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Thermographic Assessment of the Quality of EM Relays in Railroad Automation

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Abstract*: The evaluation of quality of an electro mechanical relay during production and the reliability of an entire series operated at high electric current values during the commutation process are performed using thermal imaging. Thermal photography can be used to determine which contacts need replacing and how many have worn out. A thermal picture is used to measure the length of the gas discharge, which acts as gauge of the rate of contact wear. This study provides the method for evaluation quality of electro mechanical relays designed specifically for switching of massive electrical circuits in context of railway automation.*
Keywords*: NDE, electromechanical, quality thermography, and relays*

I. Introduction

The advancement of thermal imaging, for instance, has made it one of the most useful tools for predictive maintenance. Instead of producing "heat" images (also known as thermal imaging or thermography), which are used to assess temperature, we will concentrate on creating infrared images. Corrective action can be taken before a costly system breakdown occurs thanks to thermography's assistance in detecting and benchmarking irregularities that are frequently imperceptible to the human eye. Portable infrared (IR) imaging systems quickly transform thermal images into visible images for quantitative temperature analysis after scanning structures and equipment. An IR camera with sensor electronic networks is used in noncontact full-field quantitative infrared thermography (NDE) techniques to identify minute temperature changes due to various reasons.

The latter may be an electromechanical load that is applied irreversibly. In order to spatially alter the surface temperatures and relate the measured infrared field to the stress or strain at the surface, the objective is to apply thermomechanical deformation to the material or structure. In isotropic materials, minor cyclic temperature changes proportional to the sum of principal stresses take place when a tiny cyclic load is applied under adiabatic and reversible conditions.

However, act-only relay systems are now used in railway automation to automate train traffic management. As relays, certain construction components with asymmetrical failure have been used. The likelihood of failure type $0 \rightarrow 1$ (logical 0 in the event that exit is not made, turns out to be logical 1). That is the foundation upon which the security systems are continuously synthesized, allowing the transport process to evolve in a danger-out manner in the event of a system breakdown. Consequently, just the machine's motion suspension—not the crash—can be accomplished. In a system like this, we use more than 100 relays for middle-sized rail stops. A significant issue for train traffic is contact wear and tear and the best time to replace contacts. Relay diagnostics typically involve removing the relay to a test environment (functional test, calibration, and control of the degree of wear out of contact closures). By injecting current and/or voltage and monitoring the response in accordance with the manufacturer's test protocol, the suggested parameters are confirmed.

II. Perquisites for Research Methodology

There are four working methods in which the contacts function. Wear-out, physical processes, and electrical circumstances are the causes of the discrepancy. We are interested in two of these principles: There are two types of contacts: the closed contacts, also known as closed contacts, and the opened contacts. The transience resistance R_0 is a crucial metric for closed contact. There isn't an extended over common ground point on the contacts' covered surface. Even with good connections, there are some protruding points where the contact is located and is visible when you establish touch. Currents and electrical lines are being drawn in by the contact locations. The density resistance Rc is represented by it.

The contact resistance is also derived from the resistance of the thin layers that form on the contacts' surface. As the contacts deteriorate, the working process's transience resistance rises. Using a thermographic, the accumulation of the lines—that is, the count and the total contact surface, respectively—is shown. If the dependable relay operates at high voltage commutation, the defective contacts can be eliminated at the production stage. The thermographic can reveal which contact closures need to be replaced and where in the process the contacts are wearing out. The resistance goes from R_0 to ∞ when the contact is opened. There is tension between the contacts when they are opened.

At first, there is not much space between the contacts, and discharge events like these could happen. These events are connected to the destruction or movement of material from one point of contact to another. In other words, close contact transience resistance follows a large increase in roughness if demolition does not occur. It is also based on the idea of "contacts wearing out." When the contacts were open, an increase in voltage with inductive properties was seen during circuit commutation. This has resulted in an increase in the magnetic energy conserved inside inductivity. The amount of tension that occurs depends on the inductivity of the assisting tension, the rate at which the voltage drops, and, in turn, the circuit's active resistance. The deterioration of the contacts and the properties of the inductor to subserve the source of discharge events. We couldn't completely prevent those occurrences. Conditions must be established in order to quickly halt these undesirable occurrences.

