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PROCEEDINGS

An Advanced Design Optimization and Modeling Method of Type IV Composite Hydrogen Cylinder with Experimental Validations

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ABSTRACT

Composite hydrogen cylinders are recognized as the most efficient solution for storage and transportation of high-pressure gaseous hydrogen. The plastic-lined and fully carbon fiber-wound Type IV composite cylinders are one of the most attractive advanced hydrogen storage technologies. The design of carbon fiber reinforcements on the dome section of the cylinder is one of the critical challenges in the development of Type IV composite hydrogen cylinders. Conventional design approaches ignored the variable angle of fiber-wound layers and the influence of fiber angle and thickness variations in the dome section on design and often result in either safety risks or excessive material usage due to inefficient design. This study introduces a rapid design method of carbon fiber reinforcement based on "weakness strength points" on the dome section. The load distribution in the dome section is considered in terms of the variations both in winding angles and the thickness. The winding layers and variable polar radii of the dome are optimized by the response surface methodology, with the goal of the minimum lightweight of carbon fiber reinforcement. This advanced design and optimization method can enhance the mechanical performance of the composite hydrogen cylinder and at the same time reduce weight and material usage. The optimization results are validated through a hybrid approach of experimental testing and finite element analysis (FEA). The results indicate that the 60 MPa cylinders designed using the variable polar radius winding method achieved burst pressure of 59.50 MPa with the FEA method and 58.00 MPa with the experiment. The failure area is located at the midsection of the cylinder as designed by the advanced design and optimization method.

KEYWORDS

Type IV cylinder; design optimization; response surface methodology (RSM); finite element analysis

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