Scaling of Pulsed Excitation for Boundary Layer Control

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The effect of periodic excitation on a turbulent boundary layer, subjected to adverse pressure gradient over a flat plate, was studied experimentally in nominally 2D flow [1]. The study was aimed to improve the understanding of periodic excitation influence on a turbulent boundary layer on the verge of separating without the effect of curvature. The measurements included, hot-wire, static and Preston pressures and Particle Image Velocimetry (PIV) and created a comprehensive data base. Adverse pressure gradient was imposed by a suction system placed opposite to the test plate. Fig. 1 shows the experimental set-up.

![Figure 1 The experimental test section.](image)

The effect of adverse pressure gradient, excitation type, frequency and magnitude on the receptivity of the attached and separated flow was studied. Excitation was imposed on the boundary layer by a zero-mass-flux Piezo-fluidic actuator [2], [3] through a 2D slot at the test plate, inclined at 30 deg to the flow direction. It was found that excitations lead to increase of near-wall shear stress and therefore separation delay. The evolution of the vortices created by the excitation in the turbulent boundary layer, subjected to adverse pressure gradient, was studied in detail. It was found that increase of suction level leads to decrease of vortex convection velocity. The effect of increased excitation magnitude on the integral parameters leads to decrease of the integral parameters. However, no instability was found in this incipiently separated turbulent boundary layer [4], [5], [6]. To optimize the energy expenditure of the flow control system, the temporal time scales were sought. Dimensionless temporal and spatial scales were determined for different periods of pulsed excitation. The time coefficient of turbulent boundary layer response to excitation and subsequent relaxation was
estimated as well, from a short train of four vortices created with significant time lag between the pulses.

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**Figure 2** Displacement thickness averaged in test frame, evolution in time normalized.

The currently identified time scales of a separating, turbulent boundary layer response on excitations can be seen in Figure 2. The experiment was repeated for several excitation magnitudes and universal trends for the convection, reaction and relaxation time constants were found.

The conference presentation will contain a brief description of the baseline flow, discussion of effect of periodic excitation on turbulent boundary layer and discussion of temporal and spatial scales of the flow and their utilization for effective flow control system.

1 Palei, V., Seifert, A., An effect of Periodic Excitation on a Turbulent Boundary Layer Subjected to Adverse Pressure Gradient without Effect of Curvature, Ph.D. Thesis, Tel-Aviv University, April 2012.


3 Yehoshua, T. and Seifert, A. Active Boundary Layer Tripping Using Oscillatory Vorticity Generator, Aerospace Science and Technology, 10 (3): 175-180 APR 2006