III. Thermodynamic Evaluation Methodology for EM Relay

There are two varieties of electro-mechanical relays that have been studied: We suggest neutral starting relays of the HM1-700 type and neutral relays of the HM1-300 type for railway automation switching systems. These relays are intended for use in DC electrical circuits and serve as interlock, signaling, and centralizing devices. Signs of thermographic measurements were recorded using a range of active loads (1 A, 4A, 6A, and 8A), frequencies, and commutated power (80V, 300V, and 450V). The degree of wear out has been ascertained by comparing the thermographic signatures of new metal and carbon metal contact closures with those of used contact closures. The remaining resource values of contact closures were also estimated using the same comparison.

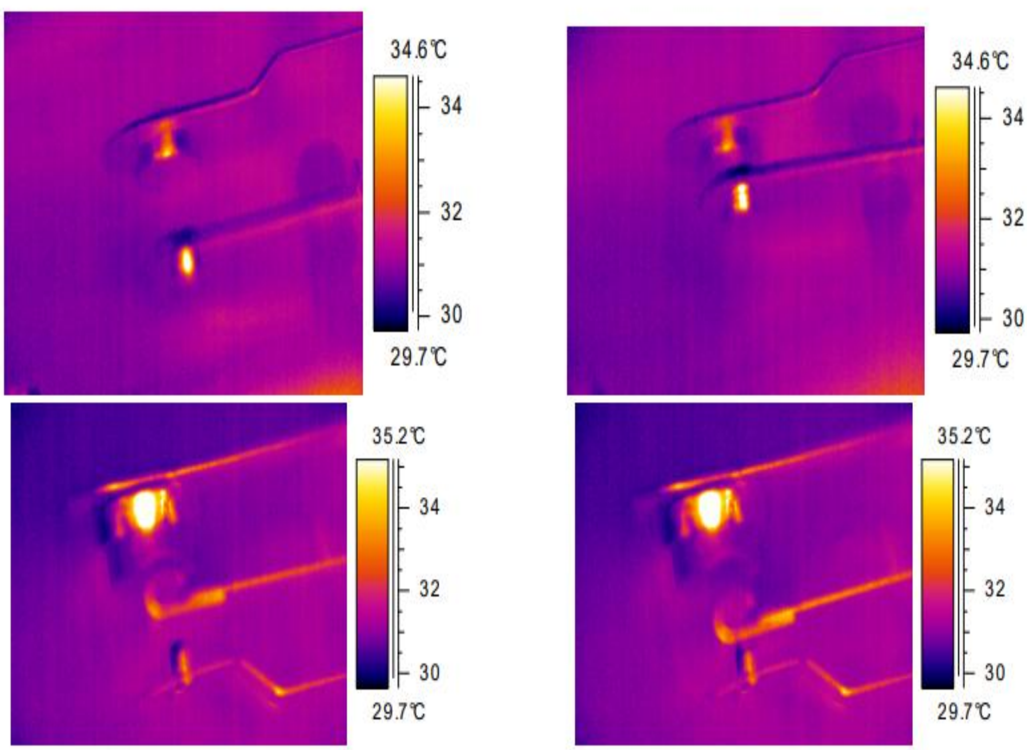

Fig 1: New contact closure thermograms commuting at idle

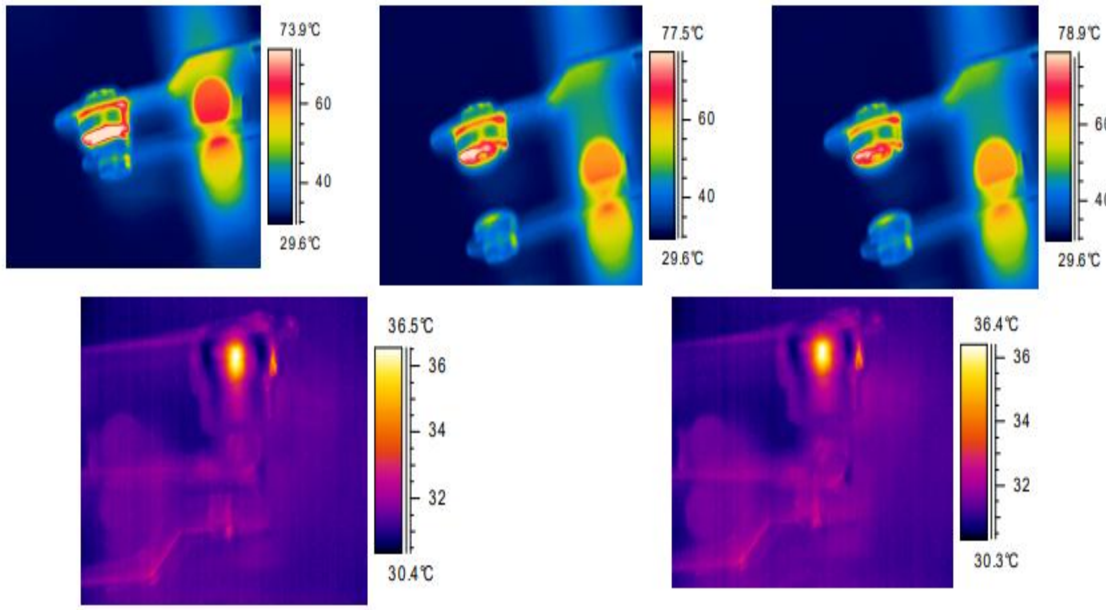

