18th International Conference
ENGINEERING MECHANICS 2012
Svratka, Czech Republic, May 14 – 17, 2012

pp. 1183–1187
Paper #106

INFLUENCE OF THE SYNTHETIC JET ON THE FLOW AROUND THE HUMP

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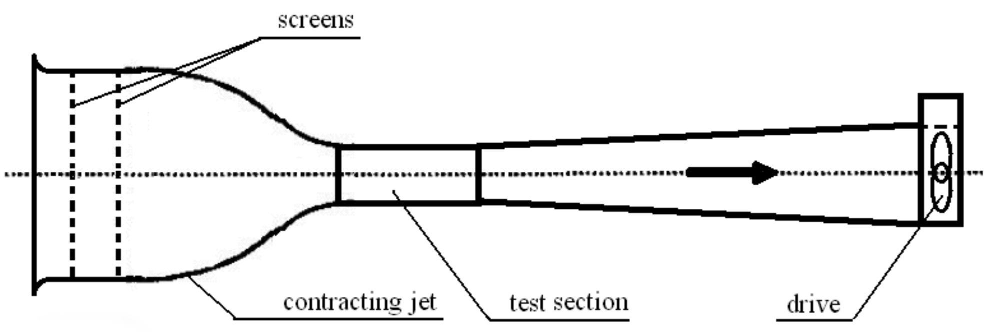
Abstract: *The work deals with measurement of characteristics of the synthetic jet generator. Synthetic jet mean velocity in dependence of the parameters of actuating signal (type of signal, frequency, electrical current value) and the velocity profile in the wake behind the hump with controlled boundary layer was studied. A hot wire anemometry method (HWA) measurement technique was used. Profiles of the mean velocity and turbulence intensity behind hump was evaluated. Variants with and without the synthetic jet were measured and compared.*

Keywords: Boundary layer, flow control, HWA, synthetic jet, wake.

1. Introduction

For the purpose of investigation of the flow with controlled boundary layer behind the aerodynamic obstacle in the laboratories of the Department of Fluid Mechanics and Thermodynamics 12112, was rebuilt sucked open wind tunnel with a closed test section, including measuring equipment with traversing device and measuring software in LabVIEW. The scheme of the wind tunnel is on Fig. 1. Synthetic jet was chosen as method of active boundary layer control.



2. Model with synthetic jet generators

Block of nine synthetic jet generators driven by electrodynamics actuators was used. The block is instaled inside the model. The outcome of generators is connected smoothly to the top surface of the model, see Fig. 2 (the flow direction is being from left to right).

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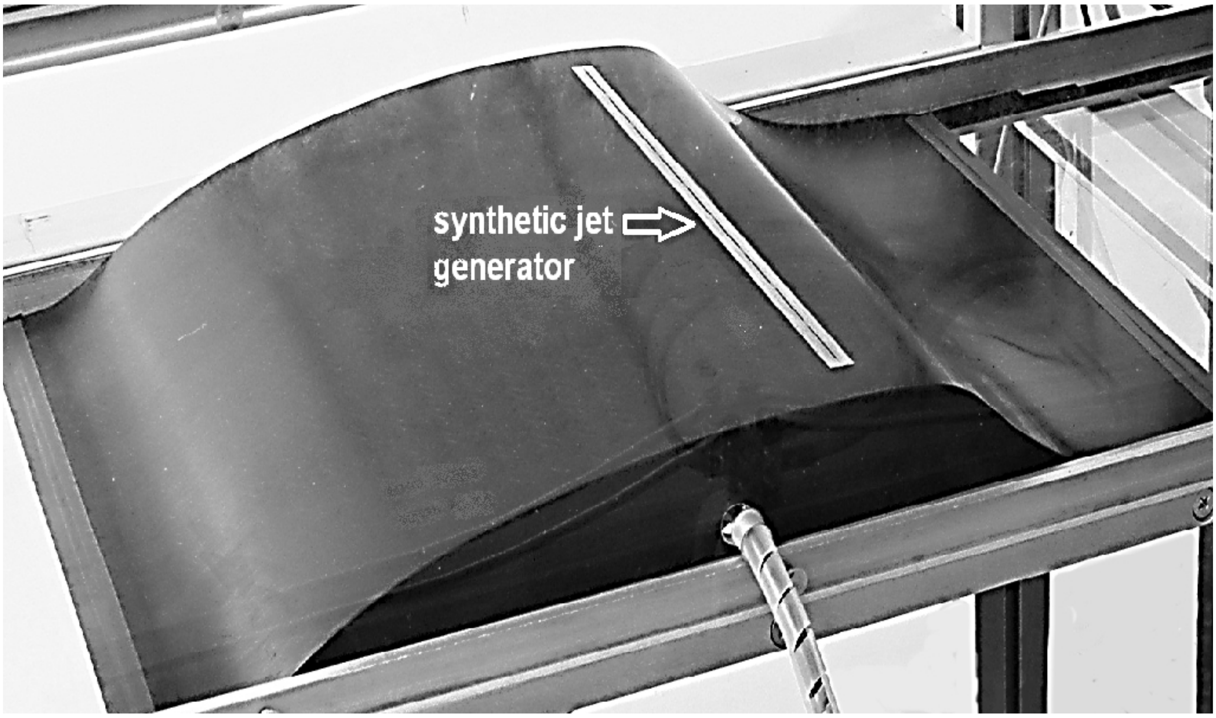

