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

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Authors

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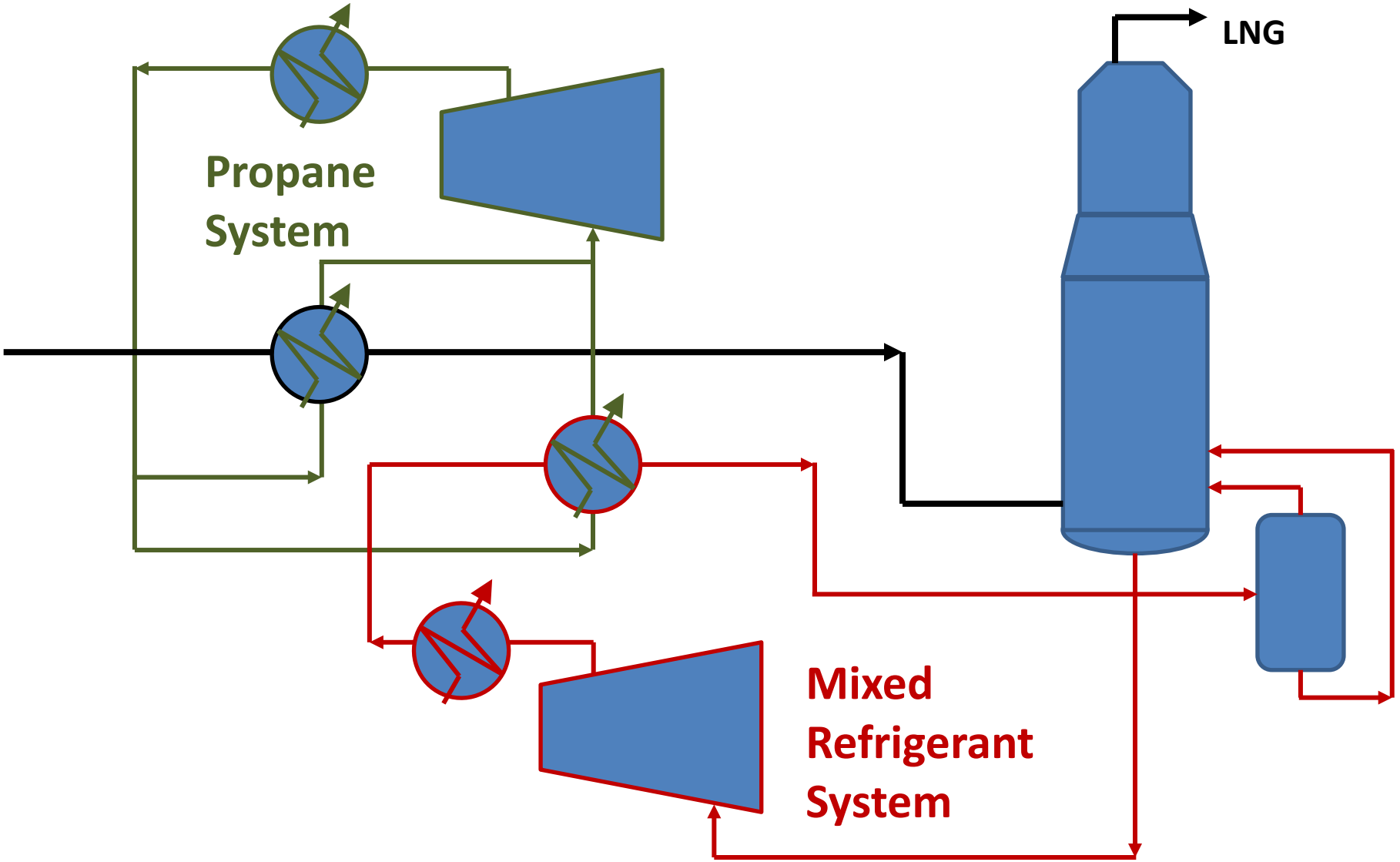
Abstract

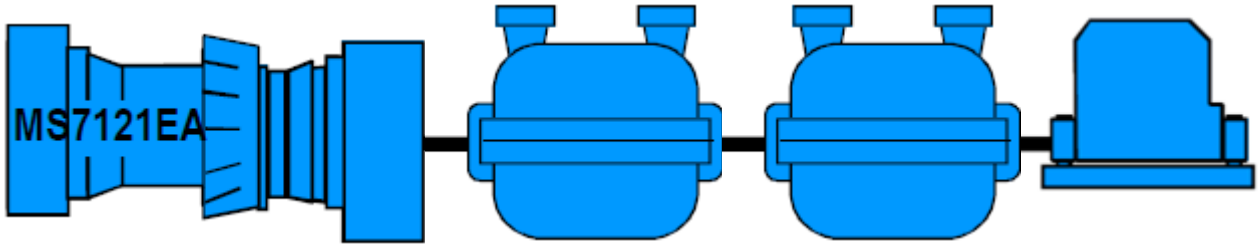
- In an LNG production plant, multiple propane (PR) refrigeration compressor failures since commissioning led to re-wheeling
- PR refrigeration system was not considered to be the main bottleneck, nevertheless improved production rates were realized
- Full refrigeration system machinery evaluation highlighted 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



