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Modelling and Optimal Operation of a Forward Osmosis Process

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Compared to reverse osmosis (RO), the forward osmosis (FO) process is a less established membrane technology. Yet, its potential is vast in water purification and solutions concentration. While in RO, a high external hydraulic pressure is applied to the feed solution, in FO, the separation is based on a natural osmotic pressure. This enables various benefits such as harmlessness to feed solutions and energy savings [1].
The FO process involves a membrane module and feed and draw solutions. The membrane, which involves a functional aquaporin layer [2] is placed between the feed and the draw solution. The osmotic pressure difference the two solutions is the driving force for the water separation from the feed. To regenerate the draw solution, another aquaporin membrane is applied and the reverse osmosis is used. Final products of the process are purified water and/or concentrated feed.
By creating a mathematical model of the process, we can anticipate system dynamics, its behaviour under different conditions and find the operation that provides the best process performance. We design the model by applying various modelling approaches (white box, black box, grey box) which are consequently compared and evaluated. These models are constructed based on fundamental physical principles, such as mass balances combined with experimentally found correlations and equations describing the system under the real conditions. Models simulate real process with adequate accuracy.
Process optimisation entails determining the best configuration needed to achieve the desired outcomes with minimal energy input. Specifically, our objective is to attain the desired feed concentration as quickly as possible while minimizing energy consumption of the pump in reverse osmosis part.
Additionally, we provide simulations of the optimized process to visualize its behaviour. This allows operators to observe the entire time evolution and actively adjust inputs as needed.

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