Characteristics of the synthetic jet generator

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Abstrakt

Práce se zabývá měřením charakteristik generátorů syntetizovaného paprsku, tj, určením závislosti střední rychlosti syntetizovaného paprsku na parametrech budícího signálu (typ signálu, frekvence, hodnota elektrického proudu). K měření rychlosti byl použit anemometr se žhaveným drátkem, metoda (HWA byly měřeny dvě varianty s různou geometrií.

Klíčová slova

HWA, měření rychlosti, syntetizovaný paprsek.

1. Introduction

For the purpose of investigation of the flow with controlled boundary layer in the laboratories of the Department of Fluid Mechanics and Thermodynamics 12112, was built a model of an aerodynamical obstacle (see Fig.1.) with space for boundary layer control actuators inside. Synthetic jet was chosen as method of active boundary layer control**.**

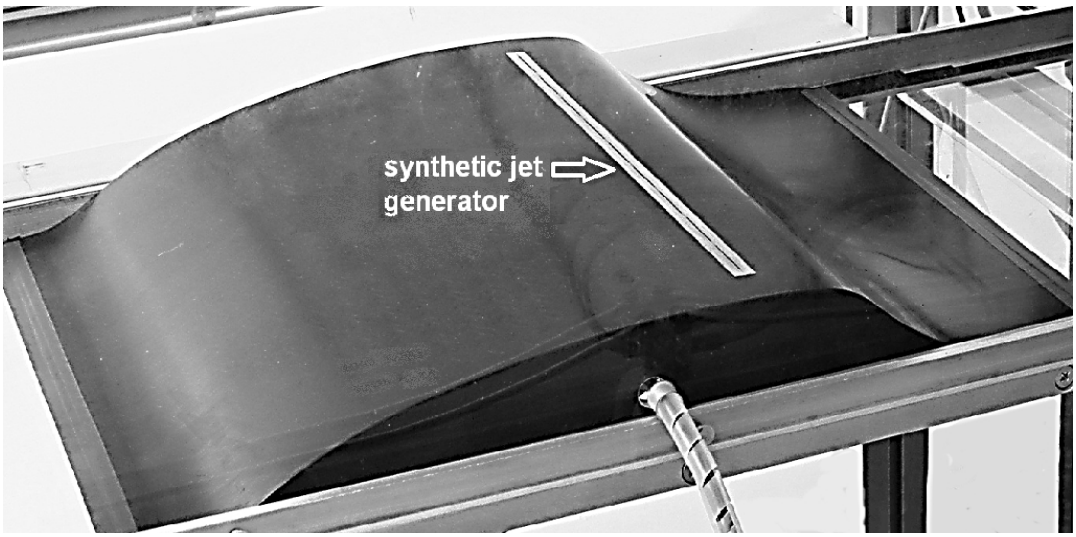

Fig. 1. *Aerodynamical obstacle - block with 9 synthetic jet generators inside*

2. Synthetic jet

2.1 Synthetic jet generator

Synthetic jet generator driven by a pair of electrodynamic actuators (see Fig.2.) was chosen as method of active boundary layer control.

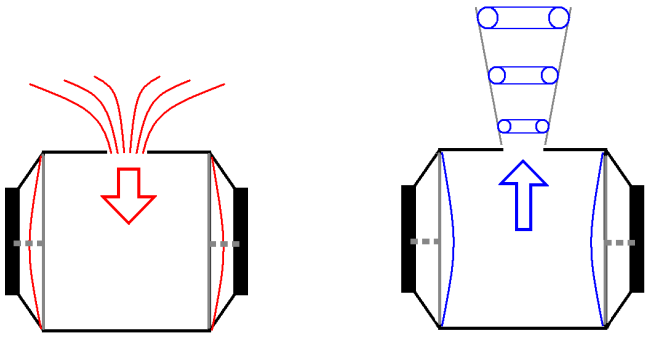

Fig. 2. *Synthetic jet generator driven by a pair of electrodynamic actuators, suction and blowing regime.*

2.2 Synthetic jet mean velocity

Synthetic jet mean velocity u_0 is defined as

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

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

2.3 Synthetic jet generator characteristics

Synthetic jet generator characteristics (calibration) means to determine synthetic jet mean velocity in dependence of the parameters of actuating signal (type of signal, frequency, electrical current value).

Subsequently for found resonance maximum determine mean velocity - current characteristics for signal modulated with rectangular signal with a modulation frequency.

