This work aims to study the impact of a droplet on liquid pools of the same fluid to understand the formation of secondary drops from the central jet and crown splash that occur after the impact. The impact of droplets on a deep pool has applications in cleaning up oil spill, spray cooling, painting, inkjet printing and forensic analysis, relying on the changes in properties such as viscosity, interfacial tension and density. Despite the exhaustive research on different aspects of droplet impact, it is not clear how liquid properties can affect the instabilities leading to the Rayleigh jet breakup and the number of secondary drops formed after it pinches off. In this work, through systematic experiments, the droplet impact phenomena is investigated by varying viscosity and surface tension of liquids as well as impact speeds. Further, using a Volume-of-Fluid (VOF) method, it is shown that Rayleigh-Plateau instability is influenced by these parameters, and capillary timescale is the appropriate scale to normalize the breakup time. Increase in impact velocity increases the height of the thin column of fluid that emerges from the liquid pool. Under certain fluid conditions, the dissipation of this extra kinetic energy along with the surface tension forces produces instabilities at the neck of the jet. This could result in jet breakup and formation of secondary drops. In other words, both the formation of the jet and its breakup require a balance between viscous, capillary and surface tension forces. Based on Ohnesorge number (Oh) and impact Weber number (We), a regime map for no breakup, Rayleigh jet breakup, and crown splash is suggested for 0.0033 ≤ Oh ≤ 0.136. For Weber numbers beyond the critical value and Oh ≈ 0.091 the jet breakup occurs (Rayleigh jet breakup regime). While for Oh > 0.091, the jet breakup is suppressed regardless of the Weber number. In addition, high impact velocity initiates the crown formation and if further intensified it can disintegrate it into numerous secondary drops (crown splash) and it is observed to occur at all Ohnesorge numbers and high enough Weber numbers, however, at high Oh, a large portion of kinetic energy is dissipated, thus Rayleigh jet breakup is suppressed regardless of the magnitude of the impact velocity. Moreover, a correlation is proposed for normalized time with respect to the normalized maximum height of jet.

Major: Mechanical Engineering

Educational Career:
Bachelor’s of Mechanical Engineering, BS, 2012, Escuela Superior Politecnica del Litoral

Committee in Charge:
Ranganathan Kumar, Chair, Mechanical and Aerospace Engineering
Hansen Mansy, Associate Professor - MAE Department
Yoav Peles, Professor and MAE Department Chair

Approved for distribution by Ranganathan Kumar, Committee Chair, on August 15, 2014.

The public is welcome to attend.