A pilot-scale nanofiltration system for treatment of cooling tower blow down water of thermal power plants

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Abstract

Cooling towers in thermal power plants require substantial amounts of freshwater intake. Given the global water security challenges, it is essential to develop and implement treatment methods / systems that enable the reuse of cooling tower blowdown (CTBD) water. Process optimisation through advanced control algorithms (AI based) fed by experimental data at pilot scale is essential for achieving the goal of near zero liquid discharge with minimal energy consumption. This work presents an experimental design of a pilot-scale hollow fibre (module of 8 inches diameter) nanofiltration (NF) system for the removal of bivalent (Ca^{2+}, Mg^{2+}, SO_4^{2-}) and monovalent (Na^+, K^+, Cl^-) ions from CTBD water that would allow the reuse of treated water as supplementary make-up of the cooling tower with the minimum specific energy consumption (SEC). Experiments were conducted with real CTBD water (from a combined cycle power plant) under varying conditions of transmembrane pressure (TMP, 1.0 - 2.5 bar) and feed flow rate (1 - 2 m^3/h). Parameters such as pressure, temperature, conductivity, turbidity, feed flow rates and velocities, SEC and major ion concentrations for the NF permeate and concentrate streams were monitored. Emphasis was placed also on calculating saturation indices to assess the scaling tendency of sparingly soluble salts, such as calcium carbonate and calcium sulphate, as well as on determining the necessary measures to mitigate these effects. The pilot-scale NF system results showed a recovery rate of 60% at 2.4 bar with a feed of 1 m^3/h. The rejection of Ca^{2+} and Mg^{2+} reached 78.5% and 82.1%, respectively, while a SO_4^{2-} rejection rate of 97.5% was achieved. The experimental setup offers a versatile platform for the study of nanofiltration applications and has the potential to serve as a tool for scaling up the CTBD treatment process.

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