System Overview

LP/MP MR String



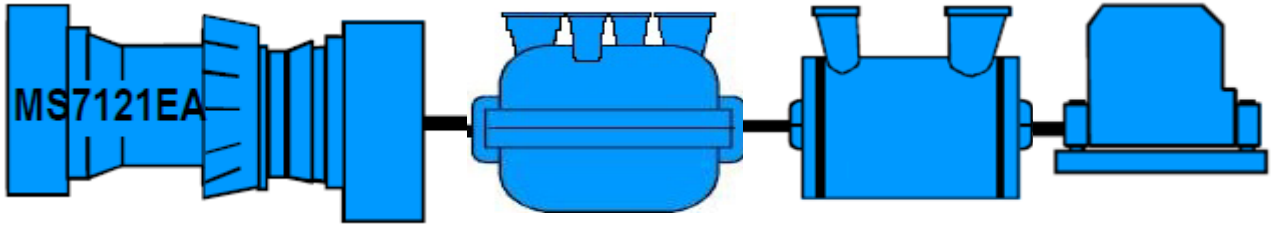
F7, DLN1
79 MW Site Rated

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

HP MR Compressor

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

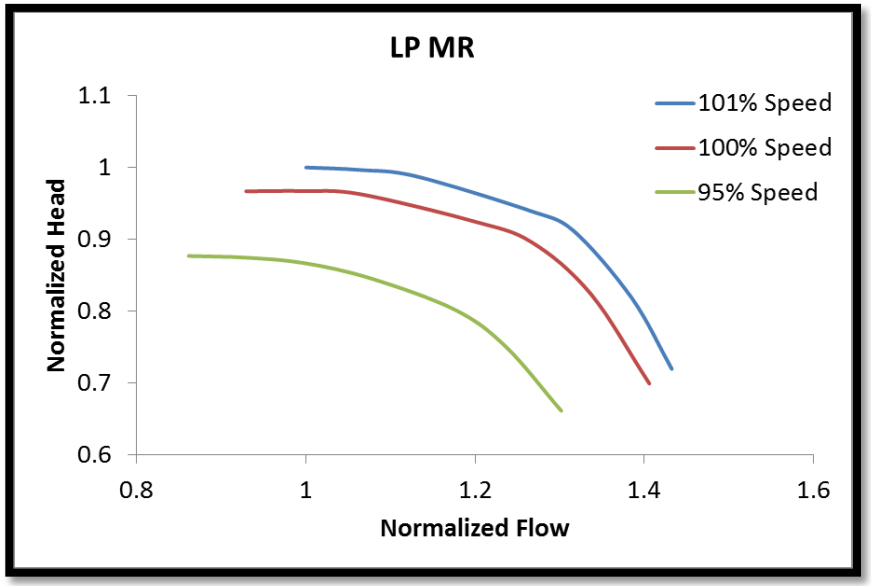
MP MR Compressor

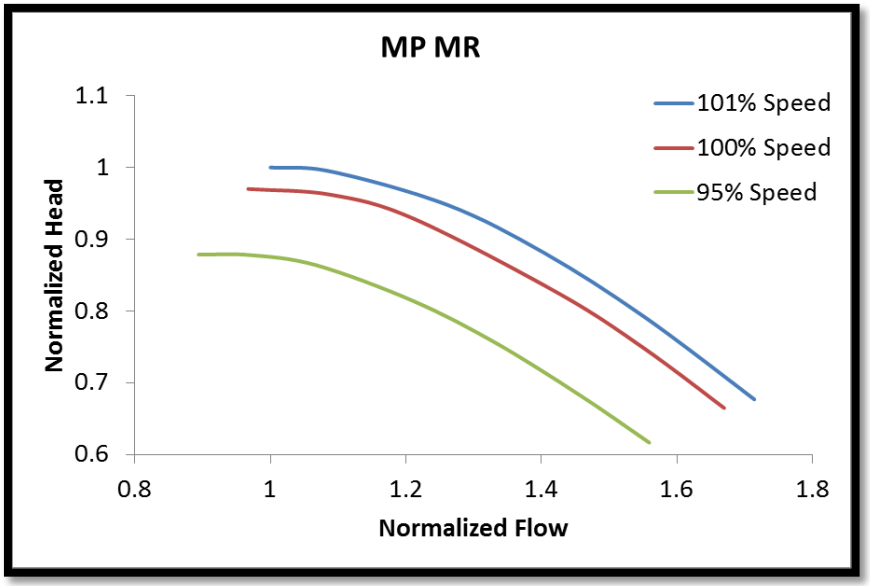
- Poly Head: 60 kJ/kg
- Mass Flow: 1.2 Tons/hr
- Power: 23 MW
- 4 impeller sections straight through

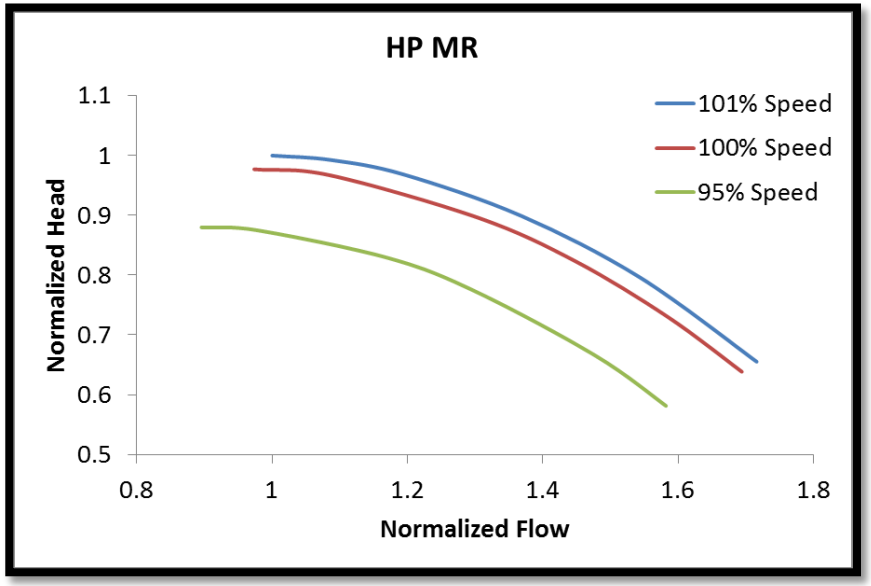
Propane Compressor

- Poly Head: 125 kJ/kg
- Mass Flow: 2 Tons/hr
- Power: 55 MW
- 4 sections side loaded