3. Measurement

3.1 Measuring system

Synthetic jet has recurring character - it is generated by the sine type signal, frequency range 50 - 1500 [Hz]. Hot wire anemometry with hot wire probe (HWA) – the CTA method was used, i.e. with a constant temperature probe.

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 with high quality filter and one wire HWA probe, ammeter and signal amplifier.

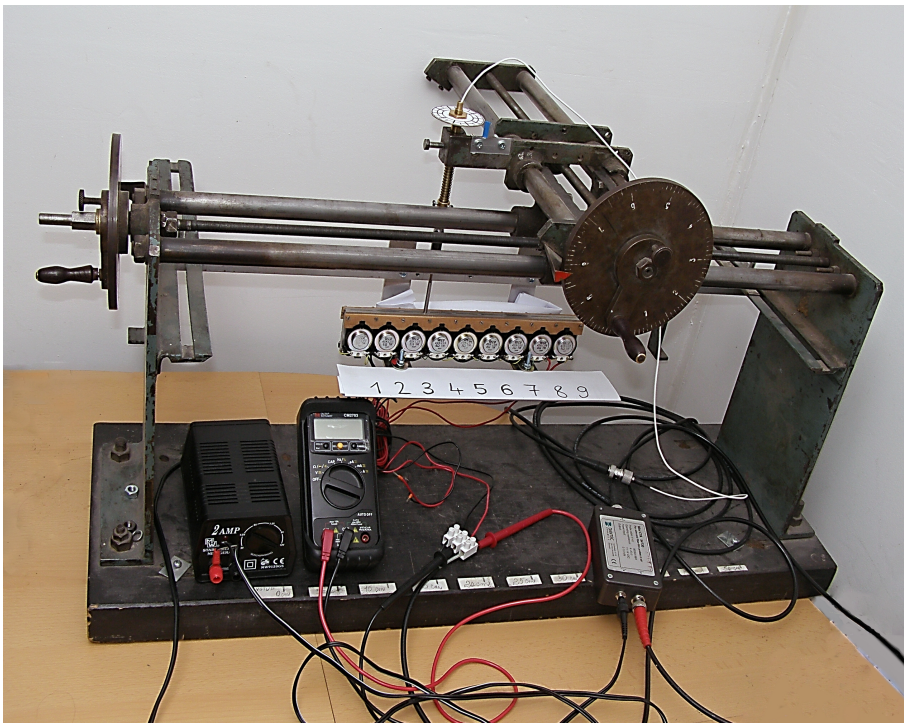

Fig. 3. *HWA probe positioning*

3.2 HWA probe positioning

Synthetic jet have narrow outlet jet. Probe positioning must be made with precision. It was used mechanical manually operated 3D traverting device (see Fig. 3.) with three fine adjustable axis. The probe does not touch the outlet walls. Firstly it must be found the position of the maximum value of mean velocity (in lateral direction of the outlet jet). This maximum corresponds to the axis of generated synthetic jet. The slackness of the screws of traversing device must be eliminated. A detailed view on the probe into synthetic jet generator outlet – see Fig.4.

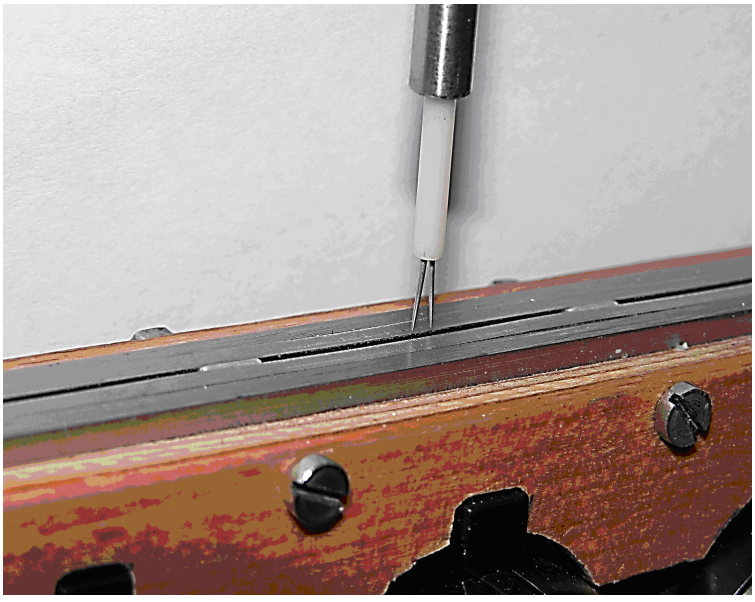

Fig. 4. *HWA probe positioning, outlet of the synthetic jet generator*

3.3 Synthetic jet generator measurement

It shows, that the properties of the electromagnetic actuators into synthetic jet generator are dependent on the temperature of actuator. The measurements was made after temperature stabilization.

