CALCULATION OF TEMPERATURE RISE IN CIRCUIT BREAKER

Ing. Ferdinand URBAN, Doctoral Degree Programme (1)
Dept. of Power Electrical and Electronic Engineering, FEEC, BUT
E-mail: xurban15@stud.feec.vutbr.cz

Supervised by: Dr. Vladimír Aubrecht

ABSTRACT

Calculation of a temperature rise is one of the important topics in construction of electrical machines and apparatus. It depends on ability of a constructor, how he or she solves this problem. The problem of temperature rise is the main theme of my thesis. The modern numerical and measuring methods have been used for solving this problem. These methods together with software give the results, which were verified by a thermo camera.

1 INTRODUCTION

In design of electric machines or electric apparatus, we have to take into account among others also heat transfer due to electrical current. The heat is dissipated and can result in degradation of an insulation in worse case destruction of the machine. Prediction of heat transfer is one of the most important steps in construction of electrical devices. Knowledge of the temperature rise is required for dimensioning of current–carrying conductor and its insulation. The value of temperature rise significantly influences selection of materials, insulation type or the best process of heat dissipation.

This work deals with the prediction of the temperature rise of current-carrying conductor in miniature magnetic circuit breaker (MCB). Modern computational tools were used for the problem solution. Finite element method (FEM) is one of the most popular methods for solution of various types of fields (magnetic, electric, thermal etc.).

2 PROBLEM

Heat generated in current-carrying conductor during electric current flow is used for temperature rise of current-carrying conductor and for radiation heat transfer to neighborhood. If the heat is not rapidly and effectively diverted, it can be dangerous, even catastrophic for electrical apparatus.

When alternate current passes through a conductor, losses grow up because of non-uniform current distribution in the conductor. Close to the conductor surface current density is much more higher in comparison with an inside area of the conductor.

On the picture recorded by thermo camera (Fig. 1) we can see places with the highest temperature (dark color). The hottest parts are the short-circuit release and the copper electrical bonding between moving contact and the overcurrent release. This is due to the passing current of 63A and size of electrical bonding to overcurrent release, which is not so big. High temperature near the coil is induced by a difficult heat dissipation. Heat energy is stored up in a metal anchor, which is a part of the short-circuit release.

2.1 BASIC PRINCIPLES OF HEAT TRANSFER

If two different points of a volume have different temperatures in the same time, heat energy is transmitted from the places of higher temperatures towards the places with lower ones. The same transmitting of energy occurs between two volumes, which are close together but separated by a specific medium (atmosphere, layer medium). Process of equalizing different temperatures is called heat exchange (transmission). There are three basic types of heat exchange: convection heat exchange, radiation heat transfer and conduction heat exchange.

Conduction is transmission of heat energy immediately from one particle of volume to another (typical example is the heat transmission in solid material).

Radiation heat transfer uses electromagnetic waves for transmission.

Convection is given by a motion of particles in a liquid or a gas.

3 CALCULATION

ANSYS package was used for calculations of heat exchange. Mathematical approach is based on finite element method (FEM).

3.1 PREMISES AND SIMPLIFICATIONS

Two main simplification were taken into account. Firstly, convection heat exchange was neglected, so that only radiation and conduction heat transmission were taken into account. Secondly, electrical resistance of the current conductor is assumed to be independent on the temperature.

The first thermal law and Fourier law were used in calculation models.

4 SUMMARY

Comparison of pictures recorded by thermo camera (Fig. 1, Fig. 3) with computed results (Fig. 2, Fig. 4) indicates very low discrepancies In case of box temperature, the error is very small. Differences between temperatures are higher in case of current-carrying conductor. We have to take the picture from thermo camera very carefully, since it is not possible to adjust IR camera for all emissivities in all space. There are places with the biggest temperature, which are close to the warmest places calculated by ANSYS.

