**Objective**

Develop the conceptual design of a neutrally buoyant hybrid vehicle (i.e., aerobot) that employs propulsion and aerodynamic lift to increase its horizontal and vertical mobility.

**Vehicle Conceptualization**

We chose the geometry of the Stingray inflatable aircraft by Prospective Concepts [11] for our design as it is both aerodynamic and voluminous. Based on published photos, we were able to determine the approximate geometry. The relative thickness of the airfoil is 23%. We also explored several ideas for the internal structure, which will be based on the tensile strength concept (inflatable beams) [4] for the larger structural members. The ribs will be made from fabric or film.

We decided to use the same skin material as Hall et al. [5] for our vehicle. This bi-lamine film consists of a 0.025 mm thick fluorinated ethylene propylene (FEP) outer layer that is bonded to a 0.025 mm thick polyimide (Kapton) inner layer. The FEP layer is metalized on the back with silver to reduce the absorption and then Inconel to provide oxidation resistance.

A model for the film and gas temperature of the aerobot was developed, based on the work by L. A. Carlson and W. J. Horn [6]. An analysis was carried out for a constant amount of buoyant helium gas. The cruise velocity was assumed to be zero. The buoyant gas temperature increases, and the vehicle climbs up higher in the atmosphere. As a result, the outside temperature as well as pressure and density drop.

**Aerodynamic Analysis**

An aerodynamic analysis employing both xflr5 and VSPAERO [8] software was carried out. The Reynolds’ number was set at Re = 2.9 × 10^6. Both xflr5 and VSPAERO predict a zero-lift angle of attack of α = 0 deg. Also, VSPAERO predicts a negative moment coefficient slope, which is required for pitch stability of tail-less aircraft.

For straight and level flight at constant altitude it was found that a cruise at 30 m/s requires a power of 35.2 kW and can be sustained for around 32.6 min. The power consumption for lower airspeeds is less, thus allowing for longer flight times. If all stored energy is consumed over 10 min, the vehicle can sustain a maximum airspeed of 41.2 m/s in straight and level flight at an altitude of 64.5 km. Lower battery discharge rates increase the flight time but reduce the ceiling and maximum airspeed.

**Conclusions**

As a compromise between a balloon and an airplane, a buoyant flying wing (aerobot) is proposed for the exploration of the upper Venus atmosphere. The vehicle shape was based on the Stingray inflatable flying wing by Prospective Concepts. A sizing analysis revealed that a wingspan of 25 m provides a good compromise between size and buoyancy force. A model for the vehicle altitude, gas temperature, and skin temperature revealed that the aircraft will climb and descend during each orbit due to changes in temperature of the buoyant gas. An aerodynamic analysis was performed to obtain the lift, drag, and moment coefficient distributions. The moment coefficient slope was found to be negative, which is a requirement for tailless flying wings. A power-off-flight analysis indicated that an airspeed of 30 m/s can be sustained for about 40 min. The ceiling is about 9.5 km above the neutrally buoyant altitude.

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