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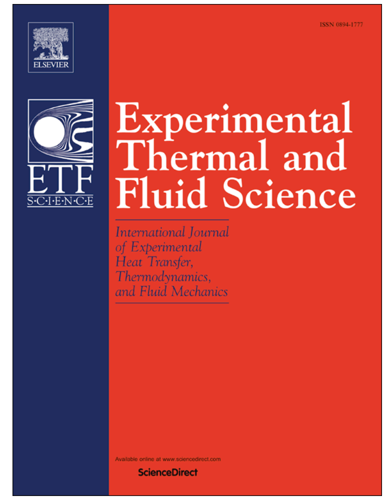

Post-Impact Drop Vibration on a Hydrophilic Surface

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Post-Impact Drop Vibration on a Hydrophilic Surface

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Abstract

Post-impact drop vibration on a hydrophilic surface has been studied experimentally in terms of the oscillation of spread and thickness factors. Water droplets were dropped from a piezoelectric droplet generator onto a smooth aluminum surface. Three different regimes featuring different oscillatory behaviors were classified based on Weber number. Quantitative characterization of the drop vibration was conducted for Regime I with $We < 30$. Mobile contact line (MCL) and pinned contact line (PCL) vibrations were differentiated for the first time in analyzing the post-impact drop vibration. A time-frequency analysis shows that the transition from MCL vibration to PCL vibration features a tiny shift to a higher oscillation frequency. The normalized oscillation frequency can be well scaled by $\Omega \sim We^{-1/2}$ as shown from the classical models. A new, empirical, unifying model was developed to account for the contact line movement in order to incorporate both MCL and PCL vibrations. The hysteresis-induced force at the three-phase contact line was found to alternate the equilibrium position of the vibrating drop with time, and thus making the oscillatory behavior nonlinear. It can be derived from the unifying model that the oscillation frequency should also scale as $\Omega \sim We^{-1/2}$ and the damping factor should scale as $\zeta \sim Re^{-1}$, which are validated by the presented experimental results. Finally, the good scaling of the damping factor indicates that the major damping mechanism, for both MCL and PCL vibrations, should originate from the viscous dissipation.

Keywords: drop impact; contact line; spreading factor; thickness factor; drop vibration; contact angle hysteresis