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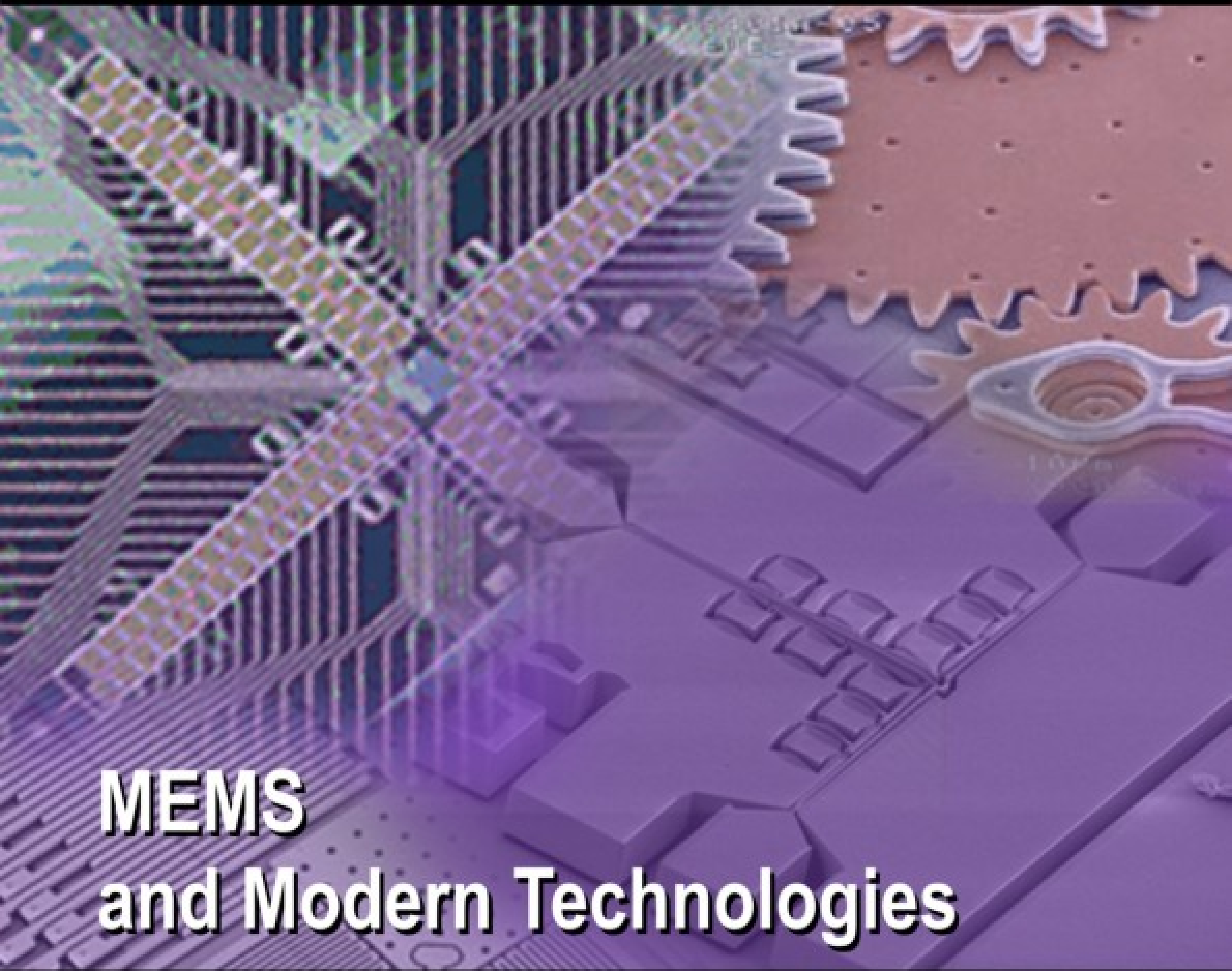

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Gaseous Fluidics Control Device

