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Modelling and experimental design of a stagnant film crystalliser for freezing desalination treatment of seawater using sweating steps and non-direct freezing

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ABSTRACT

A stagnant film crystalliser for the treatment of seawater by a combination of freezing and sweating steps using non-direct freezing, so-called PNDF, was developed. All tests were carried out with samples of seawater from the Gulf near Fao, Basra, Iraq. The pilot plant consists of a cooling cylinder. The crystallisation tubes are located in a cylinder-shaped paired jacketed tank refrigerated via a thermostatic bath. The effects of the main parameters on the sweating steps including the sweating rate, initial concentration of frozen water, sweating temperature, and sweating time were examined. The experimental design used to study the influence of these parameters limits the weight of the purified frozen product. The weight loss of frozen water increased with increasing sweating rate, from 0.0089 to 0.05 K/min, whereas the weight loss was almost unaffected by the purity of the initial frozen water film. A statistical model was built and calibrated to the experimental data to evaluate the experimental strategy and predict the purity of the frozen water using three sodium chloride concentrations 5.33, 7.42, and 14.92 mg/L. The demonstration of the statistical model enabled the selection of the optimal running time, resulting in the production of 0.4 g/kg pure water (less than the standard value of drinking water) in one stage within 29 h. The results obtained with seawater sampled near the port of Fao, Iraq, showed that PNDF can reduce the total dissolved solids to 0.3% of 41,750 mg/L with 96% recovery without using chemical additives; furthermore, chloride removal was 85%.

Keywords: Freezing; Saline water treatment; Crystallisation

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