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Assessing the kinetics and mechanisms of corrosion of cast and HIPed Stellite 6 in aqueous saline environments

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Abstract

Cobalt–base (Stellite) alloys have seen extensive use in wear environments mainly due to their high strength, corrosion resistance and hardness. Co–base superalloys rely primarily on carbides, formed in the Co matrix and at grain boundaries, for their strength and the distribution, size and shape of carbides depends on processing conditions. Currently use of Stellite alloys has extended into various industrial sectors (e.g. pulp and paper processing, oil and gas processing, pharmaceuticals, chemical processing) and the need for improved information regarding corrosion (and often tribo-corrosion) of Stellite alloys has increased. It has been recognised that processing changes, which affect the microstructure of Stellite alloys, will most probably affect the corrosion performance.

In this paper the corrosion behaviour of Stellite 6 in the as-cast and the HIP consolidated forms has been compared and contrasted using DC electrochemical techniques in static saline conditions. It has been shown that there is a significant difference in the corrosion performance of HIP consolidated Stellite 6 and it is possible to link the corrosion mechanisms to

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the microstructure. The benefits of using HIPing as a manufacturing process for the corrosion performance of Stellite 6 are discussed.

Keywords: (A) Cobalt; (B) Polarisation; Potentiostatic; (C) Passive film; Pitting corrosion

1. Introduction

Cobalt–base (Stellite) alloys have seen extensive use in wear environments mainly due to their high strength, corrosion resistance and hardness. Co–base superalloys rely primarily on carbides, formed in the Co matrix and at grain boundaries, for their strength and wear resistance. The distribution, size and shape of carbides depend on processing conditions. Solid solution strengthening of Co–base alloys is normally provided by tantalum, tungsten, molybdenum, chromium and niobium [1]. Since these elements are all carbide formers, their effectiveness in terms of solid solution strengthening is dependent on the C content of the alloy.

Stellite 6 with nominal composition Co–28Cr–4.5W–1.2C (wt%) was the first Stellite alloy developed in the early 1900s by Elwood Haynes. In recent years there have been investigations into the effect of additions of alloying elements [2] on the microstructure and mechanical properties of Stellite 6. Improved hardness through formation of intermetallic compounds and mixed carbides could be achieved in both cases. It has been shown that addition of W and Mo influences the corrosion behaviour by stabilising the face centered cubic (fcc) phase [1].

Because Stellite alloys are often used to combat wear, there have been numerous studies into surface engineering strategies to functionalise the surface for a specific application. These have included Plasma Transferred Arc (PTA) welding [3], laser surface melting [4] and plasma diffusion treatments [5] all involving Stellite alloys.

Application of Co–base superalloys was traditionally most prevalent in the nuclear industry in the 1960s and 1970s and, for this reason, much research into corrosion of Stellite was focused in conditions relevant to nuclear power applications such as simulated PWR primary heat transfer conditions [e.g. 6,7].

Currently use of Stellite alloys has extended into various industrial sectors (e.g. pulp and paper processing, oil and gas processing, pharmaceuticals, chemical processing) and the need for improved information regarding corrosion (and often tribo-corrosion) of Stellite alloys has increased. It has been recognised that processing changes, which affect the microstructure of Stellite alloys, will most probably affect the corrosion performance [8].

Hot Isostatic Pressing (HIPing) is a thermo-mechanical process [9] in which components or a contained powder are subjected to simultaneous applications of heat and high pressure in inert medium. HIPing removes internal void cavities thus consolidating the structure to be homogenous, segregation free, dense, near-net shape and requiring little or no machining. Mohamed et al. [8] used DC electrochemical techniques to investigate the corrosion behaviour of crevice-containing and crevice-free cast and HIPed Stellite 6 in 3% NaCl at ambient temperature processed