Prediction and numerical simulation of erosion arising from water droplets impact on Pelton turbine buckets

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ABSTRACT

When a high velocity water droplet with small diameter impacts a rigid surface, interaction is driven by inertial effects. Thus, viscous forces and superficial tension can be neglegted, and Euler's equations are relevant to perform the fluid behaviour [2], [6]. Upon impact, the "water-hammer" pressure appears by inertial effect at the center of the contact [1], [2], [5], [6], thouh the maximum pressure occurs on the envelope of the contact area [1], [2], [3]. Maximum pressure may be far higher than water-hammer pressure [2], [5]. The impact causes the travelling of a shock wave across the droplet, and latteral jetting occurs by compression when the wave front outpasses the contact area. Compression-tension forces inside droplet may cause cavitation, however too far from the contact area to induce damage considering the study conditions [1]. Concerning the structure, erosion comes from fatigue [4]. First, material grains are weakened during an "incubation" phase. After numerous impacts, micro-cracks emerge and lead to ejection or fracture of grains, what is called "amplification" phase. Numerical simulations including rigid solid allow to locate the most loaded zones of the area, by observing the pressure and mainly the impulse. A 2-way coupling computation with fluid-structure interaction at macroscopic scale allows to confirm the fatigue-based mechanism by oberving the hydrostatic stress. Finally, erosion program developped with a simple damage criteria provides the location of the most eroded zones of the structure during a loading cycle.

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