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Abstract: Fluidics is a new technology arising from a re-appraisal of a very old technology, namely fluid power and its control. Fluidic technology based on natural oscillation phenomena is a relevant topic in several strategic areas. This technology of using the flow characteristics of liquids or gases to operate a control system is fairly old; it was in the 1960s that researchers started to use fluidics. Important contributions from fluidic logic technologies are associated with the fluid behavior known as the "Coanda effect". A lot of attention has been paid to the transport phenomena in the micro geometries because micro fabrication enables us to manufacture low channels ranging from few micrometers to few hundred micrometers. This paper describes a new actuator for flow control applications. The gas diffusion, control is very important operation in the fields of nature and industry. *Copyright © 2008 IFSA.*

Keywords: Fluidic, Microfluidic, Amplifiers, Oscillators, Gas flow

1. Introduction

Many important contributions to fluidic technologies are associated with the fluid behaviour that is known as the "Coanda effect" [1-5]. It is observed that for a free jet emerging from a jet nozzle, the stream tends to follow a nearby curved or inclined surface. The "Coanda effect", discovered in the 1930s by Henri Coanda [1], it also –attaches- itself to and flows along the surface if the curvature or angle of inclination is not too steep. Coanda explained this tendency as being caused by the jet stream's entraining nearby fluid molecules. When the supply of these molecules is limited by an adjacent surface, a partial vacuum develops between the jet and the surface. If the pressure on the other side of the jet remains constant, the partial vacuum, which is a lower pressure region, will force the jet to bend and attach itself to the wall.

Among fluidic microsystems, micro valves play an essential role in gaseous transport and control phenomena. Most of the active (controlled) as well as passive (reacting to the flow) micro valves involve moving mechanical parts.

A lot of attention has been paid to the transport phenomena in micro geometries because micro fabrication enables us to manufacture low channels ranging from few micrometers to few hundred micrometers. Micro fabrication technique can be applied in making the micro channels, and also can be used in manufacturing the microsystems like micro cooling devices, micro turbines, and so on. The fluid low in the micro channels attracts industrials attention because it has a variety of advanced applications in the micro electro-mechanical systems (MEMS).

Some works are made on the bistable wall-attachment fluidic amplifier [1, 2, 9], which is made to oscillate connecting the output ports to the control ports. This provides a feedback loop, from each output port to its corresponding control port. In this application, a portion of each primary outflow is captured in a feedback channel, and then this captured fluid is used to redirect the primary outflow over to the opposite leg.

The geometrical characteristics of the micro fluidic oscillators defined in all works show the main parts of the device that include: supply input, interaction region, control ports, outputs, and feedback arms (or loops).

It also “attaches” itself to and flows along this surface if the curvature or angle of inclination is not too sharp [1]. The fluid molecules nearly the jet-entraining stream causes this tendency. When the supply of these molecules is limited by an adjacent surface, a partial vacuum develops between the free jet and the surface. If the pressure on the other side of the jet remains constant, the partial vacuum, which is a lower pressure region, will force the jet to bend and attach itself to the wall. Fig. 1 show a fluidic device based in this effect known as the wall-attachment fluidic amplifier [3]. A turbulent jet emerging from the supply port interacts with flows from the control ports in the interaction region. As a result, the jet from the supply port is directed to one or another output, depending on the pressure (or flow) of the control ports. The fluidic oscillator proposed in this work consists of a bistable wall-attachment fluidic amplifier, which is made to oscillate connecting the output ports to the control ports. This provides a feedback chamber, from each output port to its corresponding control port.

