

CONDUCTOR'S AMPACITY

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ABSTRACT

This article deals with the high voltage conductor ampacity. The aim of this paper is a preliminary description of the impact of ambient temperature on the final temperature of a conductor and the conductor's sag caused by that final temperature at a defined current load. The aim is to evaluate under what combinations of boundary and initial conditions could to a high voltage lead be applied more load than in the current standard. This paper is created as a first approximation, in resolving issues of conductor's ampacity.

1. INTRODUCTION

With the increasing number of difficult sources of renewable electrical energy connected to the power systems there are placed increasing demands on the transmission system and especially on its effective management. Therefore, there are efforts of the energy network operators to effectively manage the transmission system depending on the transmitted power and current weather conditions. Therefore, the issue of energy distribution networks and hence the conductor ampacity is being frequently discussed. On this issue our department cooperates with the ČEPS a.s. One part of this collaboration is to understand the influence of heat radiation on the temperature of conductors under load. Therefore, a model of high voltage leads was created so that a initial analysis of the influence of boundary conditions on temperature distribution in an AlFe lead at given initial conditions can be carried out. The aim is to use numerical modeling to explore the possible states of operation of high voltage leads and their dependency on the load and the environment.

2. CALCULATION METHODS FOR OPTIMISING THE TRADE-OFF BETWEEN ELECTRICAL EFFICIENCY AND CONTROL RANGE

2.1. Calculation results

First, it was necessary to create a model of high voltage conductor. For that model an AlFe lead 54Al/7Fe was chosen, see picture below.

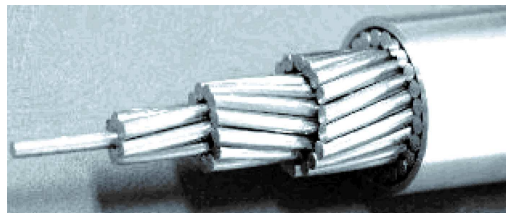


Figure 1 – AlFe rope

Based on facts described above a AlFe model was created as shown in the picture below. The whole task was solved as a semi coupled model. The solution therefore lies in calculating the distribution of electromagnetic field through the vector potential followed by determining the temperature field using the Fourier-Kirchhoff equation.

