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The effect of friction stir processing (FSP) on the microstructure, nanomechanical and corrosion properties of low carbon CoCr₂₈Mo₅ alloy

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Abstract

This work is aimed at investigating the effect of the friction surface treatment on the microstructure, nanomechanical, and corrosion properties of the low carbon CoCr₂₈Mo₅ alloy. To examine the role of the initial microstructure, the solutionised alloy was subjected to FSP and compared with the as-cast FSPed specimen. Furthermore, the solutionised FSPed specimen was subjected to isothermal annealing (850°C for 16 hr) to point out the effect of post-FSP thermal annealing on the fcc→hcp phase transformation. The X-ray diffraction patterns showed stress induced martensitic transformation ($\gamma_{\text{fcc}} \rightarrow \epsilon_{\text{hcp}}$) regardless of the initial thermal history. Significant peak broadening after friction treatment indicates considerable amount of induced stress on the surface. This was later examined and simulated by the finite element analysis (FEA) method using Abaqus software. The depth of fcc→hcp phase transformation was measured using nanoindentation technique, showing the considerable effect of the friction treatment on the surface hardness of the solutionised sample. The measured surface hardness on the friction treated samples were considerably higher whereas the Young's modulus was independent of the friction treatment. Corrosion results indicate the FSP process deteriorates the corrosion resistance of the solutionised sample whilst improving the corrosion resistance of the as-cast sample by 13%.

Keywords: CoCrMoC alloy; Friction Stir Processing; Martensite; Nanoindentation; Corrosion

Introduction

Biomaterial alloys have been used as biomedical implants since 19th century and since then the biocompatibility (non-toxicity in the human body) has been a major concern. A biomaterial is intended to be used in close contact with living organs and for this reason, it is crucial to ensure that there is no side effects, allergic reactions and/or assessable inflammation when implanted in the human body. The three major biomaterial alloys are: (I) stainless steels, (II) CoCrMo alloys, and (III) Ti and Ti alloys (1). Among them, CoCrMo alloys (known as ASTM 75 alloy) have been widely employed in orthopaedic, dentistry, and cardiovascular as an implant such as artificial hip joints, cardiovascular stents, knee substitution joints, heart valve parts, load-bearing implants, spinal fixation,

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