An individual measurement of each generator would be extremely time-consuming. A complete calibration was carried for only one generator out. For the remaining (8) generators was subsequently measured only the selected characteristics, which allows comparison all (9) generators - see Fig.5. It was investigated two variants with different outlet jet with 0,5 [mm] and 1,0 [mm]).

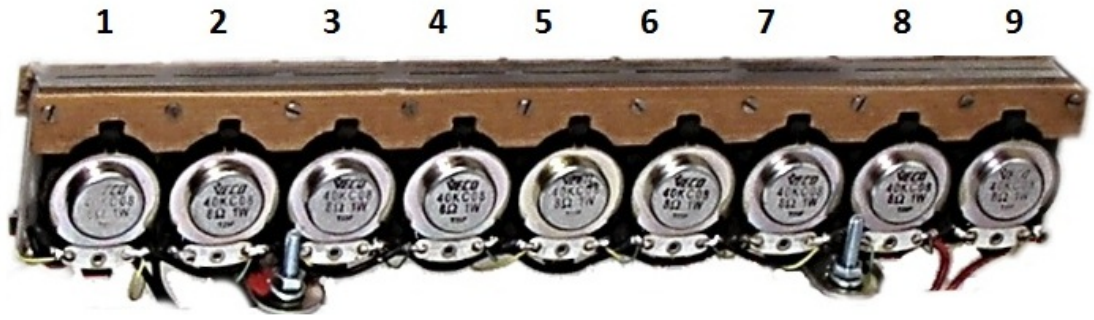

Fig. 5. *Block with synthetic jet generators (9)*

3. Measurement results

Next measurements were made with generator no.3. (see Fig.5.)

3.1 Mean velocity of SJ - frequency characteristics

Mean velocity of synthetic jet - frequency characteristics was measured in two steps. Firstly it was found the potential resonant maximum(s) without waiting for temperature stabilization. An example of instantaneous velocity u_0 *(t)* - see Fig. 6. The periodicity of suction and blowing regime is visible.

Secondly was measured all characteristics. Evaluated was the mean velocity of synthetic jet, defined in (1) - see Fig.7. and 8. Every point of characteristics was measured after temperature stabilization (about 5 minutes).

