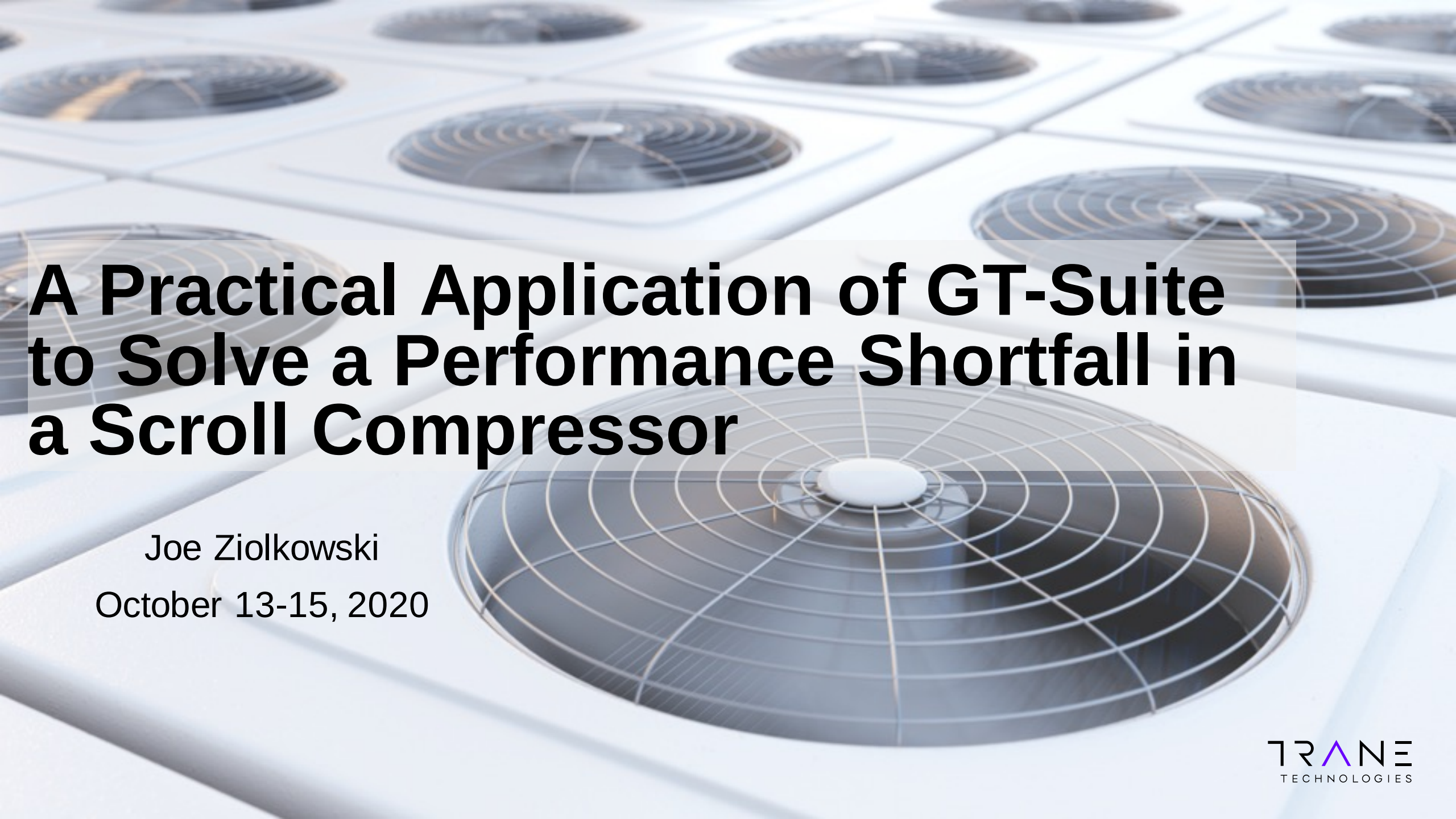

A Practical Application of GT-Suite to Solve a Performance Shortfall in a Scroll Compressor

Joe Ziolkowski

October 13-15, 2020

TRANE TECHNOLOGIES

Agenda

- Scroll Compressor Background & Terminology
- Problem Statement
- GT-Suite Sensitivity Analysis
- Results
- Conclusions

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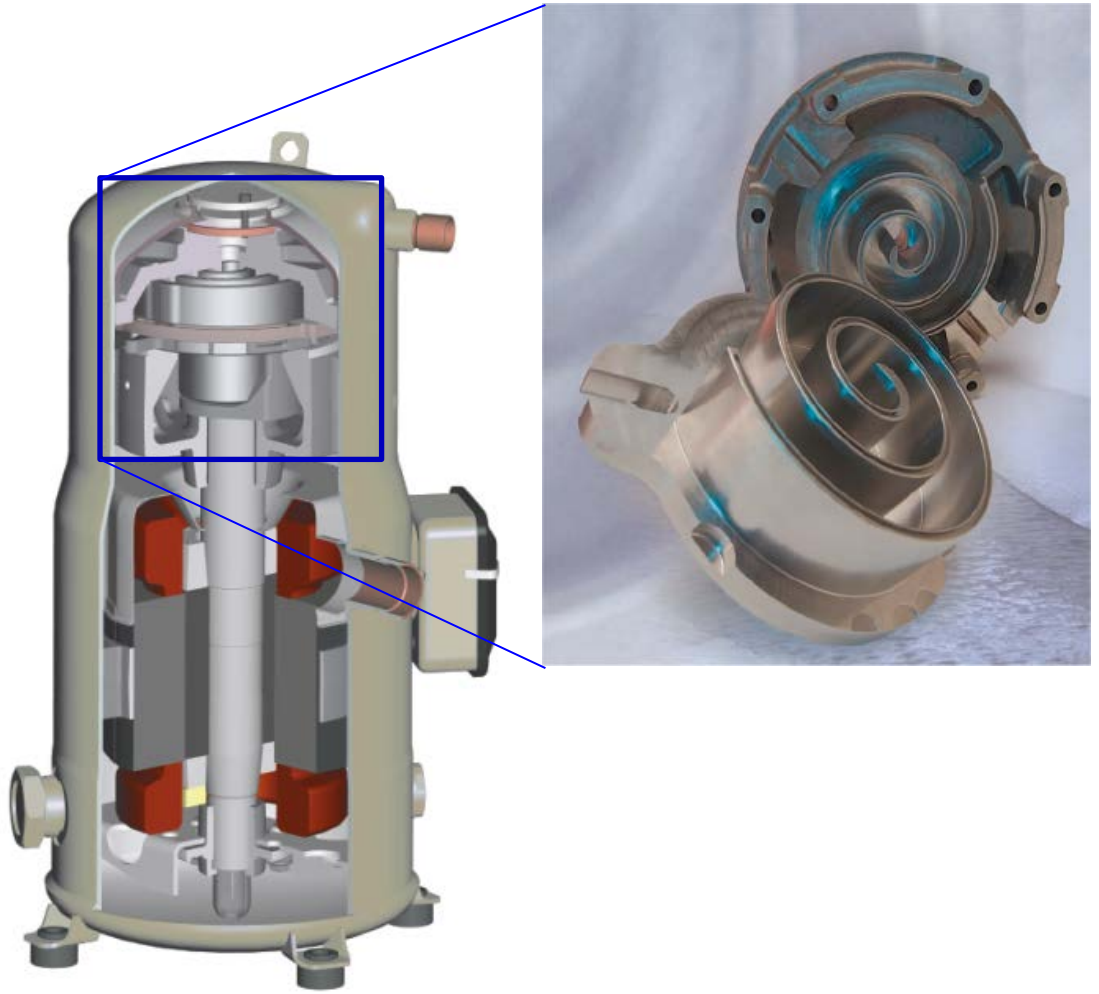
Trane Scroll Compressors

