Erosion-corrosion damage induced by a single bubble collapse: electrochemical response of the surface

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Cavitation is the formation of gas or vapor bubbles in fluids, typically caused by pressure changes, e.g. in pumps or at marine components. The following collapse of such bubbles can cause damage, i.e. cavitation erosion, on nearby solid surfaces by emitting a liquid jet or shock waves. Surface examinations have revealed that the collapse of even a single bubble can damage the surface of some metals mainly in the form of localized plastic deformation. In a corrosive medium, the bubble collapse could also locally accelerate corrosion resulting in a sudden rise in the corrosion current. Chronoamperometry is a sensitive and fast technique among other electrochemical methods, which could detect any minor electrochemical changes on the surface. We used this technique to detect, analyze and quantify the damage induced by a single bubble collapse. The samples were CP-Al wire, 0.8 mm in thickness, embedded in an epoxy. Two identical samples were used in the experiments, one of them was exposed to a laser-induced bubble collapse (WE1) and the other placed in the same solution far from the bubble (WE2). The current noise between these two electrodes at the rest potential was recorded as a function of time at a high sampling rate of 3.333×10^{-6} s. The bubble collapse was monitored using a high speed camera.

The electrochemical response of the surface to the bubble collapse was observable as a very fast increase in the current. As the bubble reexpands and collapses again in several stages, further peaks were detected. This was attributed to the localized damage in the passive layer generating a bare, plastically deformed surface at the impact region. This region has a very high corrosion rate, appearing as current peaks in the current-time curve. The surface of the sample will then quickly repassivate resulting in a current decrease to zero after less than one ms. Calculating the area under the peaks and using Faraday's law, we also obtained an estimation of the corrosion induced weight loss, in the order of few picograms (pg). This study shows that chronoamperometry allows to study details of the very initial stage of the damage progress on a metal surface, in a time resolution that cannot be obtained by other techniques.

Keywords: Single bubble, Cavitation, Corrosion, Chronoamperometry.

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