GAMMA TECHNOLOGIES

TRANE TECHNOLOGIES™

EBOOK

HOW TO SOLVE A PERFORMANCE SHORTFALL IN A SCROLL COMPRESSOR

A PRACTICAL APPLICATION OF GT-SUITE

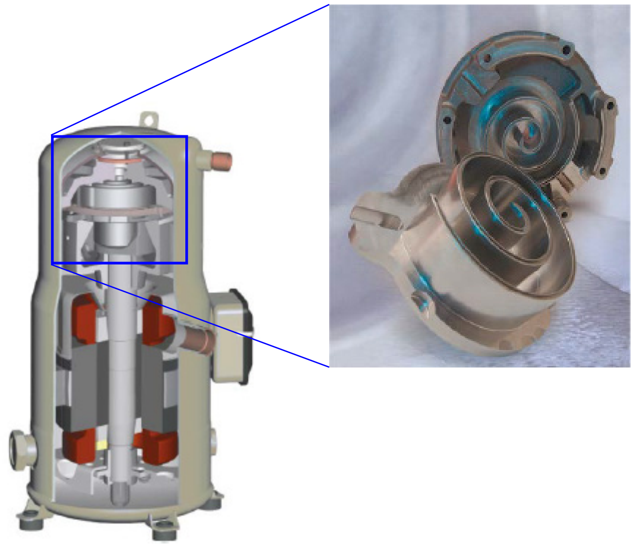
AGENDA

Credits: The contents in this eBook have been re-created from the presentation "A practical application of GT-SUITE to solve a performance shortfall in a scroll compressor" presented by Mr Joe Ziolkowski from Trane Technologies at the 2020 GT Global Conference.

SCROLL COMPRESSOR BACKGROUND AND TERMINOLOGY

TRANE SCROLL COMPRESSORS

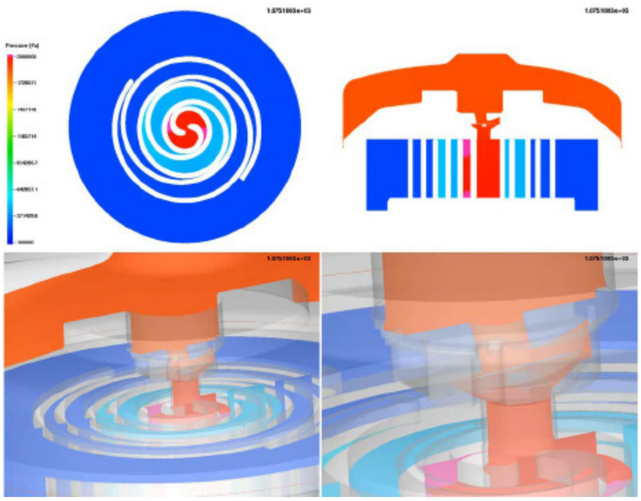
- A scroll compressor utilizes two opposing parts, with prismatic, spiral-shaped walls to form and compress a gas, usually air or refrigerant.
- Trane scroll compressors utilize a stationary "fixed" and moving "orbiting" scroll to create the compression mechanism.



