MICRO MIXTURE: A TECHNICAL SOLUTION WITH MICRO FLUIDIC OSCILLATOR IN CHEMISTRY

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Abstract- A passive mixing strategy is proposed to enhance mixing of two fluids through perturbed jet low. The diffusion flux given by the Fick's law characterizethe mixing rate.. A numerical study of passive mixers has been presented. This paper is focused on the modeling of a micro-injection systems composed of passive amplifier without mechanical part. The micro-system modeling is based on geometrical oscillators form. An asymmetric micro-oscillator design based on a monostable fluidic amplifier is proposed [2,7]. The characteristic size of the channels is generally about a few hundred of microns. The numerical results indicate that the mixing performance can be as high as 99 % within a typical mixing chamber of 0.20 mm diameter inlet and 2.0 mm distance of nozzle - spliter. In addition, the results confirm that self-rotation in the circular mixer significantly enhances the mixing performance. The novel micro mixing method presented in this study provides a simple solution to mixing problems in microsystem for application in chemistry.

Keywords- Micro Oscillator, Modeling, Micro Mixture, Diffusion, Size Effect, Chemical Equation.

I. INTRODUCTION

As biochemical reactions that are performed in bio-MEMS require mixing, mixing is an important issue in bio-MEMS. There has been increasing interest among both biologists and researchers at the medicinal laboratories on the study of mixtures on a metric and micro scale. In the context of the MEMS, a numerical study on static micro mixers and the possible prospects for technical adapted solution of microsystems have been presented.

Micro mixers can be classified under two categories, passive and active. Whereas external perturbations are introduced in active micro mixers to enhance mixing, the mixing process in passive mixers completely relies on diffusion or chaotic advection.

Were widely studied in the 1960s [2, 6] the characteristic size of the channels is generally about a few tens of microns. This miniaturization involves series of fundamental problems related to the fluid mechanic. Indeed, at these scales, the fluidic flows are laminar [1]. The working principle of this device consists in disturbing the flow of jets moving along the principal channel by flow oscillations generated by three pairs of lateral canals. The device is called micro injector.

In these cases, the oscillators use special designed geometric configurations, identified by the absence of moving parts, to create an environment where self-induced, sustained oscillations will occur [2, 3], they can be used as flow meters. A novel fluidic oscillator has been developed and tested by V. Tesar, make these oscillators attractive as micro reactor injection application. A fast micro mixing is essential in many operations that are employed in biochemical analysis, administration of drugs, and also other biological processes involving handling of cells and enzymatic reactions, which occur in pharmaceutical products.

When transverse-sectional dimensions of channel are approximately ten micrometers, the molecular diffusion can facilitate mixing of two fluids in few seconds. However, when dimensions are approximately hundred micrometers, a micro-mixer-based molecular diffusion can facilitate mixing in ten seconds [1].

The literature describes significant number devices that have been designed to improve the mixing on a nanometre scale [3 -6]; these devices are the micro mixers that have been categorized into active and passive based on the pattern of control flow [7-10].

II. DESIGN AND OPERATION OF THE OSCILLATOR DESCRIPTION:

Micro oscillator was obtained from wall attachment micro fluidic amplifiers using a feedback loop from the outputs to the control input, Fig. 1 [2-4]. The principle of oscillators is based on a fluid jet, which injected into the oscillator, bends due to small fluctuations towards one of the attachment walls.

Some examples of systems and processes that might employ this technology include inkjet printers, blood-cell-separation equipment, chemical synthesis, genetic analysis, drug delivery, electro chromatography, micro-scaled cooling systems of electronic devices which generate high power. The fluid flow on the bent side of the jet is restricted and a

low pressure regime is created, which causes the jet to attach to the wall (Coanda effect) [5-7].

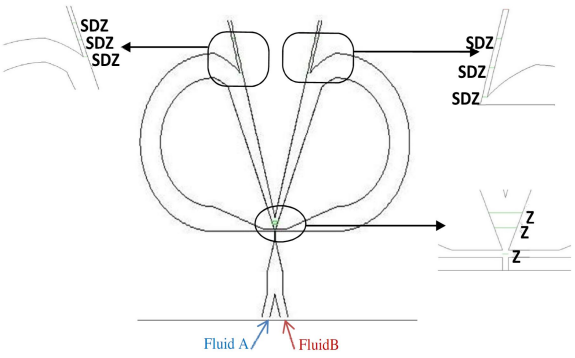


Fig. 1, Description of oscillator geometry

Table1, the geometrical characteristics

Geometric characteristics	Values (mm)
Width of the geometry	46.46
height of the geometry	39.62
the nozzle diameter	0.20
supply diameter	6.00
distance nozzle-spliter	2.00
the outlet diameter	0.50
the inclination angle	28.5

