Improved Tube Wetting and Scale Inhibition in Falling Film Evaporators for Seawater Desalination

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Horizontal tube falling film evaporators are commonly used in multiple-effect distillation (MED) plants for seawater desalination. Since the seawater flows as a thin film over the outside of the horizontal tubes and partly evaporates, an even liquid distribution from the top to the bottom of the tube bundle and a uniform liquid film are required to maintain a high heat transfer efficiency and minimize crystallization fouling of calcium- and magnesium-containing salts.

The wetting rate, which is defined as the seawater mass flow rate on one tube divided by the tube length, is one of the most important parameters in the design and operation of horizontal tube falling film evaporators. MED plant manufacturers and operators strive for low wetting rates because thin liquid films result in high heat transfer coefficients and a lower specific thermal and electrical energy consumption (pumping power). However, thin liquid films are susceptible to breakdown. Therefore, a decrease of the liquid feed flow rate is limited by the minimum wetting rate which causes film breakdown. Dry patches as a result of film breakdown decrease the effective heat transfer area and increase scale formation due to high concentrations of scale-forming components in the adjacent tip of the seawater film.

Furthermore, tube wetting plays an important role in the design of MED plants and future development. Achieving uniform tube wetting represents a major task in dimensioning the tube bundles. In order to raise the MED unit capacity and to design MED plants with high thermal efficiencies, tube wetting and crystallization fouling have to be controlled.

A common strategy to reduce the formation of inorganic scales relies on the addition of a small quantity of an antiscalant to the feed water. Polymeric antiscalants are successfully used in seawater desalination plants.

An innovative approach for improving tube wetting and scale inhibition based on the combined use of a polymeric antiscalant and a wetting agent has been developed. The addition of a novel wetting agent developed by BASF to a falling liquid film at a very low concentration affects the film flow characteristics and improves tube wetting.

Wetting and scaling experiments were performed in a horizontal tube falling film evaporator at pilot plant scale with common tube materials. Scale formation and mitigation were systematically investigated at very low wetting rates in order to mimic bad wetting conditions. The effects of the combined use of the antiscalant and the wetting agent were studied at different antiscalant and wetting agent concentrations.

The experimental results show that the wetting agent effectively enhances tube wetting on common tube materials. The wetting agent prevents film breakdown and homogenizes the seawater film. Scale formation is already reduced by the use of the wetting agent alone, especially at very low wetting rates. The combined use of the antiscalant and the wetting agent shows synergistic effects and results in scale inhibition even at very low wetting rates and in critical tube areas in terms of wetting such as the tube ends.