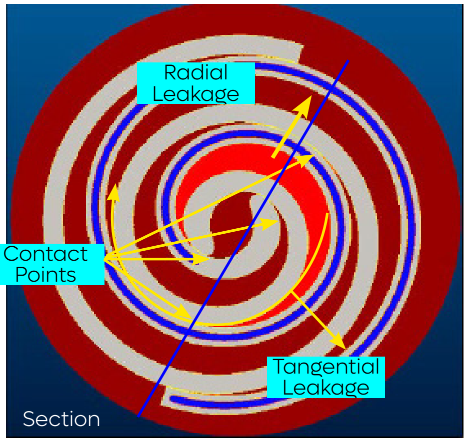
SCROLL COMPRESSION PROCESS

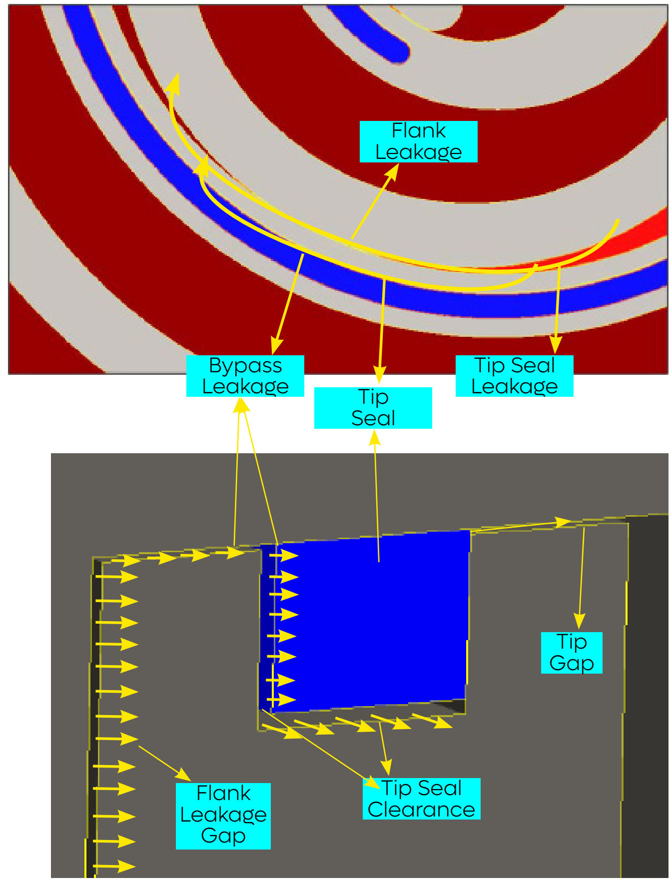
- Happens in three phases

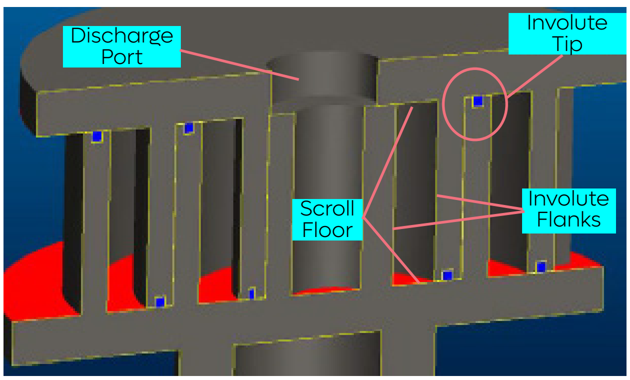
  - Suction
  - Compression
  - Discharge