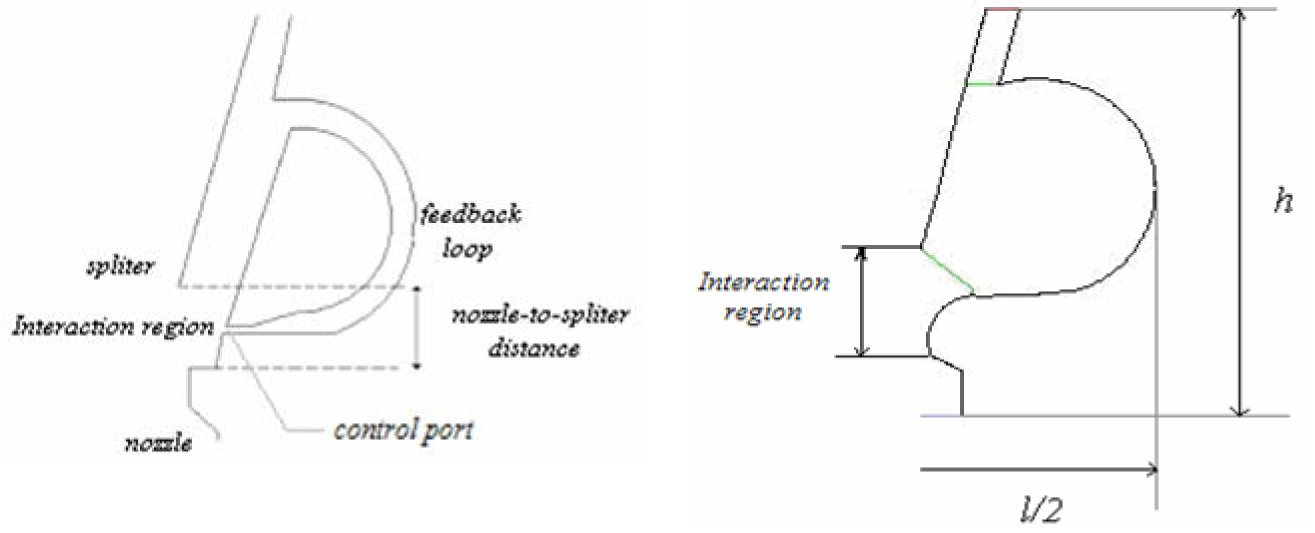


Fig. 1. Description of schematic oscillator’s geometry.

The functioning of a fluidic oscillator with characteristic dimensions in the millimetre range was verified by carrying out a numerical simulation. With this simulation also the dependence of the oscillator frequency on the geometry and the volume flow through the structure was determined.

The variation of volume chamber, the angle inclination and nozzle to spliter distant are important factors in the fluidics-oscillators behaviour. An oscillatory movement of a tool placed at the output.

The oscillation frequency as a function of the volumetric gas flow rate with the length of the feedback arm as a parameter. It can be seen that the oscillator operates with frequencies in the range of kilohertz, confirming a fast performance expected for miniaturized devices.

2. Mathematical Model of Fluidic Systems

In all the works to achieve in this domain, they kept the same phenomenon of out-flow and they are based on the geometry of the system and these dimension to measured or controlled this out-flow this which permitted to use the same formulation in this researches. A portion of each primary outflow is captured in a feedback channel, and then this captured fluid is used to redirect the primary outflow over to the opposite leg. It is now possible to detect, interlock, and power complex operations by using gas throughout a system [1]. Also, type of flow meter possesses easy maintenance and manipulation, and the advantage that the output flow meter can be transformed in an electric signal facilitate the reading process of the total flow rate.

With the device operating in an incompressible (Mach Number — ratio between local velocity and speed of sound — less than 0.3) to moderately compressible (Mach Number between 0.3 and 0.7) regime, the frequency of oscillation determined by the fluid insertion time in the control port interconnection (feedback loop), by the amplifier switching dynamics [3], and by the flow-rate if the Strouhal number expression (1) and Reynolds Number (expression (2)) are constant or linearly dependent [1]. In expressions (1) and (2) n is the frequency of generation of oscillations inside the interaction region; D is the hydraulic diameter; u is the jet velocity; ρ is the fluid density; μ is the absolute viscosity. These conditions, the feedback oscillator can be designed to give a substantial linear range of frequency–velocity, and tends to provide a cleaner signal at low velocities. The reason for the cleaner signal is that the feedback oscillator has few modes of oscillation competing for the energy at low velocities.