MR Compressors Performance Influence

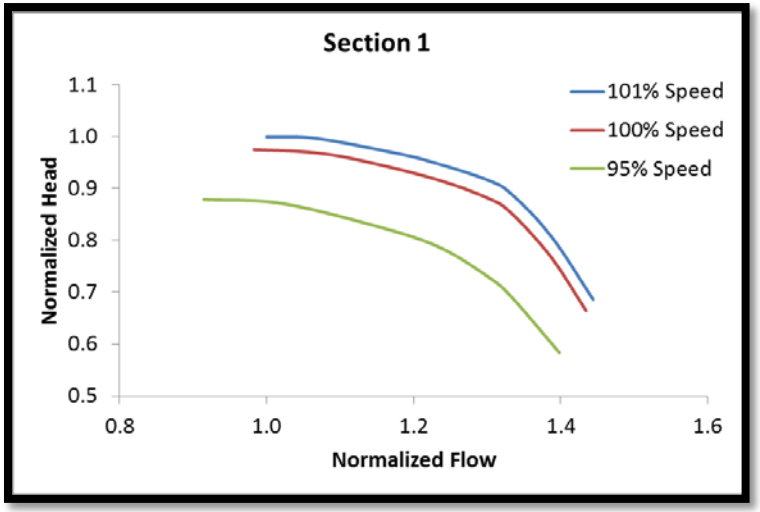


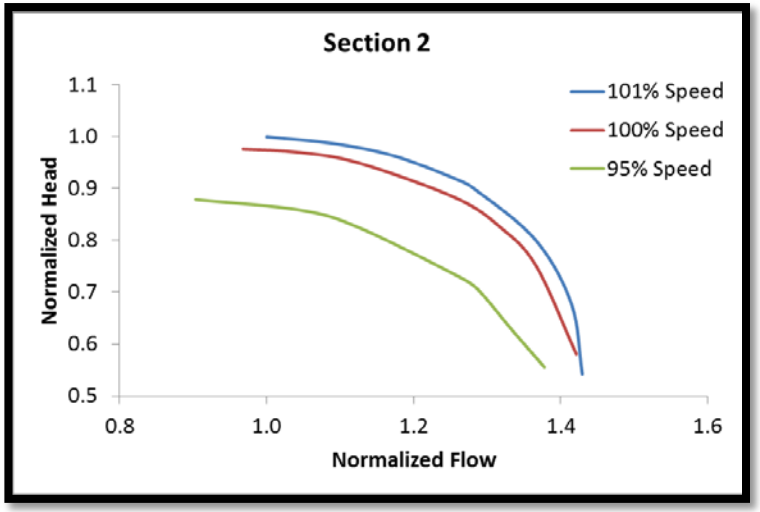


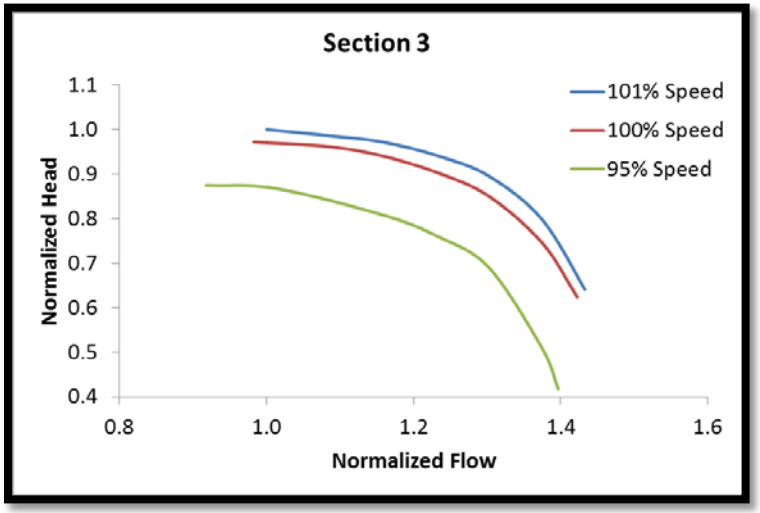


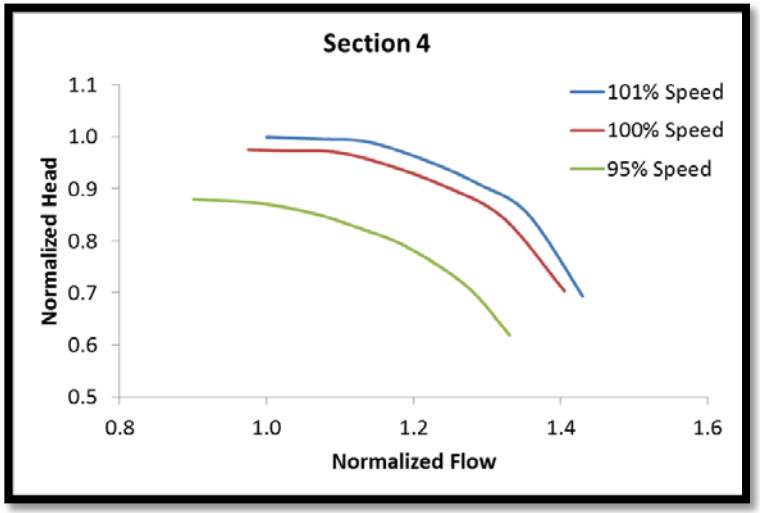
- Overall performance maps do not follow fan laws
- Significant head range for a tight speed range

Propane Compressor Performance Influence(Pre Re-wheel)