SCROLL COMPRESSION LOSSES

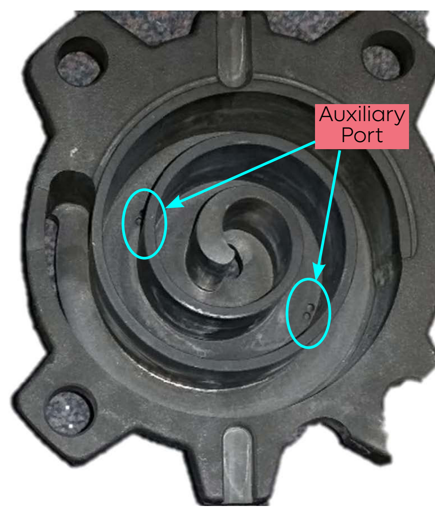




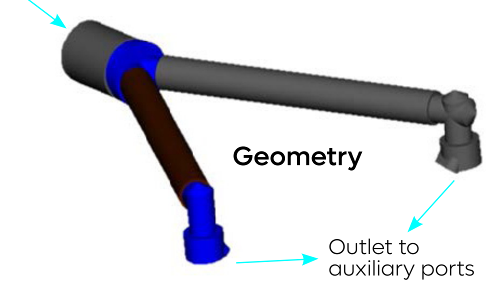


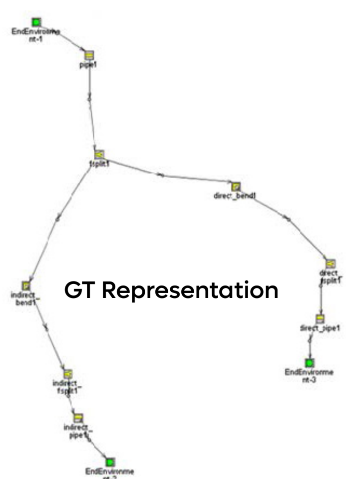
VAPOR INJECTION

- Auxiliary (economizer) port located in compression to inject refrigerant vapor
- Piping network pressure drop and heat transfer, can significantly affect mass flow rate
  - Pressure drops characterized through submodeling



