Advanced Membrane Separation Technologies for Energy Recovery

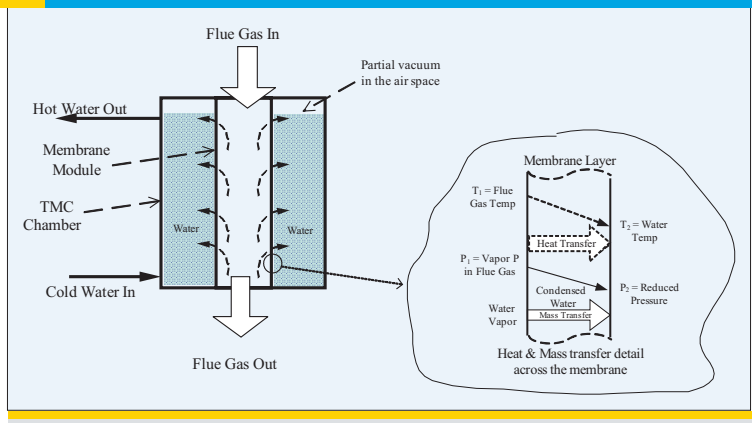
New Transport Membrane Condenser Recovers Energy and Water from Industrial Process Streams

Energy recovery from relatively low-temperature waste streams is a challenging energy saving opportunity at large scale. The use of heat exchangers with low temperature streams requires impractically large surface areas, which reduces the energy efficiency of the heat recovery system. Commercially available condensing economizers offer the potential to reclaim significant amounts of energy, but can have large footprints and require long payback periods when installed on state-of-the-art gas-fired boilers. Retrofitting costs and complex emissions streams can further lengthen the required paybacks, and as a result, this commercial technology is not widely adopted in the market.

The ceramic-tube transport membrane condenser (TMC) system is a novel approach to recovering significant amounts of heat and water from waste streams. Already tested on clean systems in laboratories, the technology relies on a porous ceramic membrane to condense water vapor and recover heat. This project is evaluating various materials and identifying those suitable for the membrane and substrate with sufficient resistance to corrosion and fouling, for industrial waste stream applications. Targeting improved durability, efficiency, and cost-effectiveness, candidate membrane systems are being fabricated, tested, and evaluated in simulated industrial environments.

Benefits for Our Industry and Our Nation

Ceramic-tube TMCs have shown recovery rates of 40-45% of the water in a flue gas, resulting in thermal efficiency improvements of 10%. Development of metallic substrate membrane tubes could allow for the use of TMCs in more aggressive environments. Energy savings could be realized from the deployment of TMC systems in wood bark fired boilers, steam boilers in integrated steel mills, and paper machine exhaust hoods. There are hundreds of other possible applications for this technology, with potential for energy extraction from sources that previously did not have an easy route to energy recovery.



Schematic of the transport membrane condenser mechanism.

Illustration courtesy of the Gas Technology Institute.

Applications in Our Nation's Industry

Opportunities exist to recover waste heat from exit gases in a number of industries, including the chemical, forest products, and petroleum industries. Examples of relevant exit gases include flue and stack gases, flared gases, vent gases, exhaust from metal heat treating furnaces, dryer vents, and combustion gases.

Project Description

The goal of this project is to develop novel materials for use in membrane separation technologies for the recovery of waste energy and water from industrial process streams.

Barriers

Major barriers to be overcome include the following:

- Incomplete understanding of the detrimental impacts of foulants and contaminants in the waste streams
- Lack of knowledge about failure and degradation characteristics of ceramic membranes in harsh industrial environments
- Insufficient catalog of mechanically robust substrates with sufficiently high thermal conductivity

Pathways

To successfully function in contaminated industrial environments, the project will identify materials that will improve thermal conductivity and robustness and provide sufficient corrosion resistance. Researchers will identify suitable materials for these advanced membrane systems and conduct both laboratory pilot-scale and field tests to verify that these membranes can usefully function in harsh industrial environments.

Milestones

- Identify at least two candidate novel materials with adequate heat transfer, durability, and corrosion resistance for membranes and substrates (Completed)
- Fabricate and test at least two experimental membranes (Completed)
- Identify the most promising material and fabricate bench-scale prototype system for industrial evaluation (Completed)
- Evaluate commercialization potential from economic analysis and commercialization studies

Commercialization

The project team has initiated discussions to determine the costs of fabrication of metallic substrate tubes on a mass production scale. Several industrial organizations have indicated their interest in serving as TMC host sites for the technology.

Project Partners

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