

Processing Studies and Challenges Faced in Development of High-Pressure Titanium Alloy Cryogenic Gas Bottles

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Abstract : Frequently, the upper stage of high-performance launch vehicles utilizes cryogenic tank-submerged pressurization gas bottles with high volume-to-weight efficiency to achieve a direct gain in the satellite payload. Titanium alloys, owing to their high specific strength coupled with excellent compatibility with various fluids, are the materials of choice for these applications. Amongst the Titanium alloys, there are two alloys suitable for cryogenic applications, namely Ti6Al4V-ELI and Ti5Al2.5Sn-ELI. The two-phase alpha-beta alloy Ti6Al4V-ELI is usable up to LOX temperature of 90K, while the single-phase alpha alloy Ti5Al2.5Sn-ELI can be used down to LHe temperature of 4 K. The high-pressure gas bottles submerged in the LH2 (20K) can store more amount of gas in as compared to those submerged in LOX (90K) bottles the same volume. Thus, the use of these alpha alloy gas bottles stored at 20K gives a distinct advantage with respect to the need for a lesser number of gas bottles to store the same amount of high-pressure gas, which in turn leads to a one-to-one advantage in the payload in the satellite. The cost advantage to the tune of 15000\$/ kg of weight is saved in the upper stages, and, thereby, the satellite payload gain is expected by this change. However, the processing of alpha Ti5Al2.5Sn-ELI alloy gas bottles poses challenges due to the lower forgeability of the alloy and mode of qualification for the critical severe application environment. The present paper describes the processing and challenges/ solutions during the development of these advanced gas bottles for LH2 (20K) applications.

Keywords : titanium alloys, cryogenic gas bottles, alpha titanium alloy, alpha-beta titanium alloy

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