Proceedings of the 11th World Congress on Mechanical, Chemical, and Material Engineering (MCM'25)
Paris, France - August, 2025
Paper No. HTFF 217
DOI: 10.11159/htff25.217

Comparison of Continuous Jet and Synthetic Jet in a Rectangular tank

Shinnosuke Tanaka[1], Daiki Iwaya[1], Akihito Kiyama [2], Donghyuk Kang [2], Kouichi Nishibe[3] Kotaro Sato[1]
[1] Mechanical Engineering Program in the Graduate School of Engineering/Kogakuin University
2665-1 Nakano-cho, Hachioji-shi, Tokyo 192-0015, Japan
am25064@ns.kogakuin.ac.jp
[2] Department of Mechanical Engineering/Saitama University
Shimo-okubo 255, Sakura-ku, Saitama-shi, Saitama 338-8570, Japan
[3] Department of Mechanical Engineering/Tokyo City University
1-28-1, Tamatsuzuki Setagaya-ku Tokyo, 158-8557, Japan

Extended Abstract

In recent years, synthetic jets have garnered significant attention for applications such as small-scale underwater propulsion systems for ocean exploration, electronic cooling, and air purification systems [1]. Synthetic jets, generated by oscillating actuators without the need for rotating machinery or external fluid supply, are easily miniaturized and thus well-suited for flow control in confined environments. These advantages make them promising for use in medical devices, liquid pumping systems, and flow circulation in nuclear reactors.

Extensive research has been conducted on synthetic jets. For instance, McGuinn et al. [2] investigated the influence of the dimensionless stroke length L_0 on the flow characteristics of axisymmetric impinging synthetic jets. Greco et al. [3] examined the effects of both L_0 and the dimensionless nozzle-to-plate distance on heat transfer performance in turbulent synthetic jet impingement. Suzuki et al. [4] reported the emergence of self-excited oscillations in two-dimensional synthetic jets impinging on a target plate. On the other hand, in a study of water jets in a rectangular tank, Mohammed Loukili et al [5] investigated jets in the y direction in a rectangular tank and found that the development of jets in the y direction was independent of the Reynolds number.

However, there is a lack of research on synthetic jet behavior in rectangular tanks [6], and no comparative analysis has been performed between synthetic and continuous jets in such geometries. Therefore, the distinction between their behaviors remains unclear.

This study aims to experimentally and numerically investigate the behavior of synthetic and continuous jets in a rectangular tank. Flow visualization was conducted with the dimensionless depth ratio h/b_0 as a primary parameter, where the slot width on the sidewall is $b_0 = 3$ mm, and the dimensionless tank width is fixed at $w/b_0 = 50$. For continuous jets, a drain was installed at $x/b_0 = 50$, opposite the blowout slot. Key findings indicate that, unlike continuous jets, synthetic jets require no drainage outlet due to the absence of a continuous fluid supply. The direction of jet propagation and vortex structures within the tank are strongly influenced by the location of the outlet. When the synthetic jet slot is positioned near the liquid surface, the jet is drawn toward the surface, forming a stagnation point there. In contrast, in continuous jets with a drain located at $y/b_0 = -64.2$, the jet is deflected toward the opposing wall, forming a stagnation point on the sidewall opposite the slot.

References

[1] A. Polsenberg, M. Thomas, M. Milano, M. Grazier, K. G'Sell, K. Fischer, and J. Burdick, "Synthetic jet propulsion for small underwater vehicles," presented at Barcelona, Spain, Apr. 2005.
[2] A. McGuinn, R. Farrelly, T. Persoons, and D. B. Murray, "Flow regime characterisation of an impinging axisymmetric synthetic jet," *Experimental Thermal and Fluid Science*, vol. 47, pp. 241–251, 2013.
[3] C. S. Greco, G. Paolillo, A. Ianiro, G. Cardone, and L. De Luca, "Effects of the stroke length and nozzle-to-plate distance on synthetic jet impingement heat transfer," *International Journal of Heat and Mass Transfer*, vol. 117, pp. 1019–1031, 2018.

[4] K. Suzuki, T. Hiruma, K. Nishibe, D. Kang, and K. Sato, "Self-induced vibration of impinging synthetic jets, “Journal of Fluid Science and Technology”, vol. 20, no. 1, p. JFST0006, 2025. DOI: 10.1299/jfst.2025jfst0006
[5] M. Loukili, A. Lakdja, M. Bouteraa, and M. Belarbi, "Numerical modeling of jet at the bottom of tank at moderate Reynolds number using compact Hermitian finite differences method," *Fluids*, vol. 6, no. 2, p. 63, 2021.
[6] L. Wang, L.-H. Feng, J.-J. Wang, and T. Li, "Parameter influence on the evolution of low-aspect-ratio rectangular synthetic jets," *Journal of Visualization*, vol. 21, pp. 295–308, 2018. DOI: 10.1007/s12650-017-0440-8