OTAGO POLYTECHNIC
Te Kura Matatini ki Otago

ELECTROHYDRODYNAMICS:

CAN ELECTRICITY IMPROVE AIRCRAFT FUEL EFFICIENCY?

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ABSTRACT

- Electrohydrodynamics (EHD) relates to the process of creating wind using electrically charged air molecules.
- In this project, I tested whether EHD could be applied to the surface of airfoil models to improve aerodynamic performance.
- Across a series of tests, lift and drag forces were recorded in order to determine whether EHD offered any performance benefit.

METHODOLOGY

- Airfoil profiles and a support mast were designed in Solidworks, cut using a CNC mill, and covered in fibreglass to provide strength.
- Using a 40kV D.C. power supply, electrodes were placed on the surface of each airfoil in order to induce artificial wind flow.
- Individual lift and drag platforms were designed and fitted to the wind tunnel. Bearings were used to limit friction.
- Load cells were used to measure both lift and drag forces. The raw readings were smoothed using an Arduino circuit and outputted on an LCD screen.

AVIATION FUEL CONSUMPTION

- The transport sector accounts for 29% of global energy usage and 68% of all oil consumption (IEA, *Data & Statistics*).
- Jet kerosene accounts for 8% of all oil production, and the aviation industry spent $188 Billion USD on fuel in 2019 (IATA, 2020).
- 1740 new aircrafts were introduced in 2018 which improved fuel efficiency across the aviation industry by 2.4% (CAPA, 2018).

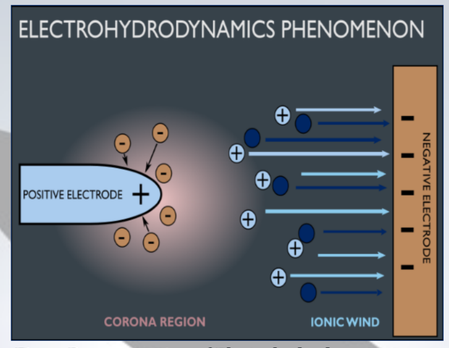

Fig. 1. Demonstration of Electrohydrodynamic Effect.

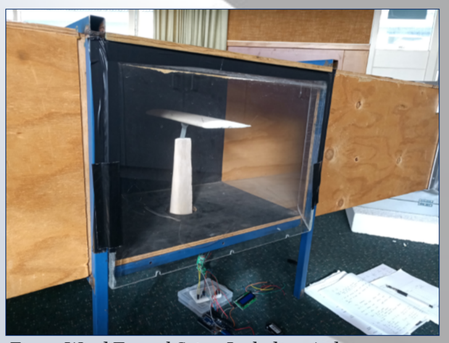

Fig. 2. Wind Tunnel Setup Including Arduino Circuit

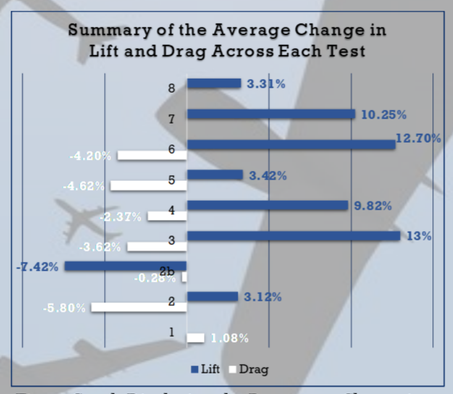

Fig. 3. Graph Displaying the Percentage Change in Lift and Drag Forces When EHD Was Applied.

ELECTROHYDRODYNAMICS EXPLAINED

- EHD is caused when high voltage is applied to a positive and negative electrode.
- Under high voltage, corona discharge tends to occur around sharp, uneven surfaces which causes the surrounding air to separate into electrons and positive ions (Fig. 1).
- As the electrons gather around the positive electrode, the negative ions flow towards the negative electrode and push the surrounding air.
- The movement causes a flow of air known as ionic or corona wind.
- EHD is used in a range of modern applications including 3D printing, pumping fluids and heat exchange systems (Fylladitakis, 2014).

RESULTS

- Eight separate tests were conducted across several days.
- For most tests, EHD proved to increase lift and reduce drag (Fig. 3).
- In Test 1, the electrodes were set at 130mm apart which proved too great. Better results were achieved when the gap was reduced.
- In Test 2b, the polarity of the electrodes was reversed. As a result, both lift and drag suffered noticeably.
- Given the success of these results, future testing could indicate whether EHD could be applied to full-scale aircrafts.

REFERENCES

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9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
11 SUSTAINABLE CITIES AND COMMUNITIES
13 CLIMATE ACTION