


Editorial

Editorial for the Special Issue on “Fluidic Oscillators—Devices and Applications”

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Fluidic oscillators are devices that produce a temporally and/or spatially oscillating output of fluid flow without requiring any moving parts. In general, there are three types of fluidic oscillators, categorized by the underlying mechanism to create an oscillatory output behavior. Figure 1 depicts representative geometries of these categories (reproduced from Ref. [1]). The key metric used in these categories is the number of feedback channels in each design, ranging from zero to two feedback channels. Fluidic oscillators with zero feedback channels, or so-called feedback-free oscillator, (Figure 1a) are based on two jets colliding within a mixing chamber, which creates an oscillatory outflow direction at the exit of the chamber. A design with one feedback channel (a so-called sonic oscillator) is shown in Figure 1b. The main jet attaches to one side of the diffuser and creates a pressure differential within the feedback channel that loops over to the other side of the main jet. Then, the main jet is pulled and pushed over to that side of the diffuser, thereby creating an oscillatory motion of the main jet. The third category features two feedback channels (Figure 1c). A portion of the main jet enters into one feedback channel that guides the flow back to the mixing chamber inlet, where it pushes the main jet over to the other side, and the process repeats. All these designs can feature a single outlet to allow for a continuous sweeping motion of the main jet, or they can have discrete openings to provide pulsating jets from each opening. The frequency of the jet’s oscillation can range from the order of 1 Hz [2,3] to >20 kHz [4], which is a function of the oscillator’s design, size, and supply rate.



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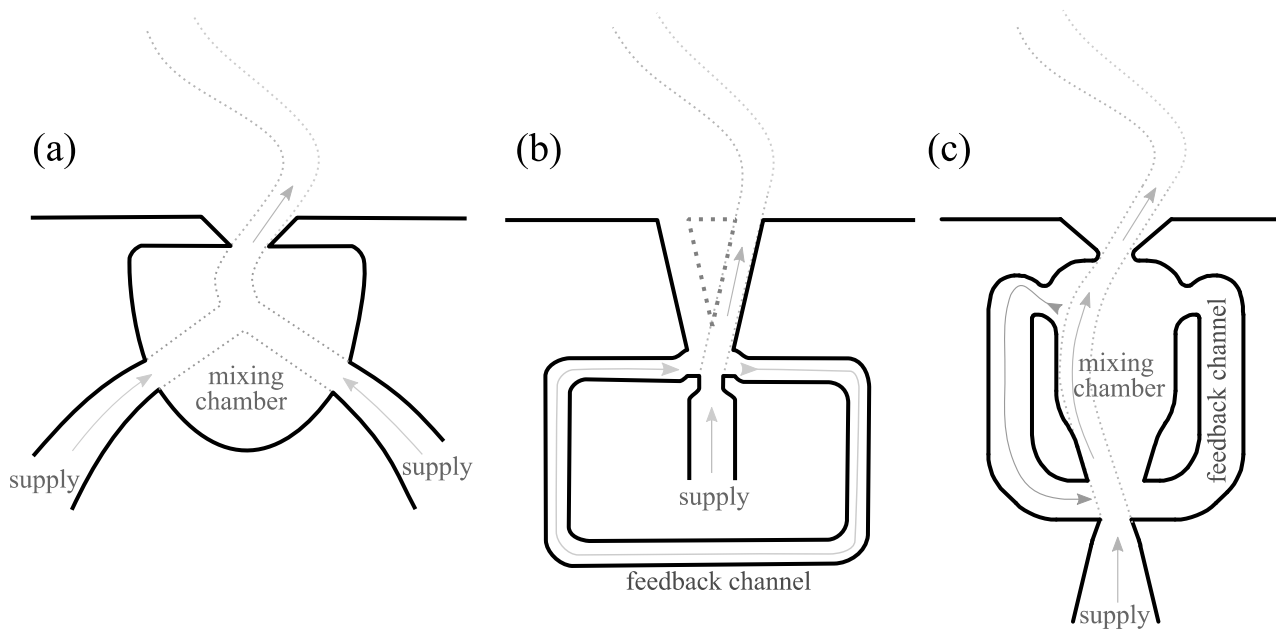


Figure 1. Main categories of fluidic oscillators (reproduced from Ref. [1]): (a) feedback-free oscillator [5], (b) sonic oscillator [6], (c) oscillator with 2 feedback channels [7].

