Kelvin-Helmholtz Instability: Studying the Effects of Density and Velocity on Vortex Formations

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Kelvin-Helmholtz Instability (KHI) is a process that forms vortices in fluids and occurs when two fluids in contact move in opposite directions. The Richardson Number, proportional to the density gradient and inversely proportional to the velocity shear squared, describes the KHI onset when the number is below 0.25. The purpose of this experiment is to create KHI under controlled environments and investigate how different conditions affect their formation. The experiment used two different fluids: fresh and saltwater. They were pumped into an acrylic box made by the researcher so that the saltwater is kept separated from the fresh water. The box was then tilted to form bidirectional flows at the contact surface through convection. The parameters for this experiment are the salinity (density gradient) at 2%, 3%, 4%, and 5%, and the tilt angles (speed gradient) at 8, 9, 10, and 15 degrees. The results showed that there were three stages of KHI vortex formations: 1) The initial vortices form, 2) The vortices merge, and 3) The vortices decay and turbulence occurs. There was a linear relationship between density and the 1st stage occurrence time, and the vortices did not form at <9° showing the formation threshold. The initial vortex size stayed mostly constant, while the merged vortex size varied depending on the tilting angle. This research can be applied to evaluate vortex conditions remotely (e.g., meteorology, planetary sciences) or to control vortex formations in unwanted situations (e.g., fusion reactors).