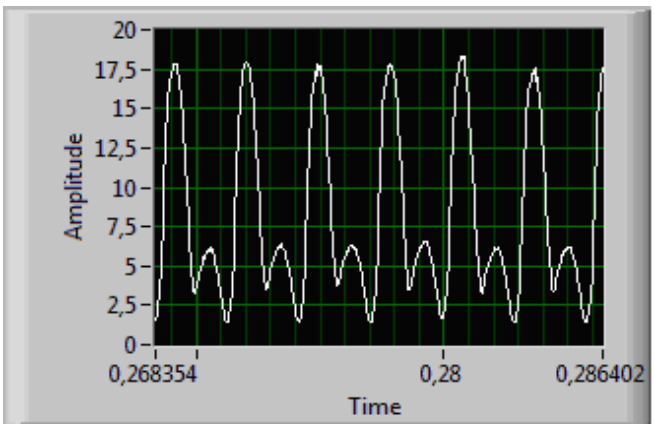

Fig. 6. *Instantaneous velocity u_0 (t), example*

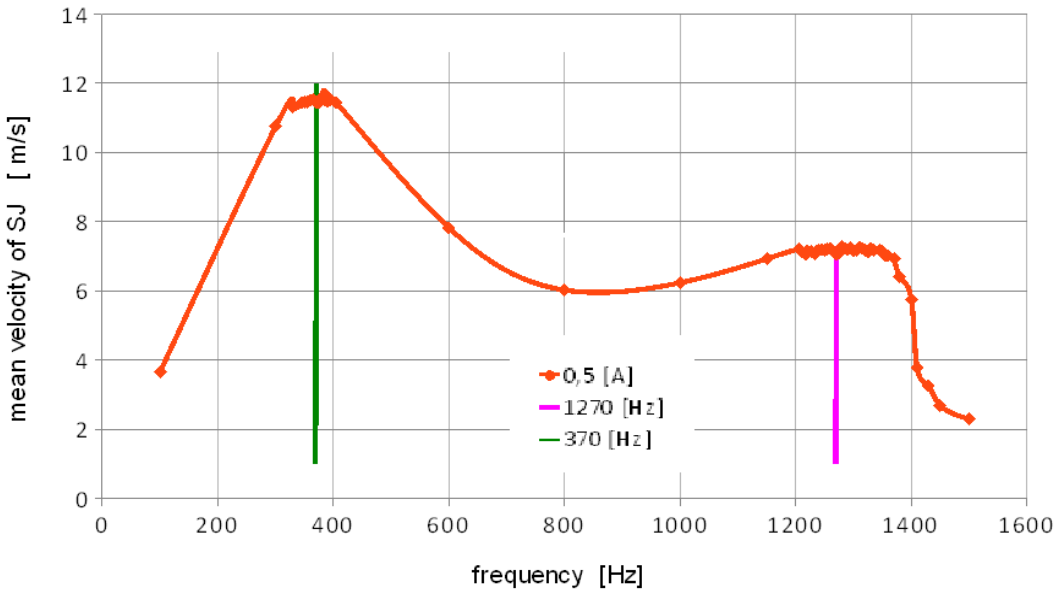

Fig. 7. *Mean velocity of SJ - frequency characteristics, outlet jet with 0,5[mm]*

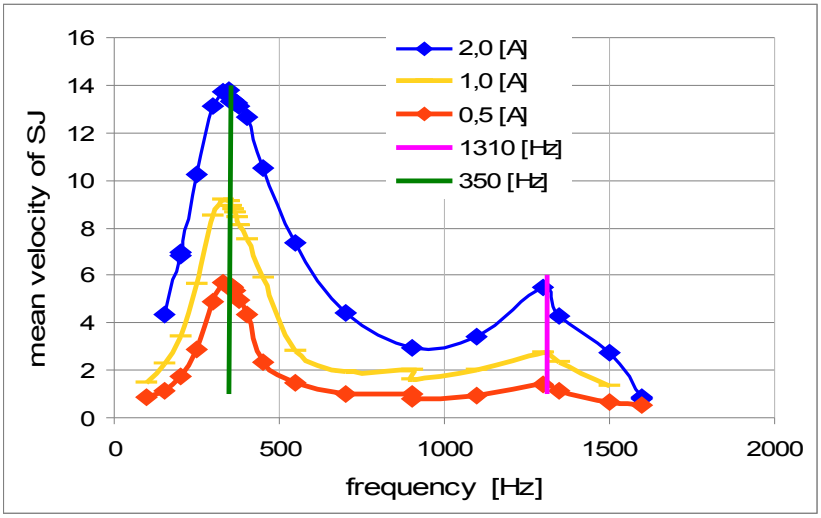

Fig. 8. *Mean velocity of SJ - frequency characteristics, outlet jet with 1,0[mm]*

3.2 Modulation with rectangular type signal - frequency characteristics

The excitation signal for this measurement was sine type modulated with rectangular signal, see Fig.9. The sine type signal – carrying signal corresponds to the resonant frequency of the actuator.

The rectangular 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:

$$St = \frac{f \cdot L}{v} \qquad (2)$$

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

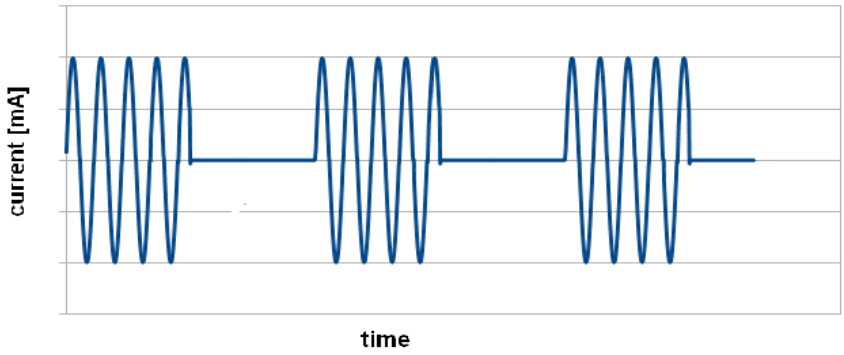

Fig. 9. *Modulation with rectangular type signal - frequency characteristics*

Evaluated was the mean velocity and maximum velocity of synthetic jet (1) - see Fig.10. and 11. Every point of characteristics was measured after temperature stabilization (about 5 minutes).

