Title: Finite Element Analysis of High-Pressure Compressed Air Energy Storage Tank

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Abstract:

A Compressed Air Energy Storage System (CAES) is a battery system in which energy is stored in the form of compressed air under high pressure. CAES has advantages over traditional pumped storage of a smaller footprint, lower system losses, and the ability to be used as distributed versus grid storage. The hybrid air/water-CAES in this research project is a 198 in. steel cylindrical tank with 39 smaller steel 17-inch cylindrical compartments inside. The space between the steel cylinders is filled with Ultra-High-Performance Concrete (UHPC) to help carry the load, provide a thermal sink for the compressible air and act as a safety barrier. Modeling the tank in AutoCAD, ANSYS Workbench is used to complete a finite element analysis under an internal pressure of 3,000 psi. A symmetric quarter cross-section model with half height is modeled with boundary conditions on the planes of symmetry. A neoprene material is used as a numerical technique to decouple the steel/concrete materials. To verify the stress convergence, the model is analyzed with different mesh sizes for the UHPC. The mesh sizes in the neoprene rubber and steel are 1 in. and 2 in., respectively. For the UHPC, mesh sizes of 2 in., 2.5 in., 3 in., 3.5 in., 4 in., and 4.5 in. are used in six different models. The UHPC tensile stresses did not change significantly with the size of the mesh. Finally, the full model is analyzed with the 4.5 in. mesh size for the UHPC. The results from the full model show that the tensile stress in UHPC is maximum at the midsection and gradually decreases towards the ends of the vessel. Using a factor of safety of 2.5, as recommended by the ASME Boiler & Pressure Vessel Code, the stresses in the steel and UHPC remain within the corresponding allowable values.

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