work. As a result of this, research into the methods of thermal imaging diagnostics of electrical equipment that prevents emergency equipment failure and enhances operational reliability by identifying local defects is becoming relevant.

In connection with the foregoing, the main attention is paid to the study of thermal imaging inspection of electrical equipment of intersystem electrical networks.

The situation that has developed in recent years in the electric power industry, within the framework of the economy, forces us to take measures aimed at increasing the life of various equipment, and this is equipment from non-CIS countries, which after installation does not require a comprehensive examination for about fifteen years, but this also both positive and negative. Therefore, the solution to the problem of assessing the technical condition of electrical equipment of electric networks is to a large extent the introduction of effective methods of instrumental control and technical diagnostics.

Diagnosis is an apparatus that allows you to establish signs of malfunction (operability) of equipment and study them, establish methods and means by which an opinion is made on the presence or absence of a malfunction (defect). In other words, technical diagnostics makes it possible to assess the state of the investigated object. Such diagnostics are mainly aimed at searching, identifying defects and analyzing the internal causes of equipment malfunctions [2-5].

Electrical equipment of MES contains a large number of devices, the long-term operation of which without proper diagnosis of the technical condition can lead to their failure and significant material damage. To implement effective diagnostics of electrical equipment of intersystem electrical networks, modern techniques and technical means of control are needed. The solution of the problems of diagnosing MES electrical equipment can be performed on the basis of thermal imaging surveys. Thermal inspection of electrical equipment is one of the first areas of application of the thermal method of non-destructive testing for the needs of industrial enterprises.

Thermography is a type of infrared image in which infrared cameras detect radiation in the electromagnetic spectrum with a wavelength of from about 900 to 14,000 nanometers (0.9-14 microns) and obtain an image of this radiation. Typically, this visualization is used to measure the temperature of variation over an object or scene, which can be expressed in degrees Fahrenheit, Celsius or Kelvin. A real-time thermal camera captures all the radiation that enters the lens. Radiation can come both from the object under study, and from other radiation sources, followed by reflection from the object, which gives some radiation.

For an object having mirror properties, temperature measurement is not possible. For example, on busbars RU-10 kV, shown in the figure below, there are colored areas that are well suited for measuring temperature. Tires are made of copper, which has a very high thermal conductivity. This means that temperature changes along the surface of the part should be small (Fig.1) [6].

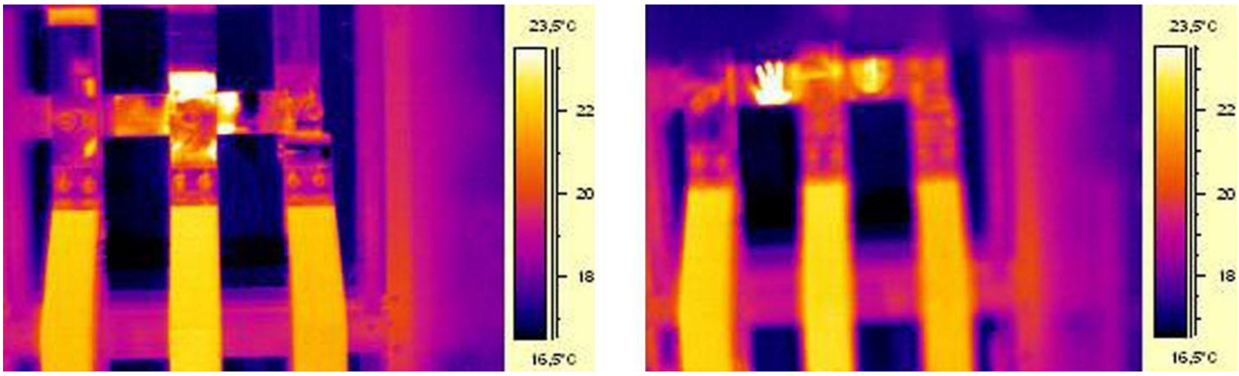

Figure 1. Thermogram of busbars RU-10 kV

Basically, the components of electrical installations act as mirrors for infrared radiation, but this is not noticeable to the naked eye. Uncoated metal parts are particularly prone to glare, while insulated plastic, rubber or painted parts in most cases do not create glare. In the figure below, the reflection of the operator from the conductive bus in RU-10kV is clearly visible. But, this reflection is not an object's hot spot. One way to determine if the image you see is a reflection or not is to change your position relative to the object. And then it will be visible if you look at the object from a different angle and follow the hot spot. If she moves with you, then it will be a reflection.