$$Str = \frac{n.D}{u} \tag{1}$$

$$\mathrm{Re} = \frac{\rho.u.D}{\mu}. \tag{2}$$

The period of oscillation, T, is given in expression (3).

$$T = 2.(\tau_t + \tau_s) = 2.\left(\frac{l}{c} + \frac{\xi.L}{u}\right), \tag{3}$$

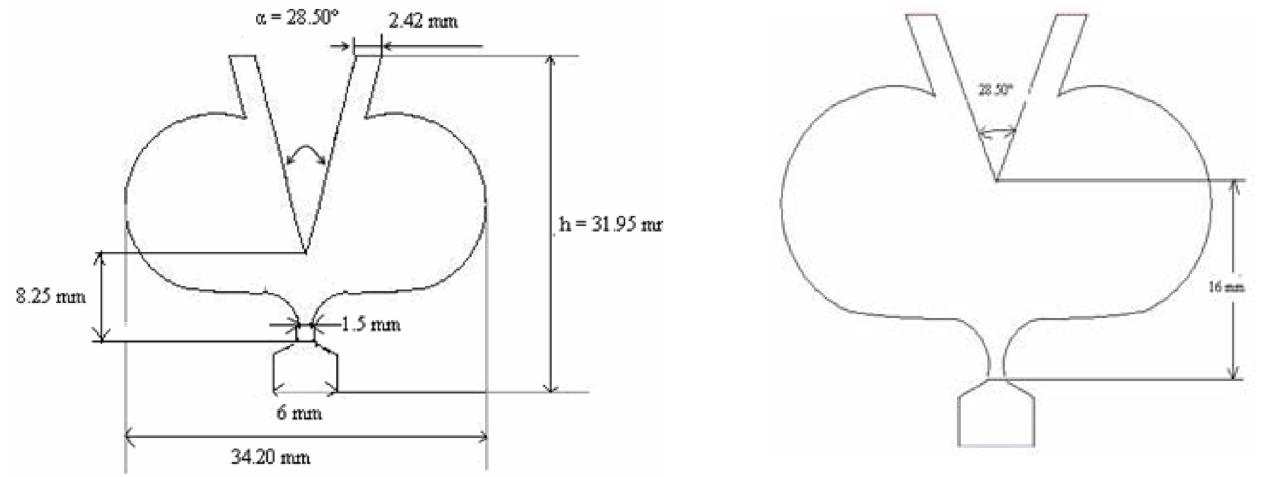
τ_t: is the transmission time; τ_s: is the switching time;
l: is the length of one feedback loop;
c: is the speed of wave propagation (if the duct is not small, the speed of wave propagation tends to the speed of sound);

L: is the nozzle to- splitter distance;
ξ : is an empirical constant. A fast switching device has a value of $\xi \leq 1 \div 2$, but higher values can occur as a function of velocity and oscillation frequency unbalance.

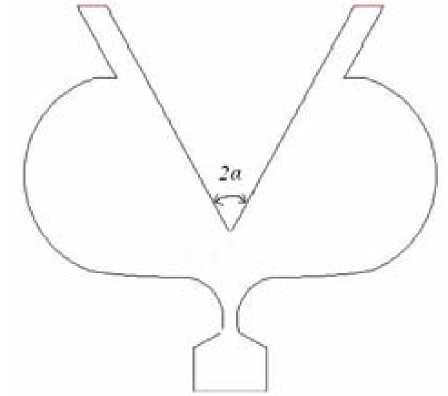
For subsonic or transonic flow, associated with quasi laminar or turbulent regime, the frequency of oscillation is determined by: the time of entrance of the fluid in the control port interconnection (feedback loop), by the amplifier switching dynamics, and by the flow-rate [5]. In this case, the typical feedback oscillator can be designed to give a long linear range of frequency against velocity characteristics. The feedback oscillator tends to provide a cleaner signal at moderate velocities (Mach Number - ratio between local velocity and local speed of sound - between 0.3 to 0.7). The reason for the cleaner signal is that the feedback oscillator has fewer modes of oscillation competing at lower velocity.

