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INTERNALLY FASTENED MANHOLE COVER FOR LIGHTWEIGHT COMPOSITE PROPELLANT TANKS

Abstract

Composite propellant tanks for space applications can be categorized based on their opening shape into boss-type tanks with narrow mouths and manhole-type tanks with openable covers. The former is advantageous for high-pressure operations and compact designs, while the latter is preferred when internal components such as baffles, Propellant Management Devices, propellant level sensors, or anti-vortex devices must be installed. This study focuses on cases where internal access is essential, and explores methods to enhance the weight efficiency of manhole covers. Conventional manhole covers in composite tanks are secured with external fastening threads on a thick flange connected to the tank body. This design poses no issue when the tank is significantly larger than the manhole cover. However, when the manhole size is relatively large compared to the tank diameter or when the operating pressure is low, the required flange thickness leads to substantial weight increases. The necessity of maintaining sufficient thread engagement further exacerbates this issue, making conventional designs inefficient for lightweight applications. The reduction in operating pressure results in a thinner tank shell, making the addition of a thick connecting flange even less desirable in terms of mass efficiency. Furthermore, as mission requirements continue to push for mass optimization, a more efficient fastening method is needed to maintain structural integrity without unnecessary weight penalties. To address this, we developed an alternative fastening method where the cover is secured internally. Bolts are inserted through an overlapping section between the tank body and the cover, with female threads formed directly in the cover's parent material. This approach relocates the fastening structure from the tank body to the cover, reducing manufacturing costs, and improving weight efficiency. Additionally, since the tank body remains largely unmodified, this method enhances structural integrity by minimizing stress concentrations in critical load-bearing areas. The refined design also reduces potential weak points introduced by external flanges, thereby improving the overall durability and longevity of the tank structure. A prototype composite tank featuring this innovative cover design was fabricated and successfully passed a room-temperature hydraulic pressure test, demonstrating its structural robustness. The results indicate that this design can effectively reduce the dry weight of composite propellant tanks while maintaining mechanical integrity. Future work will focus on evaluating its performance under operational conditions, including cryogenic environments and thermal cycling, to verify its suitability for space applications.