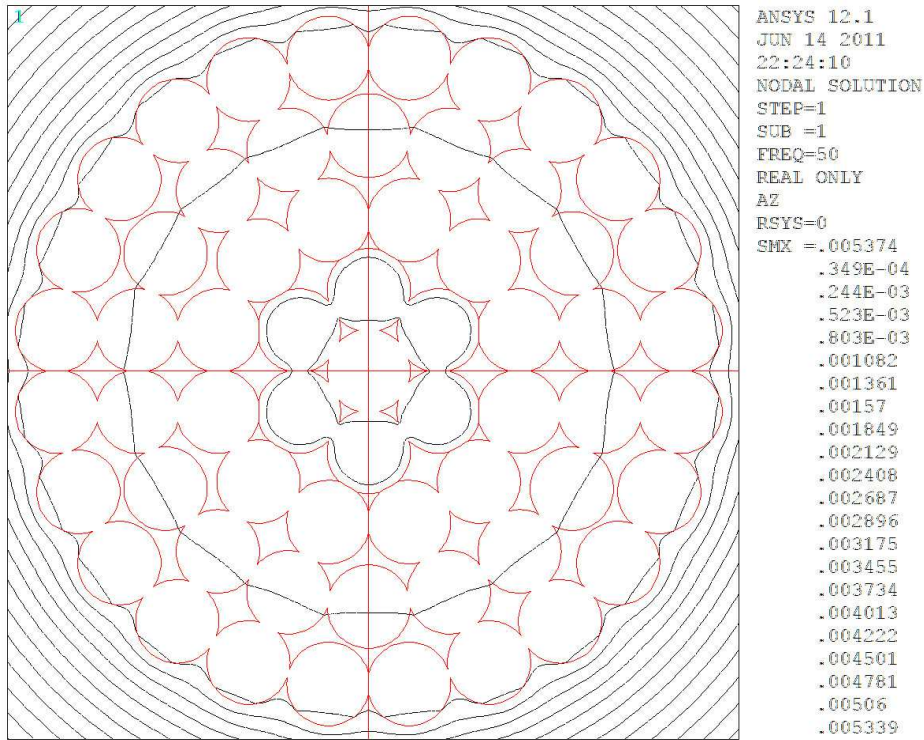


Figure 3 – Model of AlFe rope, EMF distribution

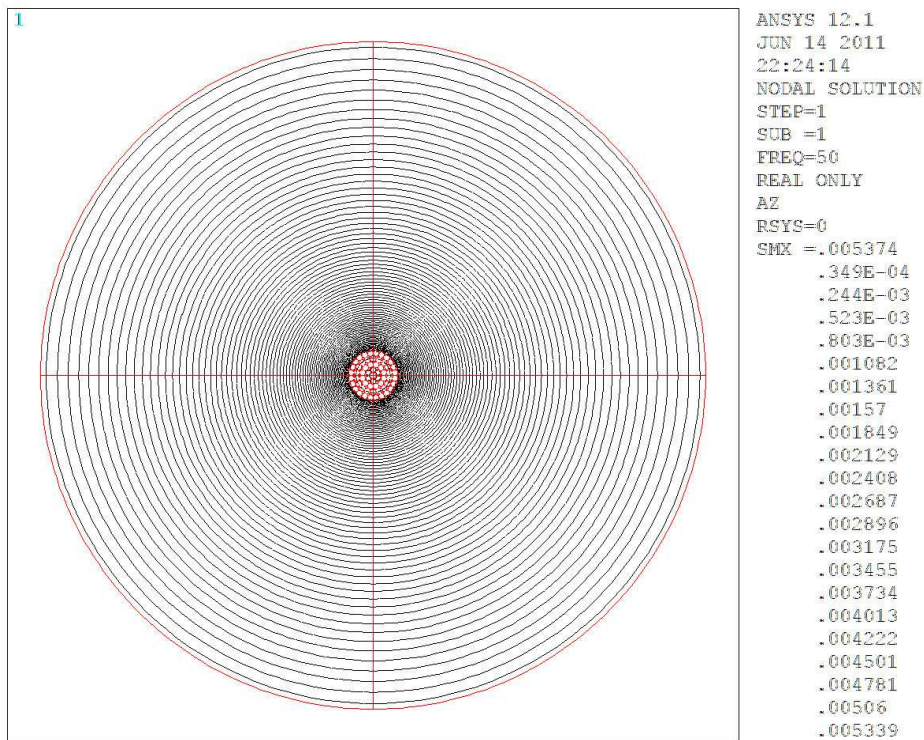


Figure 3 – Whole model of AlFe rope including the boundary environment, EMF distribution

To create the model and its subsequent solution was used professional multiphysical SW ANSYS. When solving electromagnetic field it is considered a skin effect, and electromagnetic field is described by equation $-\Delta \mathbf{A} + \gamma \frac{\partial \mathbf{A}}{\partial t} = \mu \mathbf{J}_v$ when considering Dirichlet boundary conditions

$A(\Gamma, t) = A_{\Gamma}(\Gamma, t)$ $A(\Gamma, t) = A_{\Gamma}(\Gamma, t)$ on the outer boundary / edge of the surrounding environment.

Distribution

of vector potential in AlFe lead then shows the following picture. Initial condition $A(\Omega, t = 0) = A_0(\Omega)$ $A(\Omega, t = 0) = A_0(\Omega)$. The wire was set with current $I_{ef} = 850$ A, at $f = 50$ Hz.

