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Thermal performance of stratospheric airship with photovoltaic array

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Abstract

The increase of airship applications makes it necessary for a comprehensive understanding of the thermal performance of stratospheric airships. A numerical model was proposed to simulate the thermal performance of a stratospheric airship with photovoltaic array, an analysis code was developed based on the thermal model and was verified by experimental data. A further inspection into the temperature field and flow field distribution of the airship was analyzed in detail. The simulation results suggest that solar radiation can exert great influence on the thermal performance of the airship. The higher temperature Helium was gathered in the upper part inside of the airship, the flow of Helium was regular at nighttime but was chaotic in the middle and upper part of the airship at daytime. The temperature and velocity performance of fin was different from that of the hull and other fins due to the shadow of hull and other fins.

Keywords: Stratospheric airship; Thermal performance; Photovoltaic array; Numerical analysis

1. Introduction

Stratospheric airship has wide applications in the fields of communication and observation in stratosphere space **(Colozza. A, 2003)**. Solar power is regarded as an ideal power sources for stratospheric airship, and the photovoltaic (PV) array is a practical means to convert solar energy into electricity **(Choi S H, 2006)**. The thermal performance of the airship may exert great influence on the efficient of the PV array and the mechanics strength of the airship envelope, and affect the buoyancy force of the airship. Therefore, a comprehensive and precise understanding of the temperature and flow field distribution of the airship with PV array is of vital importance for the designer and operator, which is helpful in achieving a better design and flight strategy planning.

Many investigations have been conducted on the thermal performance modeling and simulation for stratospheric airship. **Kreith and Kreider (1974**) established a simple but excellent numerical model to simulate the average temperature of balloon envelope and lifting gas, which was marked as the starting point of the subsequent research. **Stefan (1983)** studied the thermal behavior of a stratospheric airship by dividing it into a top half and a bottom half, and obtained the average temperature of these two parts. **Louchev (1992)** developed a steady-state thermal model for a hot air balloon to calculate the envelope temperature field and the average temperature of the lifting gas in different conditions. **Kenya et al. (2003)** conducted a ground thermal experiment for a 35 meter-long airship with PV array, and use the data to perfect their thermal analysis model. **Franco and Cathey (2004)** proposed a thermal performance model for NASA's scientific balloons to investigate the temperature distribution of balloon film at floating conditions without considering the convective heat transfer effect. **Farley (2005)** constructed a thermal and dynamic model for a high altitude balloon and predicted its ascent trajectory in both vertical and horizontal directions. **Xia et al. (2010)** established a transient numerical model to calculate the

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