Compressor Degradation Assessment and Wear Mitigation Strategy

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Acknowledgements

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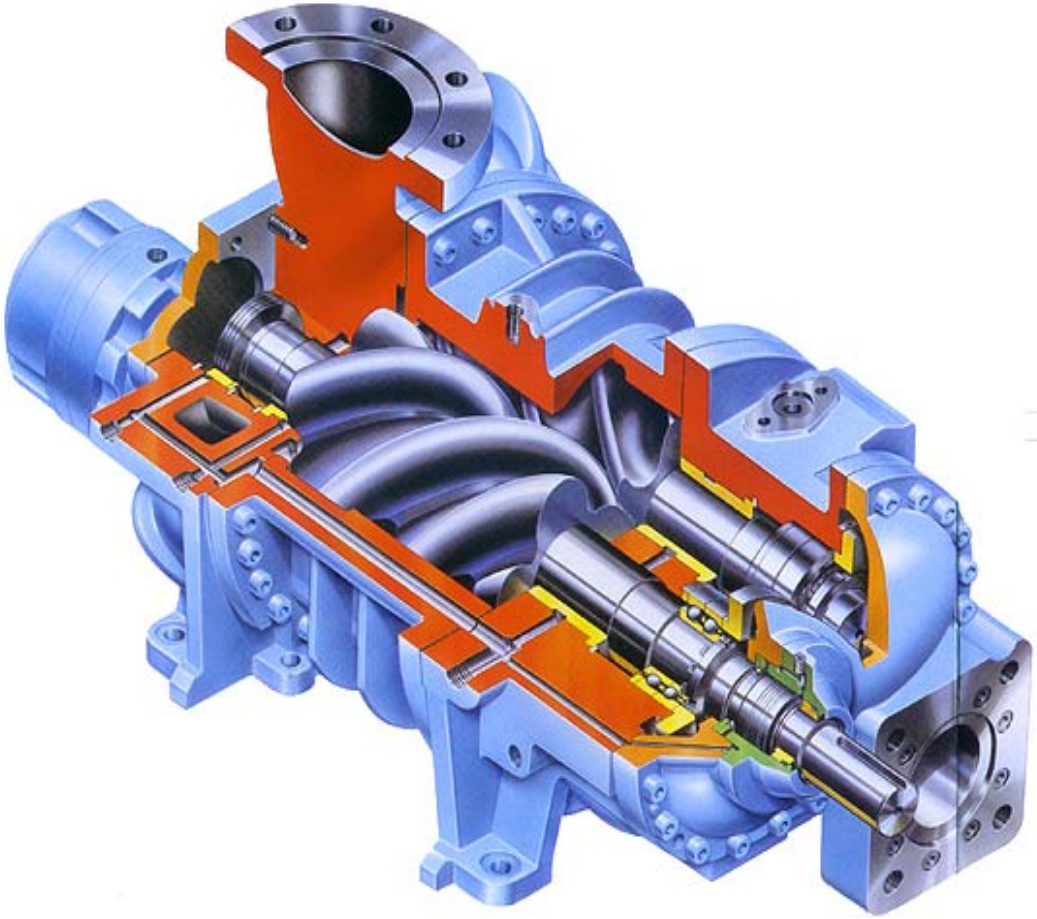
Twin Rotor Screw Compressors

- Introduced in 1970's
- Manufacturers include Frick, Stal, Hitachi, Dunham Bush, Mycom, Grasso, Sabroe and Howden
- Screw compressors have largely replaced reciprocating compressors in large industrial plants
- Some very old compressors (>35y/o) still in daily use in meat industry, and many compressor are >15y/o
- Compressors wear over time and wear increases energy use.
- "Rebuilding" does not fix screw compressor wear

Screw compressor - principle of operation



- Two meshing helical rotors
- Rotors seal against each other, the compressor housing and the mechanical slides
- Oil injection for sealing and lubrication
- Capacity and volume ratio can be varied by two mechanical slides

