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Capturing Ammonia in Flue Gas Condensate Treatment for Biomass Power Stations with 3M™ Liqui-Cel™ Membrane Contactors

Introduction

Heat and power generation in biofuel engine cogeneration plants has become increasingly important as process industries look for more economical and environmentally friendly ways to produce energy. Compared to plants powered with fossil fuel, biofuel-fired plants produce energy with a greatly reduced carbon footprint.

Flue gas produced by incinerating biomass such as paper, wood chips or animal waste contains environmentally harmful byproducts along with valuable heat energy and water vapor. Many of the byproducts, such as ammonia or heavy metals, are strictly regulated, resulting in significant discharge and disposal costs that must be borne by the power station. The water vapor and the heat energy, however, can be recovered from flue gas for re-use.

An integrated cleaning and recovery system that incorporates 3M™ Liqui-Cel™ Membrane Contactors for Transmembrane Chemisorption (TMCS) may reduce compliance costs associated with ammonia abatement from wastewater with minimal maintenance.

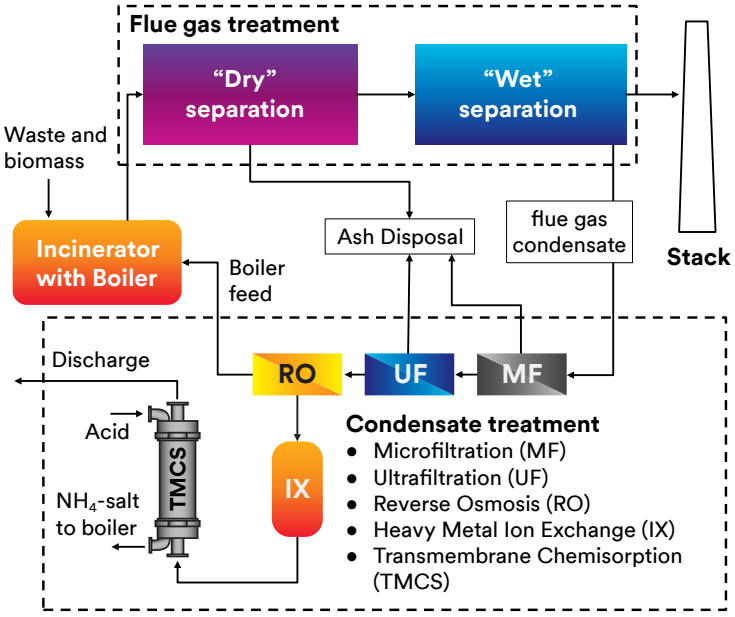

Figure 1. Typical set-up for a flue gas condensate recovery system

Flue Gas Treatment

Flue gas treatment can be divided into two main steps. First, the flue gas is treated in a "dry" separation stage to remove most particulates. Second, the flue gas passes through "wet" separation stage to remove supplementary particulates, salts, and acids. At this point, the flue gas is clean but is still saturated with water vapour from combustion and from the wet separation process. By cooling down the saturated flue gas in a quench scrubber or condenser, the resulting condensate can be purified as boiler make-up water while the concentrate is sent to the sewer or used in flue ash wetting.

Transmembrane Chemisorption in Condensate Treatment

By utilizing Liqui-Cel membrane contactors for TMCS, Radscan Intervex AB is able to offer innovative solutions for condensate treatment. The TMCS process allows power plants to meet EU compliance requirements for ammonia in wastewater, but also allows for the production of ammonium sulphate, which is used in the incinerator for CO and NOx reduction.

System Design

Figure 1 illustrates a typical flue gas condensate recovery system at a waste fuel power station.

Wastewater from the wet flue gas separation step is first treated by a 100 µm cross-flow microfiltration (MF) vibrating screen to reduce total suspended solids (TSS). A polymeric or ceramic ultrafiltration (UF) filter is used in a second filtration step to lower the chemical oxygen demand and increase particle rejection down to 0.05 µm (normally 150 kDa). The UF permeate is then purified by reverse osmosis (RO), while the MF and UF concentrate are mixed and sent back to the fuel or used to wet the flue ash prior to shipment. The RO concentrate is treated by ion exchange (IX) to remove the heavy metals and is then fed to the ammonia TMCS system.

System designs may vary, depending on water inlet parameters and quality requirements.

Ammonia Removal by TMCS

The feedwater to an ammonia removal system has a pH>10 and is normally cooled down to 50°C or lower. At this temperature and pH, ammonium ions ($NH4^+$) are available as free ammonia gas (NH3) that can be readily removed by TMCS.

As shown in Figure 2, the wastewater is introduced to the shellside (outside) of the microporous hydrophobic hollow fiber in the 3M™ Liqui-Cel™ Membrane Contactor. A sulphuric acid solution (adjusted to pH<1.5-2.0) flows counter-current through the lumenside (inside) of the hollow fiber at approximately one-third the rate of the water flow. The gaseous NH3 transfers through the membrane and reacts with the acid to form a diluted ammonium sulphate solution. This solution is sent back to the boiler as a corrosion inhibitor and to reduce the formation of CO and NOx.

Results

The introduction of Liqui-Cel membrane contactors for TMCS in the Radscan Intervex systems allowed power plants to reuse the NH3 from flue gas condensate. NH3 inlet concentrations of 100-1000 ppm were reduced 85-98% to 15 ppm. This meets EU discharge limits, so the effluent wastewater is sent to the sewer.

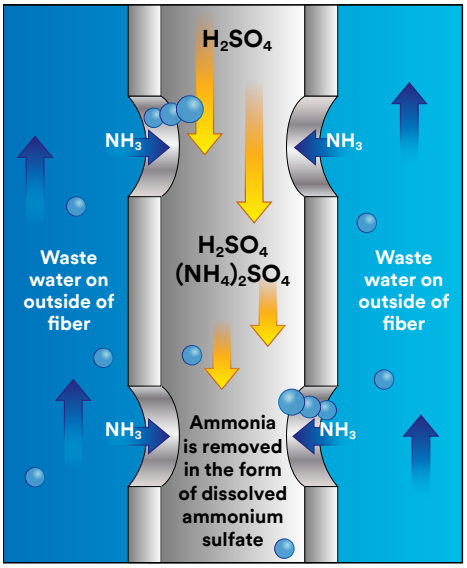

Figure 2. TMCS process scheme for ammonia removal

In addition to the environmental benefits of capturing ammonia, customers using Liqui-Cel membrane contactors realize energy savings, water savings and low maintenance requirements by using the processes described in this technical brief.

For additional information, please contact your 3M representative or visit 3M.co.uk/TMCS.

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