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GROUND THERMAL RADIATION VACUUM TESTS AND THERMAL-STRUCTURAL ANALYSIS FOR THIN-WALLED CFRP LENTICULAR CROSS-SECTION SPACE BOOM

Abstract

Due to lightweight, high package ratio and high reliability of deployment, thin-walled CFRP space booms have been extensively used as back-borne system of large space structures, such as solar sail, reflect-array, space probe, as is one of the most active field. Space boom features complex nonlinear thermal-structural coupling behavior from cycling cold-heat environment on-orbit, as depends mostly on the CFRP composite fraction and ply layout. This paper is motivated to investigate thermal performance of the developed CFRP composite and the thin-wall lenticular tube, verify the analysis procedure and provide experiences for advanced material and space boom development. Firstly, the unidirectional T300 intermediate modulus PAN based on carbon fiber pre-impregnated with epoxy resin 5258 was selected for CFRP composite material manufacture. Fiber volume fraction is measured 56.2Secondly, ground heat radiation test was carried out for a space boom which size is 104014170mm, the ply is 0.05mm thick and the ply layout is [+45/-45/0/-45/+45/0]2s.Test condition is specified as vacuum 10-5, high temperature 130C, low temperature -80C, keep-time 30minute at high and low temperature respectively. There are 28 temperature measure devices and 27 strain gauges, which set symmetrically with respect to long direction. The field temperature recording frequency was 0.1hz, and strains were recorded each five minute. Fruitful experimental results were obtained and analyzed comprehensively. Significant thermal gradient was found in cross-section and composite thickness, and nearly 1Thirdly, on the basis of the composite and space boom tests, series numerical simulations were performed through IDEAS and ANSYS package from the thermal-mechanics theory and composite mechanics. The comparison between numerical analysis and test was investigated thoroughly, as verify the correctness of numerical simulation procedure to much extent. Fourthly, the thermal-structural coupling behavior was evaluated for a pace boom on GEO condition, and the thermal-induced vibration was investigated particularly. The results indicated that the space boom vibration can not be triggered from sun-pointing to dark and reverse condition. The work is herein valuable to the advanced composite development and advanced space boom development, as well as thermal test procedure and thermal-structural coupling analysis.