Thermography is currently a well-established method used to test electrical installations. This was the first and most widespread application of thermography. The infrared camera itself has undergone a period of rapid development, and at the moment we can say that the 8th generation of thermographic systems has become available to users. It all began more than 40 years ago, around 1964, and now the method is recognized worldwide. Thermography is widely used in both industrialized and developing countries.

In recent decades, thermography in combination with vibration analysis has been the main method for the complete diagnostics of industrial plants for the implementation of preventive maintenance programs. The main advantage of these methods is that they not only allow you to check the installations during their operation. In fact, the operation of the installation in normal operation is a prerequisite for accurate measurements, thus stopping the production process is not required. Thermographic control of electrical installations is used in three main industries:

- power generation;
- transmission of electricity;
- electricity distribution.

Using an infrared camera or thermal imager, a specialist measures the heat generation locally and presents it as an image of an object emitted by infrared radiation. The fact that radiation is a function of the surface temperature of the object allows the camera to calculate and display this temperature [7].

The emitted radiation measured by the camera (thermal imager) depends not only on the temperature of the object, but also on the emissivity of the object. Radiation also comes from the environment and is reflected by the object. It is also worth noting that the radiation of the object on the reflected radiation will also affect the absorption in the atmosphere. In connection with the foregoing, it follows that for accurate temperature measurement it is necessary to compensate for the effects of several different radiation sources. This is done by the camera in real time in automatic mode. However, the following parameters of the object [8] must be entered into the camera:

- the emissivity of the object;
- visible reflected temperature;
- the distance between the object and the camera;
- relative humidity;
- ambient temperature.

An important parameter that should be correctly entered is the emissivity, which, in short, is a measure of the radiation emitted by the object, compared with the radiation of a completely black body at the same temperature.

In electrical networks, measurements are usually taken during periods of high load. In this industry - at least in northern countries with clear seasonal weather changes - inspections are carried out in spring and autumn or before long interruptions. Thus, in any case, repair work is carried out during the period of production shutdown. However, this rule is applied less and less, and recently, inspections are carried out under various loads and operating conditions of power plants.

A special role of thermographic surveys is that with their help it is possible to assess the degree of influence of external conditions on the internal state of individual units of power equipment, even if this effect did not lead to immediate critical consequences. For example, heating oil in transformer devices during the summer period contributes to accelerated aging of insulation. The measurement of the temperature of the oil in transformers during these periods is not a direct assessment of the presence or absence of defects, but can provide source material for predicting the accumulated change in the state of electrical insulation during the operation of a given transformer operating in these climatic conditions [9].

Thermographic surveys, almost from the very beginning of their application in the electric power industry, are most intensively used in this method, since the anomalies in the thermal fields of power equipment are ahead of schedule in relation to the emergency development of anomalies in electrical processes. At the same time, the frequency of thermographic examinations is currently dictated by completely different circumstances than the above considerations of an integrated approach to improving the accuracy of forecasts of failure-free operation of complexes. The existing recommendations have such terms as 1 year, 3 years, spring, etc. At the same time, it follows from the most general considerations that the likelihood of a product defect leading to a failure in operation increases with time of its operation and becomes maximum at the end of its assigned service life. Therefore, the interval between examinations should also be changed and planned based on the available a priori data regarding the degree of deterioration of this unit: the assigned resource and the real time of operation. By the end of the assigned service life of units and devices, the interval between their surveys should be reduced.

A general analysis of the damage to oil-filled equipment, carried out at RAO UES of Russia together with UES of Kazakhstan, showed that in power transformers and shunt reactors, approximately 90% of violations (deviations) occur in three main nodes [10]:

- oil-filled bushings;
- windings and on-load tap-changers;
- voltage regulation devices without load.

Therefore, during thermal imaging inspection of transformers, these nodes should be given special attention. When analyzing the results of a thermal imaging examination, it is necessary to take into account the design of this type of transformer, the method of cooling the windings and the magnetic circuit, the conditions and duration of operation. This requires preliminary preparation for the examination by examining the passport and structural data of the transformer, the term and operating conditions, information on the results of the repairs, the degree of loading of the transformer.