- 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.



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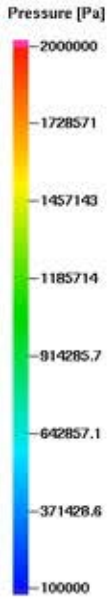

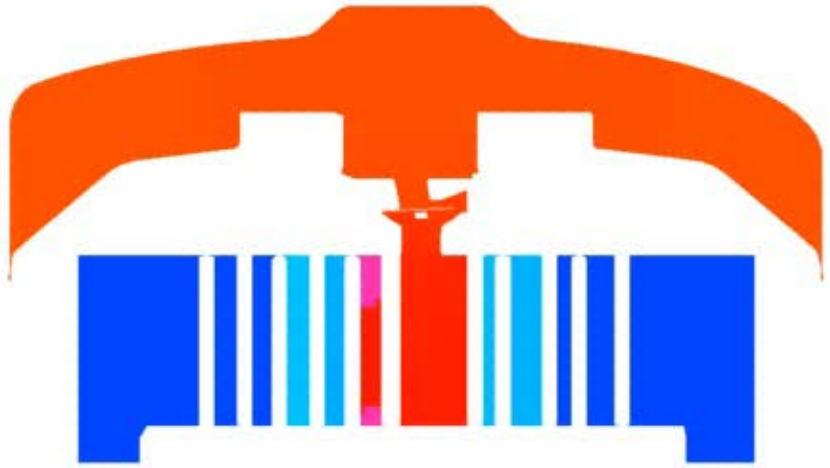

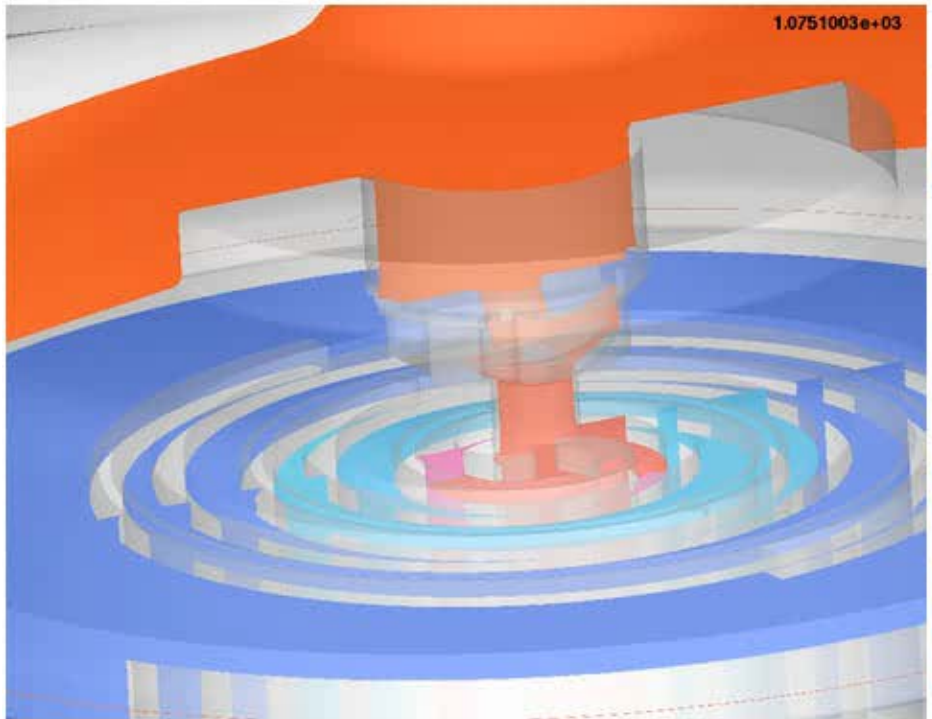

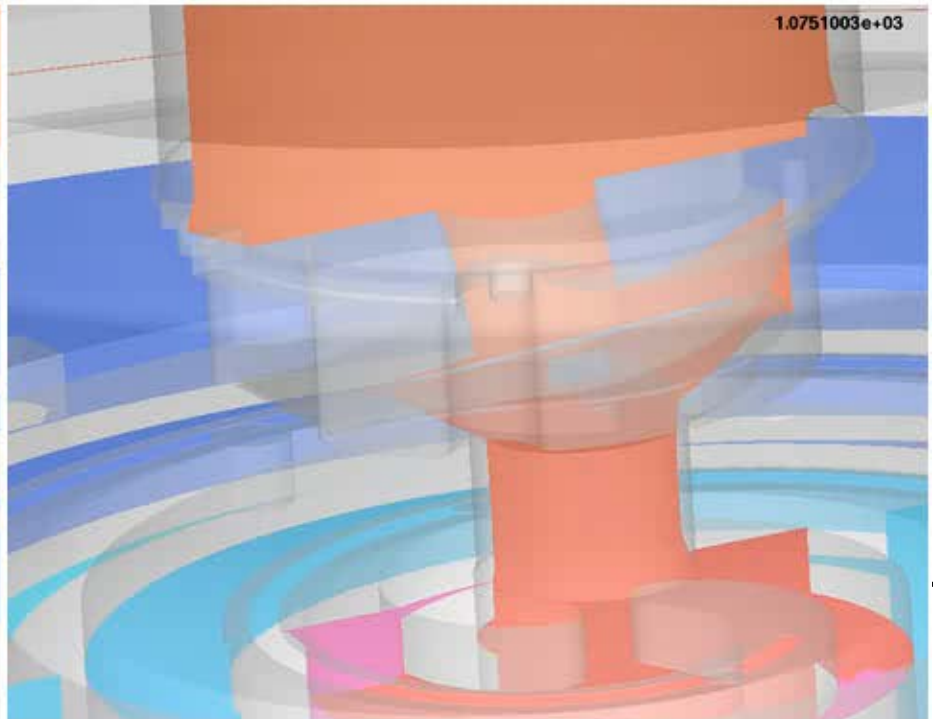