Fig. 2 Model with installed synthetic jet generators in the testing section of the wind tunnel

3. Synthetic jet generator calibration

The calibration of the synthetic jet generator is to determine dependence of the intensity/velocity u_0 of the synthetic jet on exciting frequency, type of signal and input electrical current value. Time average value of the velocity of the synthetic jet is defined:

$$u_0 = \frac{2}{T} \cdot \int_0^{\frac{T}{2}} u_0(t) \cdot dt \qquad (1)$$

where $u_0(t)$ is the instantaneous velocity generated by the synthetic jet and T is positive period of the signal.

Measuring system with hot wire probe (HWA) was used. The measuring system was realized using computer (PC) with measuring card and software in LabVIEW, to generate the jet-excitation signal and to collect measured data from the HWA device 54T30 MiniCTA, Dantec Dynamic company, stabilized power supply and one wire HWA probe.

On Fig. 3 mean velovity u_0 dependence on frequency of sine type excitation signal is visible. Value of imput current of the excitation signal was constant in this case. Maximum mean velocity u_0 of generated synthetic jet was about 11,5 m/s. Maximum intensity of the synthetic jet for excitation frequency of 370 [Hz] was found. This corresponds to the value of cavity resonance.

On the next figure, Fig. 4, the dependence of mean velocity of the synthetic jet on input current value with sine type excitation signal for resonant frequency is shown. This characteristics is useful for wind tunnel measurements to define the input current value which corresponds to the required velocity u_0 of the synthetic jet.

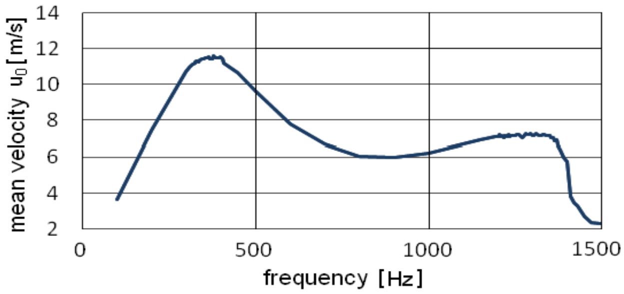

Fig. 3 Mean velocity dependence on frequency excitation signal

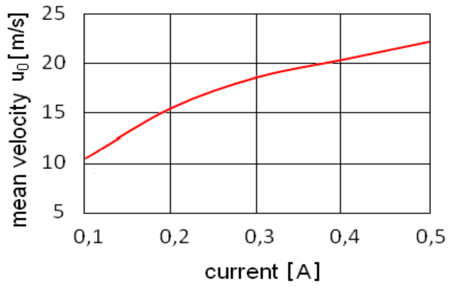

Fig. 4 Mean velocity dependence on input current for resonant frequency

4. Wind tunnel measurement

The excitation signal for measurement was sine type modulated by rectangular signal. The sine type signal – carrying was created on resonant frequency of the actuator – 370 [Hz]. The square type - modulation frequency corresponds to the natural vortex shedding frequency of the flow behind the aerodynamic obstacle. That frequency can be estimated from optimal value of Strouhal number – non-dimensional frequency. Strouhal number *St* is defined as:

$$St = \frac{f \cdot L}{v} \tag{2}$$

where *f* is frequency of vortex shedding, *L* characteristic dimension and *v* fluid velocity.

Evaluated was the mean velocity value $\bar{u}$:

$$\bar{u}_i = \frac{1}{T}\int_0^T u_i(t)dt \tag{3}$$

and turbulence intensity *Tu:*

$$Tu_i = \frac{\sqrt{\overline{u_i'^2}}}{\left|\overline{u_i}\right|} \tag{4}$$

where $\bar{u}_i$ is the mean velocity, $\sqrt{\overline{u_i'^2}}$ is the standard deviation of velocity in the i-thest point cross-section and T is positive period of the signal.

Measuerement area in cross-section is marked on Fig. 5. Measurements were made with and without the synthetic jet. Both cases was compared, see Fig. 6.