The frequency of conducting thermal imaging diagnostics of contact joints and of all electrical equipment in general should not be selected from the importance of the facilities for their purpose, not from the capabilities of diagnostics by operating personnel, not from the voltage class and not from the frequency of ongoing and major repairs or other similar considerations. The only criterion that specifically determines the frequency of diagnosis should be only the time of development of the defect, and the frequency of diagnosis should be less than this time. And as practice shows, the time of development of defects of most equipment does not exceed one year. Therefore, the diagnosis should be carried out at least once a year.

As experience shows, it is more effective to conduct diagnostics twice a year: in the spring after passing the autumn-winter maximum loads and changing the operating mode of the equipment, when defects are most clearly identified and there is the possibility of eliminating them during the «repair campaign», as well as in autumn during the autumn-winter maximum loads. Diagnostics twice a year is especially necessary at such power facilities, the equipment of which operates under intensive loads during peak hours and the service life is 15 years or more. At such power facilities, developed defects were detected during diagnosis after 5 months. Each state has its own electrical standards, standards and regulations. For this reason, the electrical control procedures described in this section may differ from standard procedures in another country. In addition, in some countries of the world, authorized persons are allowed to check electrical equipment. In this regard, it must be understood that prior to any work related to electrical equipment, it is necessary to familiarize yourself in detail with the relevant regional and state electrical standards and standards [11-15].

To take a thermal imager, the subject must be in direct line of sight. When conducting a thermal imaging inspection of electrical equipment, it is important that the infrared radiation of the object under investigation is measured, which is associated with the presence of a defect and the degree of its development. Therefore, almost all measurements should be performed in the evening and at night, when the equipment is in load mode, and also (if necessary) for power transformers in idle mode. Measurements in the summer period are made no less than two hours after sunset to exclude errors from daytime heating by the sun. In some cases, it is possible to conduct thermal imaging diagnostics during the day in continuous cloud cover, since continuous cloud cover does not pass the infrared radiation of the Sun.

During the diagnosis, it is necessary to take into account the emissivity of the surface of the object being examined, as well as the angle between the axis of the thermal imaging receiver and the normal to the radiating surface of the object. Both abnormal increases and decreases in temperature are evaluated. This approach allows us to determine how defects in contact joints, induced currents flow, insulation losses and other developing insulation defects, oil leaks, blocking of cooling medium ducts, and the efficiency of cooling systems. If necessary, analysis and correlations with the results of other tests and measurements. It should be noted that when measuring objects of the same type, it is necessary to position the thermal imaging detector at the same distance and at the same angle to the optical axis to the surface of the object in order to maximally eliminate errors from extraneous radiation, the influence of distance, humidity and other factors.

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Термографиялық зерттеу әдістері және тепловизиялық мониторингтің тиімділігіне әсер ететін факторлар

Түйіндеме. Берілген жұмыста тепловизиялық зерттеу арқылы электр құрылғыларын дистанционды бақылау және диагностикалау әдістемесі қарастырылады. Тепловизиялық диагностика қыздыру температурасын бағалау негізіндегі зерттеу нәтижелеріне байланысты. Жүйералық электр тораптарының электр құрылғыларын зерттеу өндірістің технологиялық циклына араласусыз екі кезеңде өтеді. Электр құрылғыларының шектен тыс қызып кетуін анықтау, яғни бастапқы даму кезеңіндегі жергілікті ақауларды табу апаттық жағдайлардың алдын алуға мүмкіндік береді. Осы бағытта жүргізілетін зерттеулер жүйе аралық электр тораптарының электр құрылғыларының экономикалық тиімділігін, сенімділігін және тұтыну қауіпсіздігін арттырады және апатты жағдайлардан болатын зиянның мөлшерін азайтады.

Болегенова С.А., Шортанбаева Ж.К., Максутханова А.М., Нурмуханова А.З., Оспанова Ш.С.

Методы термографического исследования и факторы, влияющие на эффективность тепловизионного мониторинга

Резюме. В данной работе рассматривается методика дистанционного контроля и диагностирования электрооборудования с помощью тепловизионных обследований. Тепловизионная диагностика основана непосредственно на результатах исследования конкретного объекта электрооборудования на основе оценки температур нагрева. Обследование электрооборудования межсистемных электрических сетей проводится в два этапа без вмешательства в технологический цикл производства. Выявление и устранение избыточного нагрева электрооборудования, т.е. локального дефекта на ранней стадии его развития дает возможность избежать аварийных дефектов. Исследования, проводимые в данном направлении, способствуют повышению технико-экономических показателей электрооборудования межсистемных электрических сетей, надежности и безопасности эксплуатации и позволяет снизить ущербы от аварийных ситуаций.