Abstract

The intriguing fluid dynamics of fluid structures like liquid sheets, liquid bells, and hydraulic jumps has evoked the attention of physicists, mathematicians and engineers since early nineteenth century. In particular, a wide range of industrial applications of liquid sheets have shifted the focus of research from physics to engineering. Liquid sheets often assume a semi-closed or closed axisymmetric geometry due to surface tension of the liquid. Due to their typical bell like shape these are commonly called liquid bells in the literature and are often used for decoration purposes for their grace and beauty.

Liquid bells are usually formed by thin liquid sheets due to the impingement of liquid jets onto disc shaped objects. Their formation and shape evolution depend on a large number of parameters which include physical properties of the fluid like viscosity and surface tension, gravitational acceleration, velocity of the liquid jet as well as diameters of the liquid jet and the target disc. Although the earlier research work has analyzed the dependence of some parameters on the formation, shape evolution and stability of liquid bells, no comprehensive study has been conducted in which the surface tension of the operating fluid has been varied in a systematic manner. This thesis aims to investigate how surface tension of the operating fluid influences the formation, shape evolution, stability and disintegration of liquid bells.

A drop of liquid or solid object impinging on the free surface of a liquid is a very common observation in nature. This results in the formation of a non planar and often axisymmetric liquid sheet projecting upward from the free surface. Considering the similarity with the usual liquid bell and noting the fluid flow in the reverse direction these structures may be termed as reverse liquid bells. Reverse liquid bells formed due to the impact of a liquid drop or a solid body on the free liquid surface are transient and very short lived. Further, reverse liquid bells may exhibit high instability since the flow of liquid is in the upward direction. The phenomenon of splashing due to drop and solid object impact on liquid surfaces has been investigated in depth. However, the topic is still far from being understood fully and hence continues to attract the attention of researchers. One of the aims of the present work is to develop an experimental arrangement to create stable reverse bells over a large range of parameters. This thesis also aims to investigate in detail the formation, shape evolution, stability and disintegration of such reverse liquid bells.

Collision of liquid jets can generate liquid sheets of different geometries. A common method for propellant atomization in rocket engines involves impingement of two or more liquid jets. In the literature circular planar liquid sheet formed due to the collision of two equal coaxial circular liquid jets and a planar oval liquid sheet obtained by oblique collision of two liquid jets have been reported. However, non-planar, curved liquid sheet (similar to a liquid bell) formed due to the collision of two jets have rarely been reported and investigated. In this this thesis an effort has been made to form axisymmetric liquid bells by colliding two liquid jets.

Keywords: Liquid sheet, Nozzle, Impingement, Target plate, Liquid bell, Gravity, Surface tension, Stability, Disintegration, Reverse liquid bell, Co-axial liquid jets, Collision