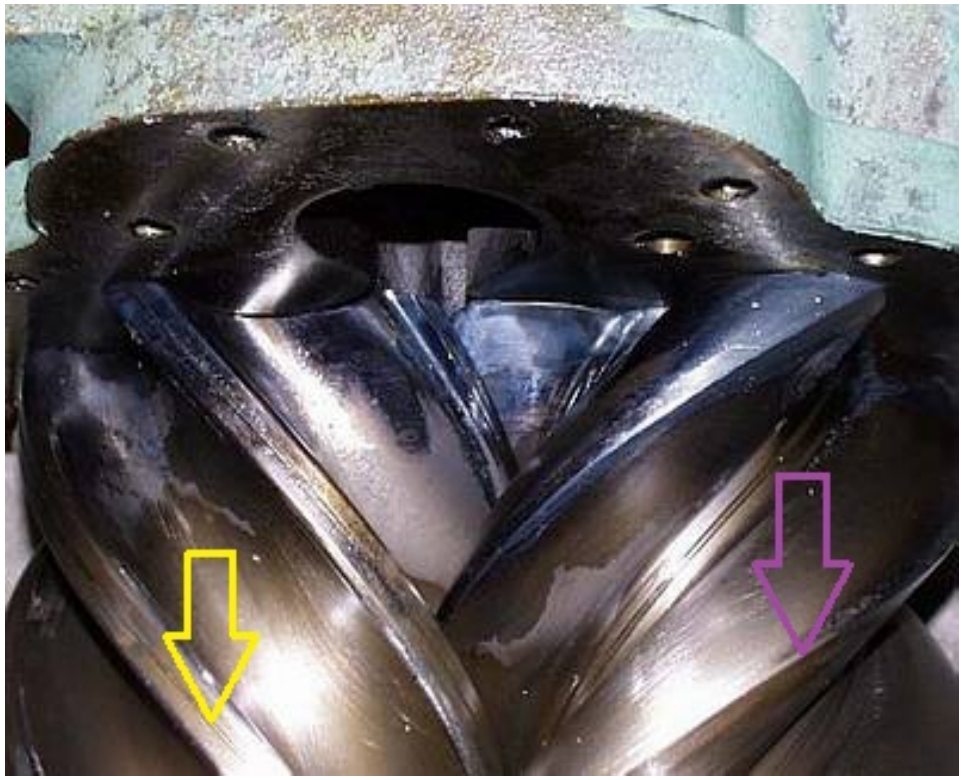
Screw compressor wear

- The operation of the compressor relies on the correct sealing of the compression chambers
- Over time the housing, slide, rotor surfaces and rotor tips wear, reducing the sealing.
- The wear is due to many factors, including maintenance regime, bearing wear, slide damage, erosion of metal surfaces, etc.
- Gas leakage and bypass reduces the efficiency of the compression process and the compressor capacity

Measuring compressor wear

- Reciprocating compressors can be tested with a simple static compression test.
- Screw compressor are hydro-dynamically sealed, so that a static test is not possible.
- No simple cost-effective strategy exists to directly measure the wear on screw compressors.
- Minus40 has developed a screw compressor test to provide fairly accurate degradation results for installed compressors

Screw compressor rotor tips



- Male and female rotors have small ridges on their tips
- These ridges reduce compressor friction but are critical for compression efficiency.
- Tip wear quickly reduces compressor efficiency

