CO2 compression capabilities

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Agenda

• CO$_2$ compression

• Experience
CO₂ Re-injection
Equation of State

• GE has used the BWRS EOS for the last 30 years: up to 300 bar on regular basis and up to 540 bar with CO₂ + HC gas mixture in specific cases ... also in the supercritical region

\[
P = RTD + (BoRT – Ao – Co/T^2 + Do/T^3 - + Eo/T^4)D^2 + (bRT – a – d/T)D^3 + \alpha(a + d/T)D^6 + c/T^2)(1 + \gamma D^2)D^3 e^{-\gamma D^2}
\]

BWRS Equation

BWRS above 480 bar requires careful verification of literature data and is not suitable for liquid-vapour equilibrium calculations

• Many existing CO₂ EOS are optimized for pure CO₂ but not for mixtures

• To allow for regions not adequately covered by current EOS, GE is introducing a new thermodynamic model to improve predictability
Product Lines for CO₂ Compression

Discharge Pressure (bar)

Inlet Volume (m³/h)

Reciprocating

Centrifugal Pumps

Centrifugal

Integrally Geared

1,000

10,000

100,000
Compression + Pumping Optimization

Compression from 1.5 bar up to approx. 220 bar

13.5MW
Compression + Pumping Optimization

Compression from 1.5 bar up to approx. 220 bar

Supercritical Compression + Pumping

11.4 MW
Compression + Pumping Optimization

Compression from 1.5 bar up to approx. 220 bar  
Supercritical Compression + Pumping

Subcritical Compression + Pumping

11.1 MW

P [bar]

H [kJ/kg]
Compression + Pumping Optimization

Compression from 1.5 bar up to approx. 220 bar

Supercritical Compression + Pumping

Subcritical Compression + Pumping

Refrigerated Compression

Refrigeration Cycle

9.5MW

11.4MW

11.1MW

13.5MW
Compression + Pumping Optimization

Compression from 1.5 bar up to approx. 220 bar

Supercritical Compression + Pumping

Subcritical Compression + Pumping

Refrigerated Compression

13.5MW

11.4MW

11.1MW

9.5MW
CO₂ Reciprocating Compressor Experience

• Many years of experience ... started with fertilizers plants

• 180+ machines in operation processing CO₂ or gases containing CO₂, H₂ and H₂S

• Up to 750 bara disch. pressure … 19,000 Nm3/h max requested capacity

• Most recent major experience CO₂+H₂S reinjection ... 55,000 Nm3/h @ 486 bara max. discharge pressure

• From small to large compressor sizes (HG frame)
CO₂ Centrifugal Compressor Experience

Technical design challenges

• Aerodynamics
  • Very high pressure ratio and compressibility
  • Wide range of flow coefficient stages

• Rotor Dynamics
  • Very high density and destabilizing effects
  • Predictability of compressor seal dynamic coefficients

References

• 200+ units installed since 1968
• Discharge pressure up to 280 bar/a
• Compressor power … up to 18 MW
• Inlet flow … 2,000 to 300,000 Nm3/h
• World’s Largest Single Train capacity (3450 t/d QAFCO Qatar)
• 90+ Urea Plants … 13 Million Operating hours
CO₂ compression … Rotordynamics

Extensive Experience in High Density Applications …

Record discharge press with centrifugal compressor: 915 bar… UHP Seal Test Rig to move the boundaries

• Operating pressure: up to 400 bar
• Rotational speed: up to 18000 rpm
• Test gas: N₂, CO₂
• Design Pressure: 500 Bara
CO₂ Pumping Experience

Brazil HP pilot project

- Custom designed mechanical seal qualification process
- Rotor dynamic stability assessment
- Physical properties of supercritical gas mixture tested by SWRI
  - Suction pressure 300 bar
  - Discharge pressure 540 bar
  - Design pressure 670 bar (API 6A 10000)
  - Flowrate 10 kg/s
  - Four pumps in series
  - Installation on FPSO
  - Triple mechanical seal configuration
  - Job delivery date: 31/12/2009

First reference for this service
CO₂ Compression Summary

• Both compressor and pump technology in-house
• Compression + pumping thermodynamic optimization
• Many years of experience in CO₂ compression ... centrifugals and reciprocating
• Leverage experience in HP re-injection compression
  • Rotordynamics
  • Seals
  • Low flow stage aerodynamics
• Validation activities in place ... Gas properties and UHP test rig
Questions