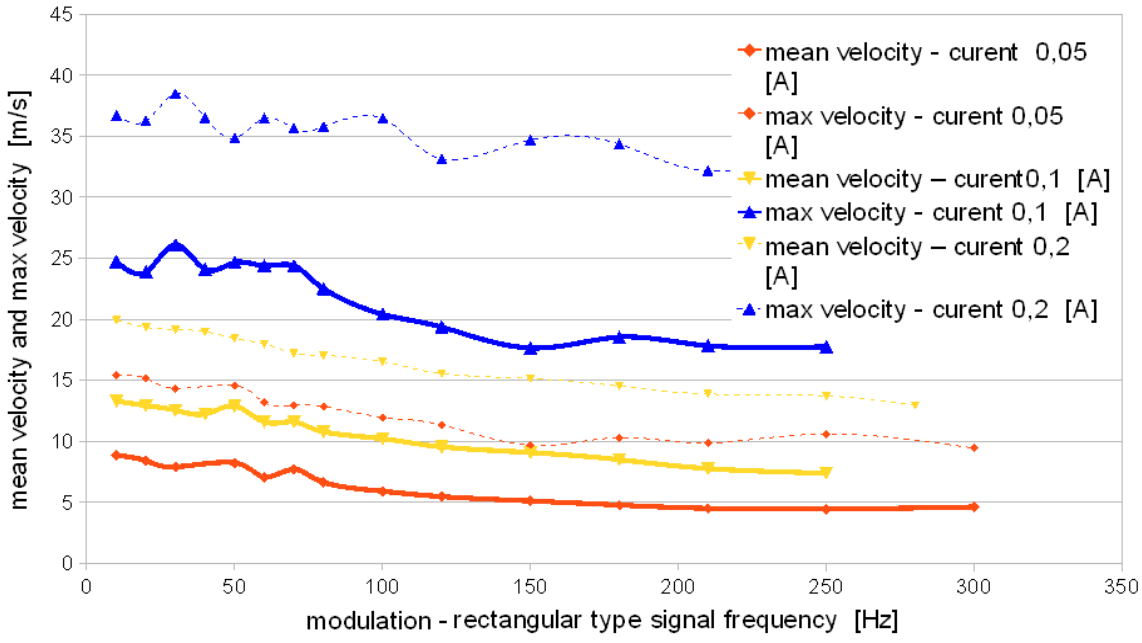

Fig. 10 Mean velocity of SJ - frequency characteristics, outlet jet with 0,5[mm]

Measured characteristics have assign linear declining of the mean velocity of synthetic jet with growing modulation frequency of the rectangular type signal.

