WATER SPIRAL

A STUDY ON CIRCULAR, ELLIPTICAL AND SWIRLING JET FLOWS

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My research explores the onset of swirl in elliptical liquid jets.

Abstract

Everyone certainly knows that when open ing the tap, a circular water jet is released into the sink. When changing the orifice shape from a circle to an ellipse, we observe a jet that exhibits a chain-like shape – the so-called elliptical jet. By further forcing a swirl on the jet, we end up with a spiral – the swirling jet. The undocumented phenomenon of swirling jets with elliptical cross-sections is investigated both experimentally and theoretically as the main novelty of this work.

On the theoretical end of the spectrum, a complex set of differential equations – the so-called Cosserat equations – lay the foundation of the overall theoretical framework. Those equations are directly derived from the renowned Navier-Stokes equations and the novel derivation is presented. This makes it possible to model various jet characteristics such as the shapes and wavelengths of the jets. On the experimental side, a liquid flow circuit is established. Furthermore, an innovative 3D-printed nozzle system is developed to reproduce the swirling jets for accurate experimentation.

The comparison between theory and experiments provides profound insight into the behavior and the underlying mechanism of the different jets. As a novelty, the physics of the particular swirling jets is explained in detail. The free surfaces (shapes) and other jet characteristics are modeled and compared to experiments. The good results allow us to assess limits and find the relevant conditions that cause a jet to twist into a spiral.