Effect of Proximity on the Thermal Rating of a Single Power Cable in Ventilated Tunnels

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Abstract

Power transmission through power cables installed in ventilated tunnels has been increasingly used worldwide and offers a complex thermal environment. These cables are placed on supports or fixed close to the tunnel walls. Established correlations currently in use have been deduced from a non-fully developed turbulent flow and the effect of the proximity to a tunnel wall is not accounted for precisely. This paper details the experimental and numerical investigations of the heat transfer from a single cable in a fully developed turbulent air flow, with emphasis on the effect of the cable spacing from the tunnel wall. Nusselt numbers have been compared for different spacing and velocities thanks to a coupled model between COMSOL Multiphysics® software and MATLAB® software, where the inverse method is used to identify heat transfer coefficients on the cable surface.

The overall heat transfer is found to be meaningfully lower than in previous studies while the same threshold value for the wall spacing is found. The local effect of the confinement is explained with the velocity profiles evolution with the confinement from numerical simulations using the open source code OpenFOAM. The velocity and wall shear stress profiles obtained for each configurations help explain the cooling derating when the cable position is beyond the threshold value of 2De (De: cable diameter).

The radiative heat exchange, assessed numerically with a radiative model in COMSOL software, is found to be up to 30% of the total heat loss which has a visible impact on the temperature profile of the tunnel wall.

To give a more precise rating of cables in ventilated tunnel, an improved cooling law for cables in tunnel taking into account the proximity of the wall has been developed from the present study and confronted to the experimental and simulated data.
Figures used in the abstract

**Figure 1**: Radiative contribution to the heat transfer for the four wall spacing values.

**Figure 2**: Mean azimuthal Nusselt number for the four wall spacing values.

**Figure 3**: Velocity profiles for ReDe = 11600, scaled for the mean turbulent velocity.
Figure 4: Local Nusselt number distributions for the four positions.