BREAKDOWN OF COMPOSITE ESTER–POLYMER INSULATION UNDER LIGHTNING IMPULSE STRESS

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Ester fluids have emerged as a viable alternative to naphthenic transformer oil; resulting in significant research into the dielectric behaviours of these fluids. Focus has predominately been on bulk breakdown of insulating liquids stressed with standard 1.2/50μs Lightning Impulses and power frequency AC voltage.

Bulk breakdown voltage however does not fully represent the practical scenario; rather part of it. This research work has modelled a more representative scenario which places the dielectric fluid in direct contact with solid polymer dielectric material. Composite insulating systems formed with the chosen insulating liquids (Midel 7131 synthetic ester, Envirotemp FR3 natural ester and Shell Diala S4 ZX transformer oil) and solid dielectrics (Nylon 6,6 and PMMA) have been stressed with standard lightning impulses of both positive and negative polarity. Experimental breakdown data has yielded information on both the level of voltage required to cause complete breakdown of the system while also providing an indication of the type of breakdown to be experienced for a given liquid-solid combination, i.e. interfacial breakdown across liquid-solid interface or bulk breakdown through solid dielectric. Under positive impulse solid dielectric samples immersed in transformer oil clearly favoured bulk breakdown with this occurring in all tests. Interfaces formed using ester fluids showed a tendency of interfacial breakdown; occurring in all synthetic ester samples and 80% of those which utilised natural ester. Thus demonstrating that under positive stress interfaces between transformer oil and the chosen polymers offer higher breakdown voltage but at the cost of increased likelihood of destruction of the polymer as compared with the equivalent ester-polymer interface. When the impulse is negative bulk breakdown of the Nylon polymer is observed in 80% of test samples irrespective of liquid used; although breakdown is observed to occur at a lower voltage level than bulk breakdown of PMMA (observed in 6% of tests involving this polymer). It can be said that irrespective of impulse polarity PMMA-liquid interfaces favour interfacial flashover at lower voltage levels, however with significantly lower probability of destruction of the polymer. This work has shown that polarity of impulse has great effect on the type of breakdown experienced by the nylon polymer but almost none on that of the PMMA; Providing useful information to designers of power and pulsed power apparatus.

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