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

Background

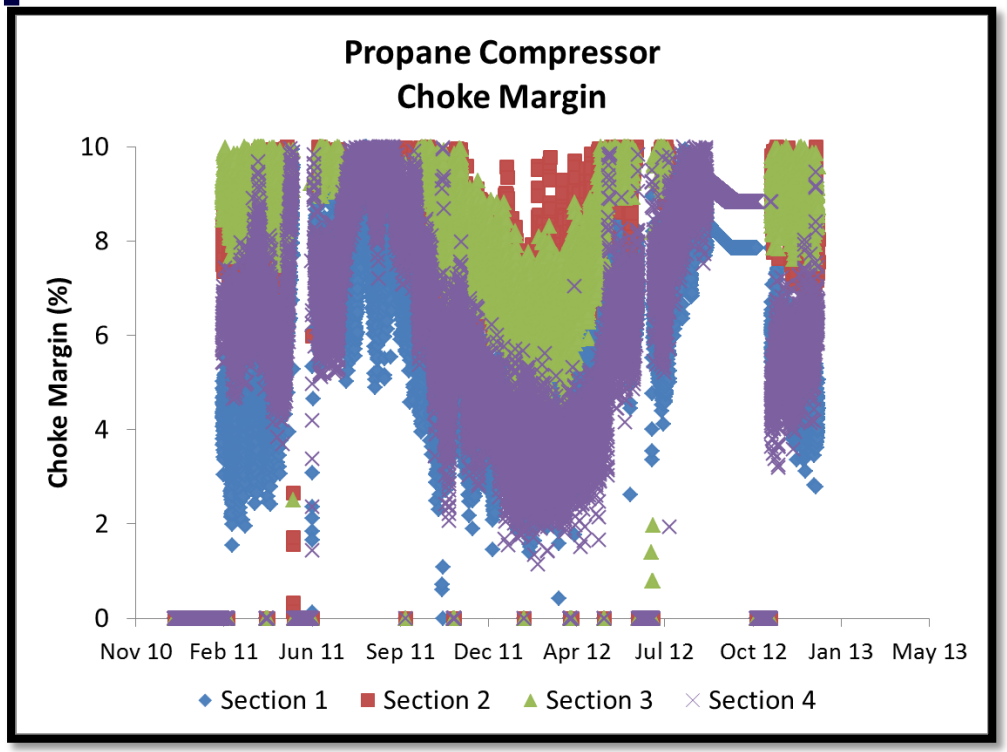
Propane Machinery

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

MR Machinery

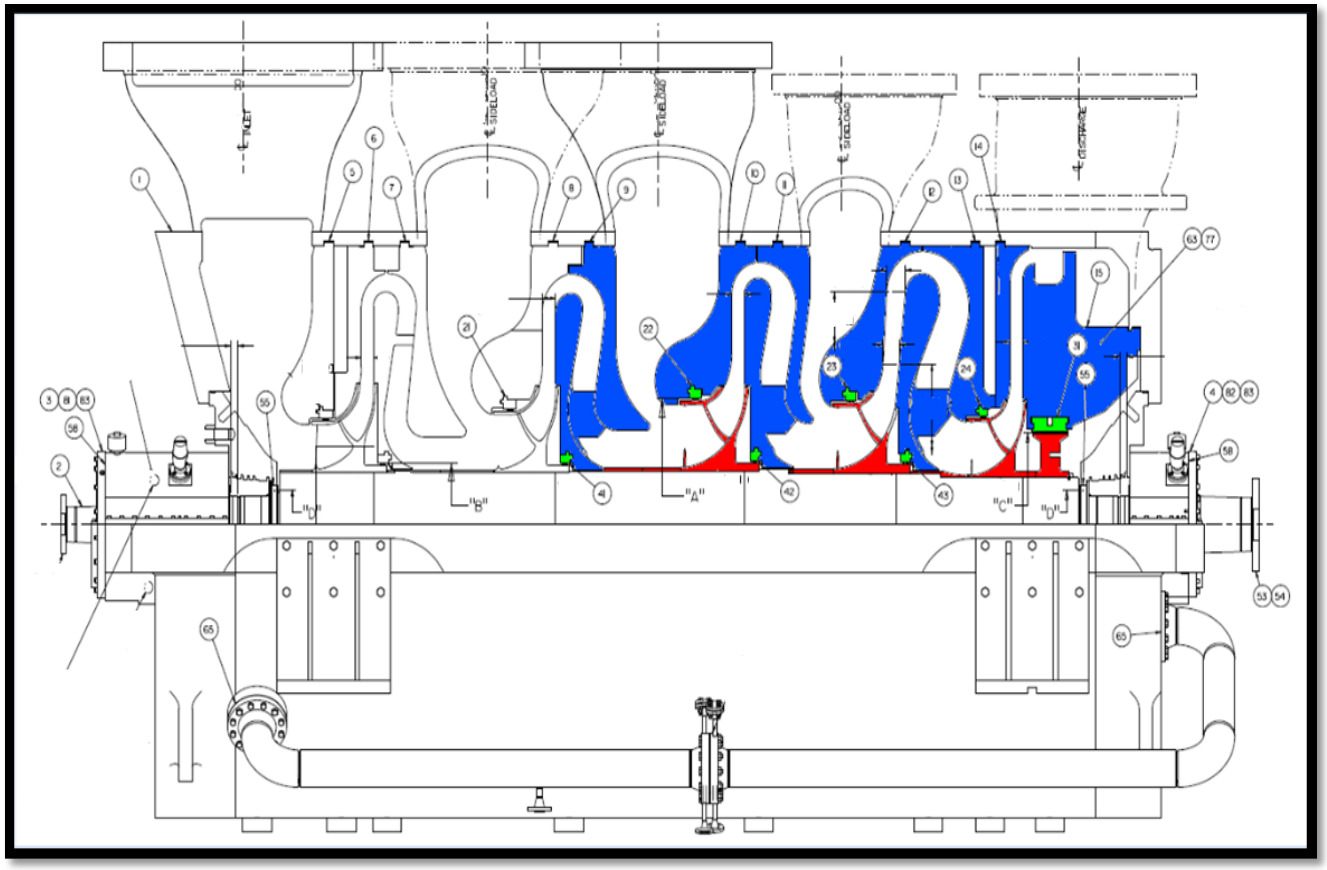
- All three compressors operate satisfactorily
- LP/MP MR string use maximum available power
- LP/MP MR string power is plant bottleneck

