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Features of thermal control of components of electrical engineering devices and systems

The article specifies the features of the thermal control of components of electrical engineering devices and systems based on them using the thermal imaging method. The samples of real electrotechnical devices show the order of thermal imaging research. A comparison of the obtained graphical and calculated values of the reduced resistance of the heat transfer of the components of electrical equipment and systems with normalized values showed a high convergence of these results.

Recently, electrotechnical devices and systems containing modern micromechanical components (micromechanical actuators, micro-valves and pumps, electromechanical micro-motors and generators, etc.) are widely used in various fields of science and technology. However, the further development and implementation of the above-mentioned components is limited by the lack of information on the heat-physical processes that occur in the mechanisms and structures that contain such components during their operation [1]. The main problem that arises in this is the change in the geometric and operational characteristics of these components when changing their temperature during operation. This leads to premature decommissioning of electrical appliances and systems as a whole. The purpose of this article is to establish the features of the thermal control of components of electrical engineering devices and systems using the method of thermal imaging.

The order of thermal imaging research. At the beginning of thermal imaging control, the geometric binding of the investigated component is performed (the location of other structural elements of the electrical device relative to this component is determined) and the distance at which the external thermal imaging is made is determined. It is desirable that this distance during shooting remains unchanged. With the help of devices, the temperature and humidity of the environment are recorded. Then the temperature of the reference zones is determined as a contact method (this is done using a contact semiconductor thermometer), and in the non-contact way (by means of a thermal imager), and the actual radiation factor of the object is determined on the basis of these data. In addition to the radiation factor, other parameters are set in the thermometer's menu, such as: distance to the object, ambient temperature, humidity, and so on. Taking into account these parameters allows to minimize measurement errors during shooting.

A further thermal imaging study is carried out on each section of the investigated component (as a sample the unit of diode modules of the converter of the voltage of the solar collector is selected) consistently from below - up and left - to the right with the overlap of frames by 15-20% (fig.1).

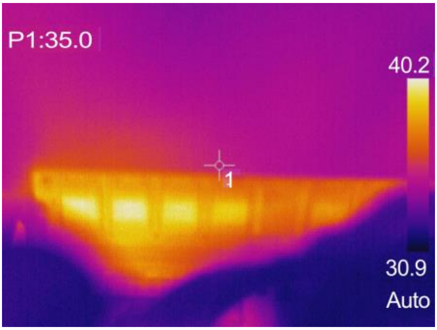

Fig. 1. The scheme of thermal imaging research of the block of diode modules of the solar collector voltage converter

This procedure is necessary to ensure that some areas are not controlled. Thermal imaging begins with the coldest area. Modern thermal imagers allow to simultaneously heat and photograph the planned areas. If the camera does not have a photo capture function, then a camera or webcam is used in this case. The angle of shooting is minimal. However, in any case, this angle should not exceed 60°. If this condition is not met, then the results of the control can be distorted.

After the object is "removed" from all sides, if necessary, it is possible to carry out more detailed surveys of separate areas of doubt (for example, overlapping zones of individual components, angles or projections of cooling radiators, etc.). It is also desirable to conduct a panoramic thermographic examination of each component of the electrical device. To do this, measure as far as possible from the object of research.

Often a situation arises when the thermographer moves away from the object of research for too long a distance. At the same time, the quality of the picture sharply deteriorates, and individual thermal parts are lost. Such a panoramic image practically does not carry the necessary information. Therefore, in order to preserve the necessary detail and not to impair the overall view of the thermal image, it is necessary to perform panoramic shooting at a not too distant distance (the distance should not exceed 1-2 m). In this case, panoramic shooting of each element can be made in several shots, and then in the process of computer processing to create a single general heat shot [2]. In this case, the quality of the thermal image does not deteriorate, the thermal parts are not lost, and we can make a general impression of the defects characteristic of all components. It should be noted that the built-in software of many modern thermal imaging cameras allows directly in the program to "sew" separate thermograms into a single "panoramic" shot, but not always the quality of the "stitched" picture at the same time remains high. As a result, after the thermovision study, thermograms of all components of the electrotechnical device, "detailed" thermograms of individual parts of the components, as well as thermograms obtained during the study of these objects are obtained. Thermograms, obtained during the thermal imaging study, are subjected to computer processing, are analyzed and applied to the thermographic report. In order to perform instrument measurements, one or more components are selected, which are supported by a relatively similar temperature regime under the same humidity conditions. For such components, reference regions are selected – characteristic homogeneous portions of their outer walls with relatively isothermal surfaces. Such areas are characterized by a conditional (on a plane) heat transfer resistance. It is necessary to register test data automatically or manually over a certain period of time (for example, 0,5 – 1 minutes) for several hours.

