PowerPlant Chemistry® **The Journal of All Power Plant Chemistry Areas**

ISSN 1438-5325
International Edition | September | Volume 6 (2004), No. 9

Abstracts

Brian J. Handy and John C. Greene
Predicting the Operating Performance of Condensate Polishing Plant Using a Mathematical Kinetic Model

NNC Limited provides an Ion Exchange Resin Technology Facility, which includes a resin testing service. A range of ion exchange resin properties is measured and this includes ion exchange capacity, resin bead particle sizes and anion kinetic performance in terms of mass transfer coefficients. It has long been considered by the authors that the experimental data for resins taken from operating condensate polishing plant (CPP) could be used to predict the expected plant performance. This has now been realised with the development of a mathematical model which predicts CPP behaviour using appropriate experimentally derived parameters and plant design data.

Modelling methods for the separate anion and cation components of a mixed bed were initially developed before the mixed bed as a whole was addressed. Initially, an analytical approach was adopted, which proved successful for simple cases. For more complex examples a numerical approach was developed and found to be more suitable. The paper describes the development of anion and cation bed models, and a mixed bed model. In the latter model, the anion and cation components modelled earlier are combined, and used to model simultaneously typical concentrations of ammonia, sodium, chloride and sulphate. Examples of operation are given, and observations and points of interest are discussed with respect to the calculated concentration profiles.

The experimental behaviour of a number of resin samples taken from operating plant was examined in a purpose-built ultrapure water recirculation loop equipped with a range of analytical instruments. This has permitted the observed experimental results to be compared with model predictions. The next stage of the model development is to identify plants suitable for testing the model against real plant performance and the authors are now seeking to identify plant managers interested in collaborating in this venture.

Allen Apblett, Satish I. Kuriyavar,Gary L. Foutch, and Phung Tran
The ETA Fouling Mechanism of Mixed Bed Ion Exchange Resin

Pressurized water reactor (PWR) nuclear power plants use amine pH control agents in the secondary steam cycle to reduce corrosion potential induced by hydronium ions. Ethanolamine (ETA) is a popular pH control agent currently used in many plants. However, some plants have reported fouling of the anion resin with ETA resulting in reduced service life. This paper presents preliminary analyses of the interaction chemistry of current fouling/degradation problems associated with the use of ETA on ion exchange resins used in PWRs.

Masayoshi Hirano, Satoshi Itaba, Toshio Sakurada, Yukio Imaizumi, Takao Minami, Li-Bin Niu, and Hiroshi Takaku

Effects of Minor Amounts of Corrosive Chemicals on Corrosion Behavior of Low-Pressure Steam Turbine Materials for Fossil Power Plants under Alternating Dry and Wet Conditions

The materials of the attachment near the last stage of low-pressure steam turbines in power plants are exposed to severe corrosion conditions due to the concentration of corrosive chemicals during alternating dry and wet phases, a phenomenon caused by the frequent shutdowns and load changes in power plants. The stress corrosion cracking (SCC) behavior of typical low-pressure steam turbine materials has been evaluated by SCC tests under the dry and wet conditions and the electrochemical corrosion method. For both materials tested (3.5NiCrMoV and 12Cr steels) under alternating dry and wet conditions, the ion which induced the most severe SCC sensitivity was sulfate (SO_4^{2-}), which concentrated greatly in crevices; the next most severe ion was chloride (Cl^-), while sodium (Na^+) caused almost no SCC sensitivity. The co-occurrence of crevices and stress considerably increased the SCC sensitivity of the 3.5NiCrMoV steel tested. The maximum corrosion pit depth became greater as the dissolved oxygen content in water increased, and it rose significantly when a crevice was present. A consideration of the SCC sensitivity and the characteristics of the corrosion film has shown that the chromium content in the materials controls the SCC sensitivity and also the corrosion potential. This may be due to the formation of the passive Cr_2O_3 film.

Albert Bursik

Polyamine/Amine Treatment – A Reasonable Alternative for Conditioning High Pressure Cycles with Drum Boilers

The polyamine/amine treatment is applied in hundreds and hundreds of fossil plant cycles, particularly in the industry. Over the last decade, the extent of its application in utilities has been increasing. This paper focuses on the polyamine/amine regime in cycles with drum boilers, although one case study is presented which reports on application of this treatment in units with once-through steam generators. The major hindrance with respect to the use of this treatment in utilities is the fact that the cation conductivity of steam increases slightly when this treatment is applied.