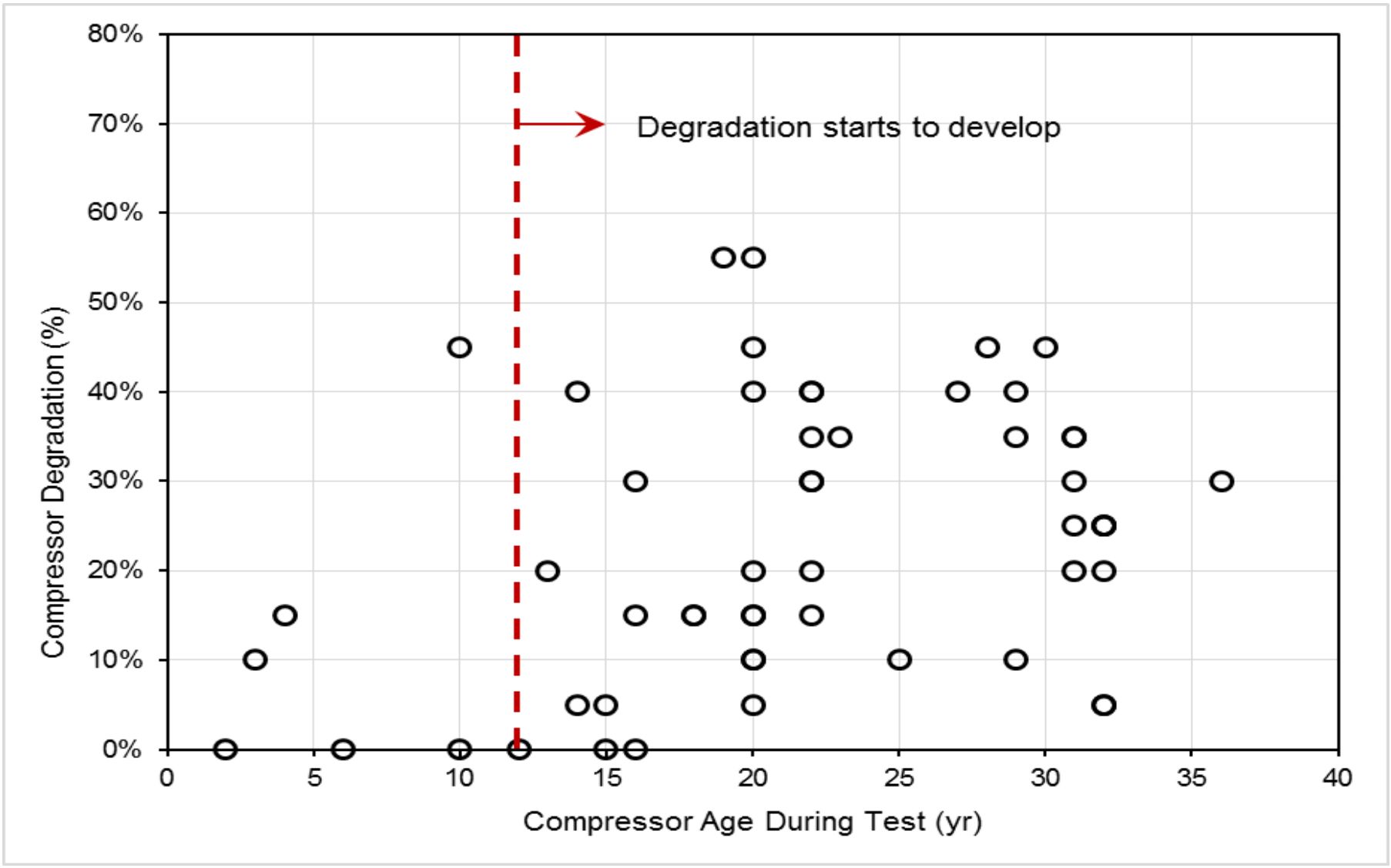
Minus40 compressor degradation test

- Type I: Run plant at known base load (reference load). Observe apparent compressor load. If apparent load > reference load, compressor is worn
- Type II: Run plant at any stable load with known new unworn compressor (reference capacity). Run test compressor and observe apparent compressor load. If apparent load > reference load, compressor is worn
- Type III: Run plant at any stable load. Add a known additional load (e.g. with electric heaters). Measure apparent load before and after. If increase in apparent load > additional load, compressor is worn.
- Wear = % difference between apparent and reference load

