Improving aerodynamics during entire flight, not just takeoff and landing

January 30 2020

Ansell's research tested an alternative device to these conventional vortex generator vanes. Credit: University of Illinois Dept. of Aerospace Engineering

Currently in use on the wings of airplanes are little fins near the leading edge or just upstream of control surfaces to help control the aircraft during takeoff or landing. But these vortex generator vanes and other similar solutions are fixed in place across the entire flight, creating a cruise penalty from the drag. A promising new idea for a device was

tested at the University of Illinois that uses an electric spark that can be turned on and off when needed to generate rotating air across the wing for better lift.

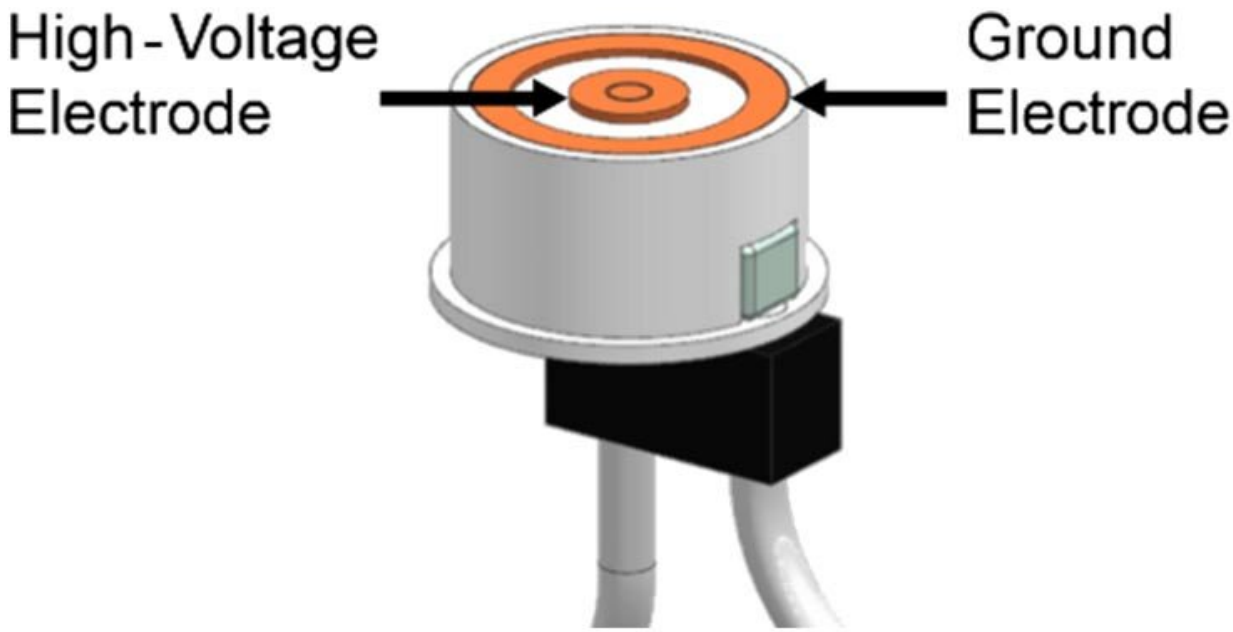
"We came up with an idea in the lab for an alternative to the little fins, but what makes this device different is we use active plasma actuation. I'm an aerodynamicist and not a plasma physicist, so I knew I needed to partner with a small business that has expertise in plasma systems. There's a lot of plasma physics in spacecraft propulsion, so I collaborated with CU Aerospace on this project," said Phillip Ansell, researcher and assistant professor in the Department of Aerospace Engineering at in The Grainger College of Engineering at Urbana-Champaign.

The design of the actuator created for this study featured a center high-voltage electrode placed within the inner diameter of a ring magnet. The ground electrode was placed around the outer circumference of the ring magnet, which provided the force required to rotate the plasma discharge and modify the flow.

In the experiment, the researchers were able to visualize the thermal effects of the plasma discharge, which showed a plume of warm air rising above the actuator along with a swirling effect. The velocity data were used to identify the existence of a vortex structure above the electrode gap. The identified vortex swirled in a direction that is consistent with the direction of rotation of the plasma filament.

"This experiment was done in what we call quiescent flow, which is still air in a box," Ansell said. "But, at least initially, it does appear this technique can produce reduced stall speed if integrated into an aircraft, meaning that we can we can turn these on and push the aircraft harder to get more lift out whenever it's needed, and turn them off to reduce drag during cruise."

President of CU Aerospace David Carroll said, "A huge volume of fascinating experimental data were generated during the course of the Phase I and II efforts that may take years to fully analyze. The program showed that increasing power into the plasma actuators produced stronger vortical structures."



CAD model of the actuator used in the wind-tunnel experiment. Credit: University of Illinois Dept. of Aerospace Engineering

Ansell said since completing the initial work, the Illinois and CU Aerospace team has continued to work on the actuator technology. More recent developments have included testing to understand what happens when there is an air flow across it. They also integrated the actuators into an unmanned flight test aircraft as a further demonstration of the technology.

"In my mind, the most exciting results were that some UAV tests showed an increase in the maximum lift capability, that is decreased the stall speed, when the actuators were turned on—exactly the effect we were hoping to observe," Carroll said.

Although the benefits may appear to be small, Ansell said, in aerodynamics, small percentages of cruise penalty add up quickly. "So if we can improve something by say, just a couple of percentages, you can save multiple millions of dollars in fuel costs every year."

The study, "Experimental Characterization of a Novel Cyclotronic Plasma Actuator," was published in the *AIAA Scitech 2020 Forum*.

More information: Georgi Hristov et al. Experimental Characterization of a Novel Cyclotronic Plasma Actuator, *AIAA Scitech 2020 Forum* (2020). DOI: 10.2514/6.2020-1567

Provided by University of Illinois at Urbana-Champaign