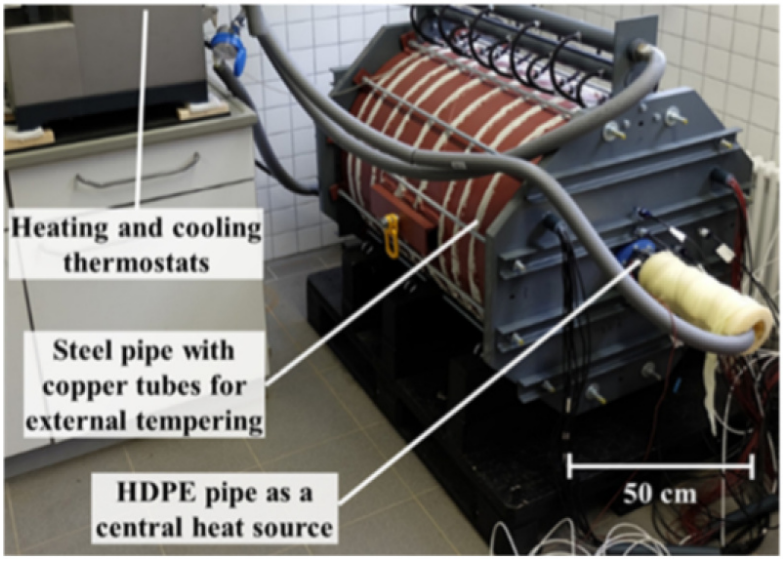
Implementation of Soil Physics Into the Ampacity Rating of Energy Cable Systems



Laboratory test to validate the diffusion model in soils.

Introduction

So far, the soil physic characterization of the bedding material is included only rudimentarily into the calculation of the thermal current rating of energy cable systems. However, the consideration of these properties could lead to a much more precise identification of the actual current carrying capacity, which would reduce the need of network reinforcements and therefore reduce the costs of the German energy transformation.

Methods

In case of transmission of electrical energy by buried cables, the electrical losses will be dissipated to the environment in the form of heat. This leads to an increase of temperature of the conductor of the cable. As the latter is limited and directly proportional to the current, the so called thermal current rating represents one important limit of the cable capacity. At present, the cable ampacity ratings are established based on standardized consumption patterns and conservative assumptions regarding the thermal properties of the bedding. Thereby, values below the actual limit are derived. This is particularly relevant for a high daily and seasonal dynamic in load patterns that is typical for power injection from photovoltaic generation. Moreover, the influence of natural water content changes of the surrounding soil on the thermal properties of the bedding is not taken into consideration. The research project

Project Manager
Constantin Balzer

Principal Investigator
Prof. Dr.-Ing. Volker Hinrichsen

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comprises primarily three distinct aspects: laboratory-based analysis under predefined boundary conditions; measurements under realistic conditions in a therefore built cable test site, and modelling the results using numerical simulations. The latter comprises the modelling of the cable test field, including the implementation of natural convection (inside air filled protection pipes) as well as the water diffusion equation inside the soil. The modelling must be implemented in a three dimensional approach to include the effect of the finite length of the cables inside the laying conditions that lead to a longitudinal heat flow. The outcomes will finally be used in order to compare the physical models with measured data.

Results

The implementation of the decisive diffusion processes of heat and mass within the bedding was successfully implemented and validated by the data from laboratory experiments. Furthermore, the derived model was applied to a large variety of soils. As an output, the relevant functions of the temperature dependent heat conductivity have been derived.

Discussion

In the period to follow, these functions have to be evaluated with respect to the resulting ampacity ratings for different configurations of cable systems.

Publications

[1] Balzer, C.; Drefke, C.; Stegner, J.; Hinrichsen, V.; Sass, I.; Hentschel, K.: Enhanced adoption of the two-zone model to implement the drying out of soil in ampacity calculations of directly buried cable systems for different types of soil. 10th International Conference on Insulated Power Cables - Jicable , D6.3. Versailles, France, June 24th – 26th (accepted) ,2019

[2] Balzer, C.; Drefke, C.;Schedel, M.;Hinrichsen, V.; Sass, I.: Quantifizierung des Einflusses von Umweltbedingungen und boden-physikalischen Eigenschaften der Bettung auf die thermische Strom-tragfähigkeit von Mittelspannungs-Energiekabelsystemen. International ETG Congress 2017, E3.13. Bonn, November 28th – 29th. Published in: ETG Fachbericht 155; International ETG Congress 2017 (ISBN: 978-3-8007-4505-0), p. 410415.

[3] Balzer, C.; Drefke, C.; Schedel, M.; Hinrichsen, V.; Sass, I.: Analytical calculation of the thermal impedance of soil under various boundary conditions to enhance current ratings of buried power transmission and distribution cable systems. 20th International Symposium on High Voltage Engineering ISH 2017, PF1, ID 317. Buenos Aires, Argentinia, August 28th – September 1st.

[4]Drefke, C.; Schedel, M.; Stegner, J.; Balzer, C.; Hinrichsen, V.; Sass, I.: Measurement Method of Thermal Properties of Cementitious Bedding Materials and Unsaturated Soils: Hydraulic Influence on Thermal Parameters. Geotechnical Testing Journal (ISSN 01496115), 40, (1), p. 160-170. http://dx.doi.org/10.1520/GTJ20160027

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