

https://dspace.org/

Development of a continuous metal recovery contactor using ion-exchange fibres

Ntimbani, Rhulani Nicolas

2016

http://hdl.handle.net/10539/20021

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

ABSTRACT

Wastewater from industrial processes usually contain heavy metals such as copper (Cu^{2+} ions) which are harmful to the environment and human health. Therefore, it is imperative that these effluent streams are treated prior to being discharged. In recent past, ion exchange fibres (IEFs) have been suggested for the treatment of such waste streams because they have higher adsorption/desorption rate due to their larger surface areas and shorter diffusion paths compared to granular ion exchangers. In this study, the development of an IEF contactor for the removal of Cu^{2+} ions from synthetic dilute solutions was carried out. The table pan filter model was proposed for a contactor for continuous and simultaneous Cu^{2+} ions loading, elution and rinsing of Cu^{2+} ions.

In order to generate the equilibrium and kinetic data required for the design of a contactor, IEFs were contacted with dilute synthetic solutions of Cu^{2+} ions in batch systems. The Temkin and pseudo-second order model were found to best describe the equilibrium and kinetics of the system, respectively. The batch tests conducted for multi-component system showed that the selected IEFs have a higher selectivity for Cu^{2+} ions.

The effects of bed packing density and flow rate on loading and elution of Cu^{2+} ions were investigated using columns at lab scale. The results showed that effective loading of Cu^{2+} ions can be conducted at low IEFs bed packing density and low feed flow rate that allowed sufficient residence time for the ion exchange to occur. The results also showed that the elution rate of Cu^{2+} ions can be increased by increasing acid flow rate provided the acid is sufficiently concentrated for elution purposes. In this study, the Yoon-Nelson model was the most suitable model for predicting how effluent concentration during loading varies with time. Other models fitted were the bed depth service time (BDST) model and the Thomas model. However, the Yoon-Nelson model had parameters which were comparable to those obtained experimentally for all tests.

Following the column test results, a segment of a rotating contactor utilising IEFs was proposed, designed and fabricated from clear polyvinyl chloride (PVC). The contactor was then tested for loading and elution duties. The study showed that the contactor was able to remove 45 mg of Cu^{2+} ions /g of fibre from the feed solution as compared to 54 mg Cu^{2+} ions /g of fibre obtained in column tests. Loading of Cu^{2+} ions onto the designed contactor pan was

found to be low due to the higher cross sectional area which consequently resulted in uneven distribution of feed solution. The IEFs loaded with Cu^{2+} ions were successfully regenerated with 3 bed volumes of 2 M HCl which removed 99.84% of the loaded Cu^{2+} ions as compared to the 7 bed volumes which was required to elute the entire loaded Cu^{2+} ions. Although the loading of Cu^{2+} ions was low, the designed contactor is promising as it was able to remove Cu^{2+} ions from feed solution and the IEFs could be completely eluted for reuse. In contrast to column Cu^{2+} ions breakthrough tests, the Yoon-Nelson model was unable to predict the breakthrough of Cu^{2+} ions in the designed IEF contactor pan. It is recommended that mathematical and/or linear driving force models be fitted into the breakthrough profile of the contactor for further development. This will allow simulations of breakthrough profile and consequently optimization of the IEFs contactor.