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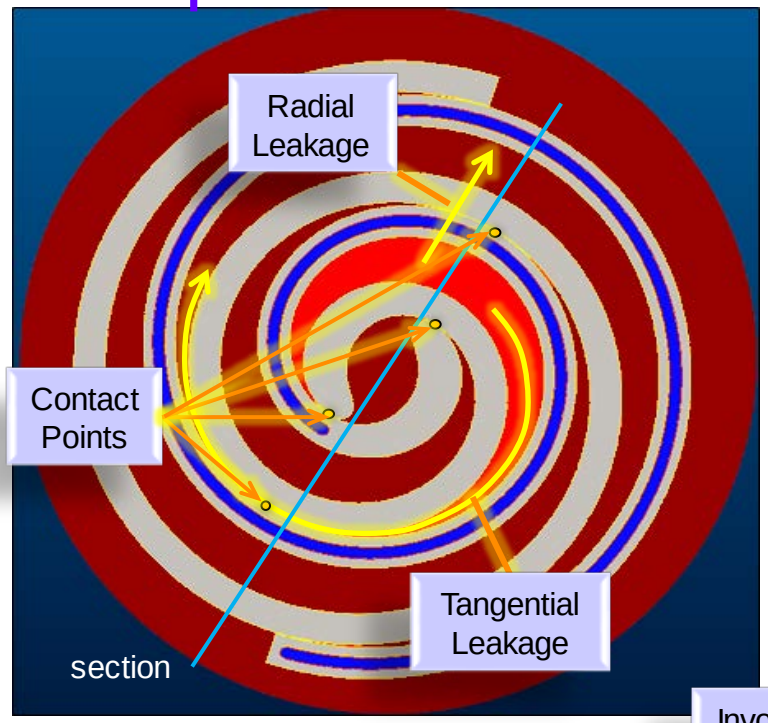
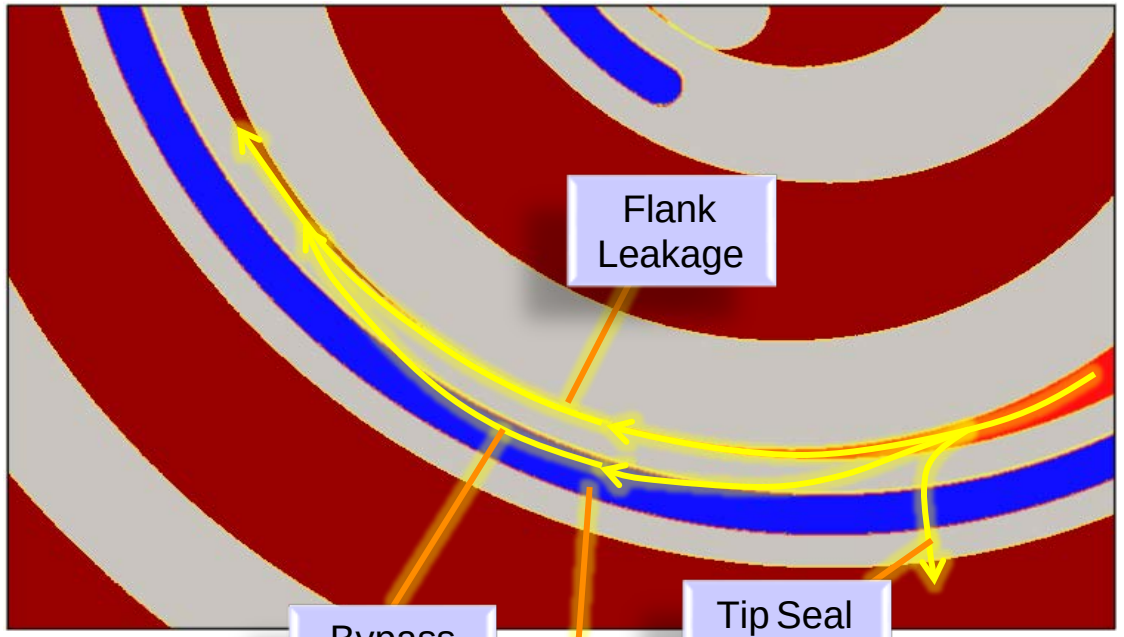
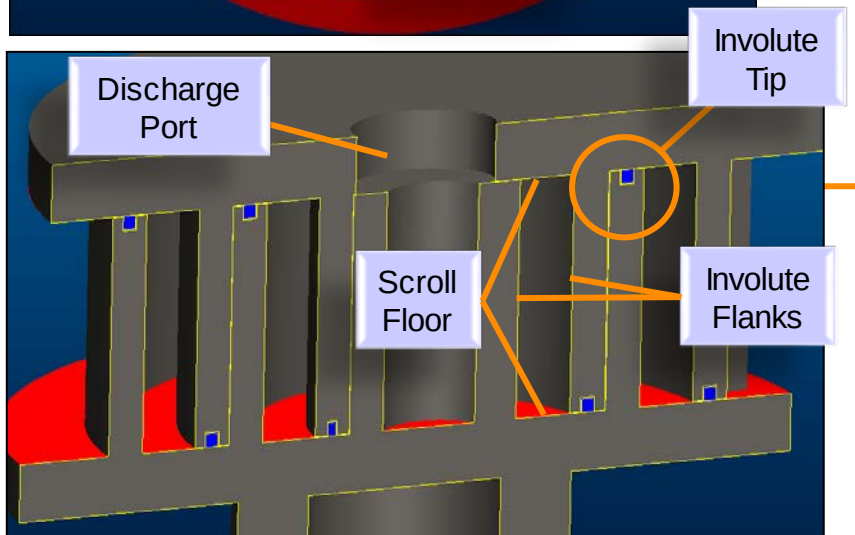
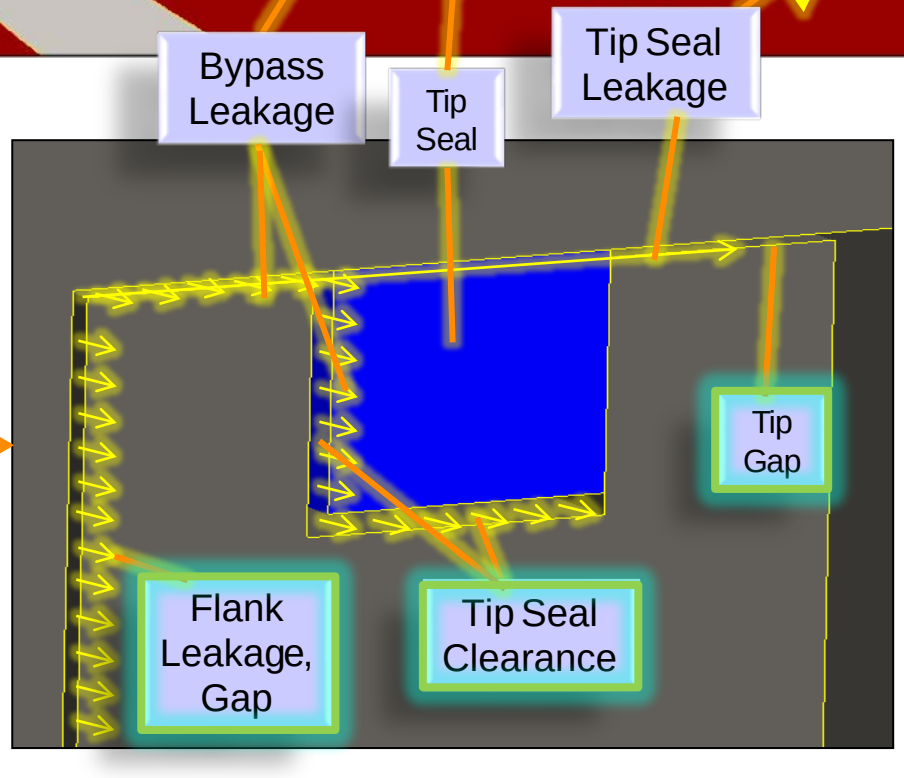
Scroll Compression Losses