3. Simulation of Milimetric Fluidic Oscillator

In this work, we undertake simulation of oscillators, the feedback loops represented by chamber Fig. 2. The geometry oscillators can use in multitude application, for example mixing, medicine and control mini mass flow of toxic gas.



Case (1) Case (2)



Case (3)

Fig. 2. Geometries of simulate oscillator.

Meshing model 16666 mixed cells is presented in Fig. 3:

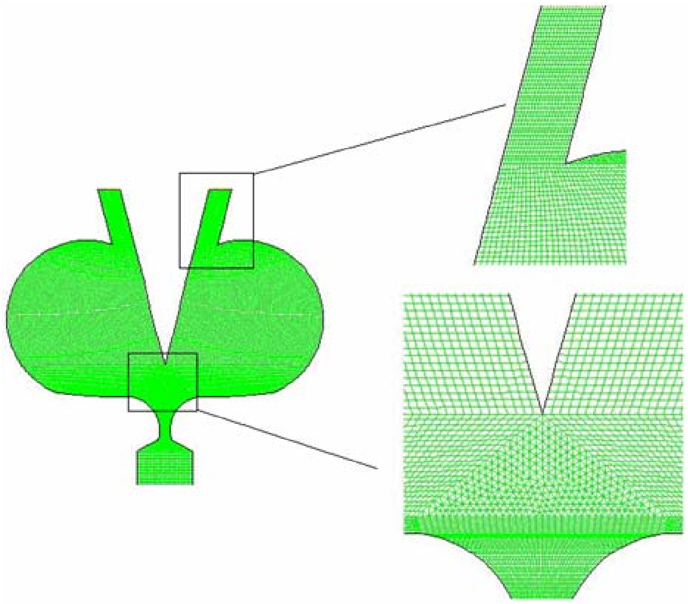


Fig. 3. Meshing geometry of simulate oscillator.

4. Interpretation of Results and Perspectives

The following results present the mass flow trough the device respectively left and right output (Figs. 4a, 4b).

