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Session:

Experimental/Numerical Study of Turbulent Wake in Adverse Pressure Gradient

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The paper presents current status of a bilateral German-Russian project launched in 2017. The project is aimed at deepening of understanding of physics of turbulent wakes in the presence of Adverse Pressure Gradient (APG) based on specially designed parallel experimental and high-fidelity numerical studies. Its primary motivation is the lack of accuracy of the existing RANS turbulence models for high-lift wing flows near the maximum lift conditions, which common challenging feature are wakes of upstream elements of the system subjected to APG created by downstream elements. Hence, an ultimate goal of the project is improving of RANS models predictive capability for this type of flows.

A new experimental setup designed for this purpose (see Fig. 1) accounts for drawbacks of earlier experiments in terms of reproducibility in CFD. In particular, thanks to employing thin airfoils ("linefoils") as an APG generating device, it ensures absence of boundary layer separation in the APG region without using suction or injection of side wall jets.

A general modeling hypothesis of the project is that its goal can be reached by calibrating existing Reynolds Stress Transport RANS models based on detailed experimental dataset, including Reynolds stress balance and dissipation rate estimates, and on results of high-fidelity turbulence resolving simulations providing relevant second moment closure terms not accessible by measurements. Considering a high Reynolds number in the experiment, the only affordable turbulence-resolving approach is Wall Modeled LES (WMLES). A particular choice of WMLES in the project is a zonal hybrid approach RANS-IDDES combined with the Volumetric Synthetic Turbulence Generator for creating turbulent content at the RANS-IDDES interface. In order to assess its capability of ensuring an accurate prediction of subtle turbulent characteristics of wakes subjected to APG, especially the dissipation-rater tensor, which is a key quantity in the context of RANS models improvement, simulations were performed of the wake in APG flow studied experimentally by Driver & Mateer [1] (D-M wake). Although this experiment does not allow an "apples to apples" comparison with results of simulations, the flow itself (a wake of the flat

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plate passing through a diffuser creating a strong AFG) is quite representative of the type of flow in question. Hence, results of its simulations present a considerable interest both in itself and as a background for the further "production" simulations of the wakes in APG, which will be studied experimentally within the project (Fig. 1).

Sample results of the simulations using 3 grids (18, 30, and 50 million cells) are presented in Fig. 2. The figure suggests that the RANS-IDDES approach ensures resolving fine turbulent structures in the wake with an extent of the inertial range up to 1.5 decades. Moreover, thanks to computing the elements of the dissipation-rate tensor based on balance of the transport equations for the Reynolds stresses, as proposed in [2], virtually grid-independent fields of these quantities are obtained on the intermediate Grid 2 with the step size in the focus region of IDDES about 75 Kolmogorov length scales. A detailed outline of the simulations and analysis of obtained results will be provided in the full paper.

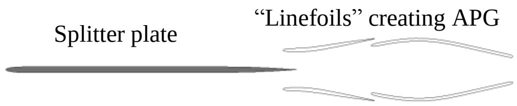

Fig.1. Schematic of experimental setup

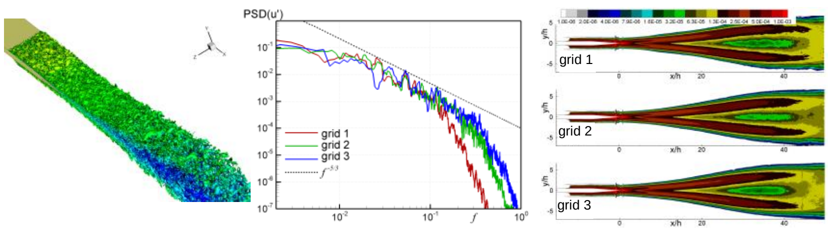

Fig. 2. Isosurface of swirl, spectra of resolved streamwise velocity fluctuations, and dissipation-rate from simulations of D-M wake flow

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