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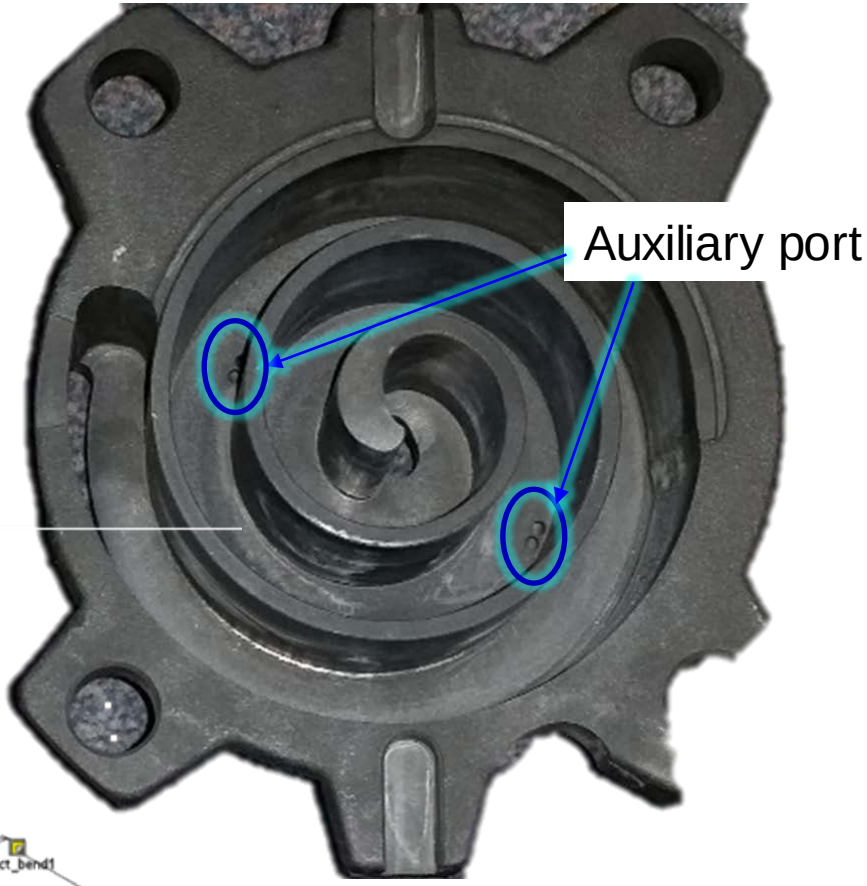
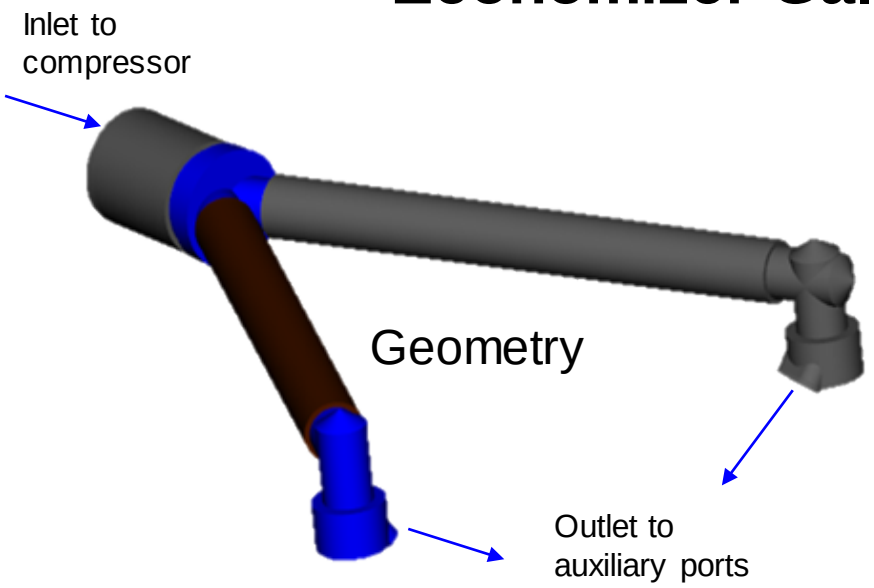
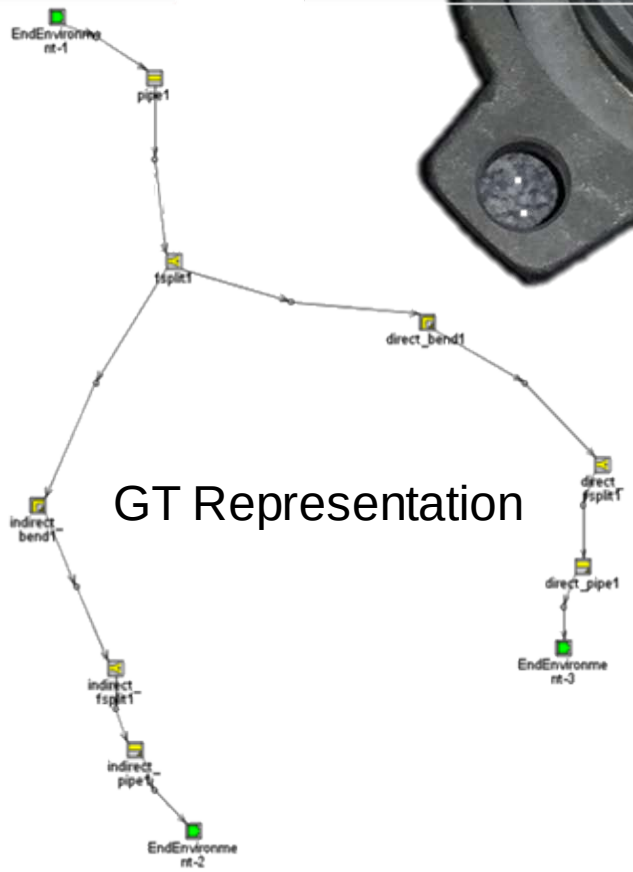
Vapor Injection

