Membrane life in a seeded-slurry reverse osmosis system

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Abstract

Membrane replacement can be a major operating cost of a membrane plant. During the development of a novel desalination technique (the SPARRO process) for treating calcium sulphate scaling mine waters the expected life of tubular cellulose acetate membranes operating in the seeded-slurry mode was investigated.

During four operating phases of the plant over a five-year period more than 9 000 h of operating data were obtained. Performance data showed that each operating phase was dominated by either membrane fouling or membrane hydrolysis. Membrane fouling was observed to begin near the front-end of the membrane stack and proceed towards the back. Hydrolysis, on the other hand, occurred first in the tail end of the stack and moved backwards towards the front end modules. Although two detailed membrane autopsies were carried out no definitive statement can be made in respect of the causes of either membrane hydrolysis or membrane fouling. However, suggestions are presented to explain the observed fouling phenomenon in relation to the turbidity of the pretreated feed water and the presence of chlorine. It is proposed that the presence of radioactive isotopes in the mine water which become concentrated in the process contributes to the observed membrane hydrolysis. A membrane life of up to two years is projected for an improved pretreatment arrangement.

Introduction and background

Desalination of water containing high concentrations of calcium and sulphate presents problems due to the potential to form calcium sulphate scale on process equipment surfaces when the solubility of the salt is exceeded. In membrane desalination processes the membranes themselves can be at risk of being destroyed by scaling. Water containing high concentrations of calcium and sulphate is found in most South African gold mines. Sulphate is introduced to the water by the oxidation of pyrite ores present in the gold bearing reefs (Juby et al., 1986), while elevated calcium levels are often a result of the addition of lime during neutralisation of the mine water underground. The concentration of dissolved calcium and sulphate increases further due to the tendency of mines to re-circulate and reuse most of the mine water. Calcium sulphate scaling water causes major technical and economic problems for the mines, and it contributes a large pollution load to the environment (Mackay et al., 1991).

As a result of the water quality problems experienced by the mines and pressures by the authorities to reduce the pollution load from mines, the Chamber of Mines Research Organisation of South Africa (COMRO) (now CSIR Miningtek) embarked on a research project to assess the viability of existing membrane processes to desalinate calcium sulphate scaling mine water. The project later expanded to the development of a novel seeded reverse osmosis (SRO) process, the SPARRO process (slurry precipitation and recycle reverse osmosis) to desalinate calcium sulphate mine water.

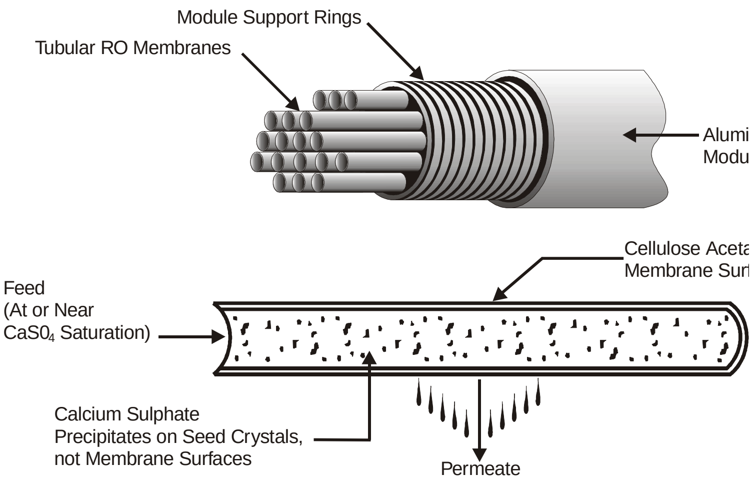

Figure 1
Conceptual illustration of seeded reverse osmosis

The research began in the early 1980s and continued until 1993 in several phases, culminating in the patenting of several of the novel design features of the SPARRO process. Several aspects were investigated in detail during this period and some of these have been published elsewhere (Juby, 1994; Juby et al., 1996).

The SRO concept (Fig. 1) was developed in the late 1970s by Resources Conservation Company (RCC) in Seattle, USA (O'Neail et al., 1981). Basically, the concept involves circulating a slurry of seed crystals within the RO system. The seed crystals serve as preferential growth sites for calcium sulphate and other calcium salts and silicates, which begin to precipitate as their solubility products are exceeded during the concentration process within the membrane tubes (Dibenedetto, 1984). The preferential growth of scale on the seed crystals prevents scale formation on the membrane surface.

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