

The Corrosion Attack on Stainless Steel 316L and WC-Co in High Sulphate-Chloride Ratio

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Abstract

Austenitic stainless steels and cermets alloy has been used extensively in many sectors due to their highly resistance to corrosion attack and excel in mechanical properties. However, in corrosive media both materials are susceptible to corrosion attack especially in seawater and high temperature. Cermet alloys are a combination of ceramic and metal. Therefore, cermets exist in high corrosion resistance in aqueous media and the corrosion rate is complex to identify. This paper presents the corrosion mechanism of SS 316L and cermets alloy exposed to high concentration of sulphate in the salinity of seawater. The corrosion mechanism were characterized to breakdown potential (E_b), which are the potential once reaches a sufficiently positive value and also known as pitting potential. The E_b value of SS 316L in high sulphate are higher compared to WC-Co which elucidate that some anions such as sulphate behaves as inhibiting effect to SS 316L.

Keywords: SS316L, Cermets alloy, sulphate, seawater

Methodology

The electrochemical response during anodic polarisation when the potential is scanned in the positive direction from E_{corr} (also known as OCP) and only very small currents (typically $<10 \mu A/cm^2$) are recorded until E_b is reached. At this point the current rises rapidly as a function of potential indicating that corrosion attack

has initiated. The current corresponding to the breakdown potential is denoted as breakdown current density, i_b (A/cm^2). The breakdown potential of the material provides information on the resistance of materials to passivity breakdown [1]. Each anodic polarisation scan was reversed once the current reached a set current (i_{rev}) of $500 \mu A/cm^2$. The degree of the increase in current beyond i_{rev} gives an indication of the propensity for corrosion propagation [2]. An indication of the extent of propagation is therefore obtained by consideration of i_{max} , which represents the maximum current attained should the current not begin to fall immediately after scan reversal.

Results and Discussion

This experiment was conducted to quantify the effect of sulphate to corrosion attack on SS 316L and cermet alloy. For passive alloy including austenitic stainless steels (SS 316L), corrosion resistance is provided by a very thin surface film, known as passive film that is an invisible film of oxide, formed by the metal reacting with the ambient environment. The cyclic polarisation performs in positive hysteresis (Fig. 1) indicates that after passive film destroyed, the material does not repair itself. Therefore, the corrosion attack propagates and localised corrosion will start.

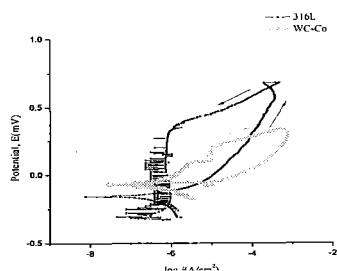


Fig. 1: Cyclic polarisation of SS 316L in high sulphate content

The presence of sulphate causes the distribution of available pit sites to be shifted to a higher potential, which causes pit propagation in both metastable and stable states [3]. The pitting observed on SS 316L is shown in Fig. 2 and Fig. 3 shows the SEM image of a pit found on SS 316L after cyclic polarisation potential test with alongside the EDX element analysis.

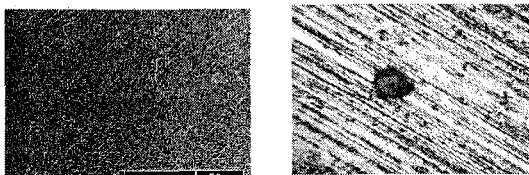


Fig. 2: Pitting observed on SS316L

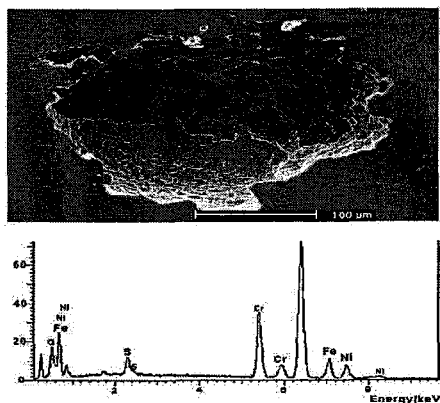


Fig. 3: SEM/EDX analysis of pitting on SS 316L

For WC-Co, the Open Circuit Potential (OCP) values shifted towards more active values compared to SS 316L, while the breakdown corrosion potential presented the opposite tendency (Fig 1). The SEM observed on WC-Co surface found that corrosion product developed during electrochemistry occluded on WC-Co and

protect from further corrosion attack as shown in Fig 4.

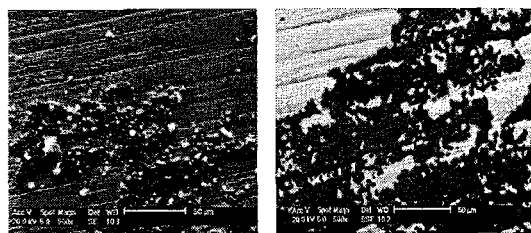


Fig. 4: SEM found corrosion product on WC-Co surface.

For passive materials such as SS 316L, anions such as ClO_4^- and Cl^- lead to formation of strong acids inside the pits [4]. The pit begins to grow after the passivating film is broken down at some weak site. Therefore, the concentration of Cl^- within the pits at first increases and gradually decrease because of tightness of the film covered which is facilitates to convective and diffusive mixing of the solution inside the pits and in their surroundings. Non uniform of distribution of current density and Cl^- concentration in the pits and time – dependent showed by the shape of pits changing from hemispherical to cup-like. The morphology of the pit indicates that it was extended and deepened during the propagation. This pit has already reached the critical size and the lacy cover is destroyed, resulting in an open hemispherical cavity. The EDX results have peaks of sulphur and oxygen, which proves that sulphide inclusion play a key role in pitting initiation on SS 316L, notably at particles physically associated with oxides.

References

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