Thermal ratings of submarine HV cables informed by environmental considerations

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With recent investments in projects like offshore power generation and international megagrid initiatives, submarine HV cables are becoming increasingly essential for modern power transmission strategies. Understanding the thermal conditions that these cables are likely to be exposed to is vital to ensure that they are efficiently and economically deployed.

A lot of research has been carried out on the thermal behaviour of land-based cables. However the performance of submarine cables has not been extensively investigated despite numerous key differences between the two respective environments. For example, the marine environment can vary on a much more dynamic time scale. Migration of sedimentary bedforms may cause variations in the height of the seabed (i.e. cable burial depth) of up to 5m per year.

We have developed 2D finite element method (FEM) simulations to assess the impact that certain environmental parameters (sediment permeability, thermal conductivity, and cable burial depth) have on the thermal performance of a cable buried in the marine environment. Both conductive and convective processes are accounted for within the porous burial sediment, and a conductive model is incorporated for the constituent components of the cable.

Traditional techniques for calculating current ratings for terrestrial cables (e.g IEC 60287) commonly assume that the transfer of heat within the burial medium is dominated by conduction (convection is often neglected, or treated in an oversimplified manner). For low sediment permeabilities, fluid flow is restricted, and heat is dissipated almost exclusively by conduction from the surface of the cable into the environment. The thermal conductivity of the surrounding sediment and the cable burial depth strongly influence the efficiency of heat transfer away from the cable; behaviour that echoes the predictions of existing methods. However, the model suggests that for sediments with a high permeability, a significant amount of heat is transferred by convection (in fact for some sediments, convection is likely to be the dominant mode of heat transfer). In circumstances where this convection is significant, the additional cooling effect can drastically reduce the temperature of the cable for a given current load. Another consequence of significant convective heat transfer is that the influence of the thermal conductivity and burial depth parameters on the cable temperature is diminished.

Augmenting cable current rating calculations to account for convective heat transfer from submarine HV cables may result in a higher current carrying capacity, or a reduction in the required amount of conductor material. Understanding how the various environmental controls affect the efficiency of heat transport in marine sediments is therefore crucial to help determine which types of sediment will provide a beneficial thermal environment for submarine HV cables.