



VortexCell2050

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Synopsis

Fundamentals of actively controlled flows with trapped vortices

Background:

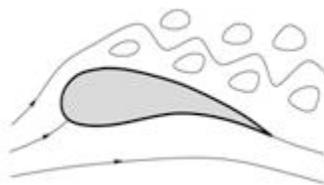


Figure 1. Vortex shedding



Figure 2. Airfoil with a trapped vortex

Trapping vortices is a technology for preventing vortex shedding in flows past bluff bodies. Vortices forming near bluff bodies tend to be shed downstream. If the vortex is kept near the body at all times it is called trapped. Vortices can be trapped in vortex cells that are special cavities in the airfoil. So far trapped vortices were stabilised only by passive means (aircraft EKIP, Russia). Active control consists in linking sensors and actuators via a control system so as to stabilise the flow. Active flow control was implemented for flows past bodies of simple shape.

Project Objectives:

To ensure a high lift-to-drag ratio, aircraft wings are thin and streamlined. From a structural-strength viewpoint having thick wing would be more beneficial. With an increase in the aircraft size the balance between structural-strength and aerodynamic quality shifts in favour of a thick wing. The flow past a thick airfoil, however, is likely to separate affecting the wing aerodynamic quality. The present project aims at resolving this problem by combining two advanced technologies: trapped vortex and active control. Specific objectives of the project are: to develop a software tool for designing a flow past a thick airfoil with a trapped vortex assuming that this flow is stable, apart from small-scale turbulence; to develop a methodology and software tools for designing a system of stabilisation of such a flow; to design and estimate the performance of an airfoil with a trapped vortex and a stabilisation system for the High-Altitude Long Endurance unmanned aircraft.

Description of Work:

At the first of the three stages of the project necessary numerical and experimental tools will be developed: a specialized experimental facility for study of cyclic boundary layers characteristic of flows with trapped vortices, a wind-tunnel test-bed consisting of an airfoil with an interchangeable wall section with a vortex cell, a discrete vortex method code as the means of testing control algorithms, RANS code

for general calculations, LES code for studying more complicated 3D effects on simple test cases, and a vortex cell shape inverse design code incorporating a cyclic boundary layer code and an inviscid cell design code based on various inviscid flow models. At the second stage these tools will be used to develop and test experimentally a vortex cell for the test-bed airfoil with a system of active control. Obtained results will be used for enhancing the tools developed during the first stage of research. The differences between intrinsically two-dimensional nature of some of the numerical tools, first of all the discrete vortex method and real three-dimensional flows will be explored and the limitations of two-dimensional approaches identified. At the third stage an attempt will be made to design a trapped-vortex airfoil for a specific practical application, namely for a high-altitude long endurance unmanned aircraft. Depending on the results obtained in the second stage of the research, the airfoil will be equipped with active or passive means of flow control. The wing will be manufactured and tested in a wind tunnel.

Expected results:

The project will ensure a significant advance in trapped vortex technology. In the case of a full success of VortexCell2050 the main outcome will be a new technological platform: actively controlled trapped vortex technology.



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