World Academy of Science, Engineering and Technology
International Journal of Mathematical and Computational Sciences
Vol:14, No:12, 2020

Water Droplet Impact on Vibrating Rigid Superhydrophobic Surfaces

Authors : Jingcheng Ma, Patricia B. Weisensee, Young H. Shin, Yujin Chang, Junjiao Tian, William P. King, Nenad Miljkovic

Abstract : Water droplet impact on surfaces is a ubiquitous phenomenon in both nature and industry. The transfer of mass, momentum and energy can be influenced by the time of contact between droplet and surface. In order to reduce the contact time, we study the influence of substrate motion prior to impact on the dynamics of droplet recoil. Using optical high speed imaging, we investigated the impact dynamics of macroscopic water droplets (~ 2mm) on rigid nanostructured superhydrophobic surfaces vibrating at 60 – 300 Hz and amplitudes of 0 – 3 mm. In addition, we studied the influence of the phase of the substrate at the moment of impact on total contact time. We demonstrate that substrate vibration can alter droplet dynamics, and decrease total contact time by as much as 50% compared to impact on stationary rigid superhydrophobic surfaces. Impact analysis revealed that the vibration frequency mainly affected the maximum contact time, while the amplitude of vibration had little direct effect on the contact time. Through mathematical modeling, we show that the oscillation amplitude influences the possibility density function of droplet impact at a given phase, and thus indirectly influences the average contact time. We also observed more vigorous droplet splashing and breakup during impact at larger amplitudes. Through semi-empirical mathematical modeling, we describe the relationship between contact time and vibration frequency, phase, and amplitude of the substrate. We also show that the maximum acceleration during the impact process is better suited as a threshold parameter for the onset of splashing than a Weber-number criterion. This study not only provides new insights into droplet impact physics on vibrating surfaces, but develops guidelines for the rational design of surfaces to achieve controllable droplet wetting in applications utilizing vibration.

Keywords : contact time, impact dynamics, oscillation, pear-shape droplet
Conference Title : ICSRD 2020 : International Conference on Scientific Research and Development
Conference Location : Chicago, United States
Conference Dates : December 12-13, 2020