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Prevention of calcium sulfate formation in seawater desalination by ion exchange

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ABSTRACT

In mechanical vapor compression (MVC) desalination, high operating temperatures (>120°C) allow for high heat transfer coefficients and reduced compressor size, both of which lower total capital costs. To prevent formation of calcium sulfate scale on high-temperature desalination heat exchangers, the inverse solubility of calcium sulfate requires high sulfate removal. To selectively remove sulfate from seawater, a weak-base anion-exchange resin (Relite MG 1/P) was used. In synthetic seawater, the resin shows high sulfate selectivity. Conveniently, the exhausted resin can be regenerated with concentrated acidified (pH 4) blowdown brine from the desalination heat exchanger. Using the same exhaustion and regeneration times, high desalination concentration factors increase chloride concentrations in the blowdown brine, which allows for slower regenerant flow rates thereby increasing regeneration efficiency and sulfate removal. Using a high concentration factor helps regeneration; however, this must be balanced against the greater tendency to form scale in the desalination heat exchanger. With a fixed concentration factor, high flow rates lower the regeneration efficiency and the extent of sulfate removal. In contrast, low flow rates require larger equipment and more resin, which increases capital costs. For a desalination plant with a production capacity of 1 million gallons per day (MGD) and a concentration factor of 2, the cost of sulfate removal – including all operating and capital costs – varies from $0.246 to $0.356/thous gallon as the maximum brine temperature changes from 140 to 180°C.

Keywords: Calcium sulfate; Ion exchange; Mechanical vapor compression (MVC); Scale; Seawater desalination; Sulfate removal; Weak-base anion exchange resin

1. Introduction

As available fresh water resources decline and demand for potable water grows, economical seawater desalination is increasingly important. The most common desalination techniques include membranes (reverse osmosis, RO; electrodialysis, ED) and evaporation (multi-stage flash, MSF; multi-effect distillation, MED; mechanical vapor compression, MVC). Despite the rapid deployment of energy-efficient membrane techniques, thermal desalination has the following advantages: minimal pretreatment, flexible salinity in feed water, and high-quality produced water. MSF is more practical when the water resource has high

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