The use of regeneration profiles as a tool to optimise the performance of demineralisation water treatment plants

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Abstract

Demineralised water is used as make-up water to compensate for losses in the condensate-boiler feed-water stream at power stations and other steam raising plants. Demineralisation plants are designed to produce pure water that contains virtually no impurities. Ion exchange is invariably used for demineralisation. Effective regeneration of exhausted resin is an important aspect to ensure optimal performance of the ion exchange process. Regeneration profiles were used in this investigation to determine the effectiveness of regeneration and to optimise the regeneration process.

Keywords: demineralisation, regeneration profiles, optimised regeneration

Introduction

The make-up water for modern high-pressure fossil-fuelled boilers has to be of extremely high quality with virtually complete removal of salts and gases. Impure water may cause failure of a turbine or boiler that will result in large financial losses amounting to millions of Rand per day. The make-up water quality depends on the design and unit operations incorporated in a treatment system. A number of processes may be used in the pretreatment of raw water, but invariably the final stage is an ion-exchange demineralisation process (Modern Power Station Practice, 1992; Drew, 1994). This article focuses on the use of regeneration profiles to optimise ion-exchange regeneration and to increase run lengths, thereby reducing water production costs.

Boiler make-up quality

Boiler make-up water is the product water from a demineralisation plant that is fed into the boiler drum to compensate for water losses. The quality of the boiler make-up water determines the boiler operating efficiency (Harfst, 1993). The Eskom chemistry standard for make-up water for drum boilers operating at 17 MPa and above is listed in Table 1.

TABLE 1
Recommended water quality limits for boiler make-up water

Parameter	Units	Limit
Turbidity	(NTU)	0.2
Specific conductivity(25ºC)	(µS/cm)	0.1
Sodium (as Na^+)	(µg/kg)	2
Silica (as SiO_2)	(µg/kg)	10
Chloride (as Cl^-)	(µg/kg)	2
Sulphate (as SO_4^{2-})	(µg/kg)	2
TOC (as C)	(µg/kg)	300

Source: Eskom, 2001

Ion-exchange process

Ion exchange is a process whereby pretreated water is stripped from unwanted cations and anions to give a product water of specific quality. Ion exchange comprises the reversible exchange of ions between a solid (resin) and a liquid in which there is no substantial change in the structure of the solid. At the start of a service cycle the predominant ionic form of the resins is either the hydrogen (cation) or hydroxyl (anion) form. The hydrogen and hydroxyl ions are exchanged respectively for unwanted cations and anions in the feed water. Exhausted resins are regenerated with a highly concentrated regenerant solution, restoring the resin bed to the ionic form that is again useful to the process (Frederick, 1996).

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Demineralisation consists of the following steps:

Cation exchange

The cation exchanger contains two types of cation resins, namely strong-acid exchange resins (SAC) and weak-acid exchange resins (WAC). The SAC can split neutral salts, i.e. remove non-carbonate hardness, while WAC can only remove carbonate hardness from the water. On exhaustion the resins are restored to the original state by regenerating the WAC downwards with a 0.8 to 1.5% H_2SO_4 solution, while the SAC is regenerated upwards with a 5% H_2SO_4 solution.

Degasification

The raw water entering the cation exchangers contains alkalinity (bicarbonate and carbonate ions) that decomposes into carbon dioxide (CO_2) and water. Forced draft degasifiers are used to remove the CO_2 to reduce the load on the anion exchanger (Meyers, 1996).