Bioinspired Snapping-Claw Apparatus to Study Flow-Accelerated Corrosion of Low Carbon Steel

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This research presents a novel mechanical device, inspired by the pistol shrimp snapper claw, featuring a controlled, periodic opening/closing motion that generates oscillating flows at transitional Reynolds numbers. An innovative method for determining the corrosion rate of carbon steel samples under oscillating acidic streams (an aqueous solution of HCl) is proposed. Very-thin carbon steel specimens (25 microns thick), coated with Zn on one side and insulated from the stream, enable electrochemical sensing of the Zn surface upon perforation. With the use of this technology and a 532 nm laser coupled into an optical fiber and video camera arrangement, corrosion may be effectively detected, enabling precise pit counting and location determination. Furthermore, the study explores the impact of hydrodynamic cavitation on the corrosion of low carbon steel samples by using the mechanical device to imitate the fast closing of pistol shrimp claws. Current-time curves reveal significant changes linked to local variations in dissolved Oxygen concentration, cavitation-induced erosion, and alterations in the nature of surface corrosion products. The methods suggested here open the door to the creation of alternative corrosion sensors that have appealing qualities such as low cost, small size, and reasonable precision in detecting localized damage in both space and time.

Keywords: pistol shrimp, bioinspired apparatus, snapping claw, flow-accelerated corrosion, corrosion sensors