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# 1D SIMULATION OF HEAT TRANSFER IN CABLE CHANNEL

# SIMULACE PŘENOSU TEPLA V KABELOVÉM KANÁLU

**Abstract**

The paper deals with the use of 1D simulation tool AMESim to predict the steady state temperatures of a high-voltage electrical cables which are installed inside a cable channel.

**Abstrakt**

Příspěvek se zabývá problematikou simulace ustálených teplotních stavů v kabelových kanálech, pomocí univerzálního simulačního nástroje AMESim.

## 1 INTRODUCTION

Rising power consumption puts demands not only on the continuous development and construction of new power sources, but also on the efficient distribution of electricity to final consumers. Since the largest amount of actually consumed electricity is produced by big and centralized power plants, the power grid has to transport electricity over large distances. The power losses in electrical power system correspond to the square of the transmitted current, therefore high-voltage lines are used for power transmission. On the other hand, the high-voltage cables are more prone to the formation of an electrical discharge and must be properly installed.

There is no problem with the correct high-voltage line installation in such areas where the overhead power lines are used. If there is no space for overhead lines the buried cables have to be used (e.g. in urban areas); hence the special cables with enhanced insulation and stored in concrete channels have to be employed, see Figure 1. If such a cable channel is buried, the waste heat from cables is removed relatively easily into the surrounding soil. Unfortunately, problems occur when the buried cable channel crosses the other lines (e.g. drainage) hence the released heat has to be transported by convection.

## 2 SOLUTION AND RESULTS

Since the maximum operating temperature of a single cable is limited to a value around 90 °C, it is very important, for the safe operation of the grid, to locate places of the worst heat dissipation to avoid cable overheating. Hence, the 1D model of a concrete cable channel for 6 high-voltage cables (Fig. 1) was developed for this purpose. In this model, the individual cables with a diameter of 120 mm are deposited in PE pipes diameter 200 mm with wall thickness 6 mm. These tubes are embedded in concrete, so that the entire cable channel is a monolithic block with a cross section of 750 × 100 mm, and the desired length (1 m in case of the developed model).

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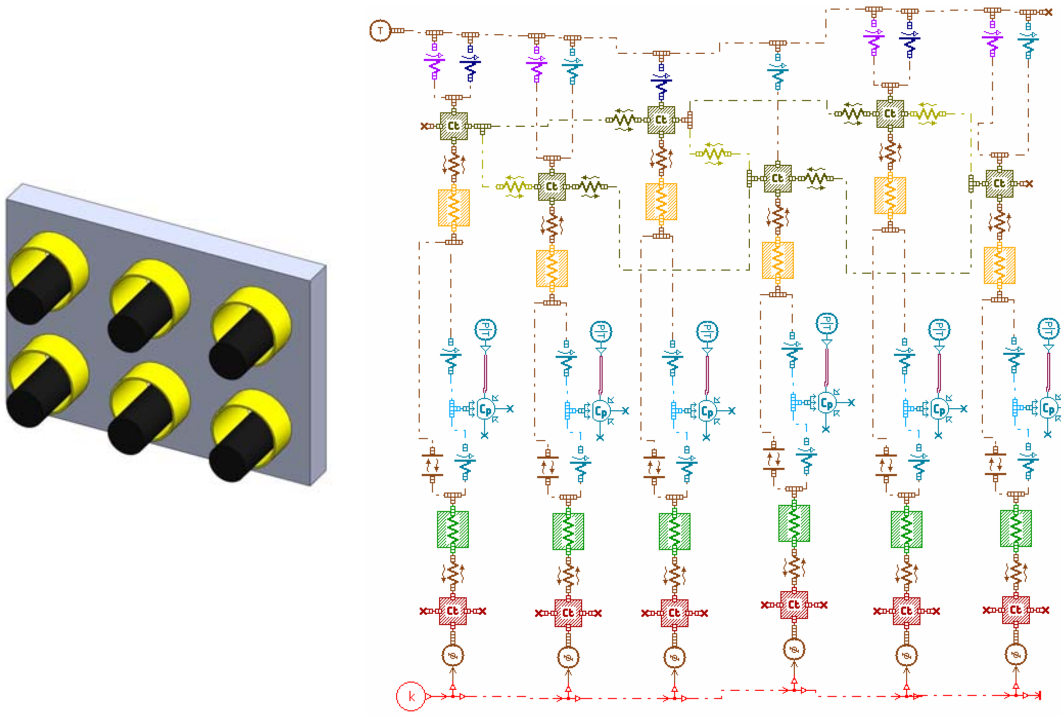

