Ultrasonic waves for nanobubble cleaning enhancement

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Abstract

With the unique physical properties of high zeta potential, formation of radicals during their collapse, and long-term suspension, the nanobubbles have been used for cleaning applications and proven to be highly beneficial. A local micro jet and shock wave caused by a bubble collapse may cause large shear forces, contributing to the removal of contaminated surface. Ultrasonic waves can be used to control the nanobubble dynamics. Therefore it is important to study the interaction of ultrasonic waves with nanobubbles for better cleaning effectiveness and efficiency.

To study the effect of the ultrasonic wave on bubble dynamics, the Keller model is adopted, which considers the external pressure driven by the ultrasonic wave and the internal pressure inside the bubble. The maximum diameter of the bubble during its expansion is suggested to serve as a gauge for evaluating the capability of the bubble to remove contaminants from the structure surface. We examine the relationship between ultrasonic wave frequency, its pressure amplitude, and bubble size. While decreasing the ultrasonic frequency and increasing the pressure amplitude, bubbles can be largely expanded but suffer from longer time to collapse. It is indicated that the ultrasonic wave parameters must be optimized for different bubbles to achieve better cleaning.

Based on the study of ultrasonic waves with bubbles, an acoustic device is developed. Using the proposed design, ultrasonic waves can drive the nanobubbles to the surface with more energy, which contributes to the contaminant removal.

Keywords: Nanobubble cleaning, bubble dynamics, ultrasonic wave