- 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





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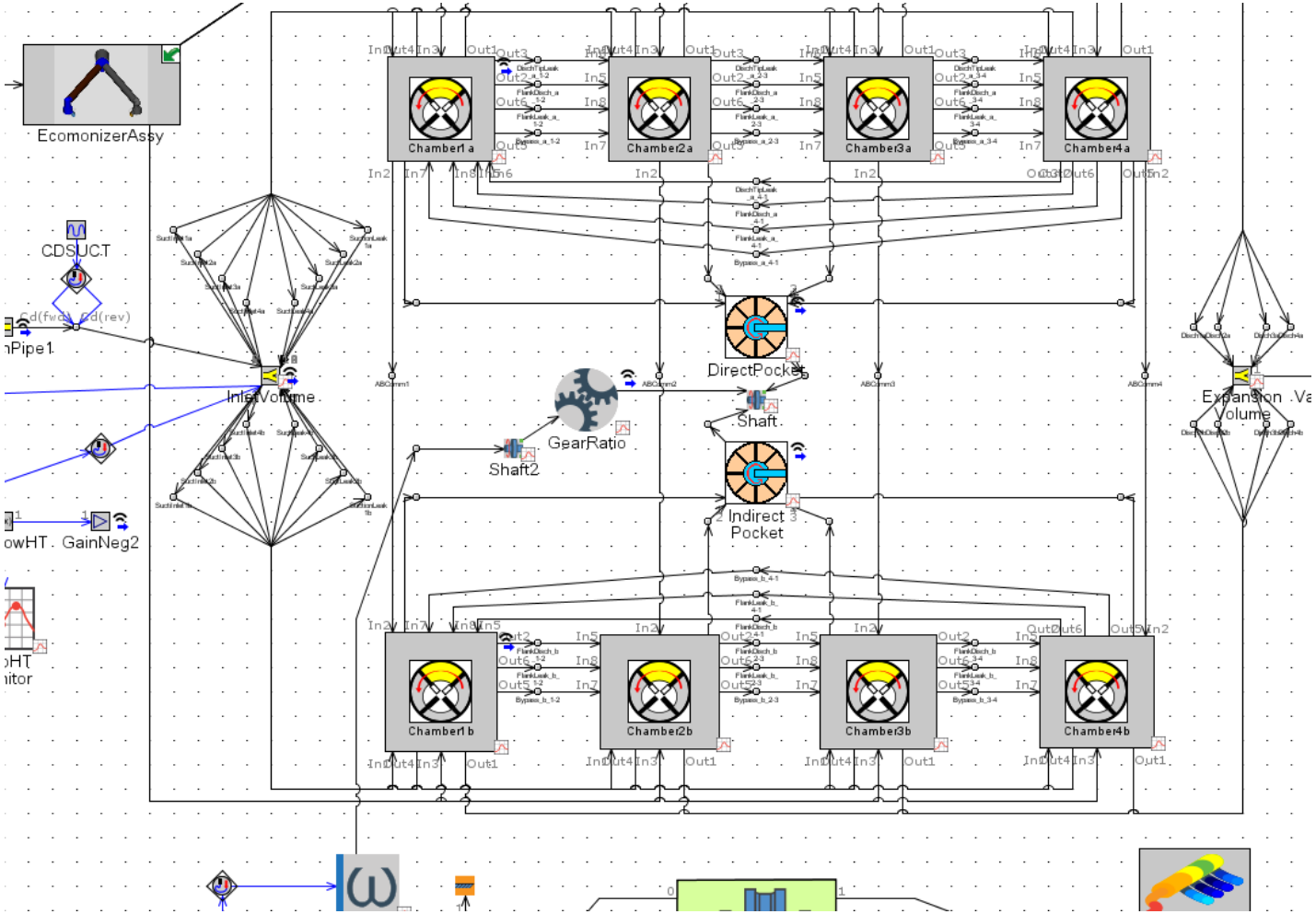
Prototype Performance Shortfall

- Based on observed performance during prototype lab testing
- Economizer Mass Flow Rate 19% below target (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



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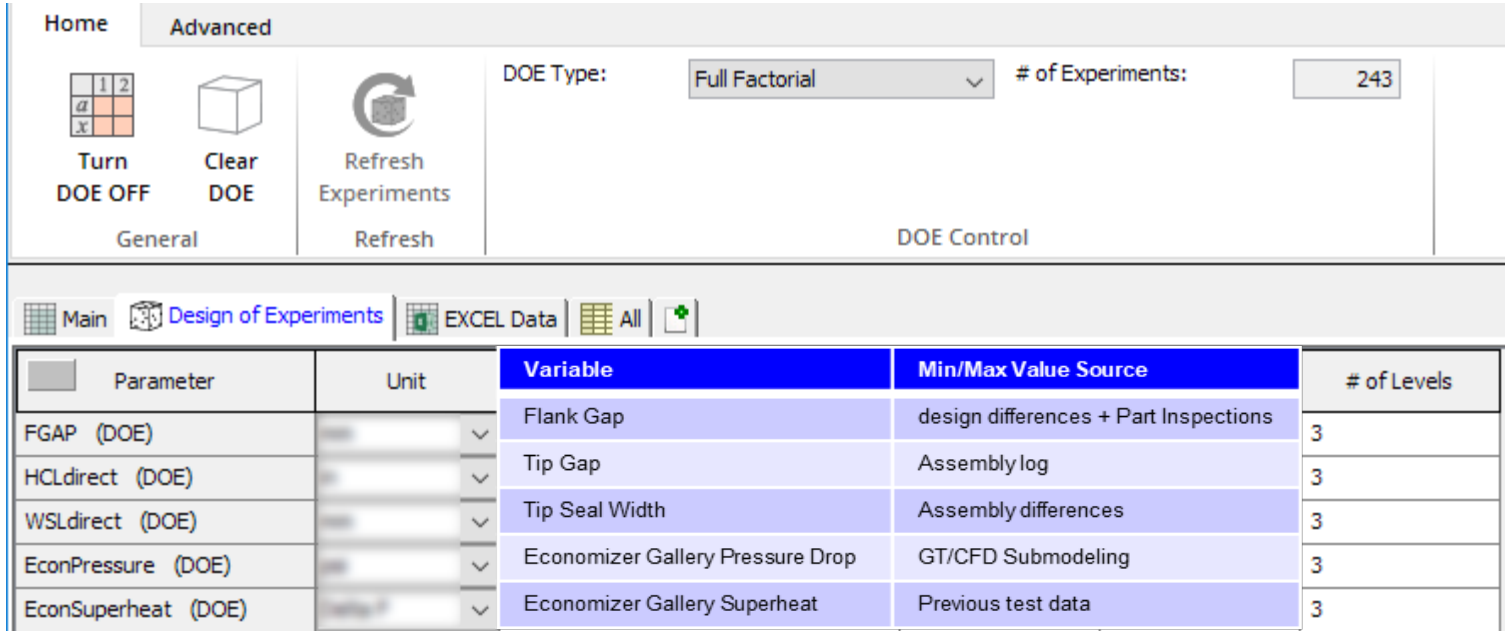
GT-Suite Sensitivity Analysis

