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SEMINAR 8: Impact of Regulatory and Market Trends on Compressor and System Design

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Compressor Modulation (Twin Screw)

Learning Objectives

- Describe the major market and regulatory trends impacting chiller and compressor design.
- Explain how design choices for compressor, heat exchangers and other major components are inter-related.
- Define how compressor design is impacted by part load efficiency focus. Including modulation via speed and mechanical means.
- Describe the impact of new refrigerants on compressor design.

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Acknowledgments

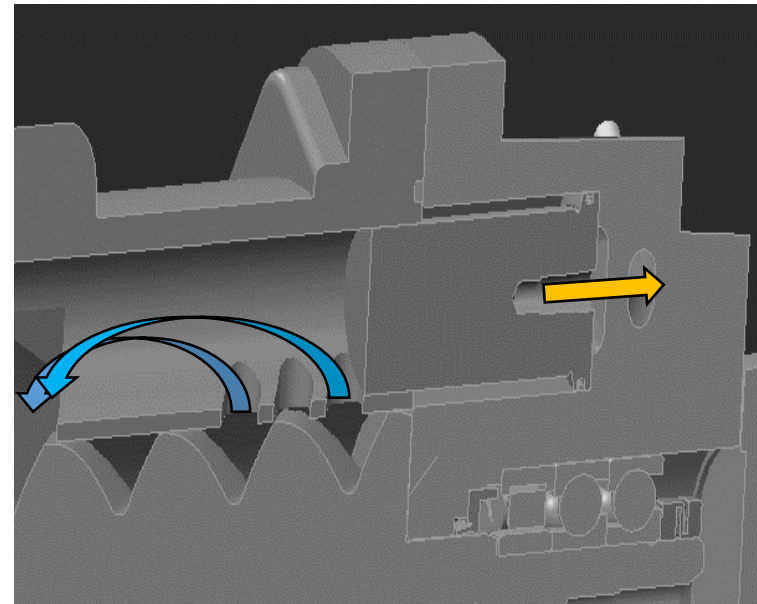
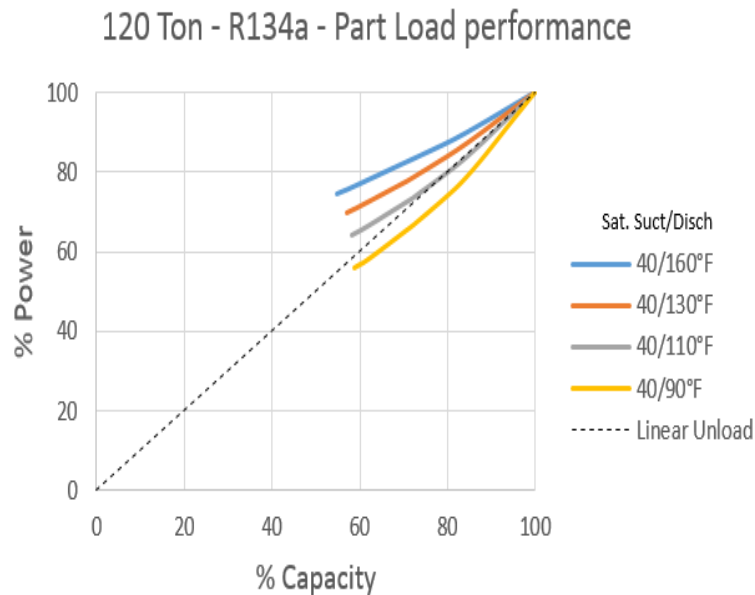
Ingersoll Rand and Jay Johnson, Compressor Group Leader, for giving permission to present test results.

