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Effect of Different Contaminants on Mineral Insulating Oil Characteristics

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Abstract : Deterioration of insulating oil is a natural process that occurs during transformers operation. However, this process can be accelerated by some factors, such as oxygen, high temperatures, metals and, moisture, which rapidly reduce oil insulating capacity and favor transformer faults. Parts of building materials of a transformer can be degraded and yield soluble compounds and insoluble particles that shorten the equipment life. Physicochemical tests, dissolved gas analysis (including propane, propylene and, butane), volatile and furanic compounds determination, besides quantitative and morphological analyses of particulate are proposed in this study in order to correlate transformers building materials degradation with insulating oil characteristics. The present investigation involves tests of medium temperature overheating simulation by means of an electric resistance wrapped with the following materials immersed in mineral insulating oil: test I) copper, tin, lead and, paper (heated at 350-400 °C for 8 h); test II) only copper (at 250 °C for 11 h); and test III) only paper (at 250 °C for 8 h and at 350 °C for 8 h). A different experiment is the simulation of electric arc involving copper, using an electric welding machine at two distinct energy sets (low and high). Analysis results showed that dielectric loss was higher in the sample of test I, higher neutralization index and higher values of hydrogen and hydrocarbons, including propane and butane, were also observed. Test III oil presented higher particle count, in addition, ferrographic analysis revealed contamination with fibers and carbonized paper. However, these particles had little influence on the oil physicochemical parameters (dielectric loss and neutralization index) and on the gas production, which was very low. Test II oil showed high levels of methane, ethane, and propylene, indicating the effect of metal on oil degradation. CO₂ and CO gases were formed in the highest concentration in test III, as expected. Regarding volatile compounds, in test I acetone, benzene and toluene were detected, which are oil oxidation products. Regarding test III, methanol was identified due to cellulose degradation, as expected. Electric arc simulation test showed the highest oil oxidation in presence of copper and at high temperature, since these samples had huge concentration of hydrogen, ethylene, and acetylene. Particle count was also very high, showing the highest release of copper in such conditions. When comparing high and low energy, the first presented more hydrogen, ethylene, and acetylene. This sample had more similar results to test I, pointing out that the generation of different particles can be the cause for faults such as electric arc. Ferrography showed more evident copper and exfoliation particles than in other samples. Therefore, in this study, by using different combined analytical techniques, it was possible to correlate insulating oil characteristics with possible contaminants, which can lead to transformers failure.

Keywords : Ferrography, gas analysis, insulating mineral oil, particle contamination, transformer failures
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