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EIC Compression for Carbon Dioxide Segregation and Capture

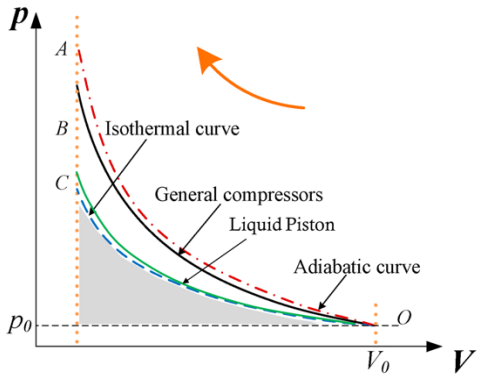
1.0 Executive Summary

EIC has developed and patented technology that permits compression of various gases to high pressures with limited temperature rise, which offers significant reduction in energy usage relative to conventional machines based on the thermodynamics of near-isothermal compression. Several aspects of the EIC compression process enable economical carbon segregation from mixed gas flow as an alternative to current processes such as amine-based systems.

This white paper is written at a high level based on the development status of the technology.

2.0 Technology Discussion

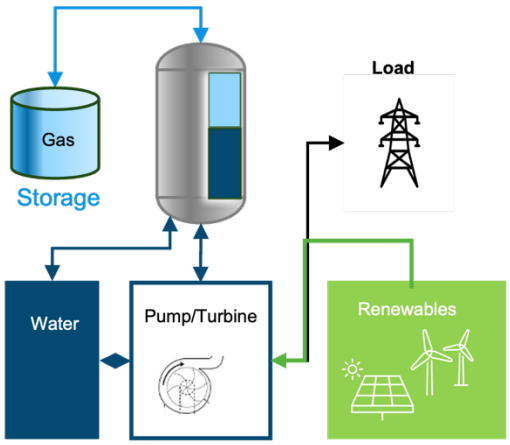
Principle: The essential advantage to near-isothermal compression is that by dissipating the heat of compression real-time as it is being created, more of the input energy goes to raising the gas pressure than if the heat builds up during the cycle. This can be observed in the graph of pressure and volume for isothermal (no temperature rise), near-isothermal, conventional and pure adiabatic (no heat transfer out of system) compression. The area under the P-V curve is the work (energy) that it takes to reach a certain pressure, clearly less as the process approaches isothermality (gray shaded area). This is also captured in the thermodynamic principle of exergy, or the mechanically *useful* energy that can be stored and recovered in a system like this.



Compression: Conventional compression systems cannot dissipate heat rapidly and can only crudely emulate the process through intercoolers after each stage of compression.

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The same amount of heat is discarded but only after it has done its damage. Liquid pistons are the key to near-isothermality, as the liquid itself replaces a mechanical piston or rotating blade. The liquid both enables the high surface area-to-volume ratio of the compression chamber, and also helps dissipate the heat. In the liquid piston system, pumps and hydraulic intensifiers flow water at increasing pressure into closed tubular compression vessels, raising the pressure of the trapped gas as its volume reduces. With just this approach, we can perform high pressure gas compression for a variety of applications with a 20-30% energy reduction, depending on the gas, pressure and flow rate.



Application: EIC liquid piston compression can be used in two ways to replace or enhance conventional carbon dioxide removal processes. In the first method, the mixed gases are compressed above the CO2 critical point pressure with a discharge temperature just above the point required to maintain the supercritical state. The supercritical CO2 is isolated, and temperature is reduced to liquefy the CO2 for storage and transport. In the second method, CO2 is selectively dissolved into the working liquid from the mixed gas stream during compression, leveraging the higher dissolution rate of CO2 relative to other gases. The liquid is isolated and degassed to segregate the gaseous CO2 for liquefaction or other downstream processing. The upgraded is them polished with conventional processes if required.

3.0 Use Cases

Use cases:

One group of use cases includes mixed gas streams containing hydrogen or hydrocarbons with carbon dioxide, such as landfill gases or waste-to-energy processes. These gases are often wet and would require drying before compression for further processing, however the liquid piston accepts wet gas and facilitates drying after compression. Leveraging the necessary compression process to also upgrade the hydrogen or hydrocarbon content reduces capex and energy consumption also.

The second group of use cases is flue gas from industrial processes such as cement making, steel making, or large building boilers. Compressing the flue gas to extract CO2 with either of the methods mentioned lowers the carbon footprint substantially. The liquid piston is more tolerant of flue gas contaminants due to its seal-less design and may in fact aid in removal of other harmful elements such as hydrogen sulfide. The still pressurized remainder (primarily nitrogen) can be used for energy storage or can be immediately expanded to return generated energy to the compression process.