Outline/Agenda

- Capacity and Vi control devices
 - Capacity Slot Valve
 - Capacity Lift Valve
 - Capacity SV regulating discharge port
 - Vi Slide Valve
 - Vi Lift Valve
 - Variable speed
- Mechanical Unload + Variable Vi
- VFD + Mechanical Unload
- VFD + Variable Vi
- VFD + Economizer

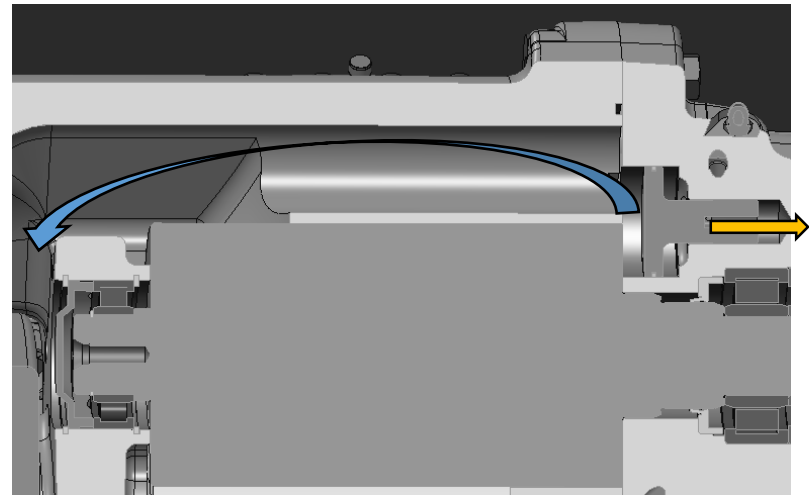
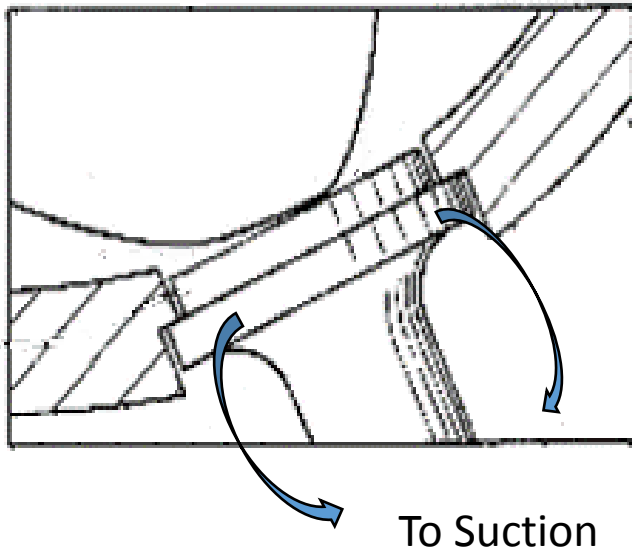
Capacity Slot Valve

- Piston or turn valve that gradually opens a number of slots following the rotor helix and facing one or both rotor bores



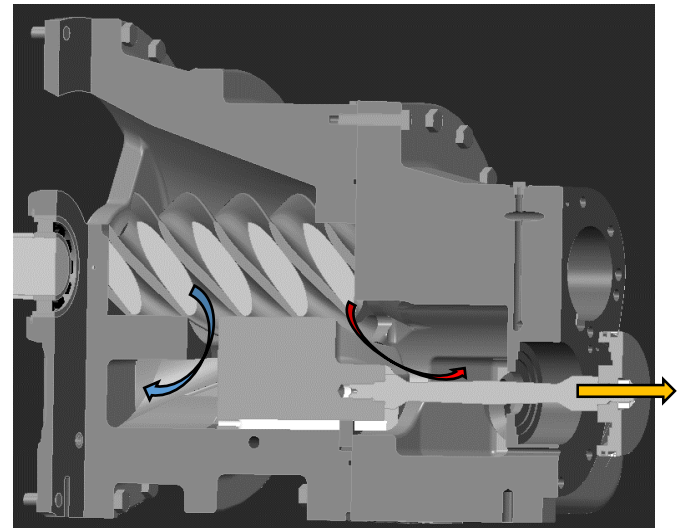
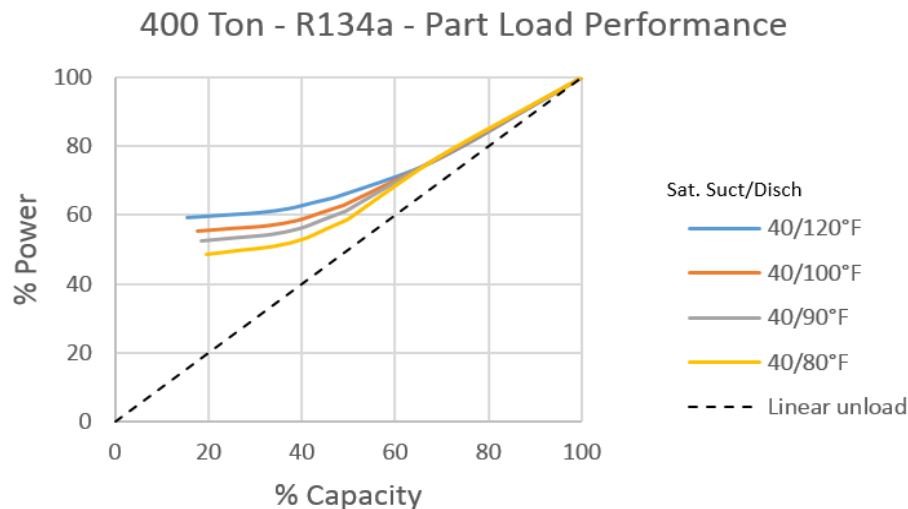
Capacity Lift Valve