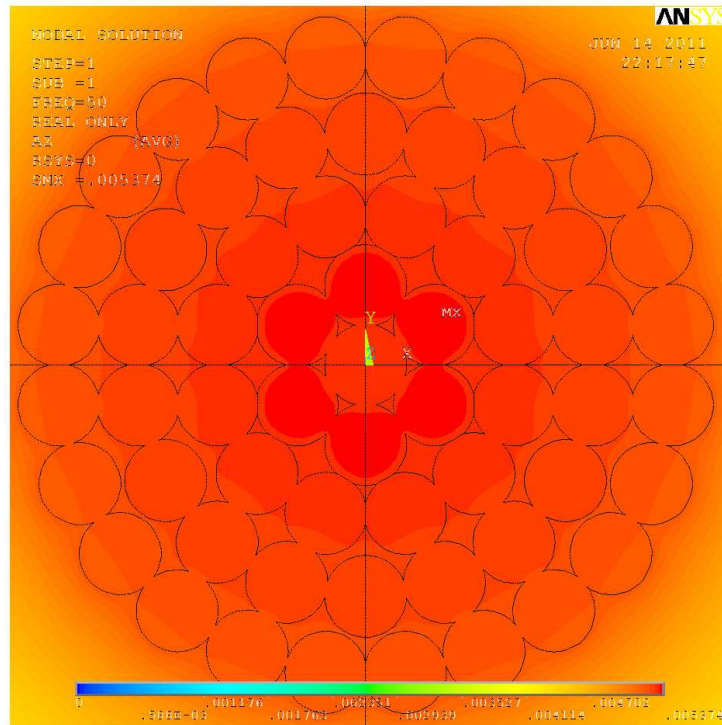


Figure 4 – Distribution of magnetic vector potential in AlFe rope [Wb/m]

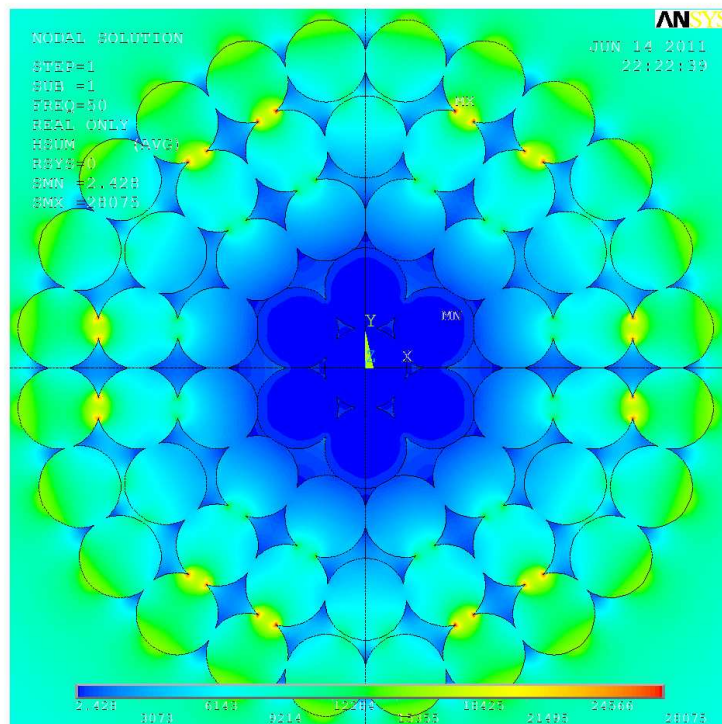


Figure 5 – Distribution of magnetic intensity in AlFe rope [V/m]

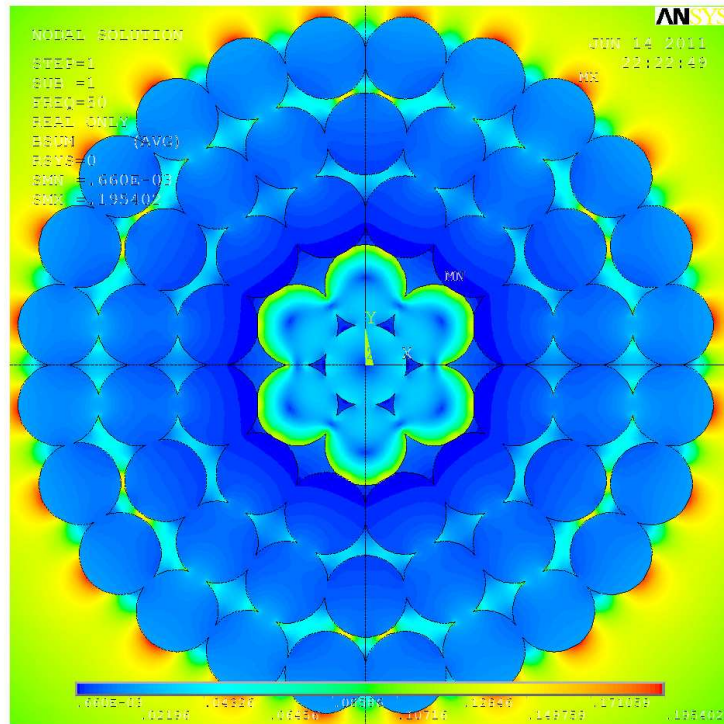


Figure 6 – Distribution of magnetic induction in AlFe rope [T]

