Small steps toward membrane distillation commercialization

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A liquid level measurement system based on a high-resolution camera allows for fuller automation.

Membrane distillation (MD) is a relatively new process that is under investigation worldwide as a low cost, energy saving alternative to conventional separation processes such as distillation and reverse osmosis. MD has many advantages compared to other, more popular separation processes. It works at room conditions (pressure and temperature), and low-grade, waste, and/or alternative energy sources such as solar and geothermal can be used to power it. MD exhibits a very high level of rejection with inorganic solutions, and the necessary equipment is small. Furthermore, since the process appeared in the late 1960s, proponents have claimed that would be cost effective. As such, it has been studied by academic experimentalists and theoreticians around the world.

In industry, however, MD has gained little acceptance and is yet to be implemented. The major barriers to commercialization include MD membrane and module design, membrane pore wetting, low permeate flow rate and flux decay, and uncertain energetic and economic costs.

The driving force in MD processes is the vapor pressure difference across the membrane, which results from an imposed temperature difference. The lower vapor pressure on the permeate side can be set up in various ways: direct contact MD (DCMD), osmotic MD, sweeping gas MD, vacuum MD, and air gap MD.

Figure 1 presents the experimental setup used in our DCMD experiments. It includes double-wall reservoirs to contain the solutions, variable flow gear pumps to drive them, liquid flow sensors to measure the flow rates, digital pressure transducers to measure the pressure, and thermostats connected to the reservoirs to control temperature. To improve the thermostatization process, two heat exchangers are connected between the reservoirs and the thermostats. PT-100 probes measure temperature on both sides of the membrane as well as at the inlet, inside, and at the outlet of the cell.

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One of the main experimental measurements in DCMD processes is the mass flow through the membrane. During the experiment the liquid level in each reservoir (feed and permeate) changes and must be measured at regular time intervals. The volume flow through the membrane is determined from the temporal evolution of the liquid levels in the reservoirs. The permeate flux is calculated by plotting the cumulative volumes, multiplied by their respective densities, versus time. This procedure also provides a method to detect membrane wetting or excessive evaporation from the reservoir.

Accurate liquid level measurement is a central problem in this kind of process. Currently we measure this level with a manual cathetometer with up to 50 µm resolution. This makes the complete automation of the process impossible. Other measurements, such as temperature, flow, and pressure, have already been automated by means of a data acquisition system.

We have thus far been unable to find a level meter that is both suitable for our system and offers enough accuracy to detect small changes in the liquid level. Therefore, we propose a high resolution camera system\(^8\) that makes automatic measurements of both reservoir levels at a rate of up to ten times per second.

Experimental results suggest that at the highest flow rates through the cell, a ‘plateau’ behavior has been reached. This implies a partial optimization of the process.

For any new technology to be industrially accepted and implemented, all of its claimed benefits must be verified, and it must exhibit superiority over other, already well-established technologies. This must first be achieved on the laboratory scale, then on the pilot plant scale, and finally in industry. Surprisingly, MD, though long claimed to be a promising separation technique, has not yet been implemented successfully at even the first, laboratory, scale. Great advances have been made, but some issues still need to be resolved.

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