Fig 2: New and old contact closure thermographs

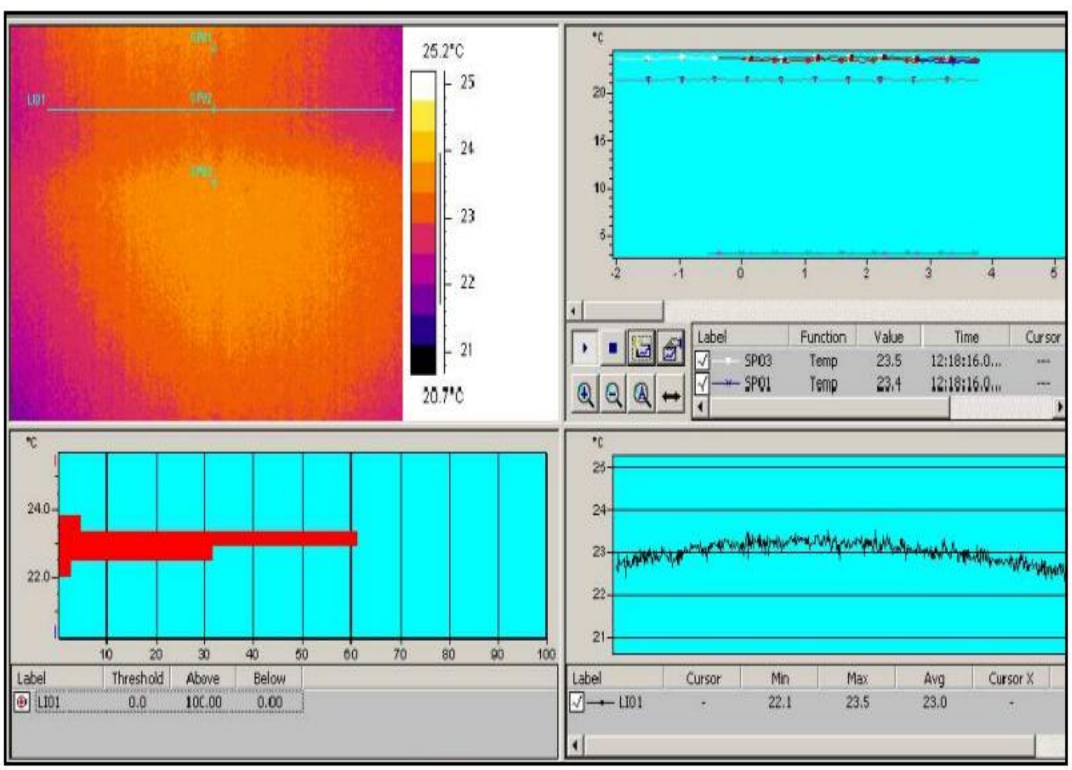

Fig 3: Outcomes of 300 novel contact closure sequences for a hermetically sealed relay

Figure 3 displays data for thermograms of hermetically sealed relays with new contact closures. The image sequences were thermographically processed using Therma CAM Researcher Pro 2.9. The 3D picture, thermogram, and contour analysis of the carbon-metal worn-out contact study's findings are displayed as is (Fig.4). During the study phase, a relationship between the temperature of the contact system and the power of a commutated circuit was developed. Relays that were both hermetically sealed and open were employed for the investigation. For every hermetically sealed and unsealed relay, frequency frame, and commutation synchronized and unsynchronized study, the temperature of a commutating element at a particular power of commutation in a switching circuit exhibiting commutation was measured.

