High Pressure H₂ Recycle Compressor Dry Gas Seals Retrofit

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Abstract

Dry gas seal conversions over the last 20 years have progressively become a standard upgrade solution to improving reliability, efficiency, safety and environmental issues related to oil seal technology. The application window of the dry seal technology capabilities continues to expand and over the last 5 years has moved into the high pressure hydrogen recycle machine where new challenges have been experienced beyond the high pressure ranges.
This case study describes a dry seal conversion into a barrel-type recycle gas compressor operating at 2900 psig discharge pressure. This HYDROCRACKER process gas has a high dew point temperature and presents additional challenges that must be addressed in order to qualify this retrofit as a success story. The economic justification, technical approach, selection of systems, seals and integration of the seals into the compressor are provided. Knowledge gained through consultations with other users operating similar systems, and the learning's and experiences gained during this retrofit are also presented.
Many of the previous known causes of dry seal failures were addressed in the original design of this retrofit. Operation of the unit since the commissioning has been very positive. However, the retrofit did not come off without challenges, and further learning’s from this application will help those currently using or considering dry gas seal technology for similar machines and applications.
Oil Seal System

- Poor Reliability → justification for retrofit
  - Oil Seal MTBF → 14 Months
  - Two or more stoppages recorded every year due to oil seal replacement or problems related to seal oil system
  - Operators reluctant to transfer from main to auxiliary seal oil pump
Advantages: Dry Seal vs. Oil Seal

- Reduced operating costs
- Increased reliability
- Increased efficiency
- Maintenance advantage
- Improved security
- Environmental impact
Reduction in Operating $$$

- Steam consumption main seal oil pump
- Seal oil consumption
- Maintenance costs
- Production costs related to seal oil system
Reduction in Operating $ – cont’d

- Efficiency increase due to reduced mechanical losses
- Reduced H2 emission
- Total Savings: $500k US/yr (approx.)
Conversion Cost

- Main components
  - Engineering & tooling
  - Dry gas seals c/w carbon ring barrier set
  - Inner labyrinth seals
  - Conditioning and control system
  - Radial and thrust bearings
  - Spare parts
Conversion Cost – cont'd

- Mechanical rework
- DCS integration
- Installation (piping, instrumentation & electrical)
- Training

- Total Cost: $700k US (approx.)
Key Issues to Consider

- Seal selection for high pressure H$_2$ applications
- Mechanical fits
- Gas supply management
- Control system
- PHD integration for monitoring and trending
Seal Selection

- Seal type options for high pressure $\text{H}_2$ applications
  - Tandem
  - Tandem-L with inter-stage labyrinth
Gaspac Seal: Tandem-L with Circpac
Supply Gas Quality Requirements

- **Dry, clean**, supply gas
  - 1 to 3 Micron liquid and particles
  - Achieve 15 ft/s velocity past process seal
  - Adequate flow during all modes of operation
  - Minimum of 36 °F above dew point
Seal Gas Control System

- Control system package
  - Pre-filter / continuous supply system required
  - Cooler and heater to manage dew point
  - Heat tracing to maintain temperature
  - Monitor both first and second stage leakages
  - Monitor all supply flows to seal individually
Dew Point Calculation – cont’d

- **Worst summer condition → 190°F @ suction drum**
  - cool gas by 2°F below suction temperature to get liquid phase

- **Winter conditions → 120°F @ suction drum**
  - cool gas by 12°F below suction temperature to get liquid phase

- **Conclusion → Dew Point is at suction drum (i.e. high pressure separator) exit temperature**
Total Control System
Dry Seal Control Panel
Challenges

- Rotordynamic analysis $\rightarrow$ loss of stiffness and damping properties
- Surge protection
- Vibration protection
- Winterization
- AMPLIFLOW (i.e. emergency seal gas supply compressor)
Future Considerations

- Tubing vs. rigid piping for high pressure seal gas lines

- Managing seal gas demister (i.e. K-O) liquid dump to address liquid spill-back when unit trips occur
  - return liquid to compressor suction during operation
  - return liquid to low pressure drum during start-up and shutdown conditions
Future Considerations – cont’d

- 2/3 voting on transmitters with ESD signals
- Improve surge protection
- Minimize liquid spill-back to prevent flooding of dry seals & control system
Current Status

- 15 months operation without dry seal system induced shutdowns

- Managed over 20 compressor starts over 15 month period operation without damaging dry seals