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Development of Thermally-oscillating Flow and Acoustic Streaming in the Liquid by Ultrasonic Vibrations

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Under a constant heat flux (q" = 9905.1 $kcal/h \cdot m^2$) boundary condition, the melting of solid paraffin was conducted in a melting cavity as shown in Fig. 1. The melting cavity filled with paraffin was positioned inside the tank which was filled with water. The water in the tank was used in order to protect ultrasonic vibrators from electric overload, a phenomenon that could have happened if ultrasonic vibrations had been applied directly to the solid paraffin in the beginning of the melting. The melting process in the melting cavity with a heated vertical wall was presented under two experimental conditions: natural melting (i.e., without ultrasonic vibrations) and melting with ultrasonic vibrations.

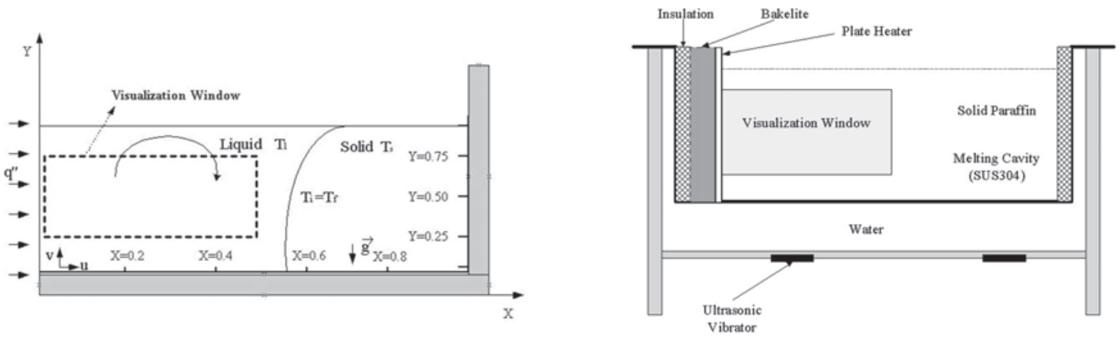
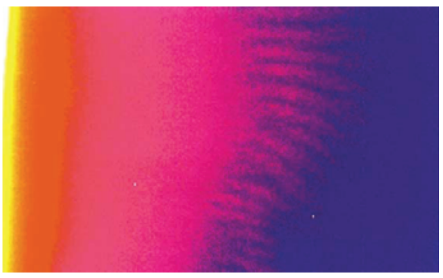
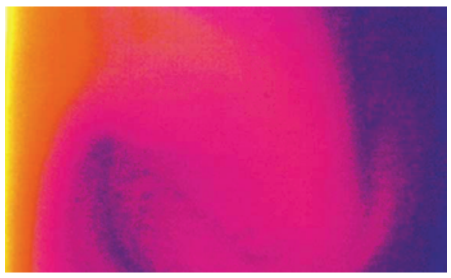


Fig. 1. Two-dimensional model for a melting procedure and schematic diagram of a melting cavity

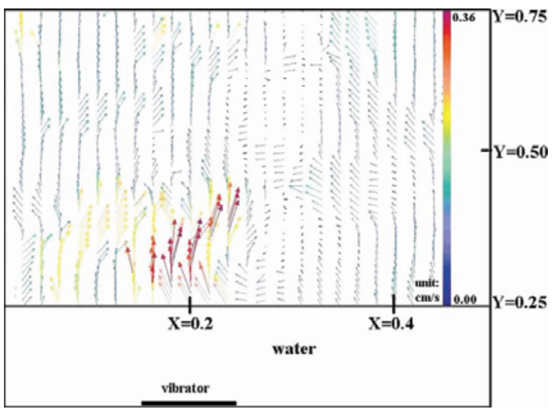
Figures 2(a) and 2(b) show two flow fields captured by an infrared thermal camera: one without the ultrasonic vibrations and the other with ultrasonic vibrations. The induced upward flow caused by an acoustic streaming was also measured using the PIV for the case of the ultrasonic vibration (see Fig. 2(c)). These fluid dynamics phenomena by ultrasonic vibrations could acclerate the heat transfer rate in the liquid.



(a) Melting without ultrasonic vibrations



(b) Melting with ultrasonic vibrations



(c) Two-dimensional velocity profiles induced by acoustic streaming of ultrasonic vibrations

Fig. 2. Thermally oscillating flow and acoustic streaming by ultrasonic vibrations observed at visualization window