Efficient production of modular silicon carbide membrane stacks

Dipl.-Ing. Michael Stahn, Dipl.-Umweltwiss. Christian Pflieger, Dipl.-Ing. Heike Heymer

Submerged membrane modules enable a particularly energy-efficient mode of operation, as no pumps are required to produce flow over the membrane surface. This membrane technology uses negative pressure on the permeate side to ensure flow and is particularly interesting for water treatment. However, the driving force is limited, so membranes with the highest specific permeate fluxes have to be used. Ceramic membranes made of silicon carbide (SiC) are suitable for this purpose, because they reach permeate fluxes of up to 10,000 l/(m^2 x h x bar), but they have to be optimized for submerged applications. The aim of the joint project "SiCaM" (FKZ: 2019 FE 9064) was to effectively produce flat SiC membranes and to contact and integrate them into membrane stacks with a high packing density. Two support geometries were considered: multi-channel plates and waved membrane elements. Each membrane support was provided with a membrane layer on the outside.

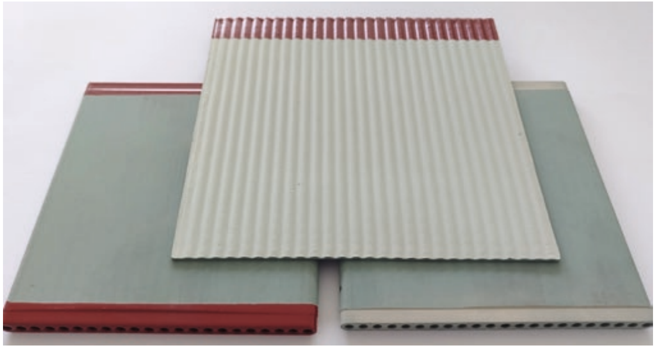

Figure 1: Multi-channel plate and waved membrane element.

A comparison of the two support geometries shows advantages and disadvantages of both forms: while the extruded multi-channel plates have better scalability and higher component strength, the waved membrane elements laminated from cast films can be produced using less material and enable a higher packing density. The project partners then focused on the more robust multi-channel plates and the interchangeability of individual plates. This in turn places demands on the contact areas in terms of dimensional and shape accuracy. Machining turned out to be the best solution in terms of detachable and reusable contacting with connectors on the end faces.

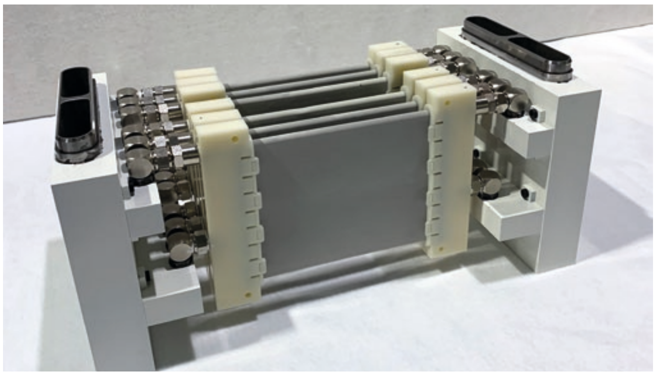

Figure 2: Membrane stack demonstrator with multi-channel plates.

As part of the project, it was possible to transfer the coating technology to multi-channel plates that are up to 50 cm long. Accompanying simulations of the flow behavior helped to adapt the design to minimize pressure losses on the permeate side.

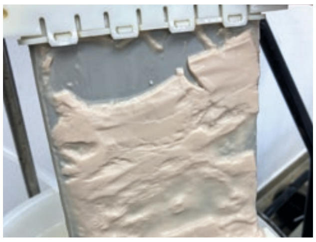

Figure 3: Multi-channel plate after filtration tests with yeast.

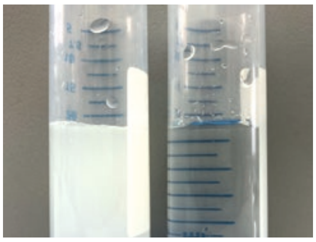

Figure 4: Feed and permeate of yeast filtration.

The membranes were tested with specially prepared waters. Filtration tests with a typical model wastewater (yeast suspension, 10.5 g/l, Figures 3/4) resulted in an easy-to-remove top layer and complete retention of the yeast cells. The filtration of defined dextran solutions and analysis of retention by gel permeation chromatography (GPC, 0.3 g/l, MW approx. 500,000 Da, Alfa-Aesar, dissolved in RO (desalinated) water) showed a separation performance comparable to that of industrially available tubular membranes in cross-flow operation mode. Submerged membrane modules with multi-channel plates based on SiC are therefore a promising alternative for separation processes with high energy efficiency.

UNISOL Membrane Technology · eitech Werkzeugbau · EFRE Europa für Thüringen Europäischer Fonds für regionale Entwicklung · Europäische Union

Contact Michael Stahn • Phone +49 36601 9301-3936 • michael.stahn@ikts.fraunhofer.de