**Fig. 1** Cable channel for buried power lines and its model in AMESim

The problem of heat transfer inside the cable channel was described with the appropriate resistance pattern, which, in addition to the resistance, included capacitance elements (the mass of the cable core, PE ducts and the concrete block). The heat transfer between elements was described with a thermal resistor for conduction (heat transfer through cable insulation, PE tube and within the concrete block), natural convection (from the cable surface to the air inside the PE tube and from this air to the PE tube, and from the entire surface of the channel) and radiation (between the cable surface and the surface of the PE tube). Additionally, a conduction heat resistance was placed between the capacitance elements to ensure lateral heat conduction inside the concrete block.

The above described resistance system was built in the simulation tool AMESim, where the basic Signal, Thermal and Thermal pneumatic libraries were used, and maximum possible build-in models of material physical properties were applied, (Fig. 1).

The thermal power dissipation of the real cable of 24 W/m was used as the boundary condition and the steady state cable copper core temperature were assessed for each cable in case of the external air temperature of 15 - 60 ° C.

The obtained results showed that the worst cooled cable is the middle one located in the bottom row of cables. Hence, its temperature was selected as a suitable indicator for assessing the possibility of using the cable channel at different ambient temperatures, Fig. 2. There is a maximum cable temperature 88 °C reached in the Fig. 2 for the ambient air temperature of 60 °C, so that the ambient temperature of 60 °C should be denominated as a limit temperature for the considered cable channel operation.

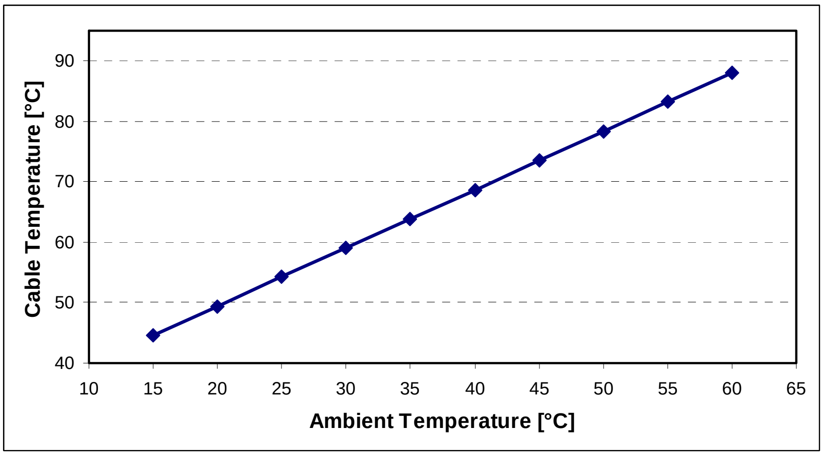


**Fig. 2** Cable temperature

## 3 CONCLUSION

The high voltage cable temperature prediction is an important means to ensure reliable transport of electricity. In terms of a possible overheating of cables, buried high-voltage cables are critical. These are placed in concrete channels for safety reasons. A 1D model of the heat transfer inside cable channel has been created in order to assess the temperature of cable lines and find the limits of operating conditions. This model was then solved with the use of AMESim simulation tool. The results were compared with the available outputs of a specialized code CYME [1] and showed that the variations in operating temperatures of cables should not exceed 10 % compared with CYME obtained temperatures. Number of other simulations, were done, based on this finding, with a simple goal to find the maximum operational temperature of the considered cable channel. These simulations showed the ambient air temperature above 60 ° C is critical for the reliable cable operation due to insufficient cooling which leads to cable overheating.

## REFERENCES

[1] *Cooper power system* [online]. c2010 [cit. 2010-05-28]. CYMCAP, Cable Ampacity Calculation . available from WWW: <http://www.cyme.com/software/cymcap/>.

## ACKNOWLEDGEMENT

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