Propane Compressor Failures



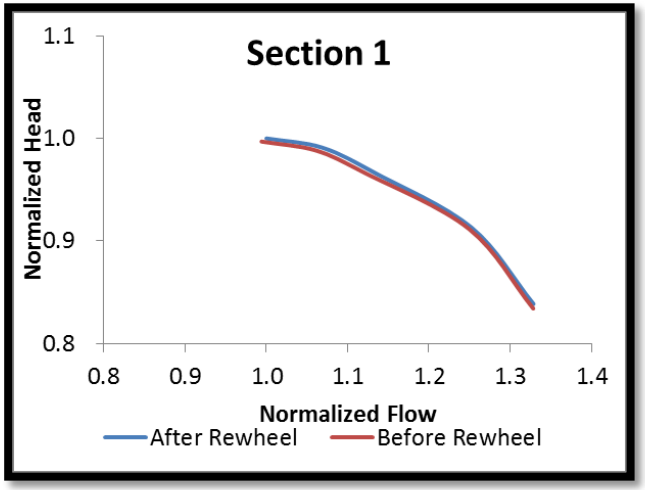
- Narrow choke margin during winter months
- History of Sections 3 and 4 impellers failure during operation

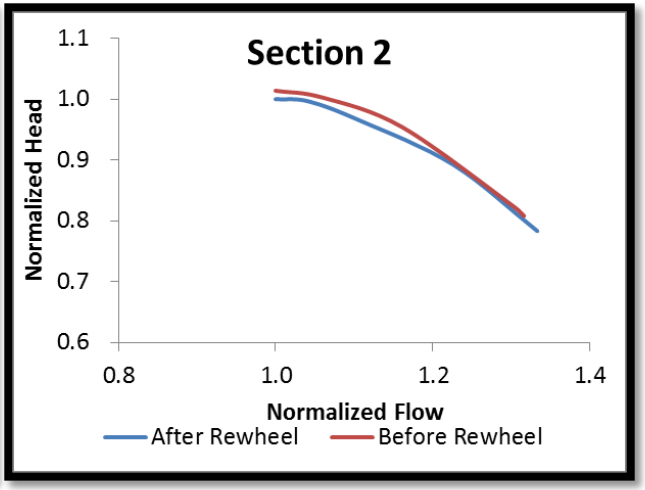
Propane Compressor Re-wheel

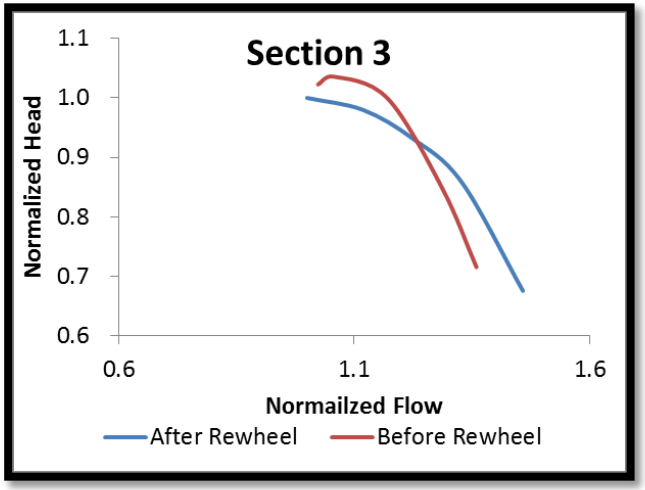


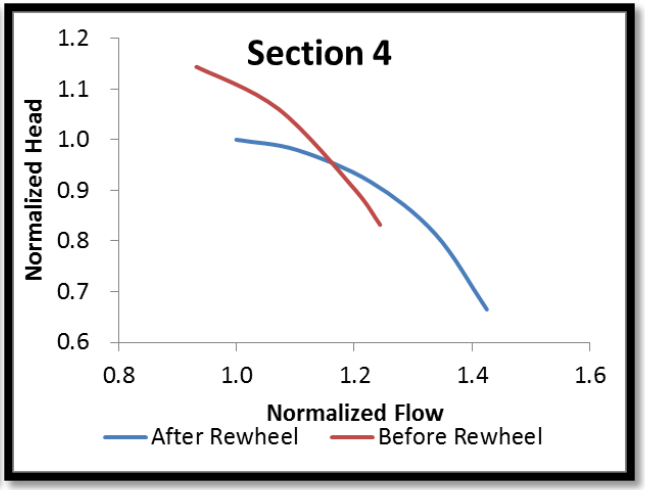
- Redesigned all of sections 3 & 4 and section 2 return channel
- Reused section 1 & 2 impellers

Propane Compressor Re-wheel







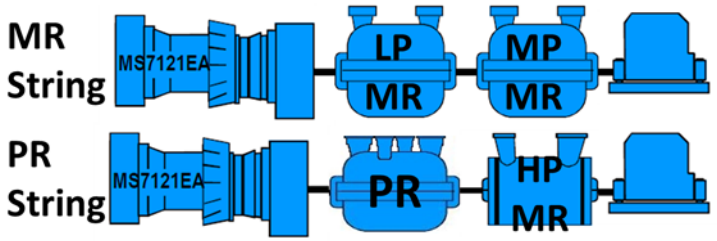


- Increase sections 3 & 4 operating range
- Maintained design operating point in all sections

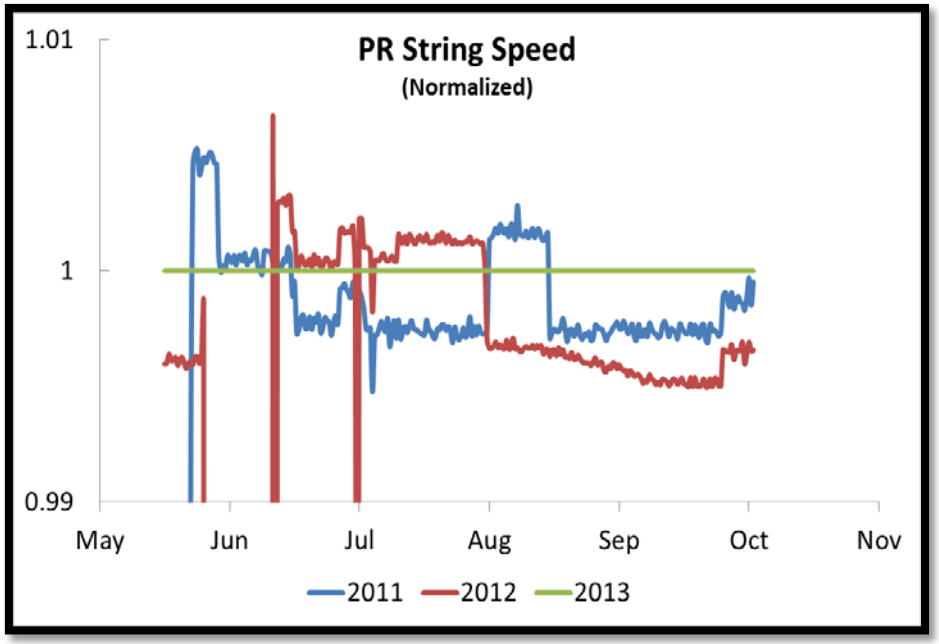
Effect of Re-wheel on Refrigeration Systems

