Cavitation Bubble Collapse Detection by Acoustic Emission

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A laboratory testing method to detect single cavitation bubble and cavitation cloud collapses is presented. The laboratory testing was done with the PREVERO cavitation tunnel, which provides an axisymmetric cavitation pattern. Information about the cavitation tunnel in: http://www.legi.grenoble-inp.fr/web/spip.php?article1265&lang=en. One face of a cylindrical steel sample experiences cavitation erosion while acoustic emission is measured from behind the sample. Cavitation impacts induce elastic waves in the sample that are detected by acoustic emission sensors. The acoustic emission sensors are placed outside of the cavitation tunnel and they are connected to the sample through a steel waveguide. The elastic waves originating from the cavitation impact travel through the waveguide to the sensor, provoking surface motion in the waveguide-sensor interface. Waveforms were measured with a sampling frequency of 5 MHz. Both resonance type and broadband sensors were used in the measurements, with different measurement goals. The resonance type sensor captures the impacts in a more distinguishable manner, as the surface motion provokes a strong response at the sensor resonance frequency. In the waveform, a single impact is characterised as a quickly rising signal that reaches a maximum amplitude, and then diminishes exponentially. The frequency content follows the sensor frequency response. The hypothesis in this study is that the maximum amplitudes of these peaks is correlated with the strength of the cavitation impact. As the diminishing vibration corresponds mostly to diminishing sensor and structure vibration, only the maximum amplitudes are of interest in this study. For this reason, an envelope function was fitted to the data. The amplitude peaks are counted for the peak distribution and the cumulative peak distribution, which may be later compared to other results for quantification. The samples were exposed to cavitation erosion for a sufficiently short duration, so that only a limited number of mostly non-overlapping pits were formed. The pits covered approximately 10 % of the surface. With the most aggressive operation point of the cavitation tunnel, and for a stainless steel sample, the duration is two minutes. After the exposure, the pitted surface was analysed with an optical profilometer. The measured surface was divided into sections and pit counting was applied to each section separately. The pit count provides a distribution of pits in diameter, volume, maximum depth and surface area. The pit size distribution may be compared to that of the acoustic emission. Assuming a linear relationship, it was found that the pit diameter and acoustic emission peak amplitude distributions may be superimposed. The dependency seems to be independent of the cavitation aggressiveness, as long as the type of cavitation remains constant. This means that the correlation between the acoustic emission peak amplitude and the cavitation pit diameter depend only on the sensor setup, signal transfer path and sample material. This also means that cavitation erosion damage may be correlated to acoustic emission measurements.