ABSTRACT

Ecological considerations compelled a steel mill in Southern Africa to pursue Zero Effluent Discharge which led to the use of substandard influent water to their open recirculating cooling systems. This resulted in severe corrosion of the mild steel equipment which impacted on the cost and risk of doing business. Extensive research has been done over the last century, particularly for potable water systems, to develop reliable mathematical models to predict the impact of various factors on corrosion. However, the application of these indices on the steel mill brackish cooling water proved unsatisfactory and all excluded the impact of fluoride.

The primary objectives of this thesis were to establish the individual and joint impacts of calcium carbonate saturation and the varying levels of the anions, particularly fluoride, at up to 90 mg/l, on the corrosion of mild steel at 45°C. Laboratory tests were performed with synthetic solutions, in accordance with ASTM methods, and on experimental design approaches. Laboratory and field data were used to construct several statistically sound and relatively accurate models and a set of hypothetical guidelines for the water chemistry parameters pertinent to fluoride-containing brackish water. SEM and EDS of the mild steel coupons confirmed the increase in uniform corrosion with increasing fluoride concentration and the tendency for micro-pitting corrosion.

An initial equation formulated solely on the calcium concentration and total alkalinity yielded superior correlation with field data than the indices produced by previous authors. It accounted for 90% of the variations in the laboratory data. Laboratory investigations into the impact of the chloride and sulphate ions indicated they differed from the indices developed for drinking water systems. The chloride ion actually decreased corrosion, similar to what was found with saline waters. The impact of the fluoride confirmed the work of previous authors performed under considerably different physical or chemical test conditions. A linear model based on fluoride, pH, calcium hardness and total alkalinity resulted in an R^2 (adj) of 88%. At above approximately 100 mg/l fluoride mild steel corrosion reached a plateau.