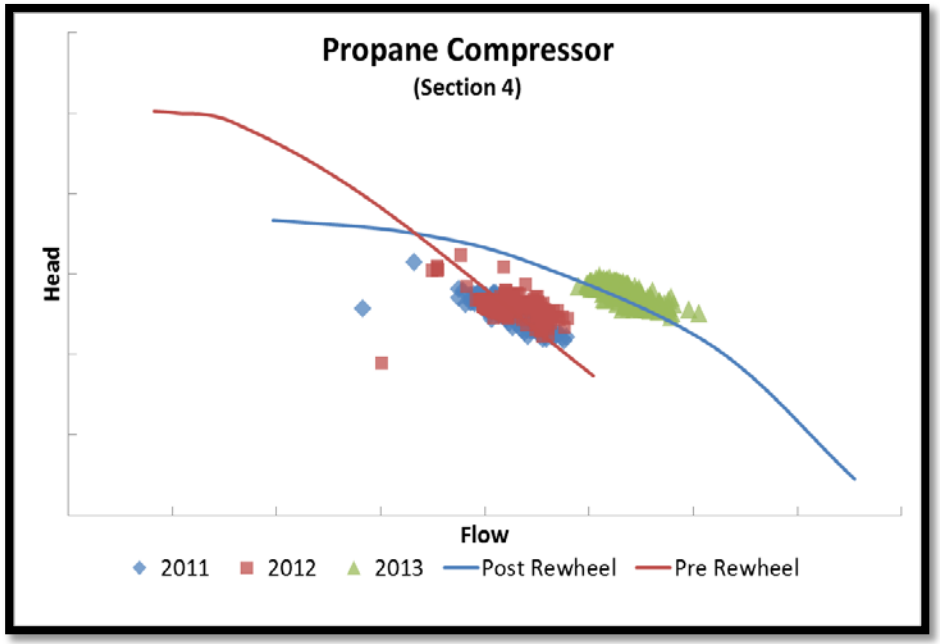
Summer 2013 Average Jun - Sep	vs 2011 & 2012
MR Mass Flow	4.1%
PR Mass Flow	1.6%
Total MR Head	-2.3%
MR String Power	0.4%
PR String Power	1.7%
HP MR Power	1.8%

Overall 2013	vs 2011 & 2012
MR Mass Flow	2.4%
PR Mass Flow	1.3%
Total MR Head	-2.3%
MR String Power	0.1%
PR String Power	1.1%
HP MR Power	0.8%



