ANALYSE OF MEDIUM VOLTAGE CONTACT SYSTEM

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ABSTRACT

This text is dedicated to computer analysis of electric device experimental contact system made by IVEP a.s. Brno. On the base of earlier experiences, simplified 3D model was made. The calculation method and basic conditions of separated analysis were appointed. The input values were experimentally measured. The ANSYS program was used for calculations. The contact was examined by many sides of view – electric, therm and magnetic calculations. This text is aimed to magnetic fields generated by current. Results of these calculations will be used in the future research and to improve contact system construction.

1. INTRODUCTION

It is necessary to had in mind number of basic problems in construction of medium voltage electric devices.

The problems are:

- dimensioning of current path,
- isolation distances between poles and ground of device,
- contact resistance (press force),
- magnetic forces on contact system, current path or on possible electric arc (switch on, switch off and running of device),
- geometric of device and contact system,
- the device cost.

These problems are linked together and they influence each other. This text is aimed to the most difficult calculable problems of magnitude and direction of magnetic force. In the past, these forces weren´t able to count exactly on geometrically complicated devices. It was possible to discover the forces by experiments only partially. The calculations were changed and became more exact with coming of computers. The shape of current path has influence on magnetic force vector which affects contact system, electric arc and other parts of device.

2. ANALYSIS

These values will be calculated in the analysis:

- voltage drop,
- magnetic calculations.

2.1. VOLTAGE DROP ON CONTACT SYSTEM

The equation 1 is Ohm law and points to value of voltage drop u_c on contact system in steady state.

$$u_c = R_c * i_c \tag{1}$$

Where R_c is a value of contact resistance and i_c is a value of network current.

Real value of contact resistance is very difficult to count even when the touch is in one place. Many values take effect on it:

- mechanic characteristic of contact material,
- foreign interlayer (corrosive, lubricating),
- size, distribution and number of clear metal contact (press force of contacts).

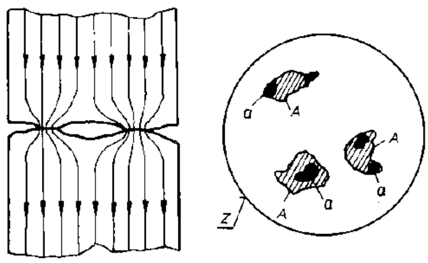

Figure 1: Touch areas of contact.

Generally, we can describe the resistance R_n of one narrow in Figure 1 by equation 2. Value d is diameter of small circle contact. Area of this is equivalent to surface a in Figure 1. Value ρ is resistivity of the contact metal.

$$R_n = \frac{\rho}{d} \tag{2}$$

Whole contact resistance R_c is parallel sum of each narrow resistance R_n.

2.2. MAGNETIC CALCULATIONS, FORCES

We can imagine current as move of electric charge. Creation of electrodynamics - magnetic forces is linked to it. We can calculate magnetic forces using magnetic flux density B. Elementary force F is given by equation 3, where J is vector of current density and B is vector of magnetic flux density.

$$dF = J \times B dV \tag{3}$$

Resultant value of forces is then given by the current magnitude and a shape of current path. For example, forces can rise between two influencing conductors or on bend of current path. Due to this effect, magnetic forces are generated on current narrows in contact system too.

3. CALCULATIONS, RESULTS

3.1. CREATION OF MODEL, CONDITIONS OF CALCULATIONS

The ANSYS program was used for simulations and calculations. Cutting simplified model of contact is sketched in Figure 2 (left). Overall three-dimensional (3D) model was created using Inventor program and then it was imported to ANSYS.

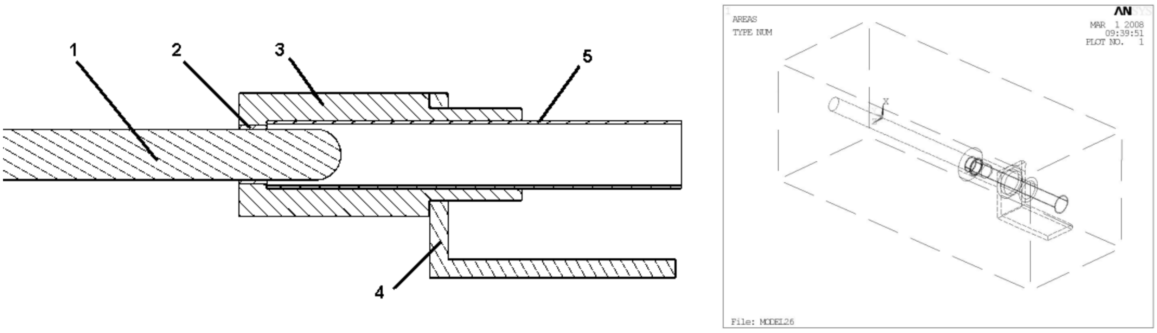

Figure 2: Simplified model of contact.

