Galvanic Corrosion Occurs Heat Experiments by Thermographic Camera

F Haraszti and T Kovacs
Óbuda University, Bánki Donát Faculty of Mechanical and Safety Engineering
Material Science Department, 1081 Budapest, Hungary
Email: kovacs.tunde@bgk.uni-obuda.hu

Abstract. A part of the electric connections has a corrosion aptitude. We can find galvanic corrosion process hazard in case of the contact between different electron potential metals. This process impairs mechanical properties and the connection increasing resistance. The conduction parameters decrease in some under power parts because of the heat rise. This heat effect can be unperceived. By thermographic camera experiments, we can discover this irregularity on time. In this work, the authors present this investigation and the emerging problems.

1. Introduction
The electric connection constructions have different metal elements with different mechanical properties. We know different corrosion forms for different materials. Between the different metals, a corrosion reaction can occur if we have different electrode potentials. This form of the corrosion is known as galvanic corrosion. This corrosion is a chemical corrosion that occurs between two different metals in the presence of a liquid electrolyte. The name of this corrosion type came from the name of the chemical process, because two electrochemically different metals and the electrolyte create a galvanic cell. The low electrode potential metal dissolves in the electrolyte and the surface damaged. This reaction effect impairs the electric current transfer because it increases the momentary resistance [1-3].

2. Theory basis of the investigation
2.1. Electrical contact testing possibilities
In our modern age, we cannot live without electric current, to assure the continuous current supply is a critical infrastructure task [4]. The metal connection bounding lifetime calculation is very difficult because of the corrosion phenomenon and is not calculable easily. The electrical contact problem can cause big problems in the industrial and personal life too. Prediction of the electric device-bounding lifetime is a challenge for our century. The simplest tests are the visual inspection and the temperature measurement. The bounding impairment causes temperature increase. The temperature measurement is not easy by the traditional ways and measuring methods, since for this process we switch off the current. The power stop can cause impairment in industries and homes. In grace of the modern technology innovations, we can find new devices for safe and exact temperature detection.
2.2. Thermographic camera usability
Temperature measuring the infrared radiation by the thermographic camera depend on the bodies heat effect capabilities. The heat radiation process influences the material heat movement that produce electromagnetic waves. The heat energy emission can be in form of conduction, convection and radiation. The bigger part of the heat emission for other bodies can be reflection or transmission. A completely black body absorbs all radiation. The sample that reflects all radiation is a completely reflective body. The one, which lets through all radiation, is the transparent body. The heat radiation like electromagnetic wave transfer does not need any media. The heat radiation fundamental law is the Stefan-Boltzmann law (1) [5]. Where temperature \( T \) [K], the radiated energy \( P_{\text{Rad}} \) [J], \( e \) [-] is the emissivity of the object, \( A_s \) [m\(^2\)] is the surface area, and \( \sigma = 5.67 \times 10^{-8} \) [J/m\(^2\)K\(^4\)] is the Stefan-Boltzmann constant. The emissivity constant depends entirely on the material of the object and is capped at 1 for an ideal black body [5].

\[
P_{\text{Rad}} = e \sigma A_s T^4 [J]
\]  
(1)

Even that \( e, A_s \) and \( \sigma \) are constant, the equation will be simple (2):

\[
P_{\text{Rad}} = \sigma \cdot T^4 [J]
\]  
(2)

By this law, the radiation of the black body on \( T \) temperature for unit area and during unit time is proportionate with \( T^4 \). In an ideal event, the black body is able to absorb and emit all heat energy. It is only a model. Different materials can emit different energy. In case of measuring, the black body like material gives exact results. In case of the different materials, we need to correct the result.

3. Experiments
3.1. Used samples and preparation
The electrical bounding is very common in the copper and steel contacts. To investigate the galvanic corrosion phenomenon, we made a bounding for our laboratory simulation test. The measured resistance before the corrosion is from 0.01\( \Omega \). Before the test we treated this bounding by surface preparation and corrosion load effect in 3\% salt spray during 168 hours on 40 °C temperature. Figure 1 shows the used samples.

![Figure 1. Copper sample, steel screw, single-phase comb busbar max. 63 A](image)

3.2. Experiment process
Fig. 2 shows the experimental setup with integrated thermographic camera (TESTO 880). In case of the heating device’s different position, the used power is different. The electric current is transferring on the prepared bounding, that causes a measurable heat because its resistance changes during the treating preparation (5600 \( \Omega \)). The thermographic camera supports a safe and exact heat measuring process [6, 7]. In this experiment, we measured the temperature of the bounding as a function of the electric current change.
The thermographic camera registered result shows on Fig. 3.

![Image of the tested bounding](image_url)

**Figure 3.** Image of the tested bounding

### 3.3. Experiment results

Tab.1. shows the experiment results, which shows a relationship between the change in temperature and the current. High-density electric power causes heat. We supposed based on of the equation (3) a relationship between the temperature and the power. The equation (3) where $P$ [W] is the electric power, $I$ [A] is the electric current, $U$ [V] is the voltage:

$$P = U \cdot I \ [W]$$  \hspace{1cm} (3)

| Number | Current [A] | Temperature [°C] |
|--------|-------------|------------------|
| 1      | 0           | 27,2             |
| 2      | 0,08        | 27,4             |
| 3      | 0,15        | 28,4             |
| 4      | 3,9         | 44,3             |
| 5      | 7,66        | 75               |
| 6      | 11,58       | 125              |

Use the fundamental equation, where $R$ is the ohmic resistance (4):

$$U = R \cdot I \ [V]$$  \hspace{1cm} (4)

The equation (3) we modified according the equation (4) to write the next (5):

$$P = R \cdot I^2 \ [W]$$  \hspace{1cm} (5)
The result equation (5) shows the relationship between the power (P) and the current (I). From this equation, we can see that the electric power in our experiment and the heat energy has square relationship with current (Fig. 4).

![Figure 4. The relationship between current and temperature](image)

4. Conclusions
The experiment results supported our hypothesis about the relationship between the change in temperature and the current. The reason of this relationship is that the electrical energy transforms to heat energy, according to Newton’s energy conservation law.

I. The temperature of the used bounding changed during the experiment. Based on this result we can conclude that in real application we can detect the same phenomenon.

II. The galvanic corrosion causes the change of the resistance. The galvanic corrosion results an extremely high resistance in the bounding.

III. The changing temperature is measurable and it can be detected by thermographic camera device. The thermographic camera is very useful because it can measure the temperature without any contact meaning that the measuring process is safe.

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