- Valve facing one or both rotor bores and delaying the actual start of compression when opened.
- Radial or axial action. The valve can provide a bypass flow.



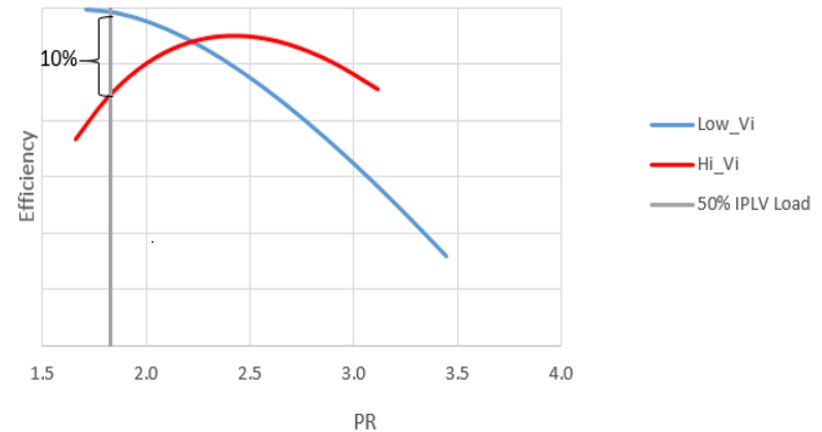
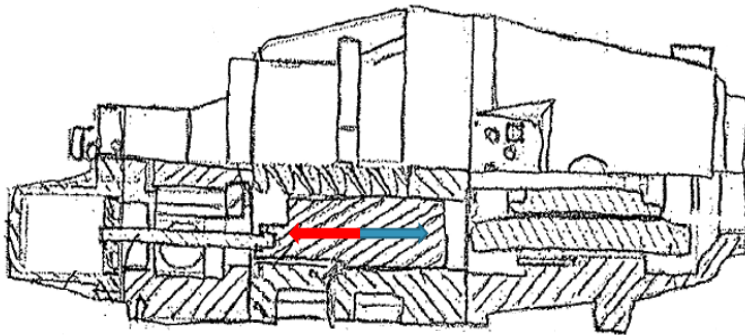
Capacity SV regulating discharge port

- Valve having a sliding action parallel to the rotor bores that controls the discharge radial port while controlling the suction opening.
- Capacity reduction goes together with a lower built in volume ratio. The delayed discharge process can partially compensate it.
- The built in volume ratio at part load condition is not always satisfactory.



