Energy and Equipment Savings through Near-Isothermal Compression

Technical Summary

RheOmega, LLC

1 Summary

We are looking to further refine our novel, near-isothermal compression process, and develop a product with a manufacturing partner. To achieve this goal, we are searching for the right customers and markets to utilize our technology's benefits, which include substantial energy savings (10-20%) and equipment savings as detailed below.

2 Technology Overview

It is well known in the compressor industry that isothermal compression of gases yields the highest discharge capacity per unit input power (kg/s per kW). Historically, the means of achieving near-isothermal conditions has been met by the use of multi-stage compressors with inter-stage cooling. Still, the reciprocating piston compressor in-cylinder process is near-adiabatic resulting in high stage discharge temperatures thus limiting the pressure ratio per stage. The result is a compromise between the desired reduction in energy and the cost and complexity of increased number of stages.

We have developed a near-isothermal compression process that reduces both the number of stages required for a given pressure ratio while maximizing overall compression efficiency. This process is illustrated in Figure 1. Low pressure gas is mixed with a liquid to form a uniformly dispersed foam matrix. The foam is drawn into the suction side of the low pressure stage and compressed near-isothermally by heat transfer from the gas to the liquid.

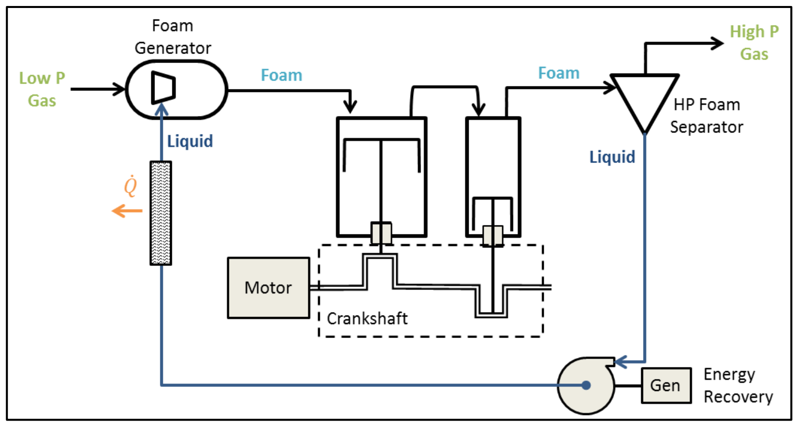

Figure 1 –Near-Isothermal Compression Process Diagram

The uniform foam is discharged from the compressor and enters a gas-liquid separator. The warm, dry gas is transported to the end process while the warm, recovered liquid is returned to near-suction-side pressure through an energy recovery machine and then cooled prior to being reintroduced to the suction side gas stream.

2.1 Near-Isothermal Compression Benefits

The advantages of near-isothermal compression over multi-stage adiabatic compression are shown in Table 1. Near-isothermal compression saves on power, energy, electrical demand charges & consumption rates, all while doing this in fewer stages with no intercoolers, and at significantly lower gas temperatures. Additionally, the aftercooler for the near-isothermal compressor is smaller & cheaper because it cools low pressure liquid as compared to cooling high pressure, high temperature gas as is the adiabatic compressor's case.

Example: Compressing air, atm to 200 bara (2900 psia), 30 m^3/hr (1060 cfm)				
	Conventional		**Near-Isothermal**	
Number of Stages	4		2	
Pressure Ratio per stage	3.7		14.0	
Temperature Rise per stage	137 °C	246 °F	25 °C	46 °F
Intercoolers	3		None	
Aftercooler	1 (HP gas cooler)		1 (LP liquid cooler)	
Power	404 kW	536 HP	341 kW	452 HP
Power Savings	-		16%	
Energy Savings, kWh per year	-		498,718	
Demand Charge Savings per year	-		$7,612	
Consumption Savings per year	-		$49,872	

Table 1 –Near-Isothermal Compression Benefits Example

2.2 Technology Requirements

Foam technology requires the direct contact between gas and liquid phases to achieve near-isothermal compression. As a result, the gas and the compressor must be tolerant of multiphase flows – gas, foam liquid and liquid vapor – but only during the compression process. Bulk liquid & liquid droplets are removed by the foam separation system leaving a clean gas. Foam technology also requires positive displacement compression and works well with reciprocating piston compressors due to their high compression ratios.

2.3 Optimum Applications

Given equal discharge capacity, total process pressure ratio, and isothermal process liquid/gas mass ratio, different gases will yield different energy savings. Figure 2 shows the first order estimated energy savings for a near-isothermal compressor versus a four-stage adiabatic compressor with intercooling for four common gases: natural gas (CNG), carbon dioxide (CO_2), air, and argon (Ar). Nitrogen and oxygen savings are similar to air. In general, the near-isothermal process favors gases with higher molecular weight (low specific gas constant), higher ratio of specific heats (k), and higher process discharge pressures. Furthermore, the benefits of improved compression efficiency will favor applications with high utilization factors or where utility demand charges ($/kW) and/or energy costs ($/kWh) are high.

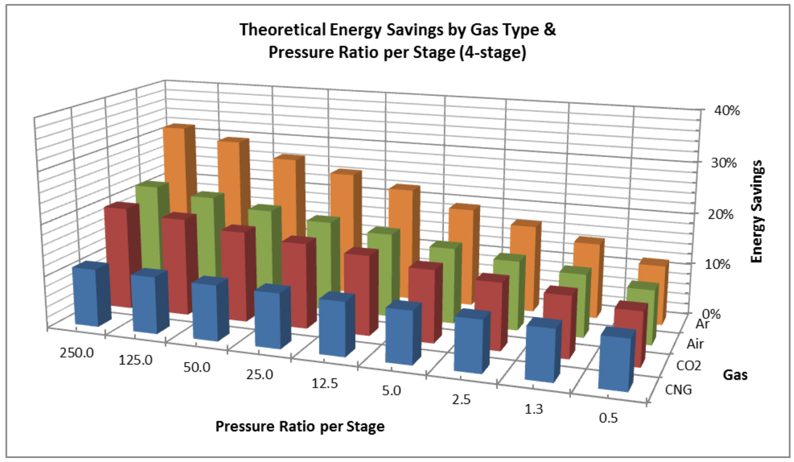

Figure 2 – Near-Isothermal Compression Energy Savings

3 Markets

Industrial Gases

- Cylinder filling
- Air separation
- PET blowing

Process Gases

- CO2 injection
- CO2 capture & sequestration

Oil & Gas

- CNG transport, storage, filling
- Virtual pipelines

4 Goal Statement

We are looking for a home for this innovative technology – customers who can benefit from the energy savings, and manufacturing partners who want to develop a new platform to grow their business.

5 Personal Biographies

Alexander Bell, Founder

Mr. Bell is an engineer and entrepreneur who's passionate about energy. He was a Senior Research Engineer at General Compression, and before that, R&D Manager at SustainX; both companies were developers of Isothermal Compressed Air Energy Storage technology. At GC and SustainX, he was the "foam guy" responsible for the development of the near-isothermal foam technology in ICAES. He has a BS in Chemical Engineering from UNH and a Master of Engineering Management from Dartmouth, and holds 4 US patents.

David E. Perkins, Adviser

Mr. Perkins was most recently Chief Technology Officer for General Compression, a developer of grid-scale compressed air energy storage technology. Previously, he was CTO for Active Power, a developer of behind-the-meter power quality systems (UPS) using flywheels and compressed air storage. Perkins began his career developing pulsed power rotating machinery and applications at the University of Texas Center for Electromechanics. He received BS and MSME degrees from the University of Texas, Austin and holds 10 US patents.