ABSTRACT

Impingement of a liquid drop on a liquid surface is ubiquitous in nature and has a range of applications in industry. One can observe that when raindrops impact on water surface, splashing occurs. However, the human eye cannot see the interplay of inertia, surface tension, and viscosity that generates this fascinating phenomenon. Underlying physics of these phenomena are of fundamental significance in the context of academia as well as industry. To gain deeper insight into these phenomena, experiments and numerical simulations are performed in the present work. This dissertation provides a comprehensive study of coalescence and splashing regimes and investigates their sub-regimes, namely, partial coalescence, complete coalescence and regular bubble entrapment as well as the associated flow structures such as the formation of the primary vortex ring, secondary vortex ring, blob, jet and a combination of them. Based on the coalescence stage, partial coalescence and complete coalescence are further demarcated into three sub-regimes: (i) first-stage partial coalescence, (ii) second-stage complete coalescence, and (iii) first-stage complete coalescence. The hydrodynamic variances of the coalescence process associated with different parametric analyses are also examined. The origin of the vortex ring and its evolutions are systematically investigated since it is a common feature in both the coalescence and splashing regimes. Subsequently, we derive a novel analytical model to study the viscous diffusion effect on the hydrodynamics of the vortex ring. The combination of experimental and numerical results, in conjunction with the analytical approach, provides noteworthy insights into the formation and dynamics of the vortex ring. In conclusion, the characteristics of different phenomena observed during the impingement of a liquid drop on a liquid pool, along with their genesis and inhibition criteria, are thoroughly examined in this work. Based on these findings, the associated phenomena are classified into regimes, sub-regimes and flow structures and shown in a series of phase diagrams as a function of controlling dimensionless parameters. This study will aid in a better understanding of the fundamental principles and mechanisms that lead to various drop impact dynamics phenomena.

Keywords: *Splashing*; *Bubble entrapment*; *Coalescence*; *Partial coalescence*; *Complete coalescence*; *Vortex ring*.