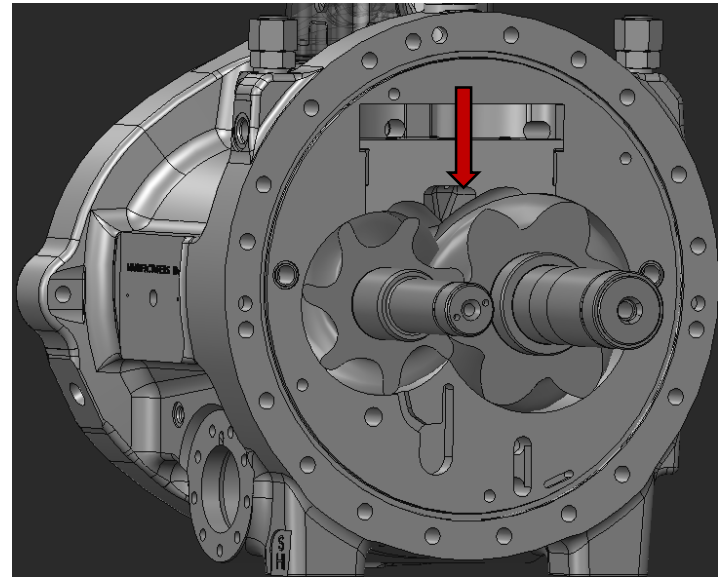
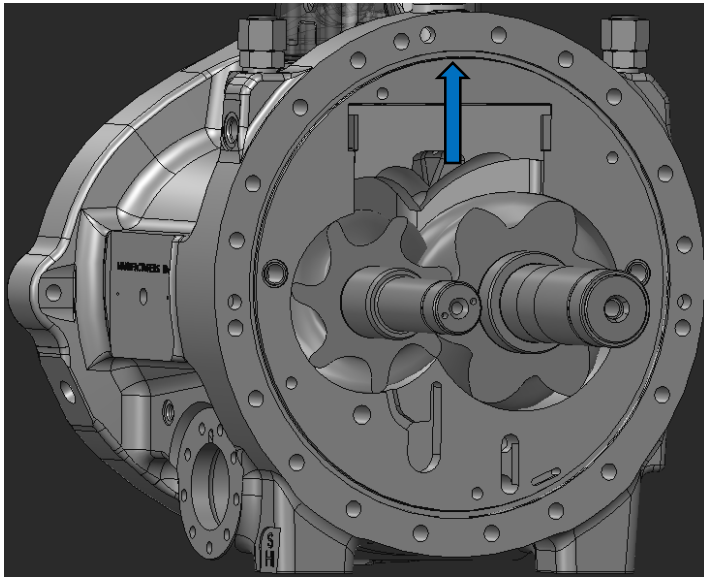
Vi Slide Valve

- Valve, having a sliding action parallel to the rotor bores, situated within the high pressure cusp region, facing one or both rotor bores and controlling the radial discharge port.
- The axial port is usually designed for the highest Vi required.



Vi Lift Valve

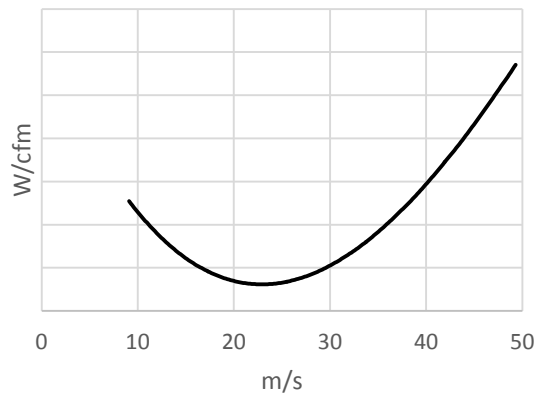
- Valve at the discharge region, facing one or both rotor bores and opening a radial or axial port when a lower Vi is required.



Variable Speed

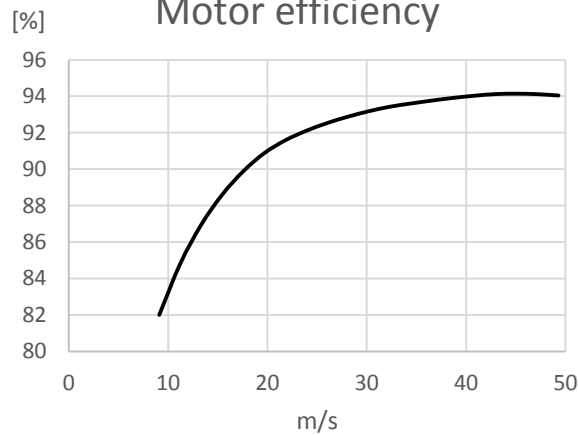
- Capacity controlled by rotor speed variation.
- Combined performance: VFD, motor, compressor.