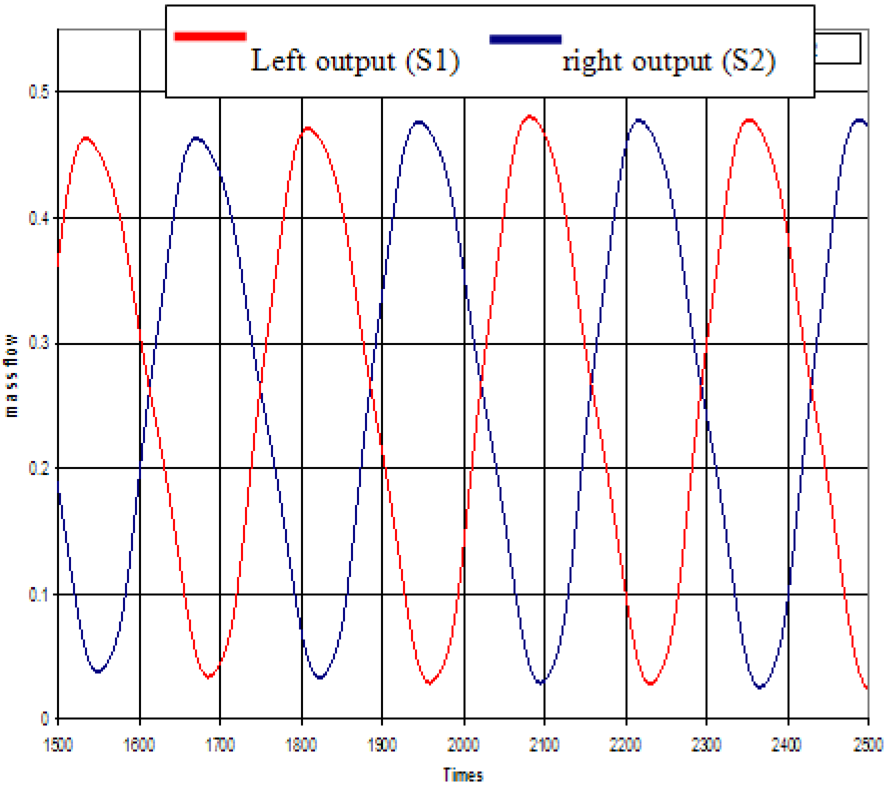


Fig. 4a. Signal of output Mass flow ΔP=1 bar, case (1).

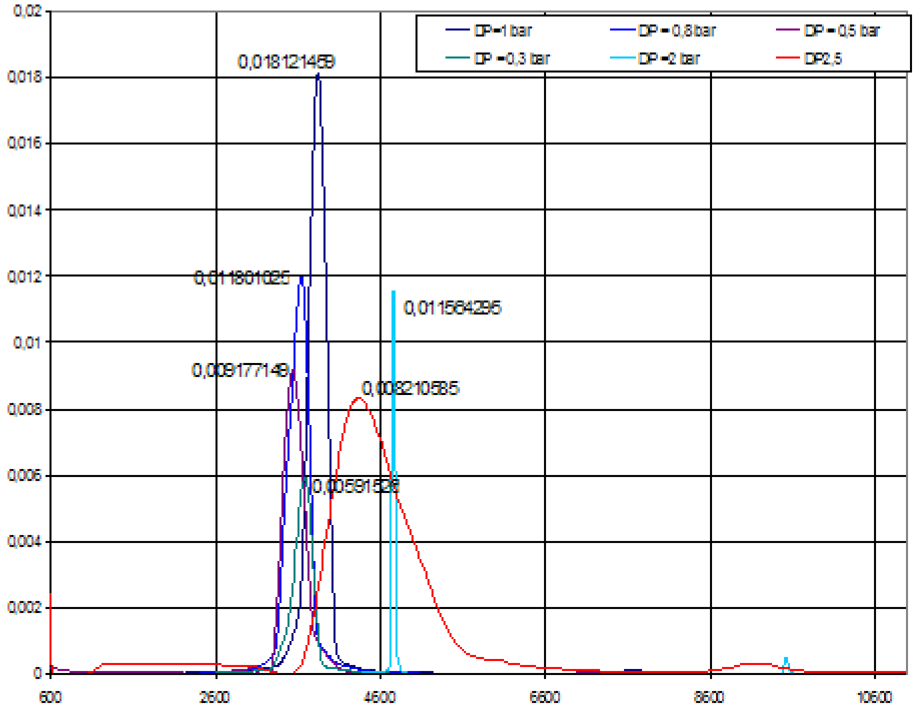


Fig. 4b. Spectral analysis of Mass Flow signal FFT.

5. Conclusions

The frequency oscillating fluidic oscillator millimetric size was simulated CFD Code. The first results of theses numerical calculations indicate evaluation oscillating frequency of fluidic oscillator. The principal geometrical characteristics are investigated to found respective frequency. The effect of combination of two phenomena's, acoustic and mass transport flows. The frequency oscillation increase by the augmentation of (ΔP/P) Fig.5. The difference behaviour between three cases is established in Table 1, the frequency of first and third cases is greatly than the second case. This result indicates the importance of nozzle to splitter distance. In perspective we propose to experiment the oscillator model for important number of gaseous industries.

