E-Field Distribution And Optimization Study Of High Voltage Resistor During Impulse

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Abstract

Voltage sensors are increasingly used for monitoring and load flow distribution. These sensors are safer, lighter in weight and lower in cost as compared to the conventional voltage transformers. The principal component of these sensors is high voltage resistors. The resistors have a small form factor and can be adjusted to fit specific applications. Voltage sensors have become a popular choice for utilities in the installations where high measurement accuracy is not required, such as Volt-VAR control, monitoring, and protection applications.

High voltage resistors can encounter several field challenges that may reduce a service life of a sensor. High electric field intensity is a significant contributor since concentrated electric fields causes excessive stress in the electric insulation of the equipment. Localized heating due to power dissipation can degrade the resistor material, altering resistance value and further decrease the performance of insulation system. Additionally, electrical discharges can form conductive paths on the resistor surface, leading to short circuit phenomenon. It is also essential to consider dimensional changes in the resistor structure and changes in its chemical composition mainly driven by electrical, thermal cycling and mechanical loads.

This paper presents a case study of electric field intensity analysis during high-voltage impulse conditions. During impulse conditions, the resistors are exposed to high-voltage transient overvoltage resulting in significantly non-linear potential and el. field distribution. The study considers application of high-voltage impulses on the resistor encapsulated in epoxy resin cast body. Analysis utilizes a 3D finite element model based on a cylindrical resistor and was developed in COMSOL Multiphysics (AC/DC module) in the time domain study. A user-defined impulse wave shape is created in COMSOL per IEEE C57.13-2016 to mimic the actual high voltage impulse test conditions. Then, the authors suggest a mitigation strategy, which is analyzed using the same methodology, and compared side by side with the original design. A parametric sweep study is conducted to find an optimal solution - the right balance between minimized electric field intensity and manufacturing suitability. Solution obtained by the COMSOL simulation analysis has been granted an international patent.

Reference

[1] IEEE C57.13-2016- IEEE Standard Requirements for Instrument Transformers, 2016.
[2] Line Post Sensor, Patent Grant number: 11125782, Date of Patent: Sep 21, 2021
[3] ABB Inc. Combined Line Post Sensors: Retrieved from:
https://library.e.abb.com/public/ed43b60e43be4145934a7556ef35e002/1VAP500007-DB_VCS-110_Rev%20H.pdf
[4] ABB Inc. Instrument Transformers: Technical Information and Application Guide. Retrieved from:
https://library.e.abb.com/public/e2462bd7f816437ac1256f9a007629cf/ITTechInfoAppGuide.pdf

Figures used in the abstract

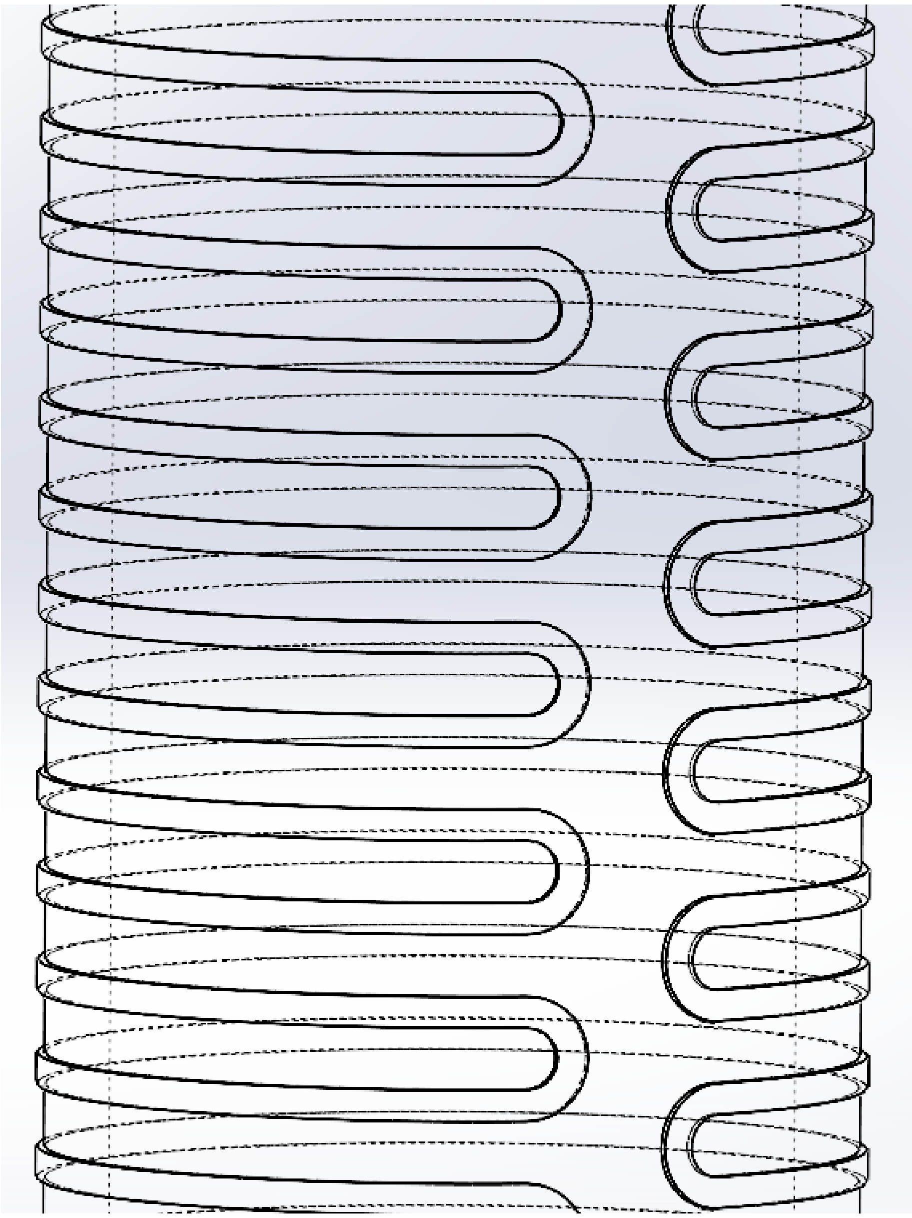

Figure 1

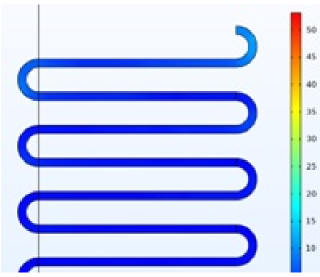

Figure 2

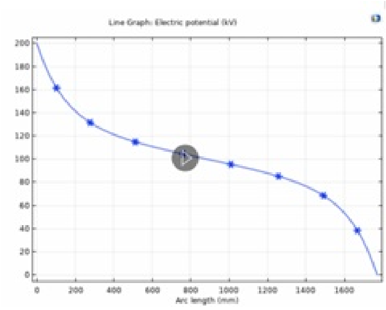

Figure 3

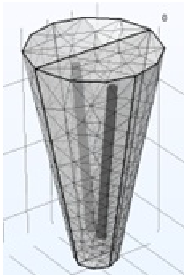

Figure 4