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Experimental and Numerical Investigation of Transversal Traveling Surface Waves for Drag Reduction

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Abstract

The active drag reduction impact of spanwise transversal surface waves on a turbulent boundary layer is investigated experimentally and numerically. The actuated surface in the experimental setup is an insert in a flat aluminum plate being excited by an electromagnetic actuator system. Particle-image velocimetry and μ-particle-tracking velocimetry measurements are conducted to determine the local drag reduction downstream of the actuated surface. Furthermore, large-eddy simulations are performed to corroborate that the overall friction decrease can be determined by the local skin friction measurements downstream of the actuated surface. The Reynolds number based on the momentum thickness located directly downstream of the actuated surface is $Re_\theta = 1300$. The spanwise traveling wave has an amplitude of $A^+ = 9$, a wave length of $\lambda^+ = 3862$, and a period of $T^+ = 115$. The experimental and numerical results of the velocity distributions show an excellent agreement upstream and downstream of the actuated surface. The low amplitude which is caused by the actuation constraints due to the technically relevant material aluminum leads to low drag reduction values of 1.27% and 0.89% in the simulation and the measurement. A dominant influence of the transition from the actuated wall to the non-actuated surface is excluded. Thus, a detection of the impact of the wall motion by local skin friction measurements downstream of the actuated surface is feasible.

Keywords: turbulent boundary layer; drag reduction; transversal traveling surface wave; particle tracking velocimetry; large eddy simulation.

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