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Drop Impingement onto a Wetted Surface: Effects of Thermal Buoyancy and Gravity Level

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Extended Abstract

The impact of liquid drops with wetted solid surfaces has numerous applications in both natural and engineered systems ranging from rain-induced erosion to the cooling of electronic components and tissue engineering. Although these flows have been studied for over a century, many questions remain unaddressed. This presentation explores the effect of various gravity levels on the impact of a single water drop onto a quiescent shallow layer of water at a different temperature from the drop. Flows in microgravity, Earth gravity, and hypergravity are compared to results previously published by Dinc and Gray (2013) for cases in which the drop and liquid layer have the same temperature. As in the previous investigation, the commercial computer code ANSYS 14 Fluent is employed to perform 2D-axisymmetric simulations for incompressible, laminar, unsteady flow conditions using the explicit Volume of Fluid (VOF) surface tracking method with the Piecewise Linear Interface Calculation scheme (PLIC), the Continuum Surface Force model (CSF), and adaptive refinement of the mesh. The present simulations also include the energy equation and account for the effects of temperature dependent density, viscosity, and surface tension. Simulations of a spherical water drop impacting a wetted horizontal surface for a case in which the flow is known to remain axisymmetric at Earth gravity (Reynolds number = 6690, Weber number = 139, layer depth/drop diameter = 0.837, and contact angle = 0°) are performed for different gravity conditions appropriate for various bodies in the Solar System. In particular, simulations are reported for Solar surface gravity (g = 275 m/s^2), Jupiter surface gravity (g = 24.8 m/s^2), Earth surface gravity (g = 9.81 m/s^2), Mars surface gravity (g = 3.7 m/s^2), Lunar surface gravity (g = 1.68 m/s^2), Pluto surface gravity (g = 0.61 m/s^2), asteroid Vesta surface gravity (g = 0.252 m/s^2), asteroid 1999RQ-36 surface gravity (g = 0.038 m/s^2), and zero gravity (g = 0). Varying the gravity level in this manner changes the Froude number from 1.83 to infinity. Earlier studies in the literature had largely ignored the effect of Froude number variation, but Dinc and Gray (2013) showed that although the evolution of the craters was generally similar, the time scale and the height of the Worthington jet were strongly influenced by the value of g. This presentation describes how the relative buoyancy between the drop and the layer affects the mixing of the fluids and the evolution of the resulting craters.

References

Dinc M., Gray D.D. (2013). Drop Impingement onto a Wetted Surface: Effects of Gravity and Shape, International Journal of Mechanics 7, 26-36.