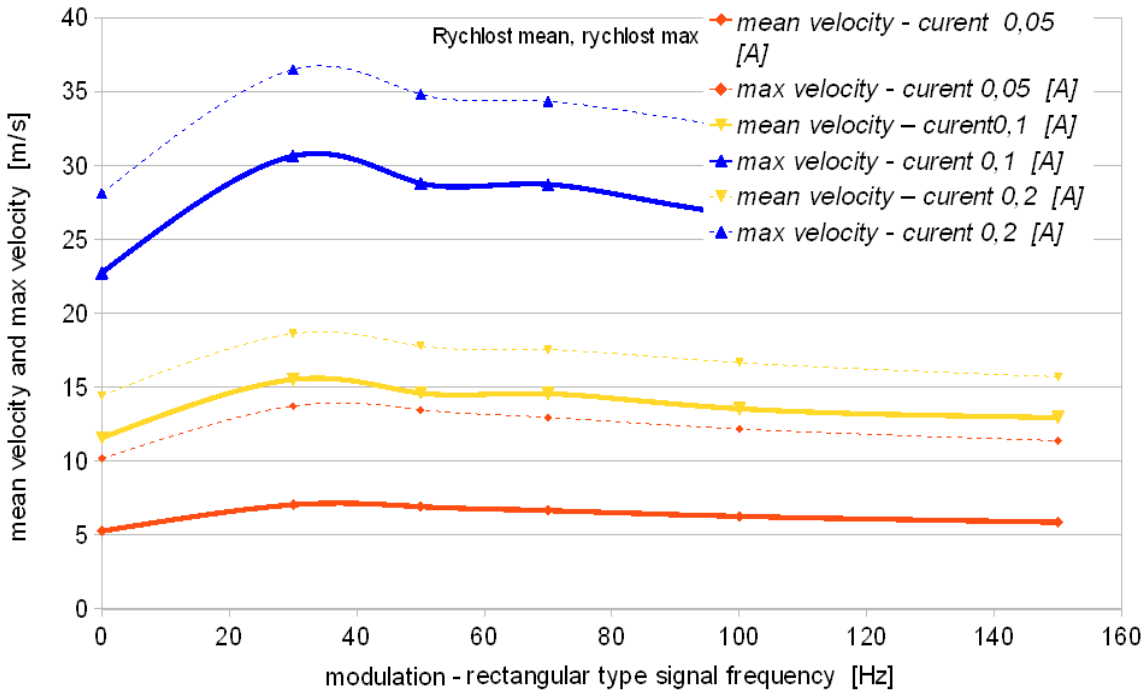

Fig. 11. *Mean velocity of SJ - frequency characteristics, outlet jet with 1,0[mm]*

3.3 Mean velocity of SJ - frequency characteristic of generators no. 1-9

This measurement shows small differentiates between synthetic jet generators no. 1-9, see Fig.12. This differenties are acceptable for next wind tunnel measurement with aerodynamical obstacle.

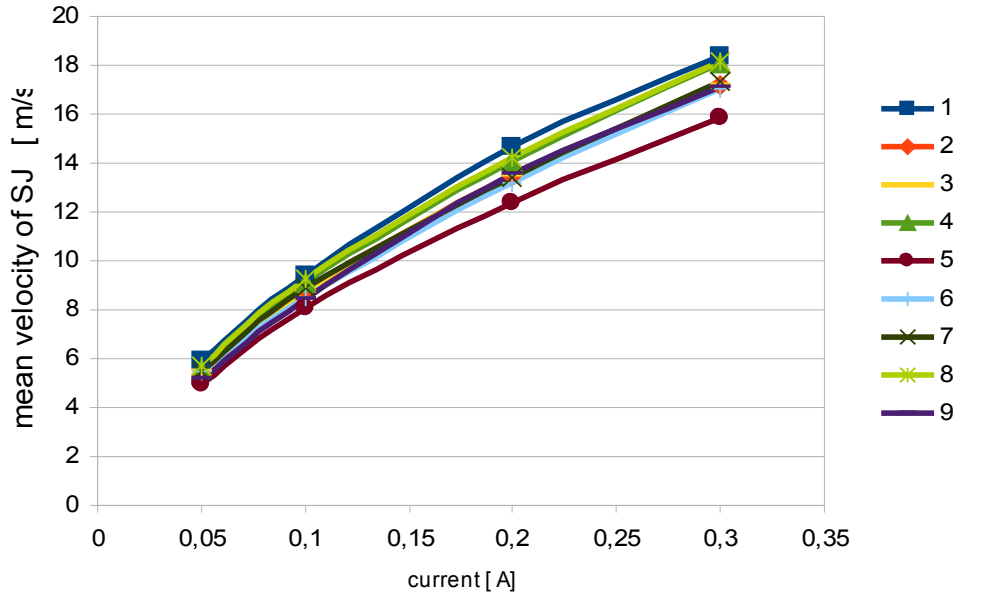

Fig. 12. *Differenties between synthetic jet generators no. 1-9, outlet jet with 1,0[mm]*

4. Conclusions

It were measured required characteristics. The complete measurement was carried forthe time - consuming for only one selected the generator out. For the remaining generators were measured only the selected characteristics, which allow comparison characteristic of all generators. Measured characteristics are useful for the wind tunnel measurements with application of this technique of active boundary layer control.

Acknowledgment

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List of symbols

L	characteristic dimension instantaneous velocity	(m)
St	Strouhal number	(1)
f	frequency of vortex shedding	(s^{-1})
u_0	mean velocity (time averaged)	($m \cdot s^{-1}$)
$u_0(t)$	instantaneous velocity	($m \cdot s^{-1}$)
v	fluid viscosity	($m \cdot s^{-2}$)

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