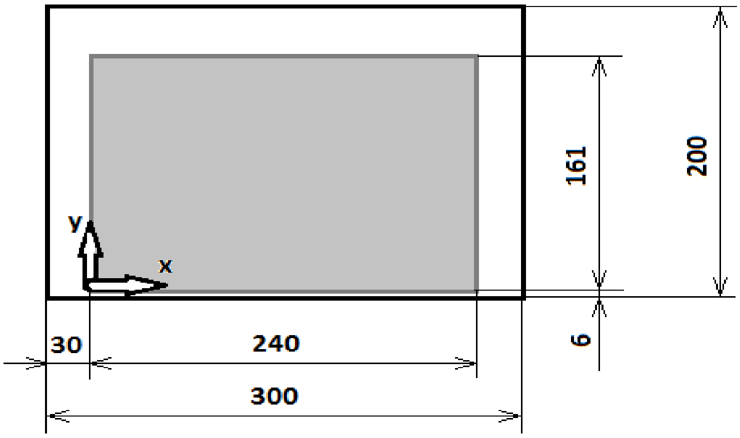

Fig. 5 Measuered area in cross-section

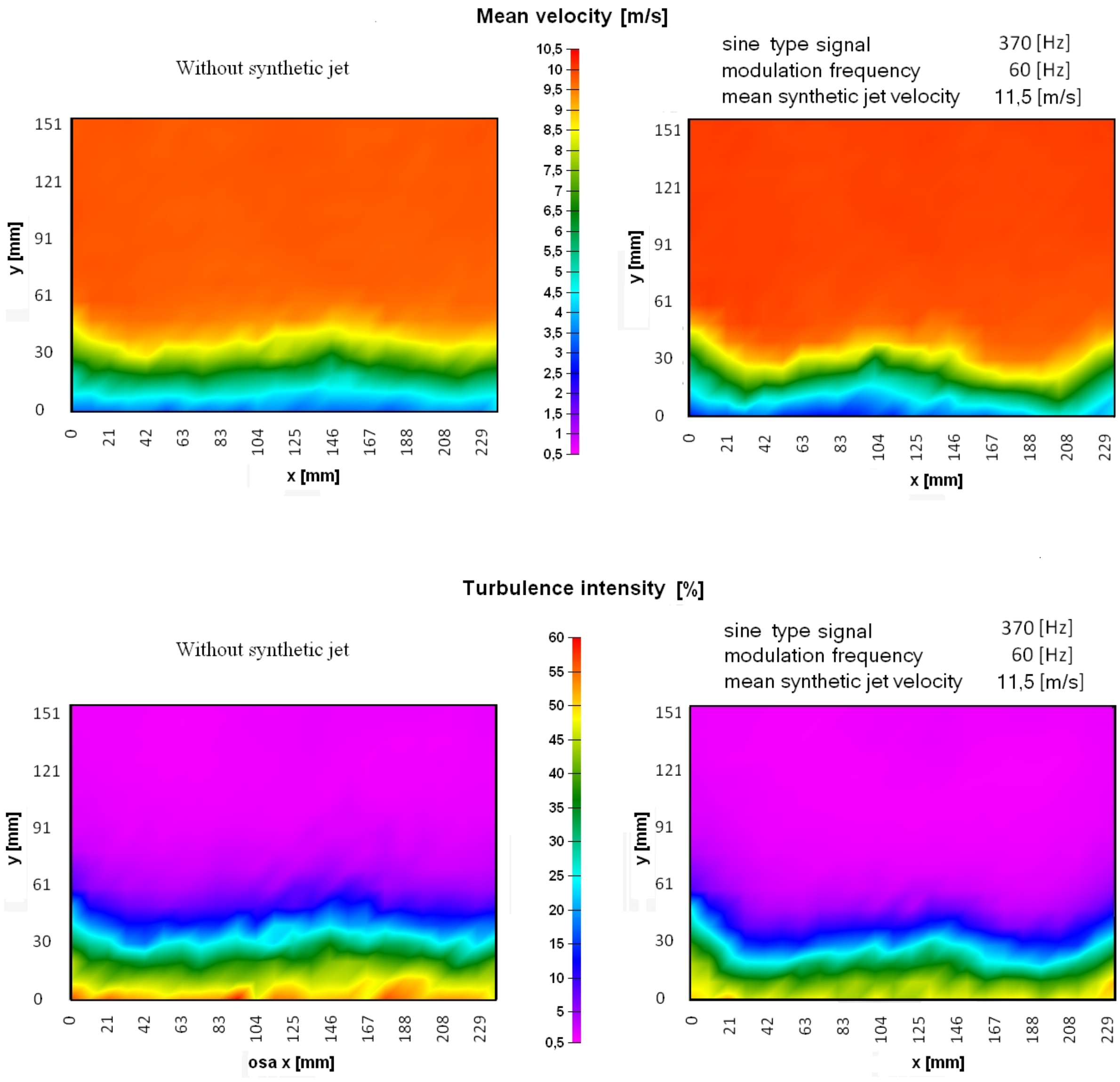

Fig. 6 Mean velocity and turbulence intensity, wind tunnel drive set on 1740 rpm

5. Conclusions

It was found, that the synthetic jet have positive influence on the flow. Dominant vortex structures can be observed probably in the wake behind the model. The mean velocity in non-influenced part of cross-section increased from 9,8 [m/s] in case without synthetic jet to 10,1 [m/s] i case with synthetic jet. The wake magnitude in cross-section was reduced. The maximum of turbulence intensity in the wake was decreased from 60% to 50%.

It was made introductory measurements. Following measurements in another cross-sections and advanced data processing give more interesting results. It seems, that synthetic jet is promissing technique of boundary layer control.

Acknowledgment

The work has been supported from GA of the Czech Republic 101/08/1112.

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