Hydrogen Compression for Energy Storage

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Elliott Group
• Revenue: ~ US$ 1 billion (¥120 billion)
• About 2,600 employees
• 38 locations in 15 countries
• Businesses:
  – Engineered Products (EP)
  – Industrial Products (IP)
  – Global Service (GS)
  – Cryodynamic Products (CP)

Jeannette, PA
- 110 Acre Campus
- 802,000 Sq. Ft Factory Area

Sodegaura, JPN
- 41 Acre Campus
- 371,000 Sq. Ft Factory Area
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Elliott Centrifugal Compressors

- Small To Large
- All kinds of fluids
Compressing Hydrogen

Various Hydrogen Rich Compression Applications in Refineries and Petrochemical Industries

- Hydrogen Recycle
- Pure Hydrogen
- Net Gas Hydrogen
- Hydrotreater Feed

Typical Conditions

- Flow Range: 345 m³/hr-86079 m³/hr
- Pressure Range: 3 BarA-162 BarA
- Nozzle Size Range: 4 in.-36 in.
- MW Range: 2.4-18.7 (depending on percent H₂)
Compressing Hydrogen

- Elliott has been building Hydrogen compressors since 1955
- Over 100 hydrogen rich compressor trains produced from 2001-2014
- Elliott has built compressors for a wide range of pure hydrogen and high-hydrogen process applications
Challenges

Issues
1. Low Mol Weight -> Low Pressure ratio per stage -> High number of stages with high running speeds
2. Hydrogen Embrittlement
3. Static and Dynamic Sealing difficulties

Solutions
1. Rotor dynamic Analysis. Advanced Bearing Designs
2. Material Yield Strength limited to 827MPa (which limits the impeller speed - an additional challenge)
3. Static O-rings. Dynamic Dry Gas Seals
Examples: Hydrogen Recycle Compressors

- Hydrocracker
- 4.0 MW (91.5% H₂)
- 161 Bara Inlet pressure
- 234 BarG MAWP
- 10” CL2500 nozzles
- 5 stages
- 12027 RPM MCOS

- Recycle
- 9.5 MW
- 82.9% H₂
- 3.4 BarA Inlet pressure
- 7.3 BarG MAWP
- 36” CL300 nozzles-inlet
- 73183 m³/hr Inlet Flow
- 5 stages
- 5517 RPM MCOS
Examples: Net Gas Compressor

**Company: PEMEX**
**Type: Net Gas String**
**Year: 2010**
- Net Gas String
- 10.4/8.9 MW
- 82.4/83.4 % H₂
- 6.4/16.2 BarA Inlet Pressure
- 21.1/51.8 BarG MAWP
- 20”/12” CL600 nozzles-inlet
- 8/8 stages
- 9001/12494 RPM MCOS

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**Company: BP Husky Refining**
**Type: Net Gas**
**Year: 2011**
- Net Gas String
- 7.26/6.87 MW
- 88.9/89.4 % H₂
- 7.3/12.5 BarA Inlet pressure
- 16.7/24.3 BarG MAWP
- 20”/16” CL600 nozzles-inlet
- 8/6 stages
- 9844/9844 RPM MCOS
Flex Operation Hydrogen Compressor Concept

- 3-4 Integral Barrel Arrangements with independent variable speed control
- High flow, high ratio, high efficiency
- Parallel and series arrangements
- Intercooled
- Potential for multiple sidestreams
- Compact and ease of access for maintenance and repair
Elliott has built hydrogen compressors for over 65 years.

Thank you!

Questions?