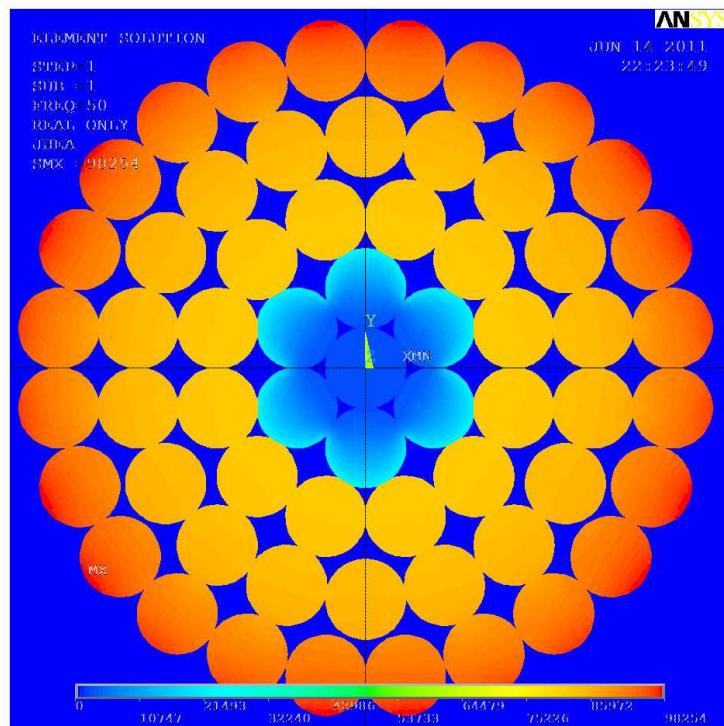


Figure 7 – Joule-heat distribution in AlFe rope [W/m³]

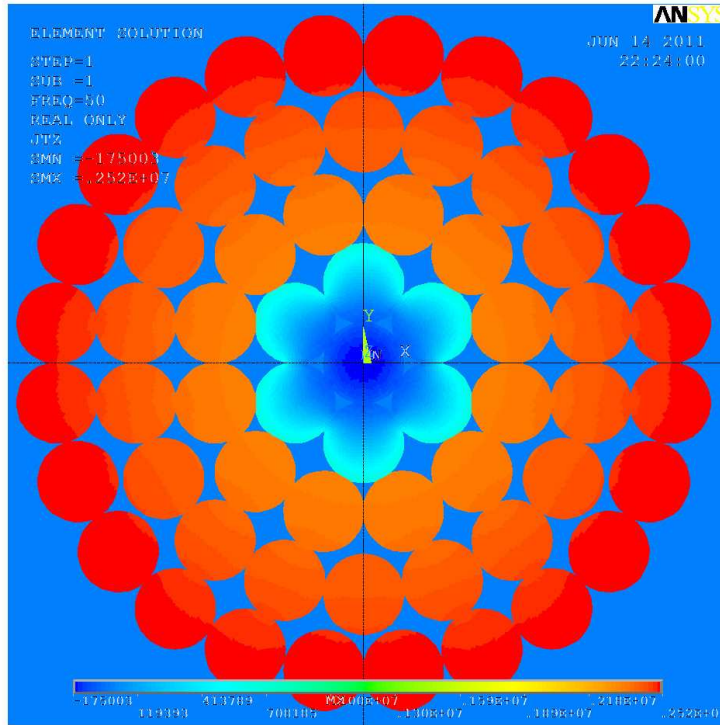


Figure 1 – Current density distribution in AlFe rope [A/m²]

Thermal field was solved with Fourier-Kirchhoff equation $c_p \rho \frac{\partial T}{\partial t} = -\text{div}(-\lambda \text{grad} T) + w_j$,
 when considering mixed boundary conditions
 $\lambda \frac{\partial T}{\partial n} = \alpha(T_{\text{gass}} - T) + \varepsilon c(T_{\text{ext}}^4 - T^4)$ on the surface
 of conductors (convection and radiation) and used initial condition $T(\Omega, t = 0) = T_0$ $T(\Omega, t = 0) = T_0$.

