Active Control of Vortices for Skin Friction Reduction

This technology offers active control of stationary vortices for aerodynamic structures to reduce CO2 emissions. This system enables skin friction reduction, a reduced drag, and an increased thermodynamic efficiency in engine use cases.

What is the Problem?

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Fuel is the largest direct operating cost for airlines. Furthermore, emissions of CO2 are a growing environmental concern, and the water vapor emissions at high altitude also plays a role in the changing climate. If the aerodynamic drag of an aircraft were to be reduced, the engine thrust (and therefore emissions) can also be reduced.

Friction on the outer layer of the aircraft is a significant component of the total drag. On large aircraft, the boundary layers between the aircraft and the passing air are almost completely turbulent, having relatively large skin friction coefficients. Decreasing the coefficient by transitioning to smooth air flow (laminar flow) at the boundary layer could decrease drag.

In many other devices, a relatively high heat transfer coefficient in turbulent boundary layers limits the performance of the device. For example, heat transfer to the turbine blades can limit efficiency of modern aircraft turbine engines, because the turbine blades overheat in operation. As another example, rocket nozzles must be cooled to prevent melting. The cooling mechanism adds weight, complexity, and failure modes to these rocket engines. Consequently, in many applications it is desirable to delay the turbulent flow by maintaining the laminar flow at the wall as long as possible.

What is the Solution?

The solution is a system for active control of stationary vortices for aerodynamic structures. Transition from a laminar flow to a turbulent flow is often accompanied with vortex formation and movement close to a solid wall. Controlling these vortices can therefore preserve laminar air flow. Active control of these vortices over a solid surface is done by sensing locations of vortices with printed skin sensors and maintaining the vortices in their positions with respect to the solid surface by actuation of printed skin actuators. This active control of stationary vortices will enable skin friction reduction.

What is the Competitive Advantage?

Technology ID

BDP 8699

Category

Hardware/Other

Selection of Available Technologies

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External structures on airplanes are engineered to reduce drag, but these structures eventually lead to turbulent air flow. With some conventional technologies in engines, excess diluent air must be added into the hot combustor gasses to prevent melting of the blades. As a result, the peak cycle temperature of these turbines is reduced, thus lowering their thermodynamic efficiency and fuel economy. This system eliminates these inefficiencies by controlling the stational vortices, which enables skin friction reduction, reducing drag, and increasing thermodynamic efficiency in engine use cases.

Patent Information:

US11085471B2

References

1. OR Dawson, M Bauer, GJ Balle, RE Breidenthal , https://www.aa.washington.edu/sites/aa/files/research/fluidDynamic/publications/Dawson%20et%20al.pdf