Post Re-wheel Analysis: Propane Compressor

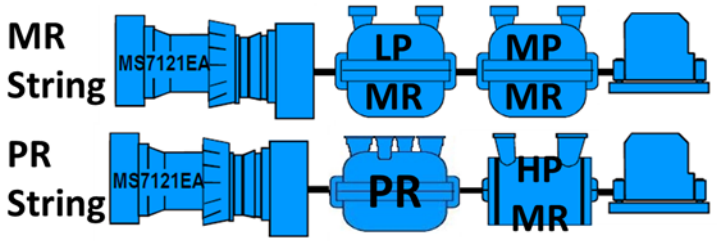




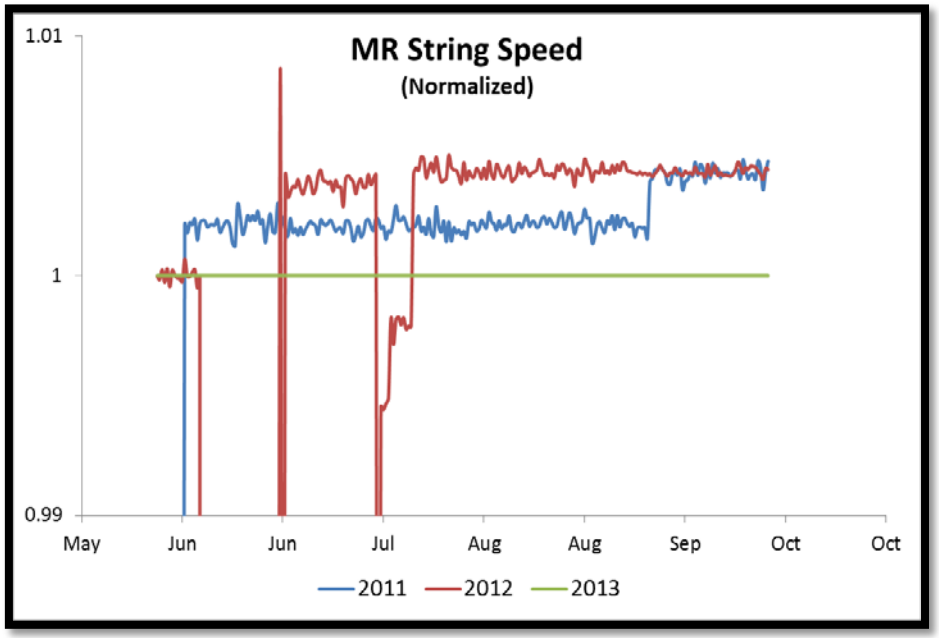
- Larger Choke Margin

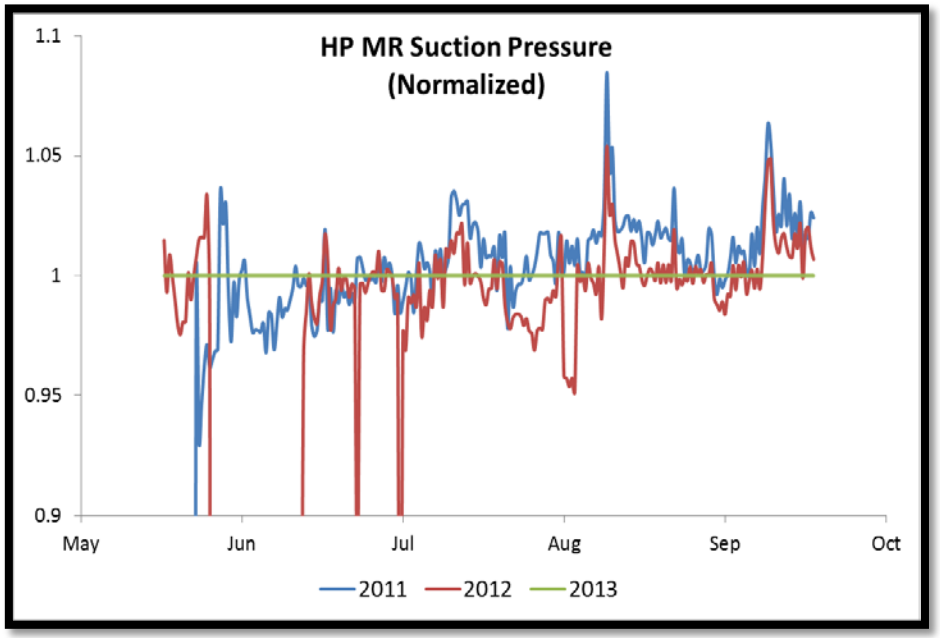
  → Increase in speed

  → Higher PR flow rate

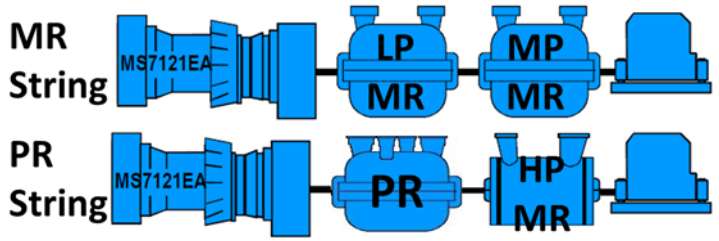


Post Re-wheel Analysis: MR System

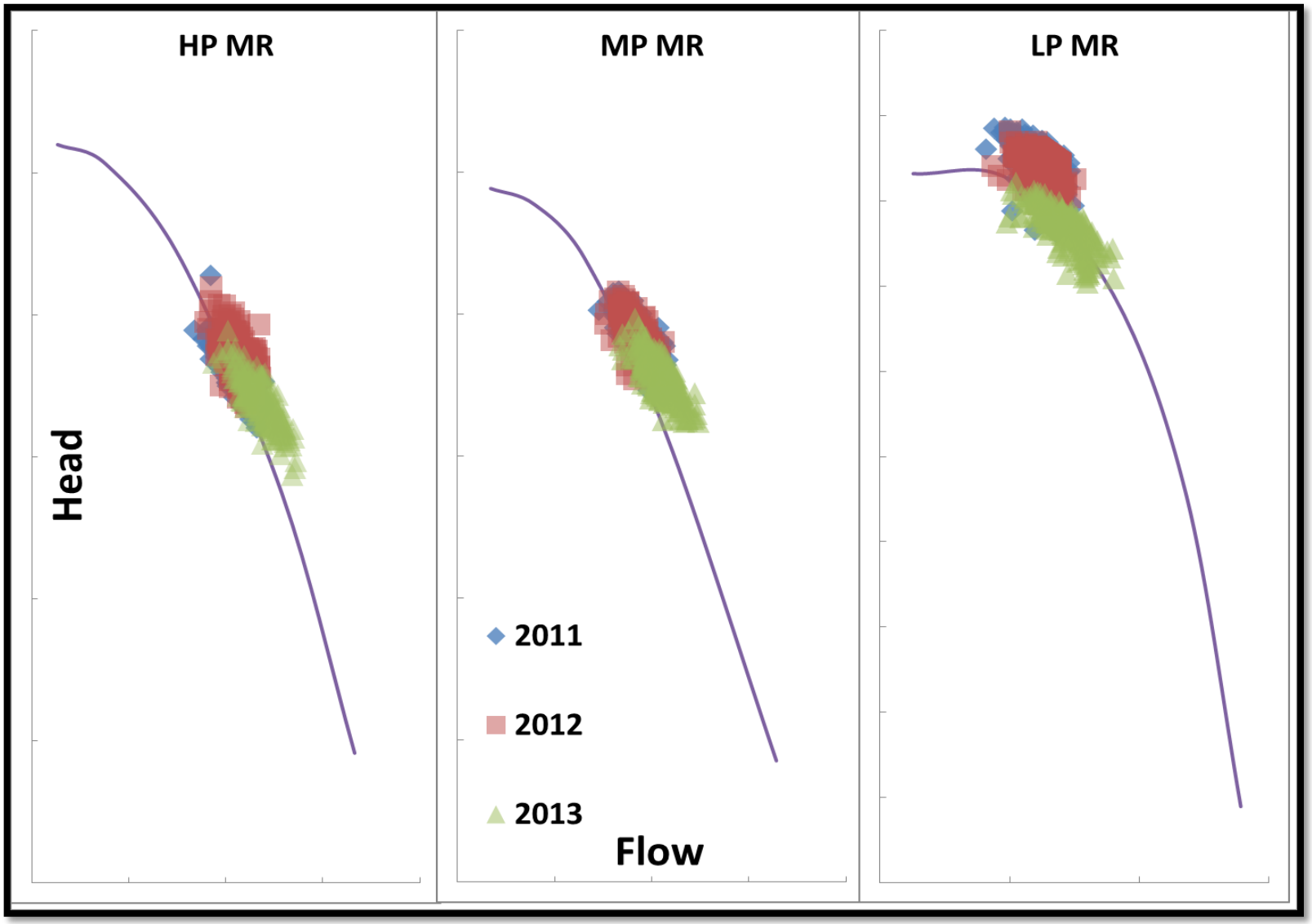