Economizer Gallery

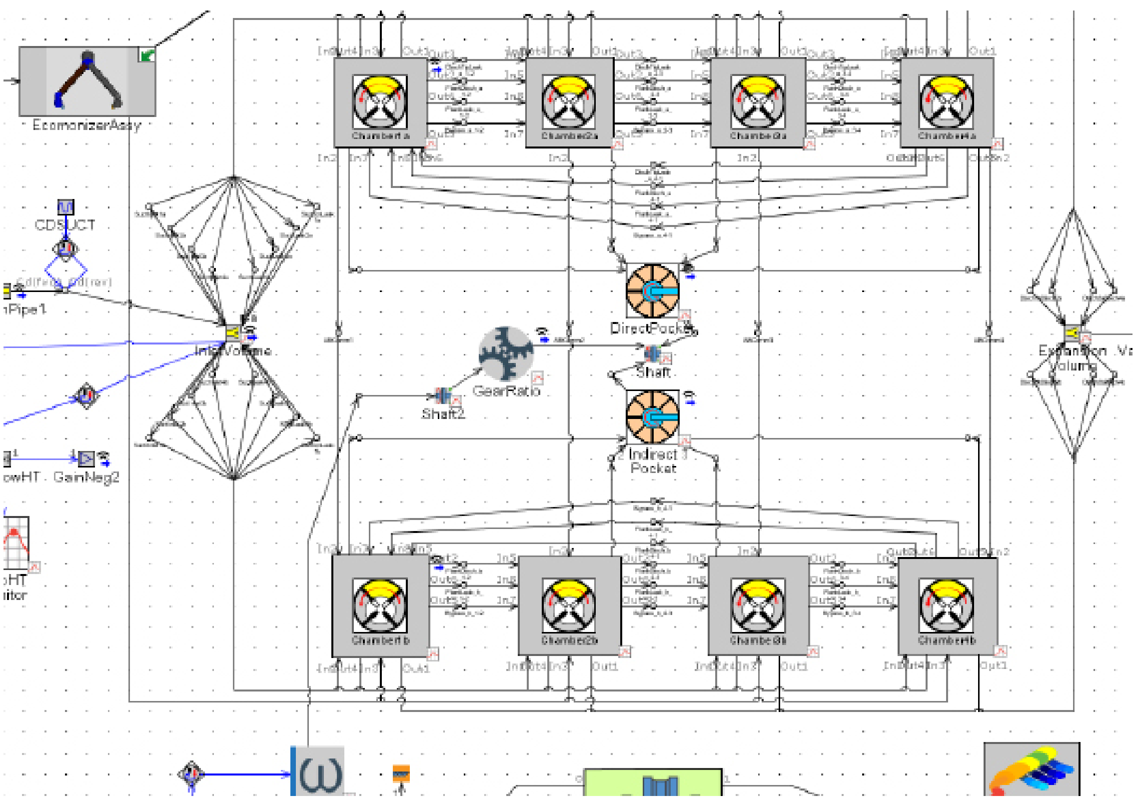




PROBLEM STATEMENT

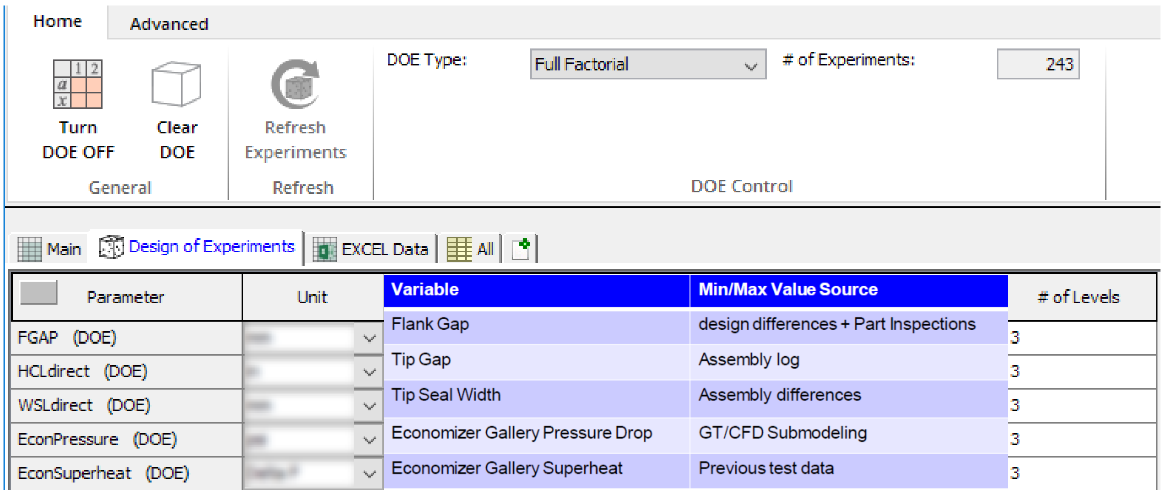
PROTOTYPE PERFORMANCE SHORTFALL

- Based on observed performance during prototype lab testing
- Economizer Mass Flow Rate 19% belowtarget (Shortfall #1)
- Compressor Efficiency 8% below target (Shortfall #2)
- Root cause investigation
  - Heavy reliance upon analytical tools
- GT-SUITE Sensitivity Analysis
  - Using detailed chamber compressor model
  - Basic level calibration



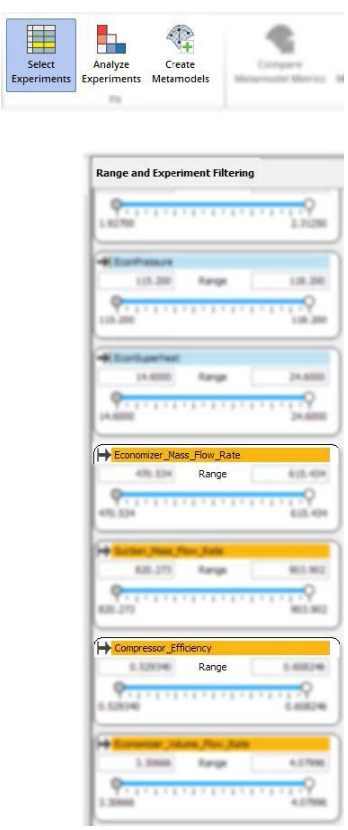
GT-SUITE SENSITIVITY ANALYSIS

- Full-Factorial DOE
  - 5 Factors
  - 3 Levels
  - 243 Experiments
- Performed at 2 performance rating conditions
- Quantitative sensitivity results desirable
  - Choice of min/max values must be realistic and reflective of actual differences