5 RESULTS

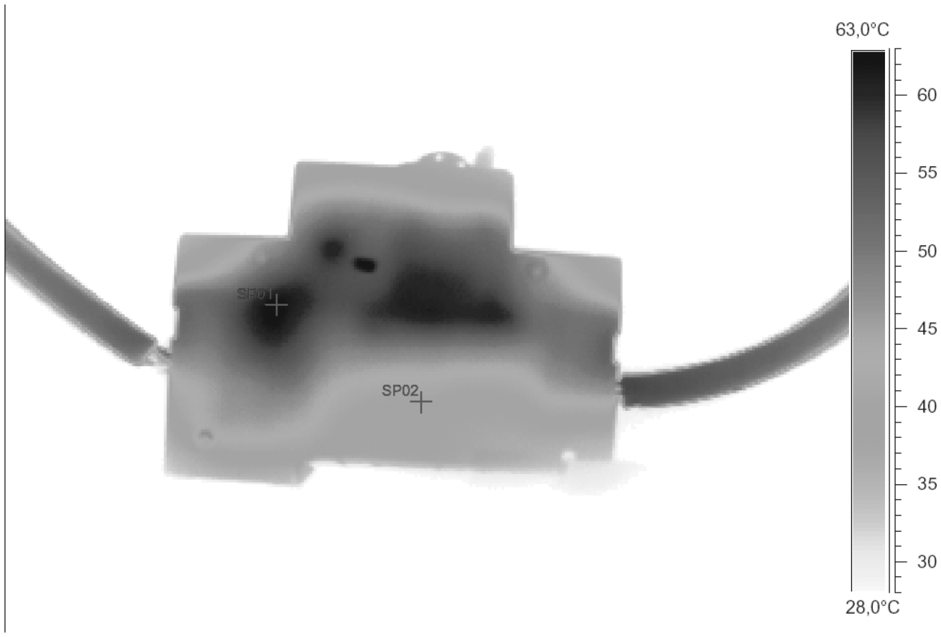

Fig. 1: *Picture recorded by thermo camera*

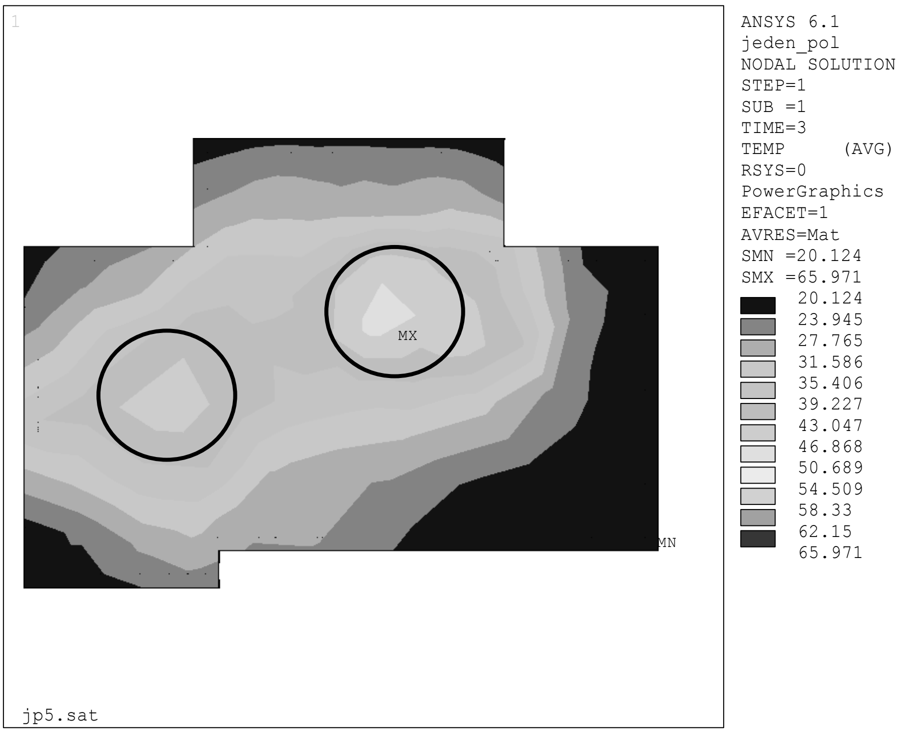

Fig. 2: *Calculated box temperature*

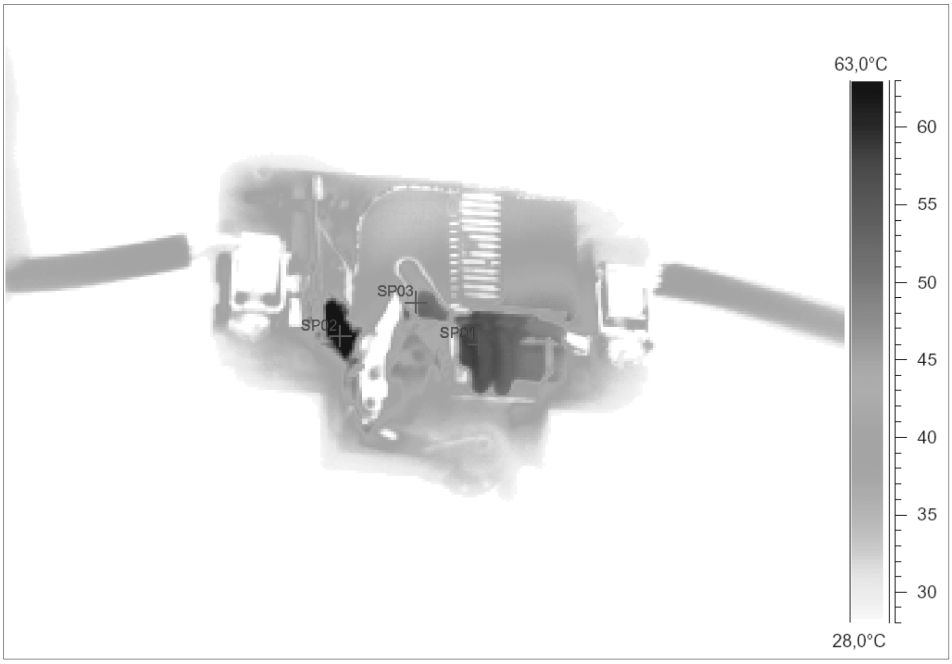

Fig. 3: *Circuit-breaker picture recorded by thermo camera*

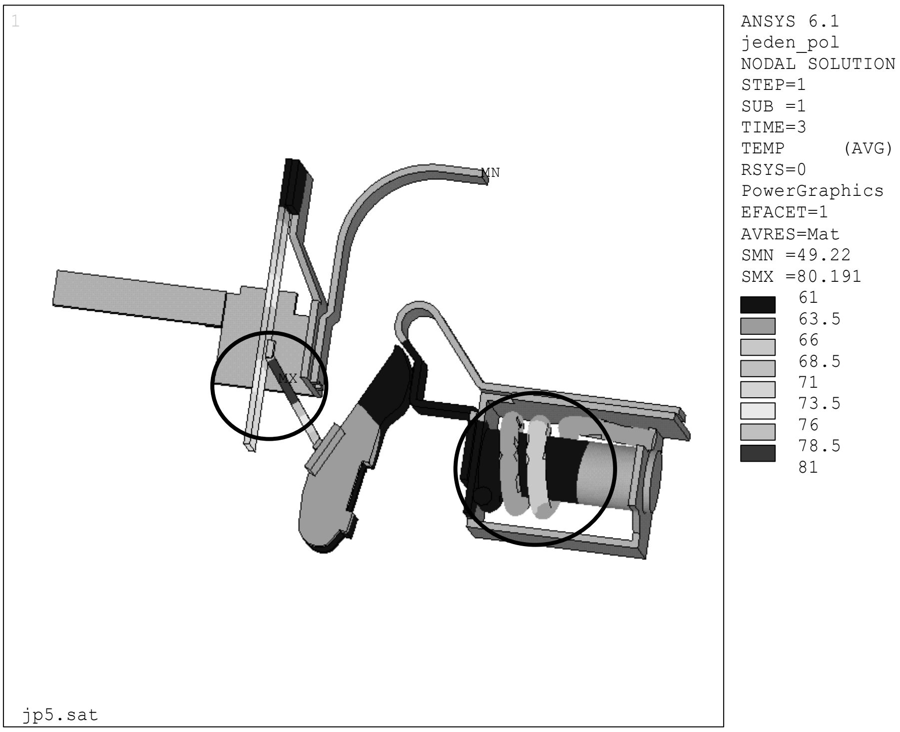

