

The electrochemical generation of ferric ions in cooling water as an alternative for ferric chloride dosing to effect flocculation

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Abstract

The research deals with the electrochemical dissolution of iron in cooling water as an alternative to ferric chloride dosing to effect flocculation. The generation of this anion-free flocculant has far-reaching implications in a cooling-water system. Its primary benefit is the elimination of chloride dosing into the system, chloride being an initiator of pitting corrosion, the most destructive and insidious form of corrosion. Alternating current was applied to the electrochemical reactor in order to curb the deleterious passivation of the electrodes, characteristic of direct current application. Through the manipulation of process variables several process phenomena were identified. Untreated cooling water proved to be an ideal electrolyte for the generation of the desired quantity of ferric ions. It was observed that dissolution in an alternating field is accompanied by the generation of heat in the electrolyte, which aids the precipitation of carbonate compounds in the clarifiers. It was also established that while the solution pH has very little effect on the process, the voltage applied to the electrodes and the flow rate of the cooling water through the reactor are significant in determining the extent of the dissolution process.

Nomenclature

- F - Faraday's constant (96487C)
I - electric current (A)
M - molecular mass of sacrificial electrode (55.85 g/mol)
n - number of anodes
t - time (s)
w - mass of sacrificial electrode dissolved (g)
z - number of electrons involved in the redox reaction

Introduction

Eskom has always been at the forefront of technology, committing itself to improving the control of water quality by accommodating technological advances in chemical treatment. The research of the electrochemical dissolution of a flocculating agent is no exception.

It was identified that Lethabo Power Station's cooling-water system is prone to pitting corrosion originating from the presence of high concentrations of chlorides in the circulating water. The root cause of this aggression is the introduction of chloride into the system via the dosing of the coagulant ferric chloride. This problem prompted the research into the substitution of ferric chloride with an anion-free flocculant while maintaining the coagulating properties of the cooling-water treatment.

It was decided to investigate the possibility of dissolving iron in cooling water for the production of this anion-free flocculant.

Literature and theory survey

In 1986 Ewald Heitz (Heitz and Kreysa, 1986) predicted that electrochemically based processes would be gaining increasing potential in order to meet the economic and social challenges

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resulting from urgent demands for energy saving, low-grade material utilisation and environmental protection. Since then, industrial needs have evolved in such a way as to substantiate Heitz's prediction. Electrochemical dissolution caters for this philosophy in that it is a reagentless process using low-grade material for its sacrificial electrodes.

The history of electrochemical treatment of water dates back to the 19th century, with England and France reporting patents to treat a mixture of sewage and sea water (Marson, 1965). More recently from Europe, Vik et al. (1984) reported on the electrochemical treatment of Norwegian river waters using aluminium electrodes.

In the United States, electrolytic sludge treatment plants were operated as early as 1911 in Santa Monica, California and Oklahoma City, Oklahoma (Vik et al., 1984). In the Soviet Union electrochemically produced iron was first used at a power station in 1925. This research was reported by Strokach (1975) and subsequently a substantial amount of research in the Soviet Union came to light.

The principles of electrochemical dissolution are those associated with basic electrochemistry. An electric current imposed on an electrolytic cell with iron electrodes gives rise to an anodic and a cathodic reaction:



The decrease in the acidity and the continuous formation of hydroxide ions in the cathode space results in the subsequent formation of ferrous hydroxide:



As the concentrated cooling water at Lethabo Power Station is saturated with oxygen, it is expected that the latter reacts with ferrous hydroxide, converting it to ferric hydroxide according to the following equation: