BASIC CHARACTERISTICS OF ARRAY OF PULSATILE JET

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Abstract: The presented paper shows the results of measurement of basic characteristics of array of pulsatile jets which are used to enhance the efficiency of ejectors. Four pulsatile jets forms cross like structure where perpendicular couples are operating in two basic modes (a) in phase and (b) in antiphase. Paper presents phase averaged velocity profiles and velocity fields. All of the presented experiments are realized using hot wire anemometry method.

1. INTRODUCTION

Pulsatile (Synthetic) Jets [1] are jets of fluid that are generated by pushing or pulling a fluid through an orifice by the interactions within the train of vortex rings. These vortex rings move with a velocity U that must be high enough to prevent interaction with suction in the orifice. Vortex rings develop and dissipate and the SJ has the character of a free jet when it is far enough from the end of the orifice. The time-mean mass flux of the flow in the orifice is zero, and so these devices are often called zero-net-mass-flux jets. Though the nozzle works with zero-net-mass flux, the momentum in the z -direction is non-zero. Synthetic jets have many promising applications such as control of primary flows [2] and are a valuable alternative for cooling applications [3, 4].

Figure 1: Schema of the pulsatile jets array operating (A) in phase (B) in antiphase

The present paper focuses on the improvement of the ejectors using pulsatile jets. Based on the papers [5, 6], the oscillating character of the so-called synthetic jet (SIJ) is used to enhance the efficiency of the ejector by affecting the mixing layer. This paper also shows influence of important parameters such as power of generated jet and frequency.

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The synthetic jets are characterized by two length scales: The length scale of the output orifice (diameter D), and the "stroke length" L_0 [1]. The L_0 is defined by integration of the orifice velocity over the extrusion (discharge) stroke [1]. The time-mean orifice velocity during the extrusion stroke, U_0 is defined as $U_0 = L_0/T$, where T is the time period, i.e. $T = 1/f$. There are many possible definitions of the Reynolds number, one of them sounds as $Re = U_0 D/\nu$ [1].

2. EXPERIMENTAL SETUP

Figure 1 shows a schematic view and main dimensions of the experimental synthetic jet actuator and the configuration tested in this study. The four actuators consist of a cavity which is equipped with an emitting orifice (diameter D was equal to 3mm) and electrodynamically actuating diaphragm originating from SP-7/4S loudspeakers of

Figure 2: Frequency characteristic of single synthetic jet. Eigenfrequency of the actuator (426HZ) is depicted by red line.

Figure 3: System of coordinates and definition of significant positions.

diameter of 66 mm, with nominal electrical resistance 4 Ω . The orifices of the actuators are oriented inside the cavity of mixing chamber. The cavity of mixing chamber has a diameter of 40mm. The power input of the actuators was 1.3W, constant for all presented experiments.

The four actuators of SJ were connected up in (A) in phase mode when all actuators are working in phase and (B) in antiphase mode when two opposite actuators are working in phase, while the other two are delayed by half a period.

Based on an analysis of the eigenfrequency Fig. 2 the working frequency of the actuators was set to 426Hz. This frequency has been used in all presented experiments.

The velocity was measured by a Dantec Stream Line system. A Dantec 55P11 straight wire probe operating in constant temperature mode was used to measure velocity magnitude. The probe was traversed over four section lines in the cavity (0° - 180° ; 30° - 210° ; 60° - 240° ; and 90° - 270°) as shown in figure 3. The sampling frequency and number of samples were 10 kHz and 32768, respectively in all of presented experiments.

3. RESULTS

The phase averaging of the velocity during one cycle was carried out by means of a decomposition of the quantity. For example, in the case of the velocity decomposition, $u = U + U_f + u'$, where U is the time-mean velocity, U_f is the periodic phase-locked

Figure 4: a/ Temporal and b/ spatial development of velocity profile in (A) phase and (B) antiphase mode

component, and u' is the fluctuation component (represented by RMS velocity fluctuations). Taking into account the pulsating velocity character at the actuator orifice, positive (extrusion) and negative (suction) flow orientations were assumed and the velocities during the suction stroke were inverted to reflect the flow direction. Because it was not possible to measure the velocity profile just inside the nozzle, the special

technique which was presented in [7] was used to evaluate the time mean orifice velocity U_0 – average velocity during the extrude part of the period.

Figure 4 illustrates the development of the fluid “puff” out of the actuator and the development of the velocity profile. Depicted angular positions correspond to angles mentioned in Fig. 3. Extrusion from the orifice is considered to be a positive velocity. The figure 4 also shows the increase of the phase shift of the maximum velocity during advection. The range of the actuator suction is approximately r/D equal to 1.8, further downstream only a positive orientation of the radial velocity component exists during the actuation cycle. From this experiment the Reynolds number was established as $Re \approx 1200$. There is any significant difference neither in maximal velocity nor in phase shift between the results of in phase (A) and in antiphase (B) modes.

4. CONCLUSIONS

The results shows, that the stream of the air is in all cases (in phase or in antiphase) powerful enough to reach the centre of the mixing cavity. This is a promising result for application of designed array for enhancement of ejector efficiency. We can assume that the stream is strong enough to affect the mixing layer of the ejector and to change the character of the mixing process by destroying the laminar mixing layer.

5. ACKNOWLEDGEMENT

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