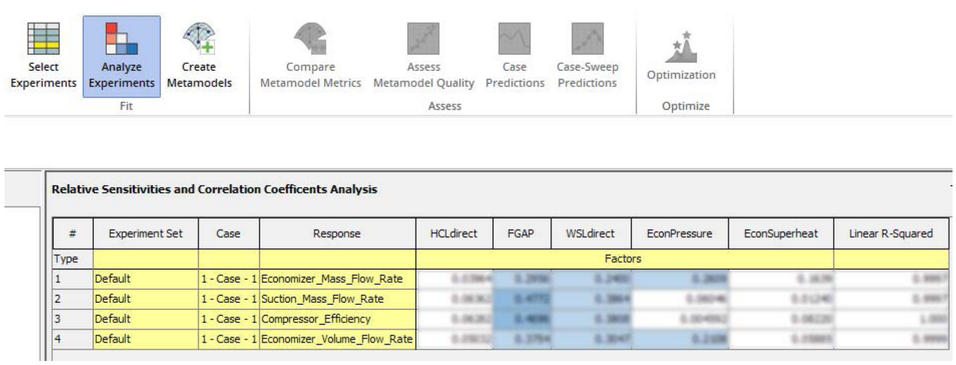


Parameter	Unit	Variable	Min/Max Value Source	# of Levels
FGAP (DOE)		Flank Gap	design differences + Part Inspections	3
HCLdirect (DOE)		Tip Gap	Assembly log	3
WSLdirect (DOE)		Tip Seal Width	Assembly differences	3
EconPressure (DOE)		Economizer Gallery Pressure Drop	GT/CFD Submodeling	3
EconSuperheat (DOE)		Economizer Gallery Superheat	Previous test data	3

SENSITIVITY ANALYSIS RESULTS

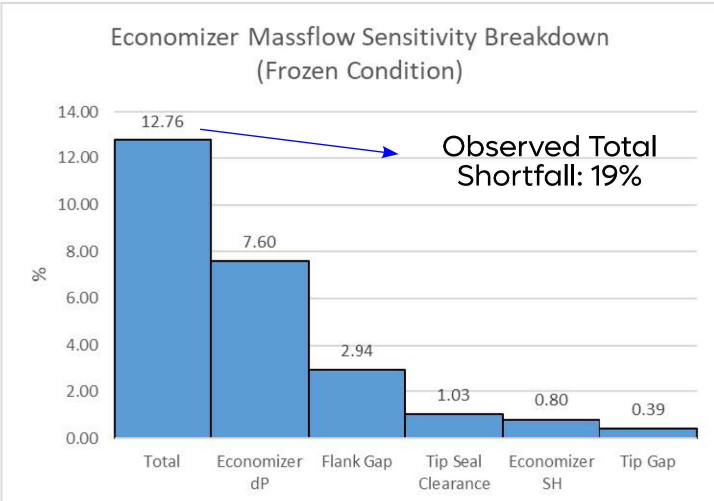


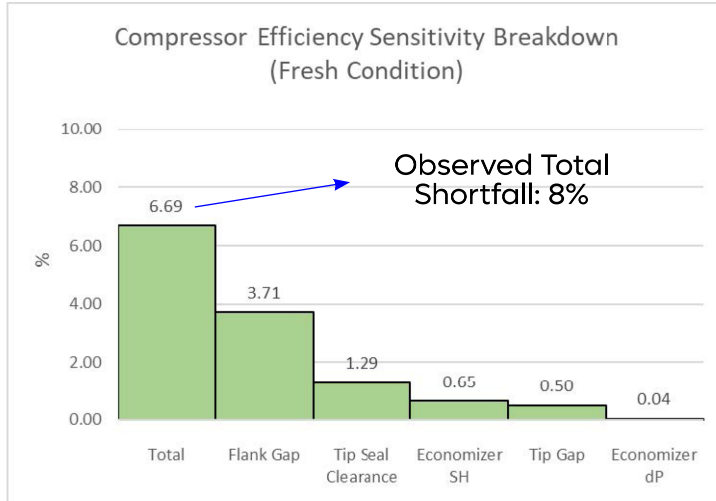
- Results post-processed to the same reference frame as the problem statement



X = ...