III. APPROXIMATION OF THE OSCILLATION FREQUENCY

Expression (1) represents the Reynolds number, with (ρ) the density and (μ) the dynamic viscosity:

$$Re = \frac{\rho \cdot u \cdot D}{\mu} \qquad (1)$$

The flow phenomenon is essentially based on the influence of the geometry and dimensions of the system to measure and control the flow. The expression (2) represents Strouhal number, with (f) the frequency of oscillation in the interaction region, (D) the hydraulic diameter and (u) velocity of the jet:

$$Str = \frac{f \cdot D}{u} \qquad (2)$$

The period of oscillations is determined by the switching time from the attachment wall to another and the transmission time through the feedback channel [3-6]; the frequency is determined by expression (3):

$$T = 2 \cdot (\tau_t + \tau_s) = 2 \cdot \left(\frac{1}{C} + \frac{\xi \cdot L}{u}\right) \qquad (3)$$

Hypotheses: The simulation of the micro-injection systems is obtained with several hypotheses:

- ✓ Air and turbulent regime
- ✓ Incompressible ideal gas flow.
- ✓ Inlet pressure 4×10^5 Pa
- ✓ Outlet pressure 10^5 Pa (atmospheric pressure).

IV. RESULT OF THE OSCILLATOR SIMULATED

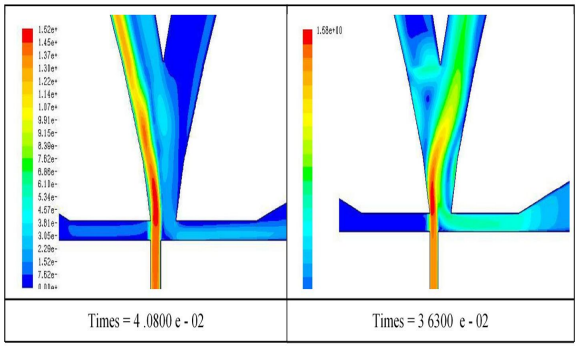


Fig. 2, Mach number of mini-fluidic oscillator to two distinct times.
Fluid: air P_{inlet} = 4 bars; P_{outlet} = 1 bar.

The figure 2 shows two different instants of the period of operation of the fluidic oscillator, supplied at a pressure of 4bars. We note that the jet toggles as left branch to the right branch.

The mass flow rate to the two outputs, left (S1) and right (S2) of the system, to pressure variation ΔP = 3bars represented in figure 3.

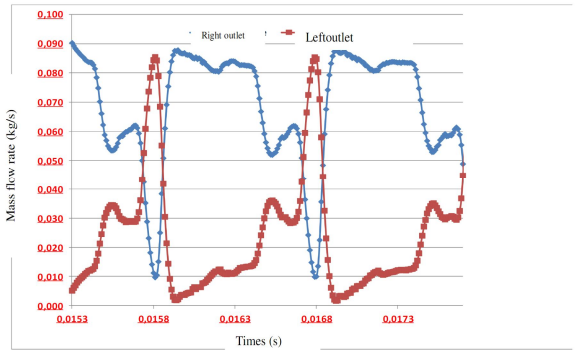


Fig. 3, the mass flow rate a function of time (s) to the two outputs left and right (ΔP = 3 bars).
We see the tilting of the fluid (air) left and right, changing mass flow is regular and sinusoidal.

A. The influence of the variation of inlet pressure
We will try to vary the input pressure and see its influence on the oscillation frequency. The oscillation frequencies were measured directly from the temporal signals and corroborated by spectral analysis of the signal flow in the O1 section. The frequency increases with the increase of the pressure variation up ΔP = 3.5 bars (figure 4).

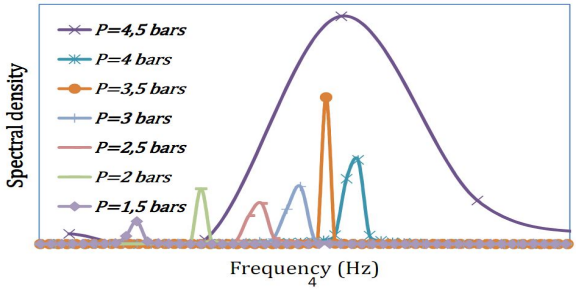


Fig. 4, the spectral analysis of the signal flow in the output

The Fluidic oscillator frequency to millimetre scale was simulated by the CFD code. The first results of numerical calculation of the evaluation indicate fluidic oscillator frequency, increases with increasing of the report ΔP/P, for a pressure range between 0.5and 3.5 bars (Figure 4).