- 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



Variable	Min/Max Value Source
Flank Gap	design differences + Part Inspections
Tip Gap	Assembly log
Tip Seal Width	Assembly differences
Economizer Gallery Pressure Drop	GT/CFD Submodeling
Economizer Gallery Superheat	Previous test data

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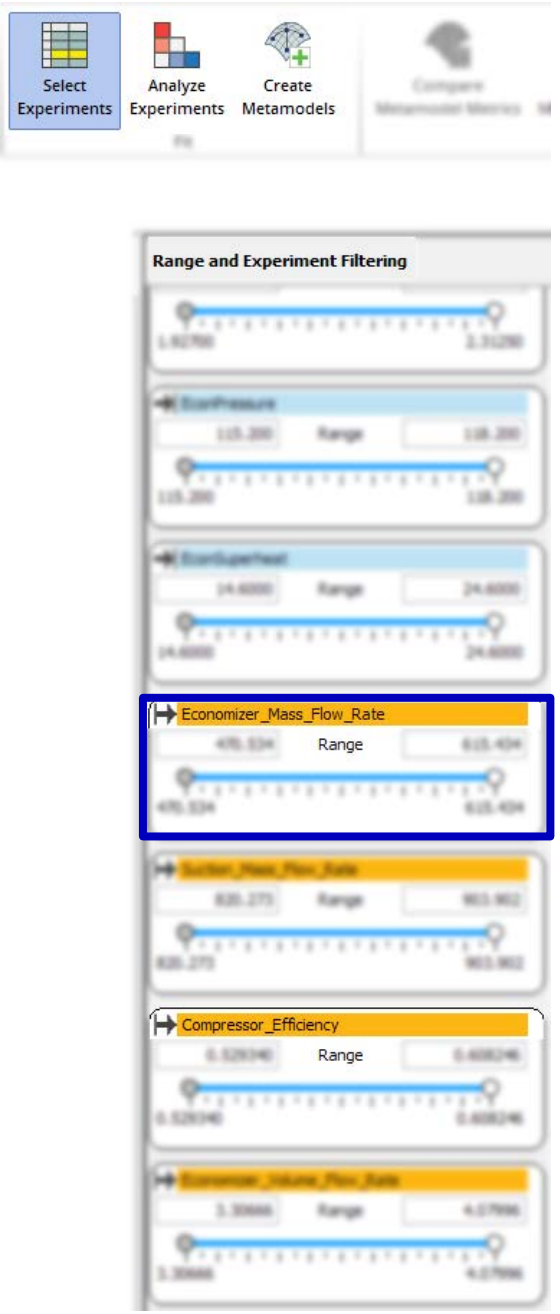
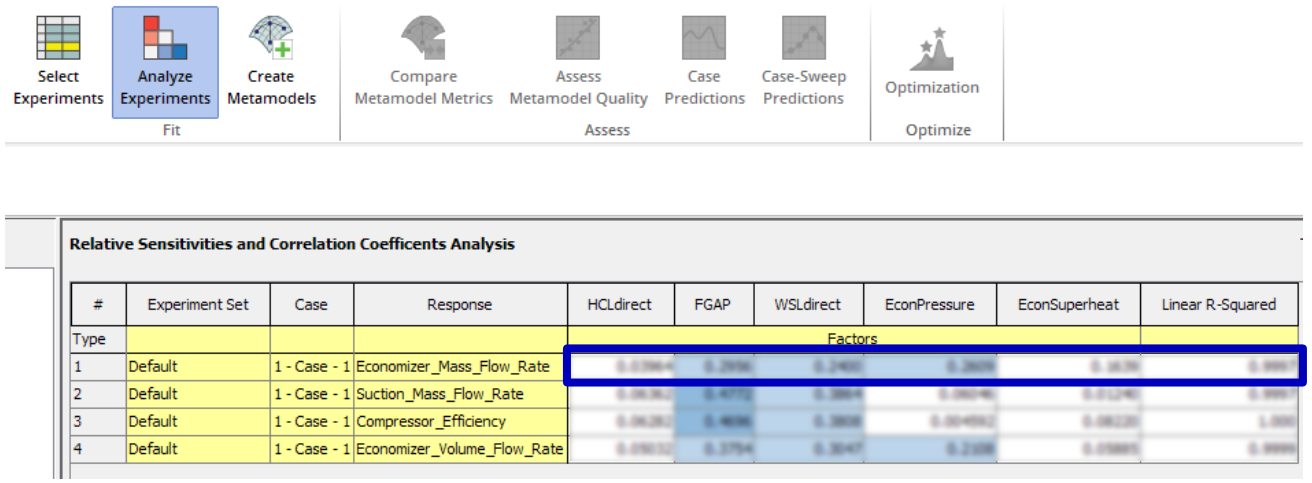
Sensitivity Analysis Results