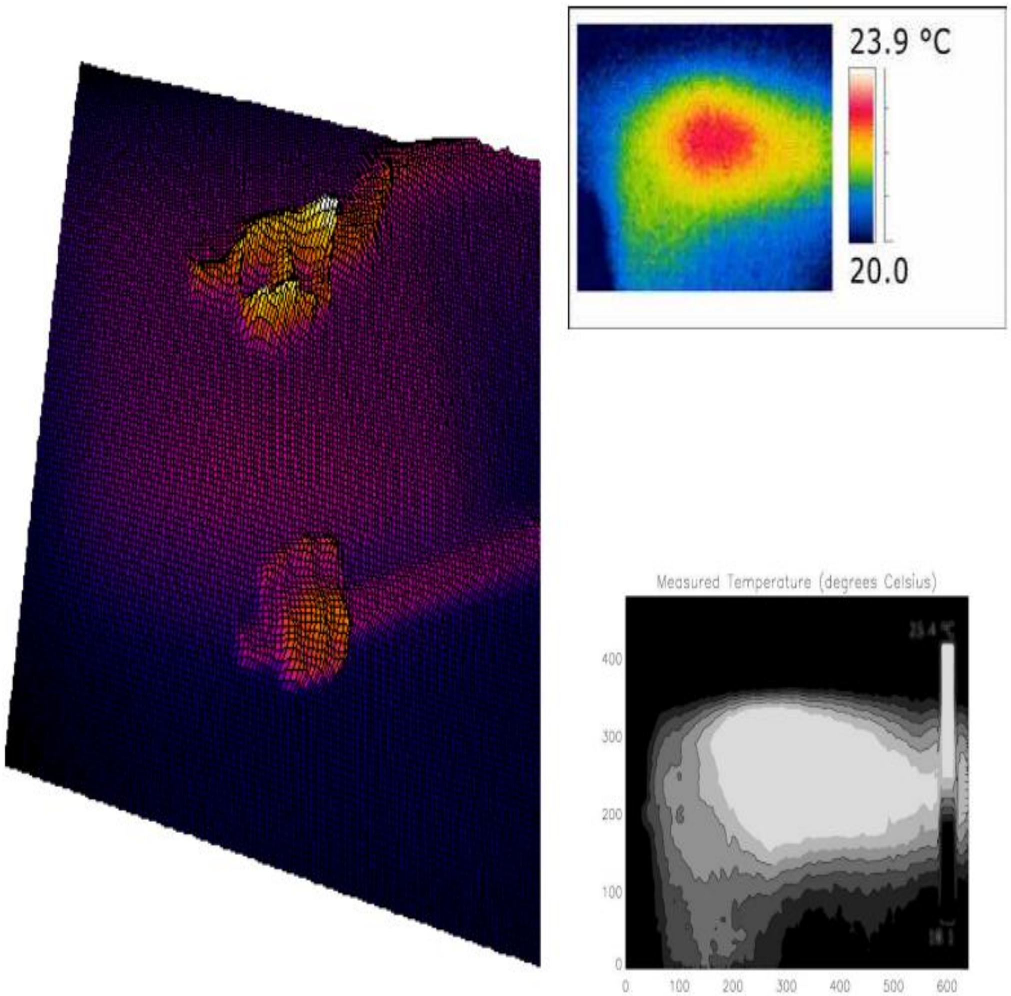

Fig 4: The identical packaged relay contact closure's thermogram and contour image (down)

When non-worn-out commutating elements are utilized, the commutating power estimation problem is resolved. Higher temperatures (20–650C over the typical temperature at the same commutated power) are created for commutating elements; in this scenario, both the commutable power and the commutating elements' lifespan are decreased. Critical contact closures and non-contact characterization are done using additional specially designed software for IR image processing with a 24-bit color department. The software view is displayed in Figure 5, and a thermal histogram of the aforementioned contact closure at 450C and 65C is shown in Figure 6.

