

NEW IMPACTS ON ECOLOGICAL TRANSFORMER DESIGN

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Reduction of environmental hazards by using natural ester

Until now, worldwide most of the transformers are filled with mineral oil. Mineral oil combined with cellulose is a reliable insulation system that has been used as the “classic insulation system” for nearly one hundred years. However, because of the low fire point of mineral oil it comes from time to time to fire accidents, which objectively can be tracked back to this circumstance. As a result of transformer fire, as the past shows, for example thousands of people cannot be supplied with electrical energy (like Los Angeles 2016, Norwich 2017, Yuzhnoukrainsk 2015) or even people are injured or killed (like Perth 2015, Istanbul 2015, Kinnaur 2015, Dhaka 2014). The statistics show that on one thousand of transformers per year of use, approximately one transformer fire happens. For specific applications, some of the liquid filled transformers have alternative insulation fluids like esters or silicone oil inside. Above all natural esters are eco-friendly as they stem from vegetable oil, are biodegradable, have a very low CO₂ footprint and due to the high flash- and fire point they are much safer compared to mineral oil. Because of the high fire point, natural esters are K-class fluids and therefore national and international standards allow reduced distances between transformers as well as to the surroundings. Compared to mineral oil, approximately 4.4 times more energy is needed to bring – for example a soya bean based insulating fluid – to its fire point. Until now, no transformer blast or transformer fire has been reported, at transformers filled with natural ester fluids - for example Envirotemp FR3, a soya bean based natural ester. In addition to the advantages regarding fire point, natural ester liquids are completely biological degradable.

Interaction between natural ester and transformer materials

Transformer failure is mainly caused by the loss of the mechanical strength of the liquid impregnated paper. Literature studies show that natural ester fluids are less harmful to the cellulose. On the one hand this is due to their chemical and physical structures which enable them to bind and absorb much more water than mineral oil. If the cellulose is kept dry, the degradation process will not start so early. On the other hand, there is a significant difference between the produced acids when the liquids age. Mineral oil produces short chain acids like formic and acetic acid and natural esters produce long chain acids which can hardly be dissociated and therefore they are harmless to the cellulose. That means that degradation of mineral oil also causes ageing of the cellulose.

Case study

For all these reasons, Energienetze Steiermark GmbH has started an investigation programme by verifying the main differences between mineral oil and the natural ester Envirotemp FR3. Researches have been carried out by TÜV Austria and a small distribution transformer filled with Envirotemp FR3 was put in operation in May 2017. If natural esters are used as an insulating liquid, it is important to take care that the air-liquid contact is reduced to a minimum. Therefore an open breathing system should not be used for transformers filled with natural ester fluids. Because of the higher viscosity of natural esters, they tend to thicken at temperatures below minus 25 °C for a long period (several days). In this case, the cooling can be affected but the dielectric behaviour remains good. Due to the mentioned advantages, in future transformers can be designed smaller having the same capacity, well knowing that an according adaption of standardization is necessary. Another idea is that existing transformers can be upgraded to provide overload capability.

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