

Flue Gas CO₂ Capture

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Separation of flue gas CO₂ from natural gas, petroleum or coal fired furnaces is difficult and expensive but key to the DOE planned capture, pipeline, and geologic storage strategy. Choice of method will be guided by cost of energy, CO₂ avoidance cost, robustness, size and feed stream/location applicability.

We have developed an enzyme-catalyzed, contained liquid membrane (CLM) permeator for the selective extraction of carbon dioxide (CO₂) from flue gas. Data were obtained from analog (ersatz) and actual flue gas feed streams; CO₂ ranged from 0.05-20% in air, and 6%-13% in combusted natural gas or propane. Feed gas composition has no effect on the CO₂ permeance. The permeance of non-reactive gases is given by the solubility of each in the solvent liquid.

The permeator has been tested for 50 days, under conditions of deliberate upset, to characterize its ability to recover as a measure of its robustness. It is robust and easy to return to pre-upset operation. The design is stable in streams containing NO_x or SO_x.

We have carried out process engineering analyses for gas composition, flow rates, and pressure at critical sites in our candidate commercial design. The test set is EPRI case 7C, for a coal burner, and case 1C, for a natural gas burner. Our target was at least 90% CO₂ removal and at least 95% purity in the compressed gas outlet stream. For coal (natural gas) feed streams containing 13.8% (3.5%) CO₂ the permeate, returned to the stack, contains 1.6% (0.4%) CO₂, while the dry compressed product is 98.3% (95.1%) CO₂.

The process engineering modeling was used to specify the major pieces of equipment, from which we derived their sources, availability and cost. Based on these costs for off-the-shelf hard goods as well as fabricated materials we were able to calculate Capex, Opex, Energy Burden, and Cost of CO₂ Avoidance. For example, the Energy Burden was calculated to be less than 13% vs. almost 29% for MEA-based separation.