Minus40 tests

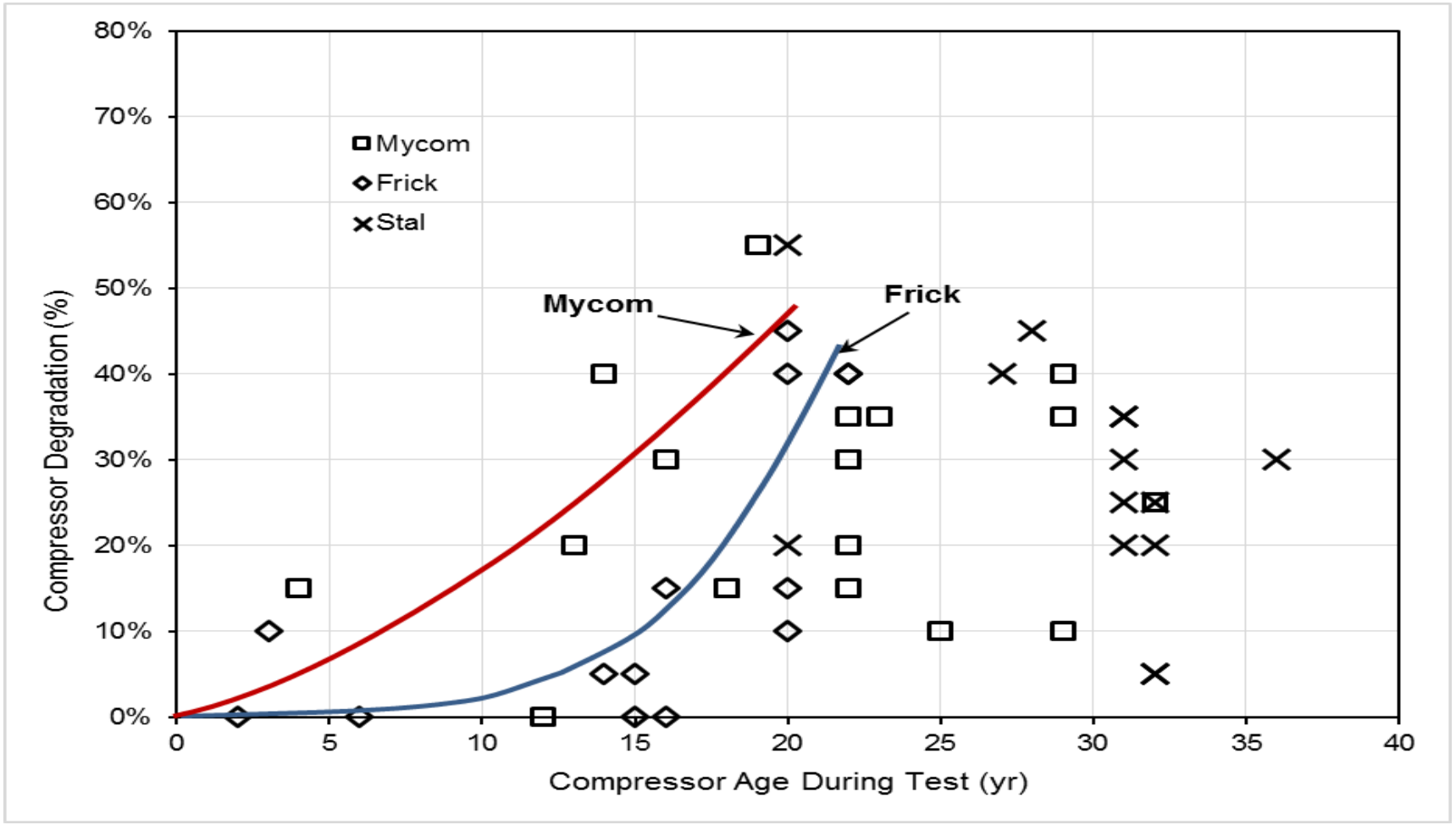
- 7 industrial sites tested
- 54 screw compressors
- Sabroe, Mycom, Stal, Frick, Dunham Bush, Howden and Grasso tested
- Degradation levels up to 55% measured
- Average degradation 23%

Compressor degradation vs age



Degradation vs age

Mycom, Frick and Stal



Effect of Site

Business case example

- Mycom 250L, 18 years old
- Annual power use 2,900,00 kWh (=420kW motor power x 7,000hours runtime/year)
- Power cost: 15c/kWh
- Block replacement cost: $156,000
- Measured degradation: 15%
- Payback on investment = ($156,000/2,900,00/15%/$0.15) = 2.4 years

Case study

- Grasso and Frick compressor each found to be 45% degraded.
- Payback on compressor block replacement calculated at 1.45 years for Grasso and 2.34 years for Frick
- Total annual energy savings predicted to be 1,179 GWh/annum
- Verified energy savings determined to be 953 GWH after compressor replacement (20% less than predicted).
- Actual project payback was 2.1 years on energy costs only.

Conclusions

- Not possible to predict degradation based on compressor age alone
- Run hours may give a good indication of wear, but reliable run hour statistics NOT available for compressors tested.
- Much better record keeping required by sites to consider predicting wear based on compressor history
- Rough rule: 1% wear per year of age. This is useful as indicator but not sufficient for investment decisions

Recommendations

- Documentation: Keep good records of commissioning data, maintenance, incidents and run hours.
- Flow meters: Install accurate flow meters in common suction lines and use software to monitor plant condition
- Where wear is established:
  - Replace compressor block or unit if business case is strong
  - Retire worn compressor to end of run sequence as interim measure

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