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EXPERIMENTAL AND NUMERICAL STUDIES OF LARGE STEEL PLATES SUBJECTED TO HIGH PRESSURE LOADING

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Low impedance faults occurring in power transformers produce electrical arcs that vaporize surrounding oil, leading in some cases to rapid increases of pressure inside. To investigate the behaviour of large steel plates that make up a transformer tank, an experimental setup was built to pressurize at small strain rates models of such plates until failure. The experimental results are reported and compared with non linear implicit finite element simulations.

Material properties as well as the true stress-true strain curve were obtained from standard uni-axial tensile tests, as input to the numerical modeling. Fillet radiuses were machined on the flange to obtain larger mid-point deflection [1]. In the experiments performed, the loading is achieved by filling the tank with pressurized water or air until failure. Strain gages were installed on the top and bottom of the tested plates to monitor their deformation. The selected gages enabled strain measurement in the post-yield range of value higher than 10%. A laser scanning device was used to quantify the displacement at the plate centre. Five plates were tested with consistent results. The maximum deflection occurring at the centre was 165 mm which translated to a deflection-thickness ratio of 35.

Nonlinear static simulations were carried on with the Ansys/Mechanical® finite element software. The model includes the upper and lower flanges interacting with test specimens through frictional contact elements in order to alleviate the stress singularities occurring at the boundary [2]. A convergence-divergence study was performed by successively reducing the element size by a factor of two from 16 to 0.5 mm for the plate's meshing to obtain a convergence of the Von Mises stress [3][4].

The model showed excellent agreement between the computed maximum plate deflection and the measured results, and predicted failure of the plates with an average error of 11%. Good correlation with the strain gauge measurements was observed in areas where membrane strain dominates. Comparison of the computed strain near the clamping plates where bending strain dominates is less satisfactory, owing to the high strain gradient area where the gages inherently underestimated the peak strain.

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