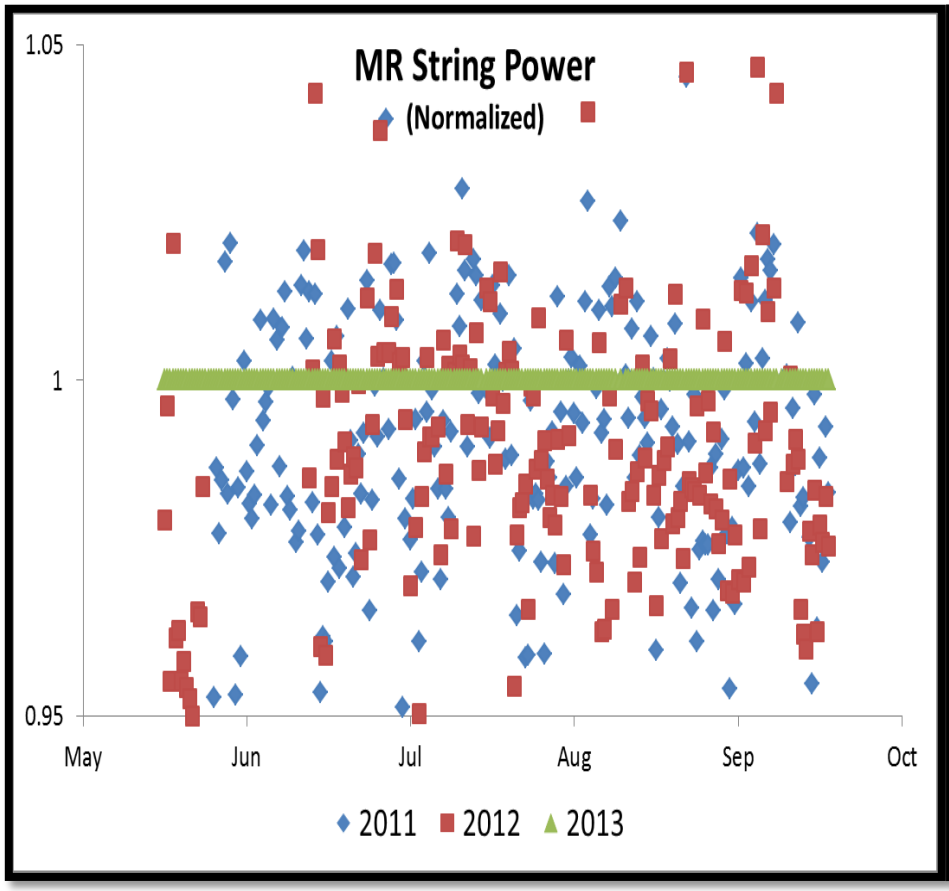
- Lower MR turbine speed
  → Lower HP suction pressure
- Same Absorbed Power
  → High MR flow rate

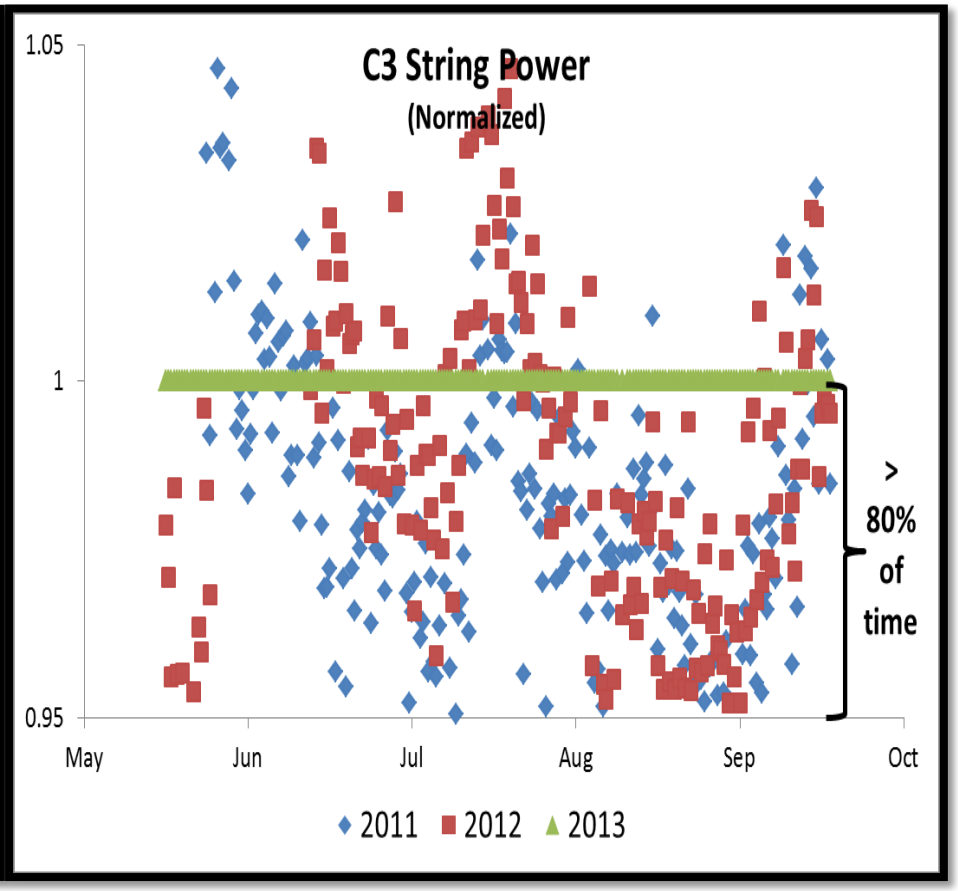


Post Re-wheel Analysis: MR Compressors



Post Re-wheel Analysis: String Power





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?