Evaluation of LNG Train Operation Resulting from Refrigeration Compressor Re-wheel

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Abstract

- In an LNG production plant, multiple propane (PR) refrigeration compressor failures since commissioning led to re-wheeling.
- PR refrigeration system was not considered to be the main bottleneck, nevertheless improved production rates were realized.
- Full refrigeration system machinery evaluation highlighted the main uplift to be a result of improvement in the Mixed Refrigerant (MR) system.
- Thermodynamic coupling of upgraded PR loop with MR loop resulted in added capacity to MR loop.
PR/MR Process Overview

- Propane System
- Mixed Refrigerant System

LNG
System Overview

LP/MP MR String

F7, DLN1
79 MW Site Rated

LP MR Compressor

MP MR Compressor

Helper Motor
12 MW

HP MR/PR String

F7, DLN1
79 MW Site Rated

PR Compressor

HP MR Compressor

Helper Motor
12 MW
String design capacity

LP MR Compressor
- Poly Head: 150 kJ/kg
- Mass Flow: 1.2 Tons/hr
- Power: 60 MW
- 4 impeller sections straight through

MP MR Compressor
- Poly Head: 60 kJ/kg
- Mass Flow: 1.2 Tons/hr
- Power: 23 MW
- 4 impeller sections straight through

HP MR Compressor
- Poly Head: 50 kJ/kg
- Mass Flow: 1.2 Tons/hr
- Power: 20 MW
- 5 impeller sections straight through

Propane Compressor
- Poly Head: 125 kJ/kg
- Mass Flow: 2 Tons/hr
- Power: 55 MW
- 4 sections side loaded
MR Compressors
Performance Influence

- Overall performance maps do not follow fan laws
- Significant head range for a tight speed range
Propane Compressor Performance Influence (Pre Re-wheel)

- Overall performance maps do not follow fan laws
- Significant head range for a tight speed range
Background

Propane Machinery
- Historical compressor impeller failures
- Compressor operated close to overload
- Abundance of power within string
- Compressor re-wheeled to address overload concerns

MR Machinery
- All three compressors operate satisfactorily
- LP/MP MR string use maximum available power
- LP/MP MR string power is plant bottleneck
Propane Compressor Failures

- Narrow choke margin during winter months
- History of Sections 3 and 4 impellers failure during operation
Propane Compressor Re-wheel

- Redesigned all of sections 3 & 4 and section 2 return channel
- Reused section 1 & 2 impellers
Propane Compressor Re-wheel

- Increase sections 3 & 4 operating range
- Maintained design operating point in all sections
# Effect of Re-wheel on Refrigeration Systems

## Summer 2013

<table>
<thead>
<tr>
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<th>Avg Jun - Sep</th>
<th>vs 2011 &amp; 2012</th>
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<tbody>
<tr>
<td>MR Mass Flow</td>
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<td>4.1%</td>
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<tr>
<td>PR Mass Flow</td>
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<td>1.6%</td>
</tr>
<tr>
<td>Total MR Head</td>
<td></td>
<td>-2.3%</td>
</tr>
<tr>
<td>MR String Power</td>
<td></td>
<td>0.4%</td>
</tr>
<tr>
<td>PR String Power</td>
<td></td>
<td>1.7%</td>
</tr>
<tr>
<td>HP MR Power</td>
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<td>1.8%</td>
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## Overall 2013

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<tr>
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<tr>
<td>MR Mass Flow</td>
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Post Re-wheel Analysis: Propane Compressor

• Larger Choke Margin
  → Increase in speed
  → Higher PR flow rate
Post Re-wheel Analysis: MR System

- Lower MR turbine speed → Lower HP suction pressure
- Same Absorbed Power → High MR flow rate
Post Re-wheel Analysis: MR Compressors
Post Re-wheel Analysis: String Power

MR String Power (Normalized)

C3 String Power (Normalized)

> 80% of time
Conclusion

• Analysis of system wide machinery is necessary to understand full effects of re-wheeling compressors on total plant production

• Plant bottleneck can be influenced by modifying coupled systems

• Selective investments are better made when whole system is assessed

• Understanding owner’s compressor characteristics helps in realizing effects of changing operating parameters
Questions?