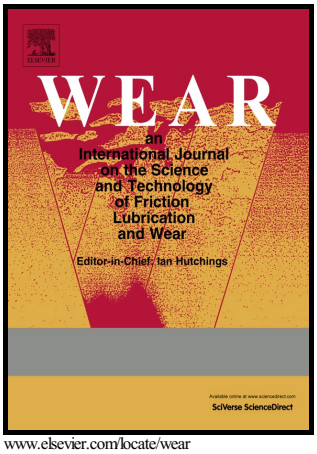

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Enhancing the Erosion-Corrosion Resistance of Steel through Friction Stir Processing

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Abstract

Erosion-corrosion is a critical problem in marine components and has huge economic impact. In the current study, friction stir processing was utilized for enhancing the erosion-corrosion resistance of SS316L steel, most widely used material for marine applications. Compared to the unprocessed alloy, the friction-stir processed specimen showed nearly 3.5 times and 5 times higher erosion and erosion-corrosion resistance respectively at oblique impingement. In contrast, erosion and erosion-corrosion resistance for processed alloy was 2 times higher at normal impingement. The unusual enhancement in erosion-corrosion resistance was attributed to surface strengthening through grain-size refinement and martensite phase formation. In addition, higher corrosion resistance due to stronger passivation also contributed towards superior performance of the processed alloy.

Keywords: Erosion-corrosion; Friction stir processing; Phase transformation

1. Introduction

Material degradation in the form of corrosion, erosion and their combination are critical problems in marine environment. Impingement of hard abrasive particles mixed in a corrosive medium is the root cause for degradation of marine components exposed to hydro-dynamic conditions. Typically, erosion involves repetitive impacts of hard erodent particles which eventually leads to surface damage and severe material loss. The presence of corrosive media further enhances material deterioration by synergistic effects of erosion (mechanical process) and corrosion (electro-chemical process). Turbulent flow, high impact velocities and hard erosive particles can further exacerbate the rate of material loss.

Austenitic stainless steels are widely used for various marine applications. Amongst these, SS316L is the most commonly used material for propulsion, seawater handling systems and shipping industries. Austenitic steels are known for their superior erosion and corrosion resistance. However, the synergistic effect of erosion-corrosion leads to significant mass loss in these materials. This is primarily due to repeated breakdown of protective passive layer during the erosion process. The total material loss during erosion-corrosion can be evaluated using the expression: $T = E + C + S$, where T represents the total mass loss, C represents mass loss in pure corrosion, E represents mass loss in pure erosion and S is the synergy component. Synergy plays a vital role in determining the overall erosion-corrosion characteristics of a material. Positive synergy indicates enhanced degradation due to combination of erosion and corrosion, results in either an erosion dominant or a corrosion dominant process. In contrast, negative synergy signifies that material degradation during erosion-corrosion is reduced compared to their standalone values.

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