Abstract

Improving the flow conditions by changing the aerodynamic characteristics is the goal of research in many industries, e.g. in aviation, wind energy or automotive. One of the methods of improving the aerodynamics is to reduce the separation zones in the flow, which negatively affect, for example, the lift on the wings of aircraft, generating higher fuel consumption and thus - higher greenhouse gas emissions. In this paper, the effect of active synthetic jet vortex generators on the separation area was analyzed using a unique arrangement of a series of generators with vertical membranes with the possibility of using one or both membranes placed in the chamber. For all generators in the system, frequency characteristics were determined in the frequency range $f = 0 \div 3000$ Hz for two supply voltages $U = 15$ V and $U = 20$ V. The influence of the generated vortex structures for the determined characteristic frequencies at which the jets reach their maximum velocities was then experimentally tested on a model generating a strong flow separation for three main flow velocities $U_\infty = 8$, 10 and 12 m/s, for supply voltages $U = 15$, 20, 25 and 30 V. Within the examined cases, it was shown that the use of a series of generators of synthetic jets with orifice diameters of $d = 1$ mm brings positive effects in reducing the size of separation zone.

Another important feature of the examined generators observed during the analysis of the measurement results is the achievement of similar effects using different frequencies and/or different voltages supplying the generators. This allows for the selection of optimal generator operating parameters depending on the needs. The presented dissertation also uses numerical simulations to complement the experimental results. The main emphasis was placed on the analysis of the evolving vortex structures without interaction with the main flow for resonance frequencies of the chamber and the membrane, which affect the size and intensity of the vortices formed. It also allowed for the initial preparation of a tool enabling the verification of design assumptions before the generators' production stage. The results of the numerical analysis show that the resulting vortex structures differ depending on the frequency that forces the vibration membrane. The presented dissertation presents new results advancing knowledge on active flow control using synthetic jet generators.

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