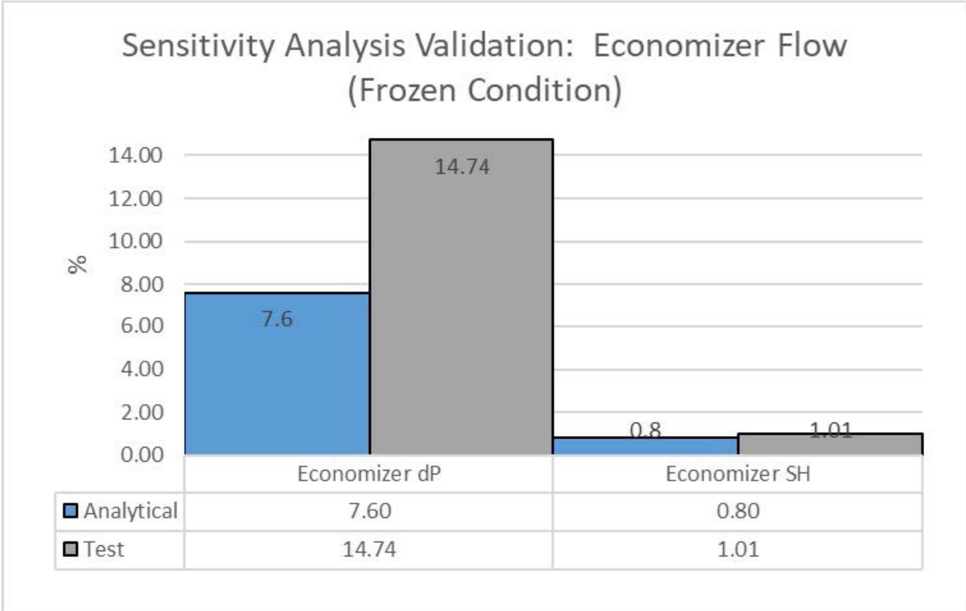
- Gives the relative contribution of each factor to the total performance shortfall
- Results show a model under-prediction
  - Closer on Compressor Efficiency





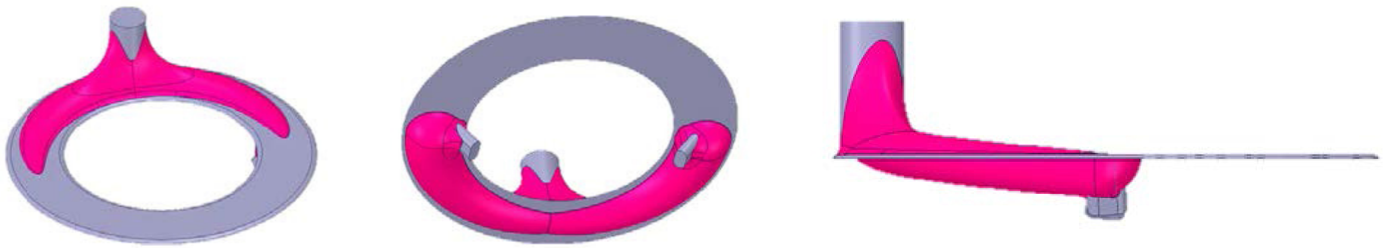
SENSITIVITY ANALYSIS VALIDATION

- A qualitative and quantitative assessment was made through testing
- Results confirm an overall under-prediction of the economizer dP factor by almost 2x
- Relative strength of the two factors produces the same conclusion