Compressor spec. power



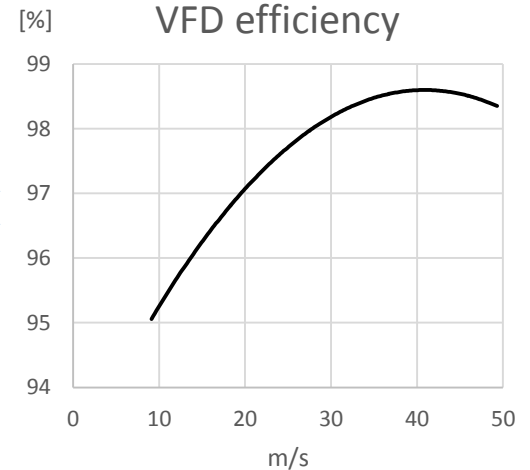
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Motor efficiency



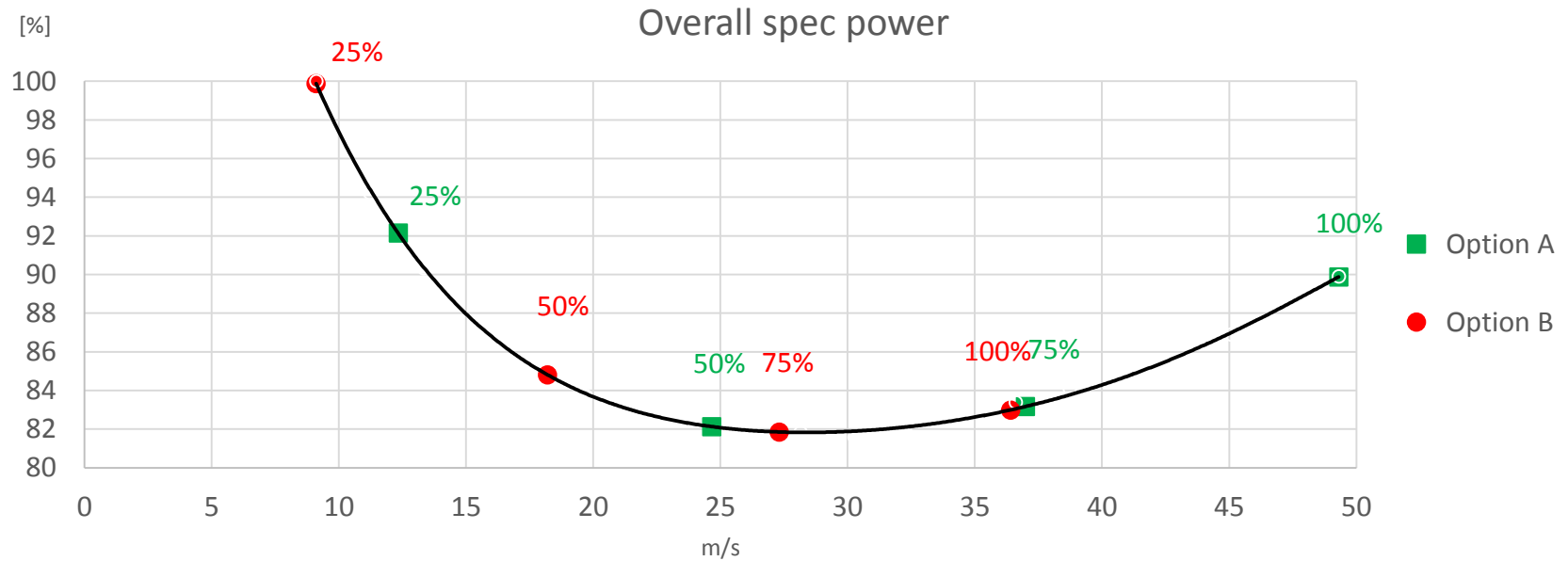
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VFD efficiency