Processing of the received results of measurements. At the end of the data registration period (usually several hours), the processing of the measured results is carried out. On the received displays of devices the actual values of the reduced resistance of heat transfer of components of electrical devices are calculated.

So, after the instrumental measurements, we will have the temperature values on the object under study and the outside, the values of the temperatures of the surfaces of structures and components of electrical equipment, the magnitude of humidity in the investigated zone and the value of the density of heat fluxes. Quantitative parameters obtained as a result of instrumental measurements need to be recorded and stored. Processing of the obtained results is carried out with the help of special software, which comes with the equipment, as well as using standard computer packages. Further, on the basis of the new instrumental measurements obtained, it is possible to calculate the necessary heat consumption indices.

Analysis and decoding of received thermograms and interpretation of results of instrumental measurements. First, it is necessary to carry out computer processing of thermograms and to detect zones of thermal anomalies – that is, zones of deviations from the predicted distributions of temperatures along the surface. When computer processing thermographs for the allocation and refinement of abnormal areas, you can use various built-in functions – for example, you can set points, lines, rectangles, ovals and the like, indicating temperature or temperature deviations. Sometimes, when analyzing and decoding thermograms, the functions of constructing histograms are also used (Fig.2).

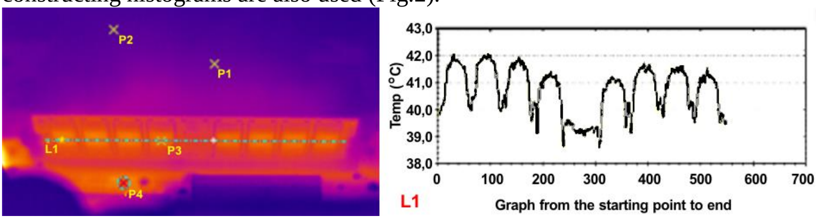

Fig. 2. Construction of the temperature distribution along the block surface of the diode module of the solar collector voltage converter

After the thermograms are analyzed, abnormal zones are detected, and quantitative calculations are started [3].

To calculate the heat transfer resistance R_0 (m^2·°C/W) for a thermally homogeneous zone, use the formula: $R_0 = (t_{int} - t_{ext}) / q_i$, where t_{int} is the average for the calculated period of measurement of the temperature of the research object, °C; t_{ext} – average for the estimated period of measurements, the temperature of the outside air, °C, q_j – the average for the estimated period of measurement, the actual density of the heat flow, W/m^2. The reduced resistance of the heat transfer R_{r0} (m^{2}·°C/W) of the components of the electrical equipment has an uneven surface temperature, calculated by the formula: $R_{r0} = A / (\Sigma A / A_i / R_i)$, where A – area of the surface of the object under study, m^2; A_i – area of characteristic isothermal zone, m^2; R_i - heat transfer resistance of the characteristic zone, m^{2}·°C/W. Data for these calculations are derived from instrumental measurements. After the calculations are obtained, the actual (calculated) values of the reduced resistance of the heat transfer components of electrical devices. Finally, the calculated values of the reduced resistance of the heat transfer component, it is necessary to compare with the normalized values.

Conclusions. Thus, the thermograms, obtained and processed in the above manner, allow to determine the presence of anomalous sites in the controlled object. Such sites, according to the authors, are related to violations during their manufacture or installation, and should be included in the thermographic report. After conducting such calculations, the actual values of the parameters of heat transfer components of electrical devices are obtained.

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