R410A Gas Insulated Distribution Transformer Design

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Abstract

In the design, manufacture, assembly and installation of transformers some of the important requirements are; protection of the environment, operational safety, minimizing maintenance requirements and the risk of fire. Oil insulated transformers have some limitations such as; low ignition value, additional insulation costs, requirement for an extinguishing apparatus, long clearance distance, toxic and expensive soil spill cleanup costs. Explosion is another danger for oil-insulated transformers. This is especially important for small-size transformers because they can be located very near to loads. There are many examples of underground and public substations for economic and environmental reasons in large cities where safety is of high concern. One of the most important factors in the transmission and distribution of electrical energy is, of course, cost. High voltage should be used where appropriate to minimize losses. However, as the voltage level increases, insulating problems occur. Distribution transformers are located near to the end-users to the greatest extent possible. Supplying electrical power to strategic buildings and large machines power or distribution transformers are usually manufactured oil or dry types. Dry type transformers have limited power ratings of 10 kVA-50 MVA due to inefficient cooling. In contrast, oil-type transformers are manufactured in a wide power range and have a very wide application area [1-3].
Therefore, the proposed R410A gas-insulated transformer project is deemed to be a more reliable solution for today's distribution network [6-11]. For this reason, R410A gas is investigated as an insulating material instead of transformer oil in this paper. This paper proposes an R410A gas-insulated transformer (GIT) design on complex distribution transformer models and investigates the optimal gas pressure to maximize the insulation level and breakdown voltage limits for a given distribution transformer model. A 50kVA indoor/outdoor distribution transformer is investigated. The breakdown voltage characteristics of the models are then compared to original models, i.e., oil-insulated 50kVA, which are widely used in distribution systems. The proposed transformers are quite light and environmentally friendly compared to oil and epoxy casting resin types. Consequently, the use of R410A gas as a dielectric insulating material will bring about many advantages, such as optimum design and reduction of maintenance costs. Thus, it will allow the efficient use of our country's own resources and increase competitiveness.
In the proposed study, the required design criteria of R410A gas insulated transformers will be achieved with the aim of meeting today's energy needs in an economical way. The most important step of this project is to obtain tank pressure, heat effects and breakdown curves at homogeneous and inhomogeneous electric fields on complex 3-D transformer models. COMSOL Multiphysics® is used for computer simulations. Five different materials are used to model R410A GIT in simulation environment. These are wood with εr 3, copper, filled epoxy resin with εr 3.6, soft iron and R410A with εr 2.0. In electric field calculations, the norm of the electric fields 〖Ed〗_x,〖Ed〗_(y,)〖Ed〗_z is used in (1).

Figures used in the abstract

Figure 1 : Figure 1 : Figure 1. 50 kVA, 34.5/0.4 kV R410A gas-insulated distribution transformer, a) general view, b) meshed view

Figure 2 : Figure 3 : Figure 2. R410A GIT of 50kVA for major details

Figure 3 : Figure 2 : Figure 7. Surface graph of peak electric potentials during lightning impulse

Figure 4 : Figure4 : Figure 8. Temperature distribution (hotpoints) inside the tank. (a)2D and (b) 2D axial symmetry analysis