Variable Speed – Part Load with No Pressure Relief

Option A	Option B
Part Load Efficiency	Full Load Efficiency
High Max Capacity	

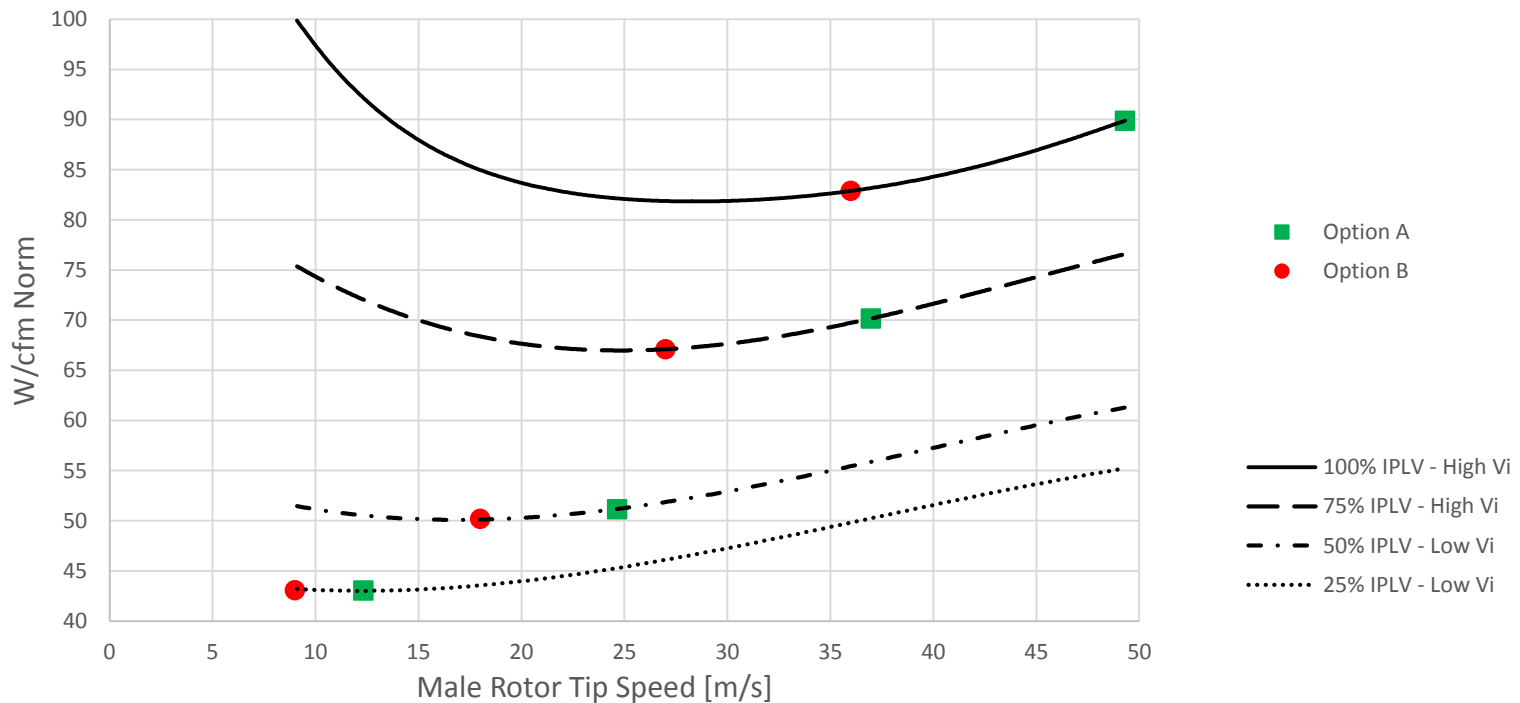


VFD + Mechanical Unload

- Mechanical unloading can supplement VFD unloading when the load request is beyond the minimum rpm range required for compressor reliability.
- Mechanical unloading can complement VFD unloading by changing the built in volume ratio to improve part load efficiency.

