Design and Analysis of Baffled Inflatable Wing

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ABSTRACT

A global Toyota research team is investigating the feasibility of a tethered wing flying at high altitude in jet stream wind. Such wing called 'mother ship' can be used to generate renewable energy, help communication and provide steady meteorology data. One of the approaches to design such wing is to use inflatable baffled structure for the structural component. Such structure is considered due to its lightweight, flexibility under heavy gust and ability to fold into smaller volume. There are many challenges associated with the development of such inflatable structures, i.e. wing fabrication using lightweight textile composites, aerodynamic design of the wing with tether attachment, the inflated wing geometry, and the structural rigidity. In this paper, we will present a design and analysis workflow for such inflatable baffled wing. Computer-aided design, wing fabrication, static loading analysis will be discussed in detail. Finite element (FE) method to simulate inflation process and subsequent bending and torsion under wind load is developed to help design and optimization of the wing structure. Also, physical parts are built and corresponding physical processes, such as 3D scan of the inflated wing surface and the bending and torsion tests, are performed to validate the FE simulation.

REFERENCES

[1] E. e. a. Haug, "The numerical simulation of the inflation process of space rigidized antenna structures.," Spacecraft Structures and Mechanical Testing, vol. 2, pp. 861-869, 1991.

[2] E. Itakura, " Save from Future Japan Social Crises! "Mothership" Project," in Airborne Wind Energy Conference, Glasgow, 2019

[3] Song, Yuyang, Umesh Gandhi, and Azwan Aris. "A Baffled Inflatable Wing made from High Performance Textile Materials: Design, Analysis, and Experiments." *AIAA Scitech 2021 Forum*. 2021.).

[4] Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)," ASTM, 2019.

[5] Standard Test Method for In-Plane Shear Properties of Sandwich Panels Using a Picture Frame Fixture," ASTM, 2019

[6] J. Wang, "A new CAL3D Airbag Inflation Model," in SAE, Detroit, 1988.