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Author: Mr. YUTA KUSANO
Tokai University, Japan, 3bmjm008@mail.tokai-u.jp

EXPERIMENTAL AND NUMERICAL STUDY OF STRUCTURAL STABILITIES OF FLARE-TYPE MEMBRANE AEROSHELL WITH INFLATABLE RING

Abstract

In order to support various future activities using spacecrafts, we need to develop a re-entry system which is useful, safe and low-cost. We have studied the structural strength of an inflatable aeroshell, which is a novel re-entry system currently under development within JAXA. The inflatable aeroshell dealt with in this paper will be reliable and low-cost space transportation system which is different from either a capsule type or a wing type. The inflatable aeroshell is composed of three parts. When the inflatable aeroshell re-entries into the Earth, an inflatable torus and thin membrane flare are expanded from a capsule and then the inflatable aeroshell is decelerated since it receives large aerodynamic forces because the cross section area of the system is significantly enlarged. Our system's merits are that the inflatable aeroshell is easily enlarged and the weight of the system is lighter compared to other systems as proposed by NASA or ESA because whole inflatable aeroshell flare is made of only thin membrane and required inflatable structure is minimized. In this system, in contrast to those proposed by NASA or ESA, the main structure component to resist to the aerodynamic forces is the inflatable torus alone; the strength of thin membrane flare part is not expected to have enough strength. Thus, the total structural strength of the system is dominated by the inflatable torus alone. In view of this structural characteristics, we carried out the numerical and experimental investigations of the structural strength of the inflatable aeroshell. First, we carried out a series of low-speed wind tunnel tests in order to investigate the structural strength of a variety types of inflatable aeroshell models. The test section of low-speed wind tunnel is 6.5m x 5.5m and the maximum velocity is 70 m/s. Second, we created finite element models for structural analysis of the inflatable aeroshell and calculated the structural strength of the inflatable aeroshell using nonlinear finite element methods with an in-house numerical code. The analysis utilized the nine-node biquadratic quadrilateral element to improve the analysis precision. The results are in good agreement with each other and will benefit efficient structural design of the aeroshell in a future development.