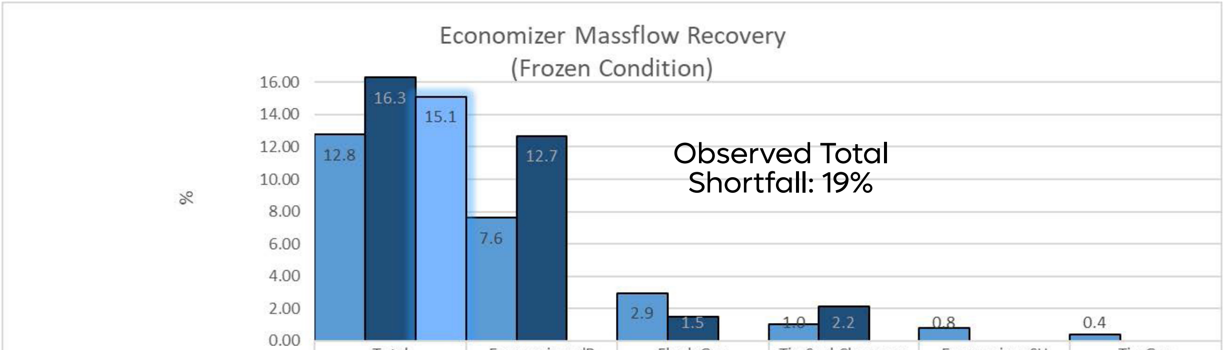


PERFORMANCE RECOVERY

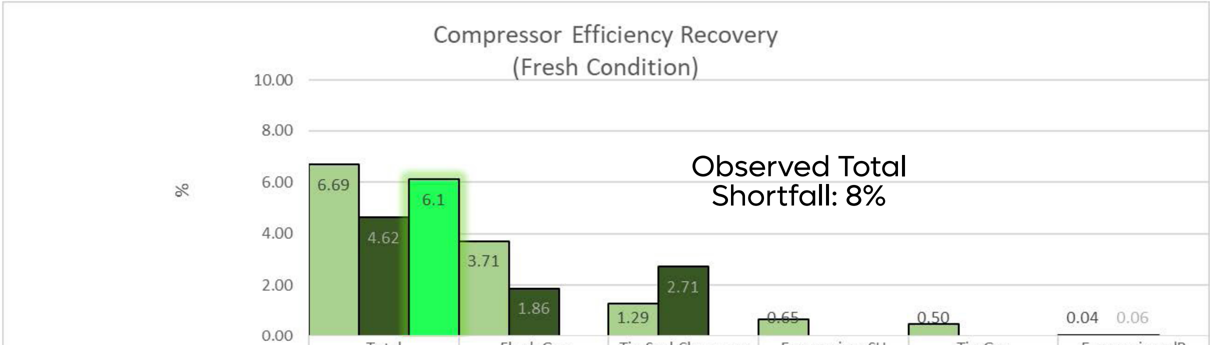
- Successful recovery of most of the performance shortfall
- Recovery achieved through:
  - Reduced economizer gallery flow resistance



- Reductions in nominal flank gap and tip seal clearance



	Total	Economizer dP	Flank Gap	Tip Seal Clearance	Economizer SH	Tip Gap
Economizer Flow Analytical Gap	12.76	7.60	2.94	1.03	0.80	0.39
Economizer Flow Analytical Recovery	16.29	12.67	1.47	2.15		
Actual Recovery	15.1					



	Total	Flank Gap	Tip Seal Clearance	Economizer SH	Tip Gap	Economizer dP
Comp Efficiency Analytical Gap	6.69	3.71	1.29	0.65	0.50	0.04
Comp Efficiency Analytical Recovery	4.62	1.86	2.71			0.06
Actual Recovery	6.1					

CONCLUSION

- A simple sensitivity analysis was used to quickly solve a challenging performance shortfall problem
- Quantitative results were obtained by using realistic min/max factor values
- A simple validation test was conducted, which boosted confidence and helped to better quantify recovery expectations
- Recovery factors were targeted based off GT-SUITE analysis, and produced satisfactory problem resolution
- The value of a quickly solved problem, such as this could be $50k-$40M!

IF YOU'RE INTERESTED TO LEARN MORE

Gamma Technologies develops GT-SUITE, the industry-leading Model-Based Systems Engineering (MBSE) CAE system simulation software.

GT-SUITE provides a comprehensive set of validated 0D/1D/3D multi-physics component libraries, which simulate the physics of fluid flow, thermal, mechanical, multi-body, structural, electrical, magnetic, chemistry, and controls.

Utilizing combinations of these libraries, accurate models can be built of practically any HVACR (Heating, ventilation, air conditioning, and refrigerant) systems such as pumps, compressors, oil and gas piping systems, and others. This makes GT-SUITE the ideal HVACR simulation software.

CLICK REFERENCES:

HVACR SIMULATION

HVACR PRESENTATIONS

INTRODUCTION TO PUMPS AND COMPRESSORS IN GT-SUITE

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