

https://dspace.org/

High recovery membrane treatment of mine impacted waters utilizing calcite and gypsum precipitation within a process recycle loop

Franzsen, Sebastian

2019

https://hdl.handle.net/10539/28418

Downloaded from a DSpace repository. https://dspace.org/

ABSTRACT

Reverse osmosis (RO) and nanofiltration (NF) membrane technologies are extensively applied to the treatment of mine impacted water. However, the volumetric recovery that is attainable by membrane treatment processes is limited by the precipitation of sparingly soluble minerals on the membrane surface and the elevation of osmotic pressure as the volumetric recovery ratio increases. Research studies have shown that intermediate chemical demineralisation (ICD) of primary RO (PRO) concentrate followed by secondary RO (SRO) desalination, (PRO-ICD-SRO), can substantially improve the volumetric recovery of brackish feed waters. The application of secondary NF (SNF) or PRO-ICD-SNF is thought to be particularly attractive in total or near total SNF concentrate recycle processes due to the reduction in osmotic pressure of the recirculation liquor attributed to the higher monovalent salt passage of NF membranes. The transport mechanisms in NF membranes include convection and electro migration in addition to the solution-diffusion mechanism that dominates in RO membranes. Currently, no integrated process simulation solution is available to track the evolution of bulk phase aqueous species in total recycle PRO-ICD-SRO or PRO-ICD-SNF processes as a function of key process parameters such as sludge solids and moisture content, secondary RO or NF rejection characteristics, pH targets, gypsum and calcite precipitation performance and concentrate purge from SRO or SNF concentrate recycle. The aim of this research was to model a total or near total recycle variation of a brackish water PRO-ICD-SNF process in which the bulk liquor total dissolved solids (TDS) would cycle up to a steady state point which is adjustable to the degree of volumetric recovery and sludge waste minimisation sought. The cycling up and subsequent approach to steady state of the recirculation liquor TDS were experimentally observed for the selected PRO-ICD-SNF process. A model of the process was developed in Microsoft's Visual Basic for Applications that utilised the aqueous geochemical modelling capabilities of USGS's PHREEQC. The model showed good agreement between the predicted and experimentally observed aqueous species concentrations and reagent consumptions. A NF submodel based on the Donnan steric pore model with dielectric exclusion (DSPM & DE) was developed to improve the performance prediction of SNF systems SNF systems are sensitive to the evolution of the recirculation liquor chemistry, the hydraulics and membrane properties of SNF system designs and the process configuration and design of

the precipitation reactor systems. A recommendation for future work is to incorporate a rate-based reactor sub model in the ICD-SNF model with the DSPM & DE sub model for the NF. The combination of rigorous ICD and SNF sub models could substantially extend the applicability of the model.