Study of HVDC Grounding Systems Using Finite Element Methods

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Abstract

High Voltage Direct Current transmission (HVDC) is a suitable alternative for long distance transmission. During the years, the use of this technology has been increasing, which is one of the several reasons to improve methodologies in HVDC grounding systems.

Unlike the usual approach in AC, a HVDC grounding system is distinguished by its operating procedures, which is, when it is configured to monopolar operation, basically an intense current injection on the ground, eventually for hours. Hence the reason to choice remote areas for the electrode construction. The project conception is mostly accomplished by simplified or empirical methods, that present several peculiarities that may compromise its validity, depending on the soil properties.

This work presents the study of some soil properties and grounding electrode projects characteristics. The first aspect is the soil modeling [1, 3]. One of the most disseminated procedures is Wenner's method [2], that consists on the current injection on the ground by a pair of electrodes, with another pair dedicated to the voltage measurement. The usual proceeding is to considerate the soil as composed by horizontal layers (stratified).

A hypothesis with irregular soil was simulated using the software COMSOL Multiphysics®. There were considered Wenner's Method and the deviation found from the approximation of the grounding resistance by the analytical method of finite element. Three-dimensional simulation enables a very accurate modeling of any irregularities.

The second part of this paper is a comparison between usual projects for HVDC electrodes. Two examples were presented: a vertical electrode (rod) and an horizontal one (ring). As seen in Figure 3. Some aspects worth to be observed are the equivalent electrode resistance, the maximum current density, the ground potential rise (Figure 1 and 2) and the maximum electric field. This part involves a multiphysics study that includes: soil heating due to the current flow, electroosmosis and corrosion effect, not only on the electrode itself, but also on surrounding structures. Another relevant effect is the saturation of grounding distribution transformers coils, simulated by the "electric circuit" study coupled with the "electric currents" physics.

For the FEM modeling, an important ascpect is the use of infinite elements, which an evaluation of the domain size was carried out, bringing good quality for the results. The scale difference

(from few centimeters in the rod diameter to hundred of meters for the domain size) was compensated with a proper meshing. Also a good quality in the material parameters were important for the results, such as electric and thermal conductivity [5].

Reference

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Figures used in the abstract

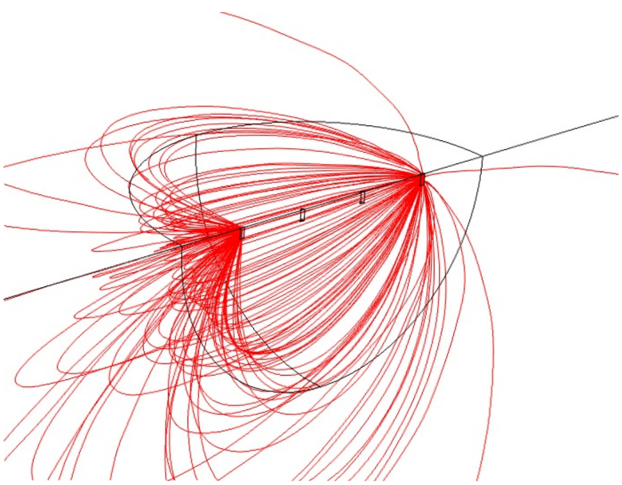

Figure 1: Electric current injection trough the electrodes in the external positions and electric potential measurement by the internal electrodes.

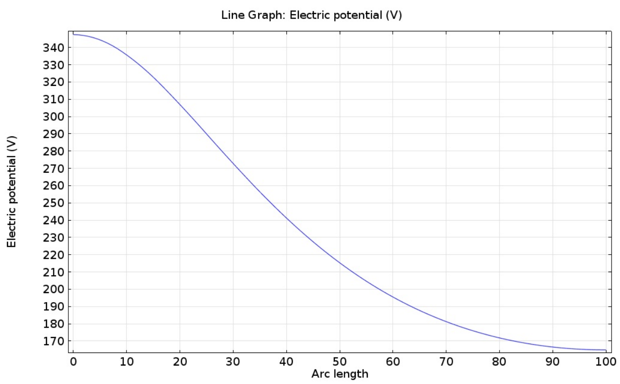

Figure 2: Electric potential elevation at ground caused by a ring electrode (fig. 3).

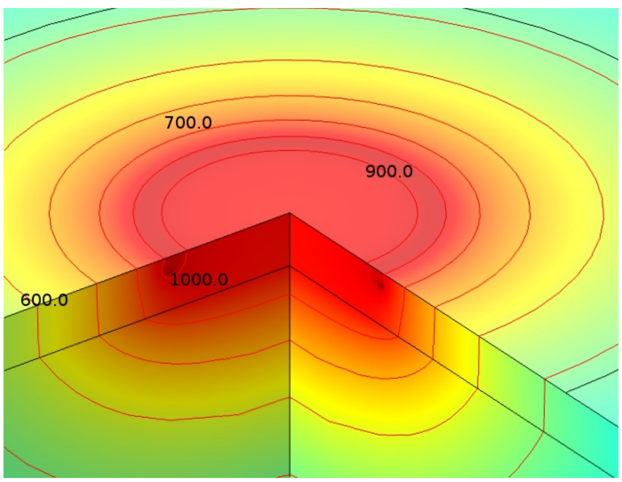

Figure 3: Electric potential caused by a ring electrode in a soil with two layers.