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A DISTRIBUTED STRAIN SURVEILLANCE SYSTEM FOR CRYOGENIC TANK

Abstract

It is very significant to develop an on-board real-time strain surveillance system for cryogenic tank. In the present research, the real-time strain measurement for a cryogenic propellant aluminum alloy tank, was attempted. Adhesive property of the optical Bragg grating fiber (FBG) was investigated first of all. It was found the reflected spectrum of coated FBG was easy to be chirped and that of bared FBG was normal, which implied the cause was cryogenic thermal stress. The hypothesis was verified by the numerical analyses of FBG reflected spectrum under non-homogeneous strain. As a result, polymer substrate boned FBG sensors and polyurethane adhesive were adopted, which could reduce FBG chirping greatly at cryogenic temperature. Secondly, as we know, the latitude strain was twice as the longitude strain for a cylinder propellant tank under inner press, as a result, the reflected spectrum of FBG may be overlapped, which cause improper strain measurement and wrong measure position identification. This problem was solved by selecting appropriate FBG with character spectrum matching for strain field, namely, the optical fiber used to measure longitude strain were fitted with Bragg gratings having similar character spectrum and for the latitude strain was another optical fiber with different Bragg gratings. After the two problems were solved and verified by cryogenic sample test, the FBG net were bonded on the tank, and some Bragg gratings were treated as temperature sensors for the separation of strain effects from temperature influences. By contrasting FBG results with traditional strain gauges, the strain surveillance system were verified to work correctly, which could be used as part of on-board structure health monitor in future.