VFD + Variable Vi - IPLV AHRI Standard 550/590

Option A	Option B
High max capacity	Full load efficiency
	Part load efficiency



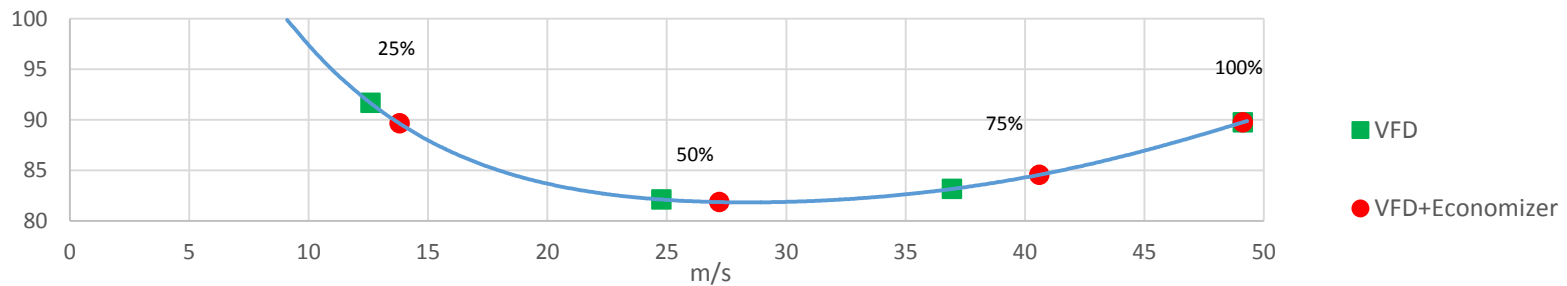
VFD + Economizer

- Economizer open at 100% load, only.

Equal max RPM	Equal min RPM
10% more capacity	Full load efficiency
No benefit on part load (IPLV)	

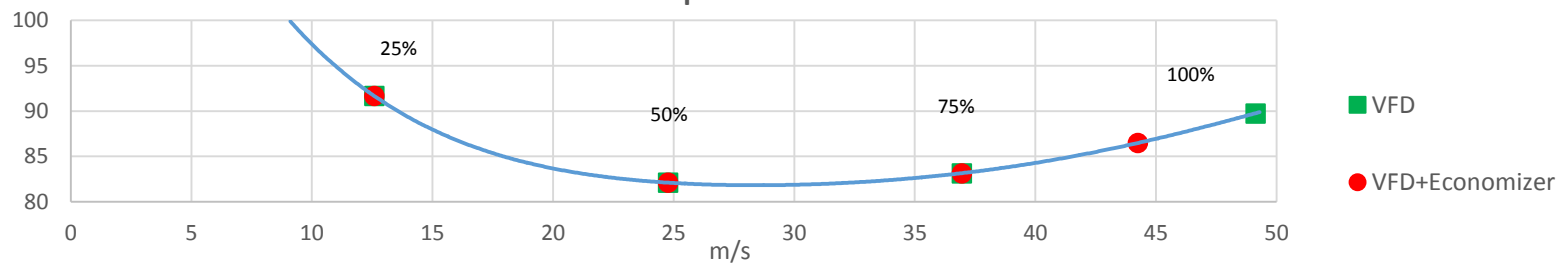
[%] Specific Power

Equal max RPM



[%] Specific Power

Equal min RPM



Conclusion

- The screw compressor is a very flexible machine, probably better than other compressor typologies. Suitable for a wide pressure ratio and speed range in order to accomplish very specific needs.
- Despite the fact the screw compressor is a mature design there are still opportunities to be competitive with centrifugal and scroll technology, especially at part load condition.
- VFD technology and variable V_i together appears to be the way to approach part load efficiency, the flexibility for handling a larger variety of refrigerants.

Bibliography

- ANSI/AHRI Standard 550/590. 2011. Performance Rating of Water – Chilling and Heat Pump Water-Heating Packages Using the Vapor compression Cycle
- Sjöholm, L. 1986. “Variable Volume-Ratio and Capacity in Twin-Screw Compressors” International Compressor Engineering Conference”

Questions?



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