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Separation and Purification Sciences Division

Application Brief

Simultaneous Oxygen and Carbon Dioxide Removal from Boiler Feed Water in Waste-to-Energy Plant Using 3M™ Liqui-Cel™ Membrane Contactors

Introduction

Abfallwirtschaftsgesellschaft (AWG), a waste management company located in Wuppertal, Germany, expanded their waste-fueled power station with a water heating system that is connected to the central city district heating network. This led to a significant efficiency increase for the power station. Additionally, the district heating route enabled AWG to take the coal-fired plant off the grid reducing its carbon footprint.

Central district heating systems distribute heated water from power plants to densely populated residential and industrial areas through insulated piping networks. Large tanks are typically used to store heat, volume balance and safety make-up water for use during peak demand times. High water quality with low dissolved oxygen (O_2) and carbon dioxide (CO_2) gas content is required to help prevent internal corrosion and increase lifetime of piping and storage tanks.

Traditionally, a Forced Draft Degasser (FDD) would have been installed for CO_2 removal in the demineralization system in combination with the expansion of an existing downstream thermal deaerator for O_2 removal. By installing a system using 3M™ Liqui-Cel™ Membrane Contactors , O_2 and CO_2 removal could be accomplished in a single process step. The complexity of expanding additional thermal deaerator equipment could be avoided.

3M Liqui-Cel Membrane Contactor Technology

3M™ Liqui-Cel™ Membrane Contactors contain microporous hollow fiber membranes, as illustrated in figure 1.

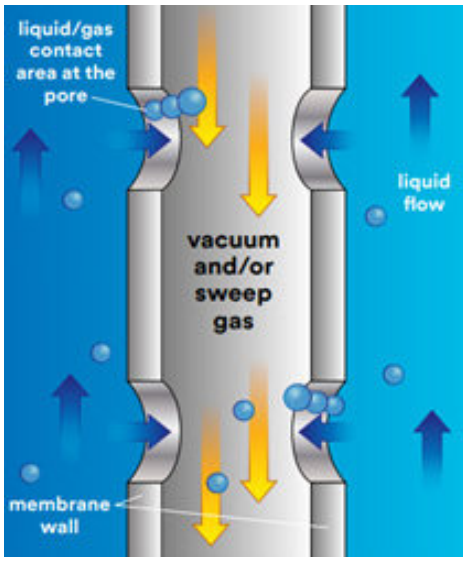

Figure 1. Principle scheme of a hollow fiber membrane in a 3M Liqui-Cel Membrane Contactor

Water flows through the contactor on the outside (shell side or liquid side) of the membrane. Because the membrane is microporous and hydrophobic only gas molecules can pass through the membrane wall. Applying a vacuum and/or using an inert sweep gas on the inside (lumen side) of the hollow fiber membrane lowers the partial pressure of the gas that needs to be removed, carrying excess gasses away into the vacuum. 3M™ Liqui-Cel™ contactors degas water without using chemicals.

System Design

Power plants requiring additional water to compensate for increased demand typically need to treat the incoming water. Depending on the feed water quality, the water treatment system can have different designs. For this project, an ion exchange demineralization system using membrane degassing was built to process the local drinking water supply using for both CO_2 and O_2 (see figure 2).

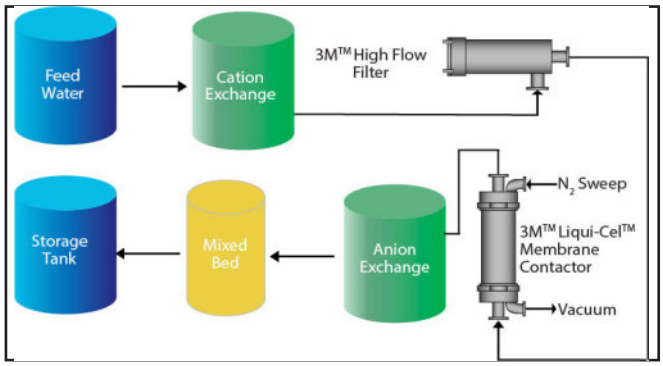

Figure 2: Flow diagram of the new water treatment system at the AWG Wuppertal

Three lines each containing three 3M™ Liqui-Cel™ EXF-14×28 Series Membrane Contactors in series were installed between the cation exchange and anion exchange (see figure 3).

Figure 3: Three 3M Liqui-CelEXF-14×28 Series Membrane Contactors

In front of each of the three lines a 5µm absolute 3M™ High-Flow filter was installed to protect the 3M™ Liqui-Cel™ Membrane Contactors. This particle filter contains a large area of separation surface on very small footprint (see figure 4).

Figure 4: In front, a 5µm absolute rated Single Cartridge 3M™ High-Flow 40-inch Filter

Each line with three EXF-14×28 contactors can deliver up to 50 m^3/h water and is operating in vacuum assisted Nitrogen (N_2)-sweep gas (combo) mode to achieve low O_2 values. For simultaneous CO_2 reduction, the sweep gas rate and vacuum capacity was increased.
Nitrogen gas is coming from a liquid nitrogen tank with a purity >99.99%. It enters the contactors from the top gas port and a liquid ring pump pulls vacuum of around 70mbar absolute (50 Torr) from the bottom gas ports for each line.

Results

The goal of the AWG was to remove oxygen to a requested specification of 30ppb at maximum water capacity for a downstream nitrogen blanked storage tank. In lower water demand situations, the O_2 level drops to lower values. The maximum performance level for deaeration with 3M Liqui-Cel Membrane Contactors is 1ppb O_2. Deoxygenation after a cation bed results in the longer lifetime of following anion resins.
The membrane contactor solution was chosen because in addition to oxygen removal the carbon dioxide could also be removed to <10 ppm. Carbon dioxide removal increases the anion exchange capacity and decreases resin volume. The system has been in operation since the beginning of 2019 and continues to meet specification.

For more information and system sizing, please contact your 3M representative or visit 3M.com/Liqui-Cel.

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