Operation experience in industrial power and steam generation and in utilities demonstrates that a slight cation conductivity increase in the steam does not cause any turbine-related problems, assuming that the pH is correctly set by low-molecular volatile amines being a part of the polyamine/amine formulation. Steam cation conductivity-related studies for establishing the actual interaction of slightly contaminated steam and turbine materials in the presence of an adequate alkalizing agent (a low-molecular amine with a favorable distribution behavior), i.e., when the early condensate is adequately alkaline, are suggested.

Terry L. Maddox and Kal Farooq

Control of Copper Transport during Boiler Startup Using High Flow, High Efficiency Condensate Filtration

Copper deposition on turbine blades, resulting in a significant loss of power generation capacity, is a fairly common occurrence, especially in plants using high drum pressures (17.9 MPa (2 600 psi) and higher), copper alloy condensers, and LP and HP feedwater heaters with copper alloy tubes. The primary source of the copper deposition on turbines is the copper oxide that forms during the layup on metal surfaces where oxygen and water are in prolonged contact with the metal. This copper oxide along with other metal oxides and silica is dislodged and transported during plant startup. These solids settle out or circulate in the system and turn into dissolved contaminants under appropriate conditions of temperature, pressure and alkalinity. Solid contaminants, therefore, serve as a primary source reservoir in the formation of dissolved contaminants, making their control beneficial for the reduction of dissolved metals and the resulting problem of copper plating. Besides copper, significant amounts of iron are also present, causing underdeposit corrosion of tubes, as well as silica deposits on the IP and LP sections of the turbine and on boiler tubes.

Startup is the most appropriate time to capture the solid contaminant since temperatures are low and most of the particles are in suspension due to thermal expansion, vibration, and fluid drag associated with startup. Utilities that monitor copper levels in the boiler feedwater and steam report copper levels during startup that are as much as 1 000 times higher than the levels seen during normal operation. To date, utilities have employed several methods to reduce solid particulate transport. Improved layup practices are helping minimize oxidation of metallic surfaces and better operational procedures on startup help to reduce particulate in the feedwater and condensate. Examples of these practices are feedwater heater shell side blowdown and wide open boiler blowdown during the first few hours of startup.

Additional work at the Ottumwa plant has shown that the installation of an inline condensate filtration system will substantially reduce the transport of solid particulate and consequently reduce the amount of dissolved metal found in the boiler. Mitigating the transformation of particulate metal to dissolved metal, particularly copper, has the beneficial effect of reducing boiler tube deposits and copper deposition on turbine blades. Boiler tube deposits contribute to underdeposit corrosion and ultimately forced outages due to tube failure. Copper deposits reduce turbine efficiency and increase required corrective maintenance during outages. Both of the above have a negative impact on plant revenue. The implementation of Pall Ultipleat High Flow filters, specifically designed for application in the condensate system, will provide an effective and economical control of copper, iron, silica, and all other solids for drum and turbine protection.

Santhanam Ranganathan, Madapuzi P. Srinivasan, Pandalgudi S. Raghavan , Sevilmedu V. Narasimhan, and Raghavachary Gopalan

Dissolution Studies on Nickel Ferrite in Dilute Chemical Decontamination Formulations

Nickel ferrite is one of the important corrosion products in the pipeline surfaces of water-cooled nuclear reactors. The dissolution of the nickel ferrite by chelating agents is very sensitive to the nature of the chelant, the nature of the reductant used in the formulation and the temperature at which the dissolution studies are performed. The dissolution is mainly controlled by the reductive dissolution of the ferrite particles, but complexing agents also play a significant role in the dissolution process. This study deals with the leaching of iron and nickel from nickel ferrite prepared by the solid-state method. The dissolution studies are performed in pyridine-2,6-dicarboxylic acid (PDCA), nitrilotriacetic acid (NTA), and ethylenediaminetetraacetic acid (EDTA) formulations containing organic reductants like ascorbic acid and low oxidation state transition metal ion reductants like Fe(II)-L (where L = PDCA, NTA, EDTA) at 85 °C. The dissolution of nickel ferrite in PDCA, NTA and EDTA formulations is influenced by the presence of reductants in the formulations. The addition of Fe(II)-L in the formulation greatly enhances the dissolution of nickel ferrite. The preferential leaching of nickel over iron during the dissolution of nickel ferrite was observed in all the formulations.

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