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





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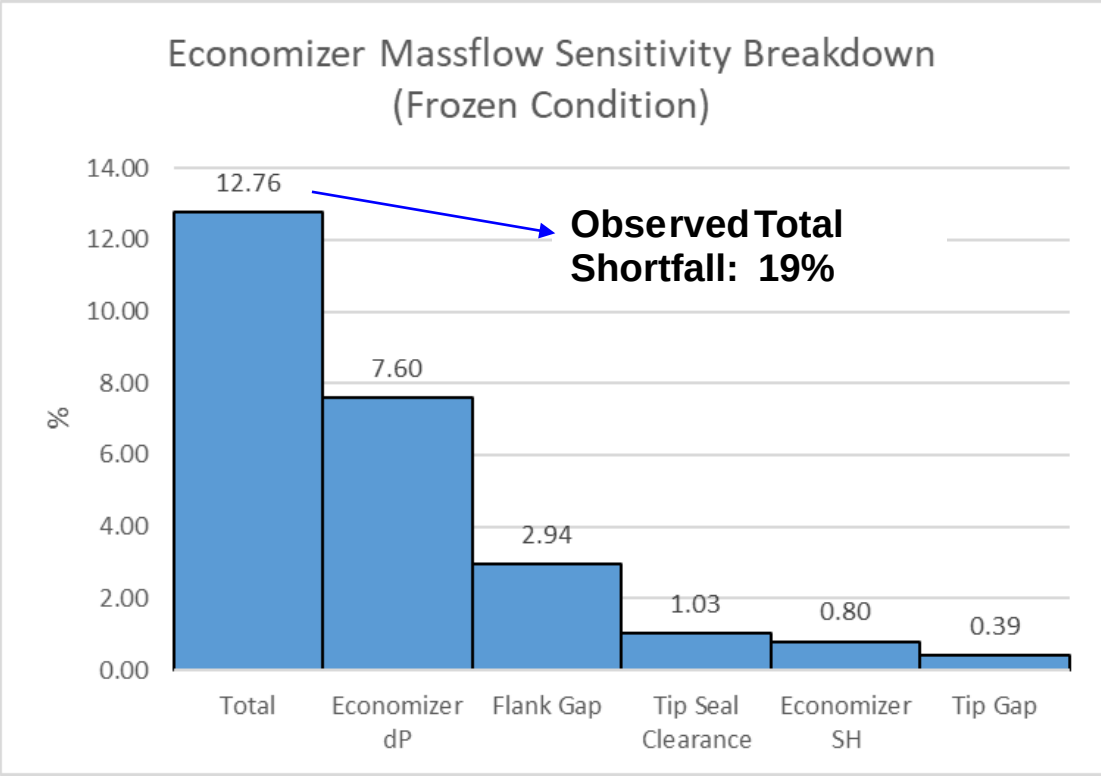
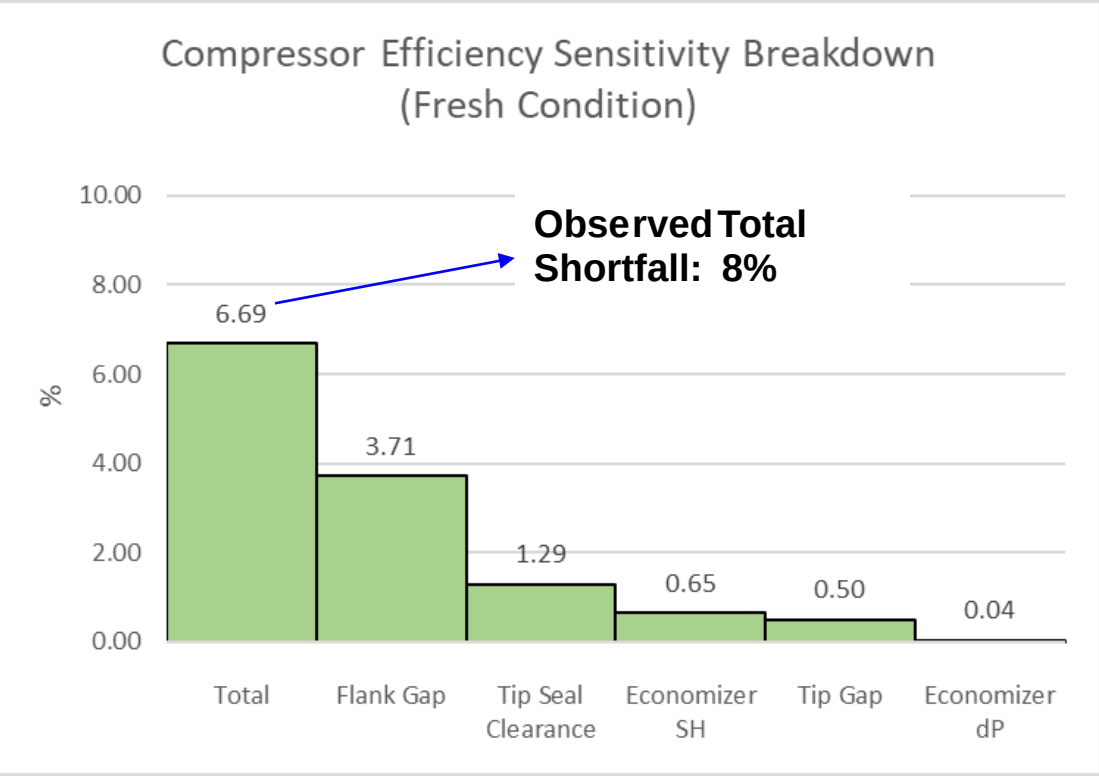
Sensitivity Analysis Results

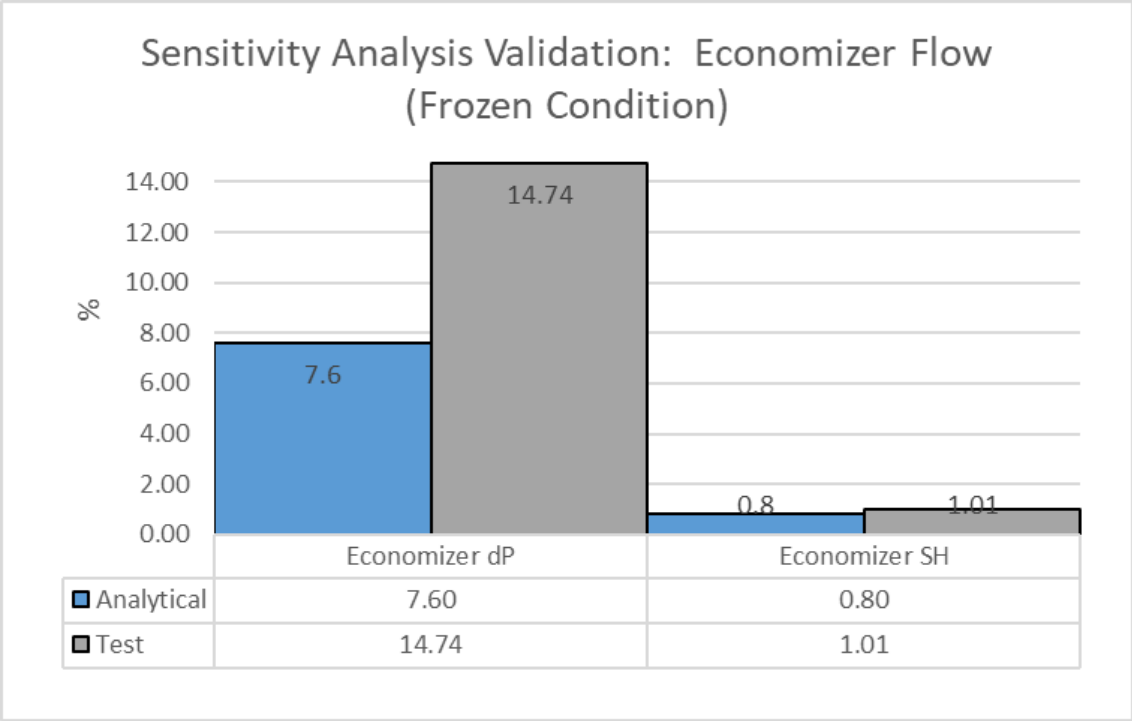
- Gives the relative contribution of each factor to the total performance shortfall
- Results show a model under-prediction
  - Closer on Compressor Efficiency