Fig. 4: *Calculated temperature in circuit-breaker*

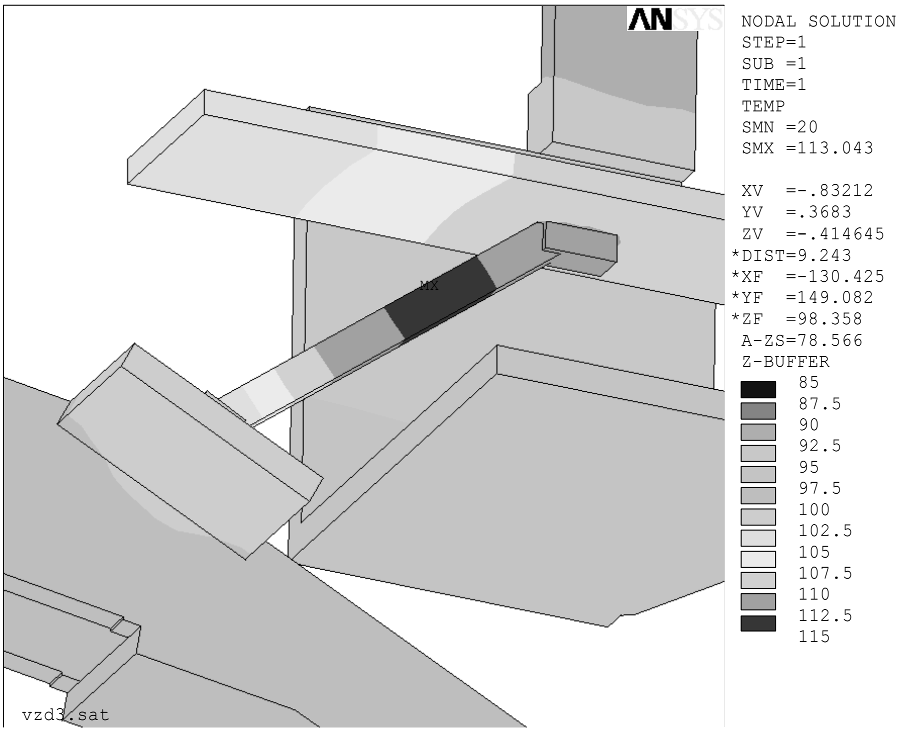

Fig. 5: *Temperature in copper electrical bonding between moving contact and the overcurrent release*

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REFERENCES

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