EIC. Solutions.

EIC Compression for Industrial Refrigeration

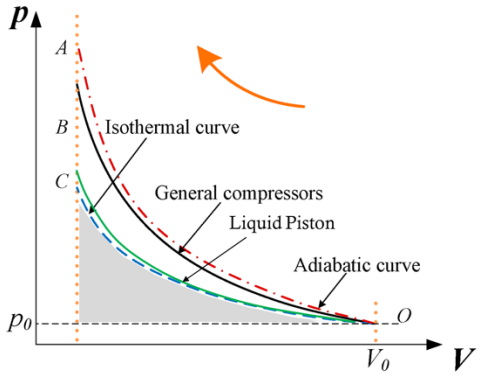
1.0 Executive Summary

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. As most refrigeration processes are compression and expansion based, lower energy consumption compression has the ability to greatly affect efficiency in this growing market. Applications include cold-storage facilities, facility HVAC, data center cooling and gas liquefaction.

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

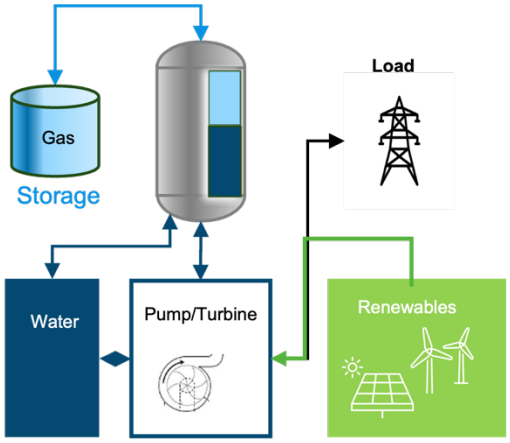
2.0 Technology Discussion

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.

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.



Expansion: Using the EIC system in reverse permits the controlled expansion of gases that recovers a significant portion of the compression energy expended, while controlling the rate of expansion to prevent unwanted thermal effects. While not mandatory for storage like the compression process, leveraging the equipment capex to further reduce energy is beneficial for large gas storage applications. Essentially, the system operates in reverse to reduce pressure while generating electricity.

3.0 Refrigeration

Primary compression: Most refrigeration processes begin with compression of refrigerants to produce a phase change, followed by heat transfer out of the system, which enables heat transfer into the system from the load when the pressurized refrigerant is expanded and phase changes again. Compressing refrigerants near-isothermally not only reduces the energy input required but reduces the amount of heat transfer needed for the relatively cooler discharge stream. Additionally, super-heating and super-chilling that are commonly used to protect the compressor can be minimized with the liquid piston design. Primary challenges are related to the compatibility of the working liquid and the refrigerant.

Expansion enhancements: Several approaches can be used to extract work from the pressurized refrigerant stream which improves its capacity for heat removal and improves efficiency by returning the work to the compression side. EICs expansion technology is one of several options that can further improve refrigeration efficiency.

Use cases: The best use cases will be for high energy consumption processes such as cold-storage warehouses for food or pharma/bio sites, data center cooling without evaporative water loss, large building HVAC in hot climates, and liquefaction cycles for hydrogen, natural gas, nitrogen and similar.