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



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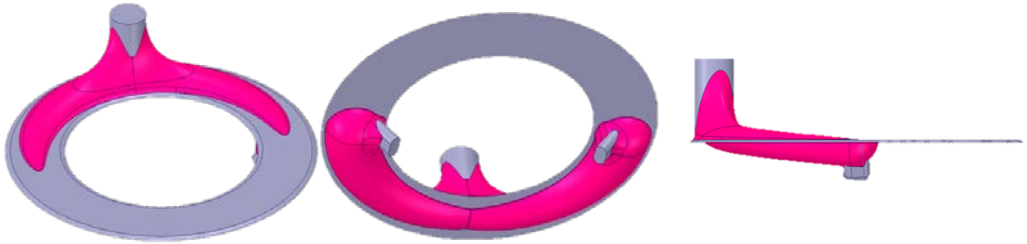
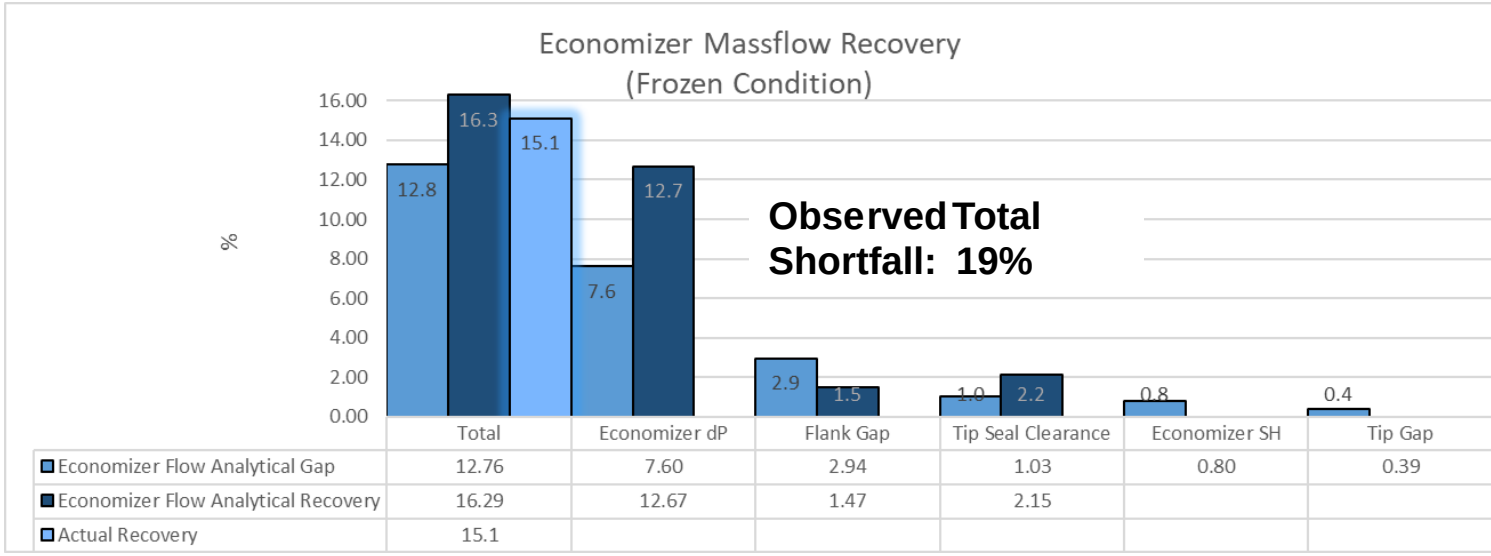
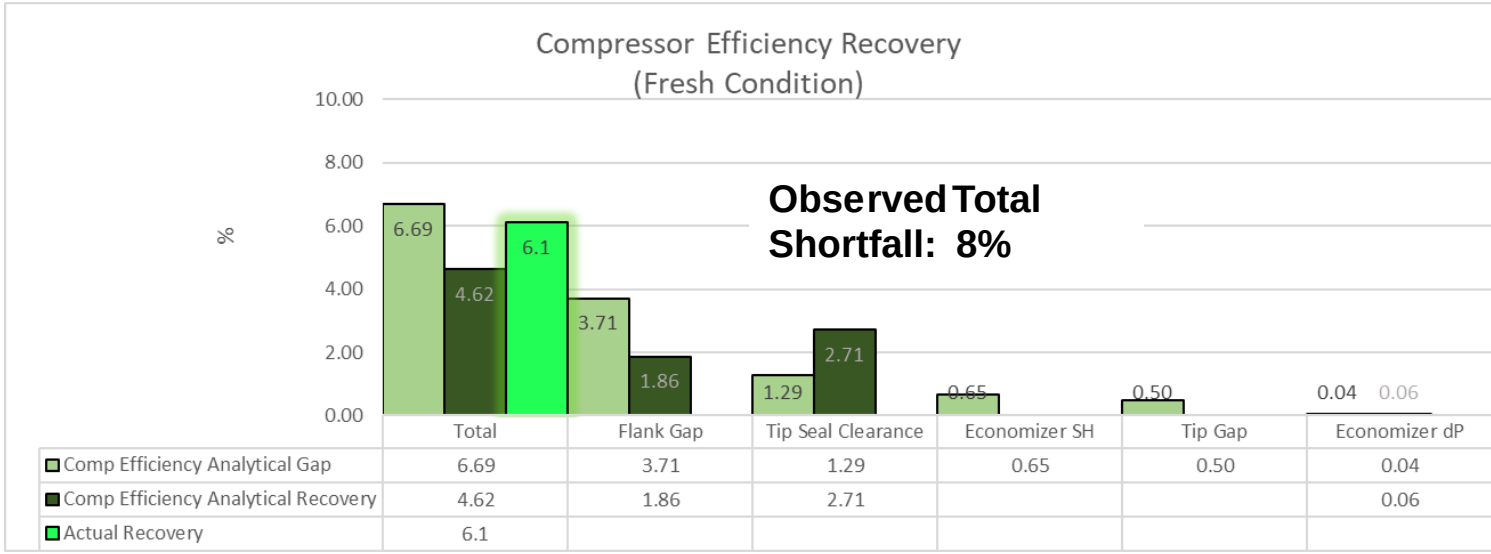
Performance Recovery

- 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





Conclusions

- 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!

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Questions?

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