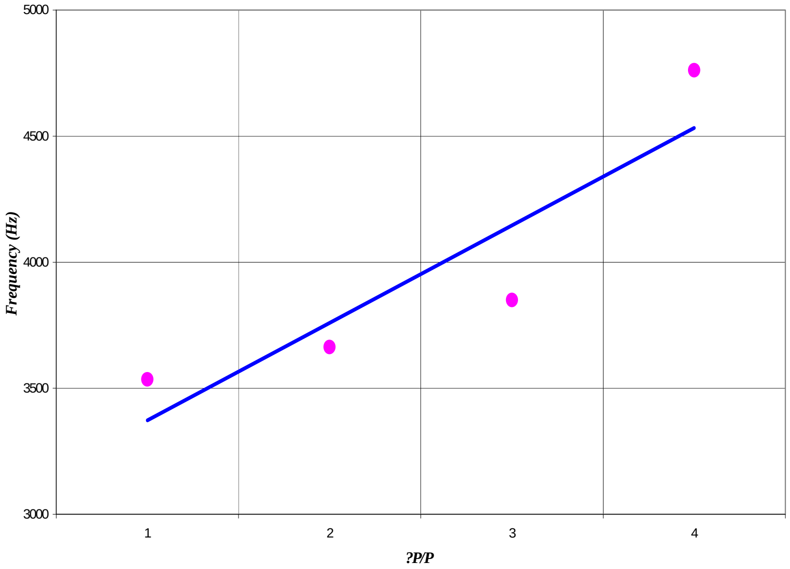


Fig. 5. Frequency oscillation of various (ΔP/P), case (1).

Table 1. Mach number, Reynolds at nozzle and Frequency oscillations devise for three studied cases ΔP =2 bar.

Geometries	Mach number	Reynolds	Frequency, Hz
Case (1)	1.18	34715	4854
Case (2)	0.58	32065	324
Case (3)	0.52	29766	4377

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Guide for Contributors

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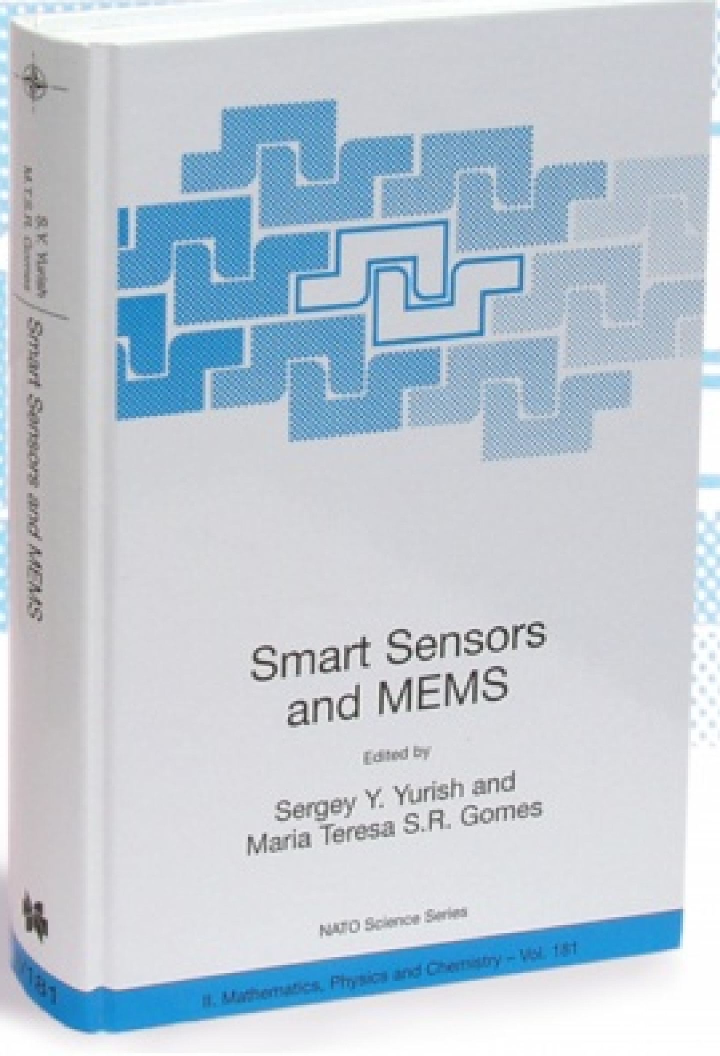

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