1 – pin (cooper), 2 – transition layer, 3 – body (cooper), 4 – terminal (cooper), 5 – tube (steel).

It was necessary to thing about contact resistance between the pin and the body with regard to the theory. In this case, simulation of current narrow will be very difficult and non-efficient. Then the transition layer which simulates contact resistance was made. The voltage drops were measured on existing contact system in testing laboratory. The value of this drop is 90mV, network current is 100A. At first, model was calculated with cooper transition layer (ρ_{cu}=1,92 e^{-8} Ω.m) on the computer. Then the voltage drops were analyzed. Sequentially the resistivity of transitions layer was modified so that value of voltage drop of whole modeling contact system was approximately 90mV. Value of this new resistivity was assessed to ρ_2 = 3,5 e^{-4} Ω.m. This model is very similar to a real contact.

Value of testing current was set up to 100A. Whole model was supposed to be in air, this fact we can see on Figure 2 (right). The temperature of 273 K was applied on outside walls of air. Whole simulation was calculated in a steady state condition.

3.2. ELECTRIC, THERMAL CALCULATIONS

Figure 3: Calculation of voltage drops.

For analysis of contact, it is necessary to perform electric calculations and to get values of the current density. Distribution of voltage drops is shown on Figure 3. Drops were placed only on transition layer. It is due to the proportion of cooper and transition layer´s resistivity. Results of calculated temperature rise are sighted on Figure 4 (left). Final temperature rise of contact was above 200 °C and the contact with this pressure force would fail temperature-rise test but this fact isn´t important for this analyze. In practice, it would be necessary to increase the contact pressure thereby the contact resistance will be decrease or more precisely final temperature rise of contact will be decrease.

On the next Figure 4 (right), distribution of the current density is shown.

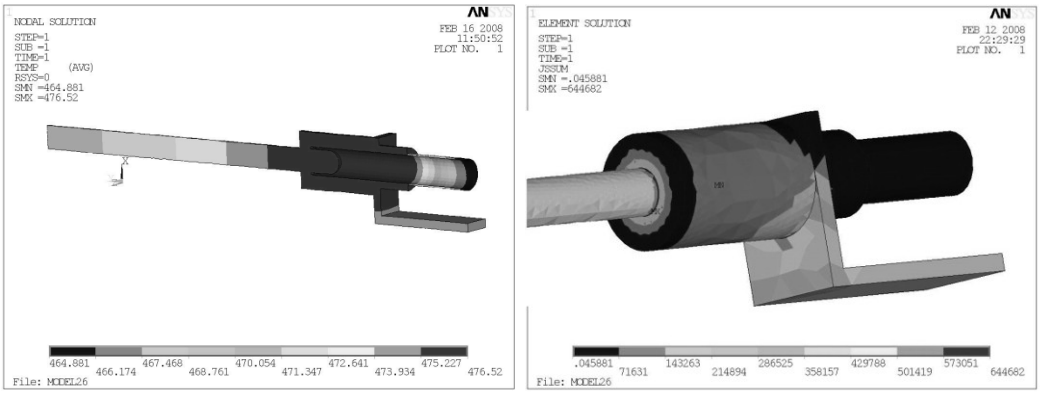

Figure 4: Temperature rise and current density.

Calculated values are only for demonstration. If we would like to calculate a real value, we have to reason about the current narrows where the current density would be higher. Maximum values of calculated current density are about 640 $kA.m^{-1}$.

3.3. MAGNETIC CALCULATIONS

The results from previous paragraphs were necessary for the next magnetic calculations. The permeability of steel tube was set to 1000 for simplification, BH curve wasn´t used. The highest value of flux density, 0,014T, was fixed there.

