Karlsruhe Institute of Technology

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MSc Project – numerical

Active flow control for laminar flow wings

Motivation

Laminar flows tend to develop flow instabilities that eventually lead to a turbulent flow. These instabilities can be modeled as traveling waves undergoing spatial growth. Turbulent flows on aerodynamic surfaces accounts for $\approx 40\%$ of the total drag. Novel airplane wings and fuselages have been designed to guarantee a laminar flow over most of their surfaces. Nonetheless, the need to extend the operational envelope of these designs led to the formulation of active flow control techniques where the flow-controlling parameters can be optimally adjusted for a broader range of flow conditions.

Boundary layer suction is a proven approach to delay the boundary layer transition to a turbulent state. Its working principle leverages on increasing the average momentum of the boundary layer flow, therefore leading to a more stable configuration. Despite the working principles are today rather known and understood, designing a laminar flow wing with active flow control by means of boundary layer suction is still a challenging task and indeed, to date and despite the prolonged effort, only a handful of prototypes has flown with this technology successfully deployed (see figure). The goal of the current project is a preliminary design of the ISTM active flow control experimental test-bench.

Task description

Following a thorough state-of-the art survey, the student will implement a numerical model based upon the solution of the boundary layer system of equations embedding surface suction boundary conditions. The resulted solution will be used as input to a linear stability theory (LST) solver to retrieve the instability modes evolution. The numerical tools are available but need further development. Several parameters are to be investigated such as the wing shape, its angle of attack, the flow velocity range, the amount (mass flow rate) and position (onset and extent) of the suction slots leading to the preliminary design of the experimental test-bench.

This project aims at the scientific diffusion of the performed activities. For this reason, the project language is English and a thorough knowledge of scientific English is a prerequisite.

Starting date:

Ending date:

Student name:

Signature:

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