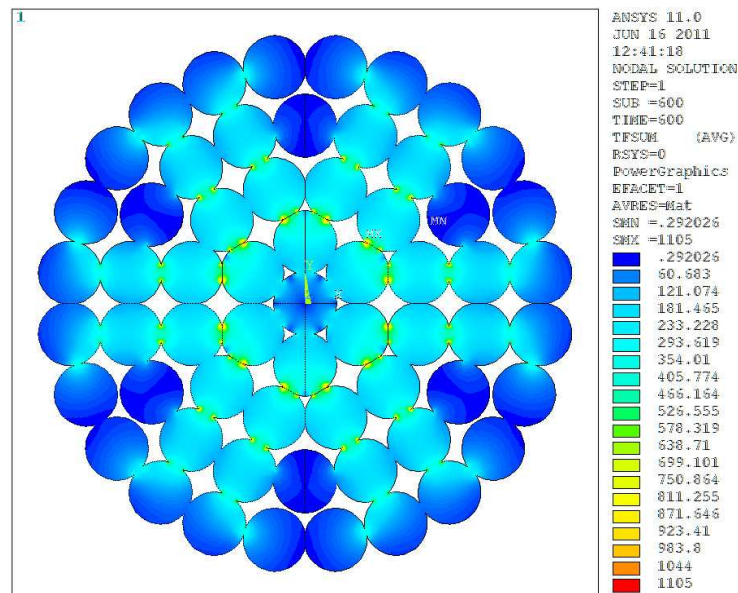


Figure 9 – Thermal flux distribution in AlFe rope [W/m²]

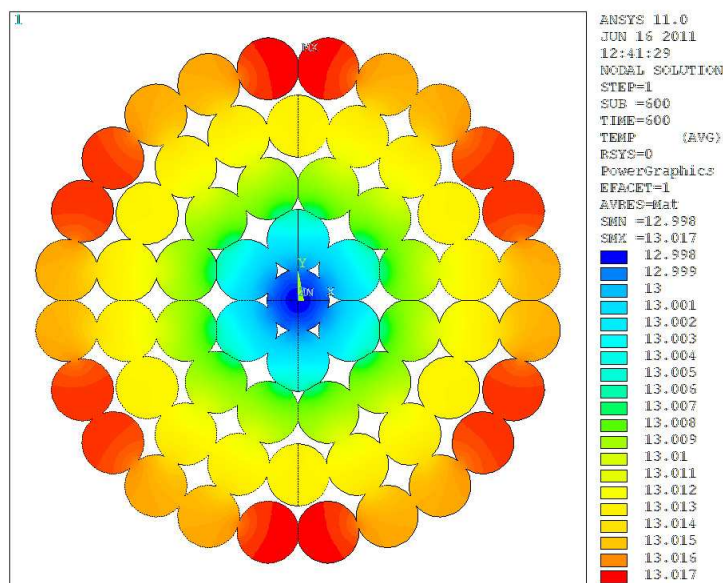


Figure 2 – Temperature field distribution in AlFe rope [°C]

The initial temperature of the high voltage conductor and the environment while solving the temperature field was considered to be 0 °C. Thus it is the first calculation of large series of simulations describing the distribution of temperature field at different combinations of initial and boundary conditions of the electromagnetic and thermal fields.

3. CONCLUSIONS

The aim of this paper was an initial approximation of ampacity conductors characteristics. That is why there was created the above AlFe lead model, which will be further tested at various initial and ambient conditions, those that might occur in real operation. The aim will be to analyze and evaluate the impact of heat radiation for warming wires when operating high voltage lines. Therefore, using specialized software, selected states of the transmission system at different meteorological conditions (boundary conditions) will be modeled. By carrying out that simulation number of models combining various current loads (initial conditions) and the environment as a result of heat radiation effect on the resulting temperature of the conductor will be generated. The expected outcome will be recommendations for traffic control in high voltage lines, depending on meteorological conditions in the surrounding area.

REFERENCES

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