Fluidic oscillators were developed in the 1950s in the Harry Diamond Laboratories. Originally, they were often referred to as fluidic diverters, fluidic amplifiers, fluidic switches, or flip flop nozzles. Initially, these devices were intended to be used for non-electronic circuitry for guidance, navigation, and control. Thereby, this field was often referred to as fluid logic, hence the name “fluid-ic”. From the 1960s to the 1980s, these devices and their applications were comprehensively studied. A compendium called “Fluidics Quarterly” [8] captured a wide range of publications on this topic. A very thorough historical overview is provided by Gregory and Tomac [9], with several useful references therein. Additional examples for summaries of fluidic oscillator concepts and their properties were compiled by Campagnuolo and Lee [10] and Woszidlo et al. [1].

After an apparent reduction in research output, the topic of fluidic oscillators has seen a revival as of the early 2000s. One of the most prominent research areas is focused on using fluidic oscillators for active flow control. These devices have been shown to prevent flow separation over a highly deflected surface, thereby significantly increasing the aerodynamic performance of aircraft [11–13]. It is hypothesized that fluidic oscillators are more efficient than steady jets and require less mass flow, because the jets’ sweeping motion provides greater lateral impact, thereby allowing for increased jet spacing and fewer jets needed. Other noteworthy areas of using fluidic oscillators include noise control [14,15], combustion control [16], and film/impingement cooling [17].

The aforementioned research topics have sparked the development of new fluidic oscillator concepts and novel applications, as evident by over 100 related patents in recent years. Until now, only a few industrial applications (mostly involving water as a working fluid) have been established (e.g., irrigation sprinkler, shower heads, and windshield wiper nozzles). However, there are a multitude of potential applications involving fluidic oscillators, which is the basis for this journal’s Special Issue.

This Special Issue, titled “Fluidic Oscillators—Devices and Applications”, captures a few examples of current topics involving fluidic oscillators, ranging from flow control over combustion applications to various industrial systems. The use of fluidic oscillators for active flow control purposes remains a focus area of the scientific community, as showcased by Löffler et al. [18] and Koklu [19]. Liebsch and Paschereit [20] discuss the use of active flow control with fluidic oscillators for an industrial application to reduce flow separation and recirculation of harmful gases in laboratory fume hoods. Fluidic oscillators

increase the system's efficiency without reducing its safety. This application exemplifies the broader notion of using fluidic oscillators for efficiency improvements in existing systems. For example, in combustion processes, a homogeneous mixture is essential for a stable and emission optimized flame. Stability does not only involve flame position and the prevention of backward propagation but also the formation of thermo-acoustic instabilities. Those can be harmful for the process and the device itself. Due to high frequencies and high entrainment, fluidic devices have shown that they are applicable for fuel-mixture preparation for liquid fuels in gas turbines [21] as well as for hydrogen in piston engines for trucks [22]. Furthermore, lean combustion devices often involve swirling flames that may be accompanied by a precessing vortex core, which can lead to combustion instabilities and suboptimal emission. In order to prevent this phenomenon, fluidic amplifiers were investigated for volumetric flow modulation of the fuel stream by Adhikari et al. [23].

The aforementioned studies typically do not exceed oscillation frequencies of 2 kHz. However, devices employing an actively triggered fluidic switch are capable of producing an ultrasonic impulse that can be employed for non-destructive testing in concrete structure, as described by Schweitzer et al. [24]. This results in an air-coupled testing device allowing for significantly faster testing of these structures. Measurement time per test point is one of the key metrics, especially when considering large structures such as bridges or runways. The air-coupled method has the advantage of being contactless and theoretically allows for measurements in passing, which is substantially faster than conventional tests that may take up to 20 min per datapoint.

The range of potential applications for fluidic oscillators is rounded off by the topic of air bubble generation, as discussed by Tesař [25]. Creating air bubbles with defined diameters is of high interest not only for scientific observations but also for several practical applications such as waste water treatment or oxygen supply at fish farms.

The Special Issue on “Fluidic Oscillators—Devices and Applications” showcases a few examples for potential applications of fluidic devices. Several other groups are researching fluidic oscillators, and the interested reader is encouraged to follow their work. The small selection of references provided in this editorial introduction contains a vast number of pertinent citations.

Fluidic oscillators are fascinating devices with exciting research currently ongoing. The authors are confident that these devices will emerge in several industrial and commercial applications in the near future.

Conflicts of Interest: The authors declare no conflict of interest.

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