III.6.1.2. Variation in the distance Nozzle - splitter

For enriching the previous results, we increased the distance nozzle - splitter and see their influence on the frequency response.

Table III.2: The oscillation frequency for different nozzle - splitter values (with different values of pressure).

ΔP (bars)		1	1,5	2	2,5
Frequency (Hz)	case1 : DNS=2mm	4395,6	5151,51	5757,57	6239,31
	case2 : DNS=2,5mm	4090,9	4848,48	5576,92	6107,22

DNS : Distance Nozzle - Splitter

Increasing the distance between the nozzle and the splitter decreased frequency.

B. Influence of the stability position

To see the influence of the position of the stability of the frequency response in order to get a good mixing thereafter, we will study two cases, single and double oscillator.

Table (3) summarizes the different frequency values obtained for the two cases studied (mono and bistable) for various values of inlet pressure.

Table 3, frequency for the two cases mono and bistable for differents values of pressure.

ΔP(bars)		1,5	2	2,5	3	3,5
Frequency(Hz)	Bistable	4642,85	5172,30	5560	6006	5770
	Monostable	979	1221	2307	2500	2700

From the results obtained for the two simulated cases (monostable and bistable), shows that the change of the position of stability in the second case the frequency decreased.

V. SPECIES TRANSPORT EQUATIONS

When you choose to solve conservation equations for chemical species, FLUENT predicts the local mass fraction of each species, Yi, through the solution of a convection-diffusion equation for the ith species. This conservation equation takes the following general form:

$$\frac{\partial(\rho Yi)}{\partial t} + \nabla.(\rho \vec{v} Yi) = -\nabla.\vec{J}i + Si \qquad (4)$$

In the first equation, Ji is the diffusion flux of species i, which arises due to concentration gradients. By default, FLUENT uses the dilute approximation, under which the diffusion flux can be written as:

$$\vec{J}i = -\rho D_{i,m} \nabla Y_i \qquad (5)$$

Where Di;mis the diffusion coefficient for species i in the mixture.

A. Estimation of the efficiency of mixing:

For estimating the mixing of index mixture, the following expression [11-13] is specified:

$$Ie = 1 - \frac{1}{\tilde{M}}\sqrt{\frac{\sum (M_i - \tilde{M})^2}{N}} \quad \text{with} \quad \tilde{M} = \sum \frac{M_i}{N} \qquad (6)$$

M and Mi, represents mass fraction of i pixel and average, respectively

VI. DESCRIPTION OF THE GEOMETRY

In this section, we will try to analyze the performance of the mixer-type bistable fluidic oscillator. The basic geometry of our micromixer has two inputs in diameter 1.38mm and two out puts circular section of diameter 0.5 mm, its profile is shown in (Figure4). We impose the inlet and outlet pressure conditions, as a total pressure in the entry area and a static pressure at the output (figure 1).

VII. MIXING RESULTS

A. Estimation of mixture efficiency

We present are below the mass fraction (I in %) of the mixture for two different inlet pressure (p= 3bars and p =3.5 bars), we will interested at the quality of the mixture observing fields mass and normalized efficiency index in different sections along the oscillator fraction. The percentage values of the various positions are summarized in the following table:

Table 4, the values of the index mixture

Position		Z1	Z2	Z3	SDZ1	SDZ2	SDZ3	SGZ1	SGZ2	SGZ3
I(%)	ΔP = 3 bars	90	75	85	99	99	99	99	99	99
	ΔP = 3,5bars	99	95	83	95	99	99	89	99	99

The mass fractions of the oscillator along show that the mixing is continued in the discharge channel. It is noted that the oscillation phenomenon promotes mixing by diffusion.

Efficiency Index from 75% to the input of the mixing zone (Z1) to a value of 99 % at the output of the oscillator (SDZ3 and SGZ3) and imposing different pressures at the input of mixer (ΔP = 3bars, ΔP=3.5bars). We notice an improvement in the index of the mixture zones Z1and Z2

CONCLUSION

In this work, over all modelling of a microwave oscillator has been proposed to normalize his behaviour as passive mixer. The performance of the injection system oscillating millimeter size was simulated. Our results show that efficient mixing can be obtained along this by taking advantage of the geometry of the oscillatory frequency which serves to destabilize the diffusion layer between the two fluids to be mixed. Through this study, we showed that the value of the mixing index is very interesting and improves the long output channels, until it reaches the value of 99% at the output. This will lead us more (perspectives) to use this model for mixing chemicals.

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