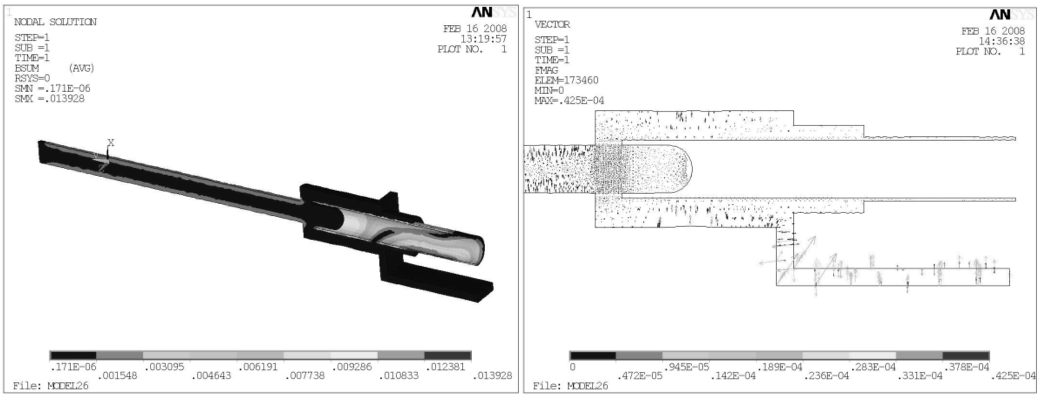

Figure 5: Magnetic flux density and magnetic forces.

This event is shown in Figure 5 (left). In Figure 5 (right), the results of calculated magnetic force are shown. Size and orientation of arrows illustrate the force in calculation points. We can see various incidences of magnetic forces to contact system. For example we can see forces, which press down contact and practically increase the press force. Through this fact we can obtain more powerful and faster drive.

3.4. COMPARISON OF MODELS

For interest and comparison, the next another model calculations were made. We can see the results on next two Figures 6, and 7. Due to the different geometry of these models, the magnetic forces and magnetic flux density are different. Both magnetic forces and magnetic flux density vary according to the used geometry a very much. We can see the contact without tube on Figure 6 and on the next figure contact terminal have another shape and it´s without tube too.

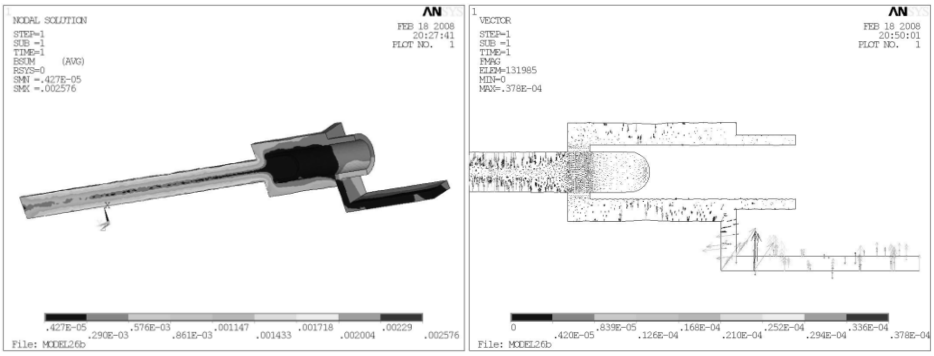

Figure 6: Magnetic flux density and magnetic forces, model 2.

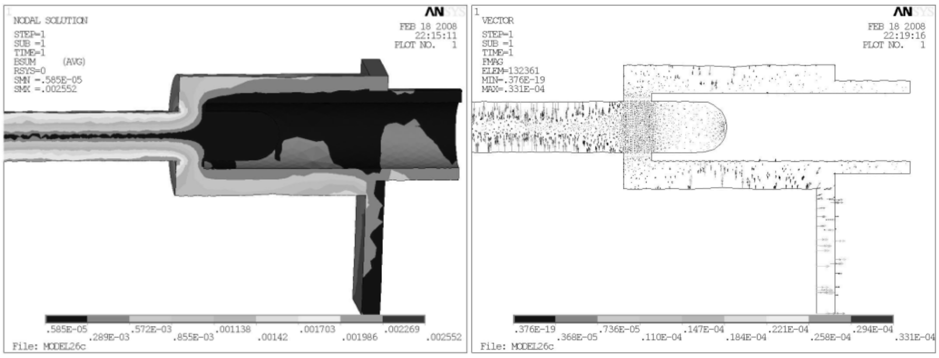

Figure 7: Magnetic flux density and magnetic forces, model 3.

4. CONCLUSION

This text is verified and indicated computation possibilities in this branch. These pieces of knowledge will be used for next research and for development of devices in IVEP a.s.

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