Investigation of velocity profile and structure of counter-flowing jet

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Turbulent jets are among the most common types of free shear flows. They are significant due to their occurrence in nature and their use in environmental applications, including the discharge of pollutants into water sources and the rapid mixing of chemicals in industrial processes. Turbulent jets are typically discharged into an environment with an existing flow; therefore, different flow types can be defined based on the angle between the jet's axis and its receiving environment. Counter-flowing jets, where the angle between the jet and the background flow is 180 degrees, have received less attention from researchers.

The primary objective of the current experimental study is to investigate the velocity profile, structure, and turbulent statistical parameters of a counter-flowing jet with different jet-to-counter-flow velocity ratios. Additionally, since the structure of turbulent jets depends on the characteristics of the background flow as well as the characteristics of the jet, investigating the effect of the turbulent intensity of counter-flow on the velocity profile and dynamics of counter-flowing jets is the second goal of this research. In order to achieve the stated goals, a series of controlled experiments were undetaken in a flume with dimensions of $9 \times 1 \times 0.5\ m^3$. Point measurements of velocity were measured using a SonTek 16 MHz Acoustic Doppler Velocimeter.

The results show that counter-flowing jets can penetrate the background flow only up to a certain distance (axial penetration length). Beyond this point, the opposing flow overcomes the jet and dissipates it by a distance twice the axial penetration length. In this context, increasing the jet-to-counter-flow velocity ratios enhances the axial penetration length of the jet. Conversely, increasing the background turbulence intensity reduces both the maximum mean velocity and the axial penetration length, while simultaneously increasing the width of the jet and increasing the mixing of the jet with the background flow, as observed by the increased rms velocity in the jet . Therefore, it can be concluded that the structure of a counter-flowing jet is has two regions, the first is a jet region with rapidly decreasing characteristic velocity due to the counterflow, whose endpoint has zero velocity. This is followed by a region in which the fluid which was the jet, is advected, until it reaches the cofow velocity, will is diffuses.

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