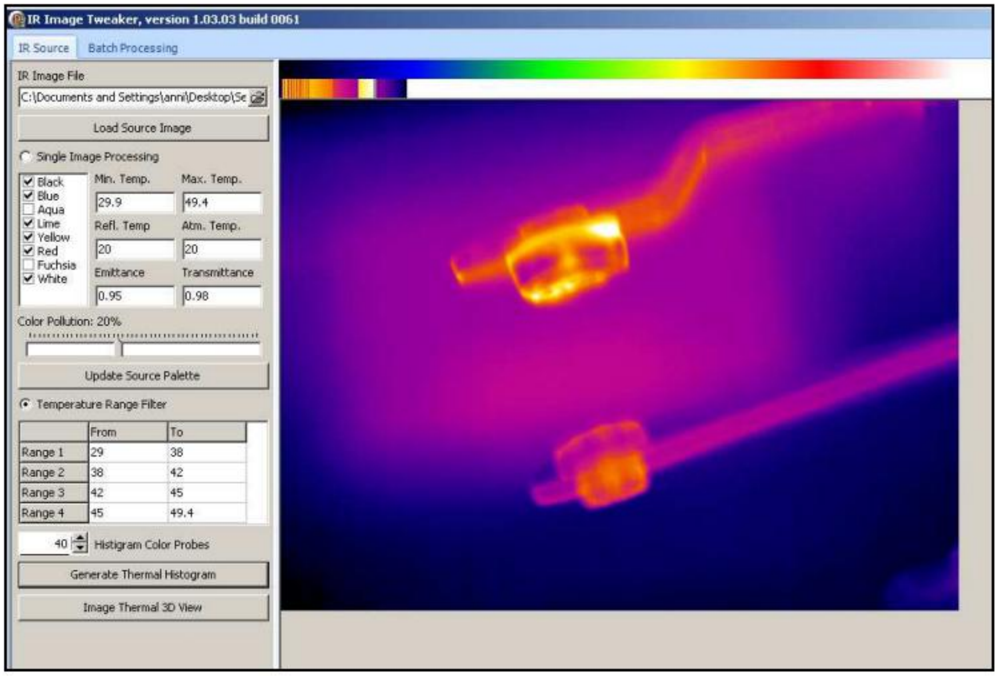

Fig 5: An overview of the relay contact closures evaluation software

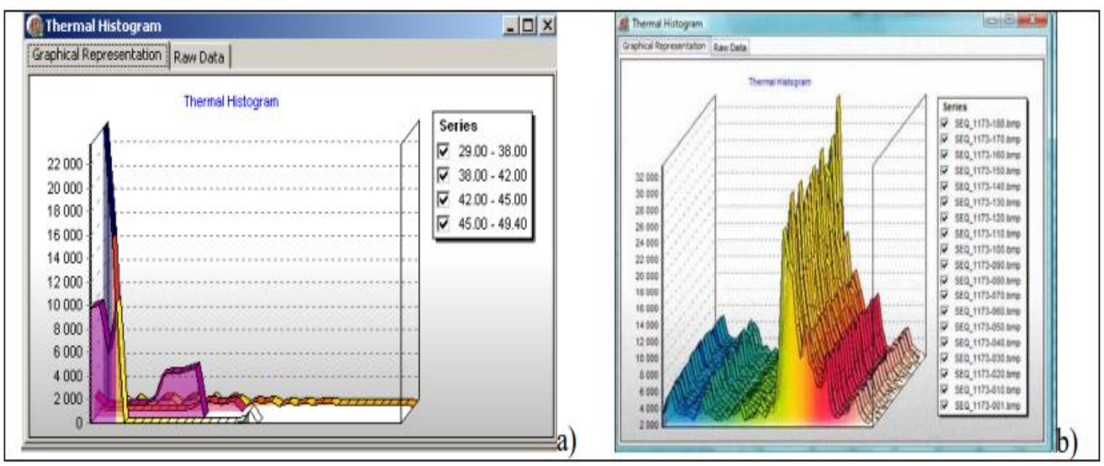

Fig 6: Histograms of temperatures

The thermal histograms can be compared over four arbitrary temperature ranges. if many thermograms of the same object are processed in batch mode with respect to the surface temperature (working rate). During the transition process, one or one sets of individual photos can be created based on the time interval between the snapshots, either by specifying the duration from the time of thermodynamic equilibrium or by using a frequency of up to 50 Hz. Using the camera-controlled computer, snapshots can be captured at intervals longer than ten seconds. The thermal histogram results established a standard for diagnosing and assessing the tested relays resources. Locally elevated temperature in the areas of the contacts towards the surface creates hot areas. After that, these surfaces are thermally scanned online to determine the fault's severity and to find any hot spots. Naturally, fixing these issues will also lessen the likelihood of the signal system breaking down and increase reliability.

IV. Conclusion

This paper presents the findings of the application of thermo-monitoring techniques and infrared image processing for relay contact wear out monitoring. It is extremely important to solve the issue of the best replacement schedule for railway safety equipment. Areas of increasing resistance and worn-out contact can be tracked using the thermographic image closures. This is done by conducting routine inspections in order to identify and replace any defective contact closures on relays. Software and a method were developed for estimating the resource of contact closures in electromechanical relays.

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