Experimental and numerical analyses of progressive damage in non-circular metal/composite hybrid vessels under internal pressure

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Abstract

In this paper, the damage behavior of non-circular metal/composite hybrid vessels subjected to internal pressure was investigated. The effect of the fiber orientation on the failure mechanism of the filament wound structures was also studied. Thin-walled steel square section vessels wrapped by glass fiber-reinforced polymer (GFRP) with different fiber orientations were tested under hydrostatic pressure. A progressive damage model was employed using the finite element analysis (FEA). Hashin's damage initiation criteria and energy based damage evolution were applied for GFRP. From the obtained results, two different failure modes were detected for the steel/GFRP hybrid specimens: composite failure as the dominant failure mode and metal liner failure. It was observed that the extension and the shape of the damaged zone were strongly influenced by the lay-up configuration of the composite layer. To show the effectiveness of the reinforcement on failure pressure, damage in an all-metal vessel as the benchmark was compared with damage in the hybrid structures and the improvement in the failure pressure was observed. The numerical results were found to be in good agreement with the experimental data.