Desalination of calcium sulphate scaling mine water: Design and operation of the SPARRO process

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Abstract

The South African mining industry discharges relatively smail quantities of mine service water to the environment, but these effluents contribute substantially to the salt load of the receiving surface waters. The poor quality of mine service water also has significant cost implications on the mining operations. Of the two main types of mine service water encountered in the gold mining industry, the so-called calcium sulphate scaling type is found in the majority of cases. Preliminary lestwork on this type of water using membrane desalination processes revealed that only the seeded reverse osmosis type of process showed promise. To overcome certain process problems and high operating costs with this system, a novel membrane desalination technique incorporating seeded technology, *called the* SPARRO (slurry precipitation and recycle reverse osmosis) process, was developed. The novel features of the new process included; a lower linear slurry velocity in the membrane tubes, a lower seed slurry concentration, a dual pumping arrangement to a tapered membrane stack, a smaller reactor and a modified seed crystal and brine blow-down system. Evaluation of the SPARRO process and its novel features, over a five-year period, confirmed its technical viability for desalinating calcium sulphate scaling mine water. The efectrical power consumption of the process was approximately half that of previous designs, significantly improving its efficiency. Membrane performance was evaluated and was generally unsatisfactory with both fouling and hydrolysis dominating at times, although operating conditions for the membranes were not always ideal. The precise cause(s) for the membrane degradation was not established, but a mechanism for fouling (based upon the presence of turbidity in the mine water) and a hypothesis for a possible cause of hydrolysis (alluding to the presence of radionuclides in the mine water) were proposed. Product water from the SPARRO process has an estimated gross unit cost (including capital costs) of 383 c/m^3 (1994).

Introduction

The mining industry in South Africa uses vast quantities of water during its daily mining operations. This mine service water is recycled for reuse and can be classified as potentially calcium sulphate scaling in the majority of gold mines. The poor quality of mine service water has significant cost implications on mining and the excess water adds a considerable salt load to the environment when discharged.

Mackay et al. (1991) estimate that poor mine service water costs the gold mining industry in the region of R300 m. annually, based on its corrosive, scaling and fouling potential. The quality of mine service water varies from mine to mine but in general the total dissolved solids (TDS) concentration is above 1 800 *mg/l*, as confirmed in a mine water survey often mines during 1988/1989 (Pulles, 1991). The major contributor to the high TDS of mine service water is sulphate resulting from the bacterial and chemical oxidation of pyrites which are associated with the gold-bearing reefs.

An example, which highlights the impact that large salt loads from industries can have on the limited water resources, is the contribution by three active gold mines (Grootvlei, ERPM and Durban Roodepoort Deep) over a period of 16 months during 1988/89 to the Klip River, which is the main contributor to salt load entering the Vaal Barrage (Rand Water Board, 1988; 1989). The volumetric contribution to the river from these mines amounted to 9% of the flow, while the salinity contributed 48% to the TDS load and 60% to the sulphate load (Funke, 1990).

In general, the pollution potential from the mining industry is significant. The Department of Water Affairs and Forestry through the Department of Mineral and Energy Affairs is bringing pressure to bear on the mining industry to manage the effects of the mining activities on the environment; to mitigate the negative impact while maximising the positive features. In order to enforce this responsibility the Minerals Act, 1991, requires the owner of every mine to submit and obtain approval for an Environment Management Programme Report (EMPR) before mining operations commence (Department of Mineral and Energy Affairs, 1992).

Depending upon the age of the mine and its geographical location, it is possible to have a mine service water which has high concentrations of calcium, sulphate, sodium and chloride. Table 1 shows analyses of water from selected mines in different mining areas and illustrates the range of water quality that is possible.

These analyses reveal that from a treatment point of view mine service water in the gold mining industry may be grouped into different types, namely: those that are dominated by the presence of calcium and sulphate (Mines B and C) and those that are dominated by the presence of sodium and chloride. Although Mine B has high concentrations of sodium and chloride as well as calcium and sulphate, the latter ions are more important, because of the relatively high degree of $CaSO_4$ saturation of the water (41 %). Waters such as those from Mine A are termed non-scaling mine waters (relative to $CaSO_4$) while the other two are termed $CaSO_4$ scaling mine waters (Mines B and C). Most of these waters are undersaturated with respect to $CaSO_4$ and should therefore strictly be termed potentially $CaSO_4$ scaling mine waters, but the term $CaSO_4$ scaling mine waters is that which is used in this paper. The high degree of CaSO, saturation has severe implications in desalination technology due to the problems caused by scale

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