A POSSIBLE WAY TO IMPROVE THE PERFORMANCE OF ELECTRO AERODYNAMICS AIRCRAFTS.

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Introduction

Electro aerodynamics has been a subject of interest for engineers and physicists for a long time. As a solid-state propulsion, electro aerodynamic (EAD) is a growing research area for small and lightweight aircraft. Recently, MIT engineers built and flew a plane with no propellers, turbine blades or fans. Instead of these moving parts, the plane is powered by ionic wind that generates thrust to propel the aircraft. Such new technology can be revolutionary in the field of military engineering, as aircraft using it are silent, unlike today's drones.

Unfortunately, for now, the MIT team directed by associate professor of aeronautics and astronautics Steve Barret achieved a steady level flight of 55 meters of distance and 12 seconds. This paper suggests a new way to improve the performance of electro-aerodynamic aircraft.

Background and Possible Solutions

An ionic wind is an electric current between a thick and thin electrode. If the voltage between the electrodes is large, enough energy can be produced to propel an aircraft with a specific mass. The thrust of the ion wind flows in the opposite direction of the ion flow. Electro aerodynamics is the mean of propulsive sources generation. MIT engineers used the corona discharge method to generate ions. It is known as the most common method of ion generation. The Corona discharge method is achieved by positioning two high-voltage electrodes asymmetrically. As demonstrated by Barret's team testing, their aircraft suffered from high drag in gliding, mostly due to the electrode configuration.

To improve the performance of such aircraft, most researchers have focused on the electrode type material, size and location. Other efforts were put into maximizing the limitations of low thrust to the area and to power ratios, which are both considered the major limitations of electro aerodynamics propulsion. However, one of the possible solutions can be the dependency on the dielectric-barrier-discharge (DBD) method in ion generation instead of corona discharge which is more effective by using a decoupled ion source. DBD can provide a better thrust-to-area and power ratio [3]. Also, to solve the high drag while gliding, the electrodes should have a better-integrated structure. A better approach can be implementing a retractable electrode system in the aircraft. Such systems can allow the electrodes to change positions at specific times during the flight. Different stages of electrode deployment can be designed in such a system. Raspberry Pi can control the deployment level of electrodes. This approach could better manage power usage and help in the increase of flights' range. Thus, better results can be obtained to improve this new technology.

Theory

From Gauss's law we have the following equation for electrostatic behavior:

$$\frac{dE}{dx} = -\frac{d^2V}{dx} = \frac{\rho}{\varepsilon}$$

where E is the electric field strength, V is the electric potential, ρ is the density, x is the distance, and ε is the permittivity of free space. Christenson and Moller substituted the above equation with density's and Euler's equation and derived them to acquire the following equation :[2]

$$\frac{T}{P} = \frac{1}{\mu E(1 + \varphi)}$$

where μ is the ion mobility of the fluid, and ϕ is the non-dimensional fluid performance parameter related to the fluid dielectric constant, ion mobility, and fluid density. This proves lower thrust to power for higher electric field strengths. With the increase of the distance between electrodes, electric field strengths also increase [1]. Based on this, the proper ratio to mass should be found.

For thrust to area, Barrett and Gilmore got to the following equation: [4]

$$\frac{T}{A} = \frac{9}{8} = \varepsilon\lambda E^2$$

where A is the electrode area, and λ is the current density ratio. This proves the counteracting nature between thrust to area, which should be taken into consideration when determining the parameters of the EAD aircraft.

Conclusion

In this paper, a few ways to improve electro aerodynamics flights were suggested. Michael Alexander Fredricks, a student from the University of Arkansas, in Fayetteville, performed experiments using a prototype aircraft and retractable electrode system. However, he didn't obtain the expected results due to several factors. More experiments should be performed based on these suggestions with proper management.

References:

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