Supercritical CO_2 Power Cycles Symposium

Concepts NREC

The Experts in Turbomachinery

A Design of 2MW Rated s-CO2 Compressor Test Rig

Presenter: Mark .R. Anderson

Zhang Jingxuan

Huang Weiguang

Shanghai Advanced Research Institute (SARI), CAS

Center of Advanced Energy System and Equipment R&D

Francis Di Bella

Kevin Fairman

Alex Gofer, David Karon

Concepts NREC, LLC

contents

- Background
- Description of Compressor Test Loop
- Compressor Aerodynamic Design
- Structural Analysis
- Rotor Dynamics
- Conclusion and Future Work

Background

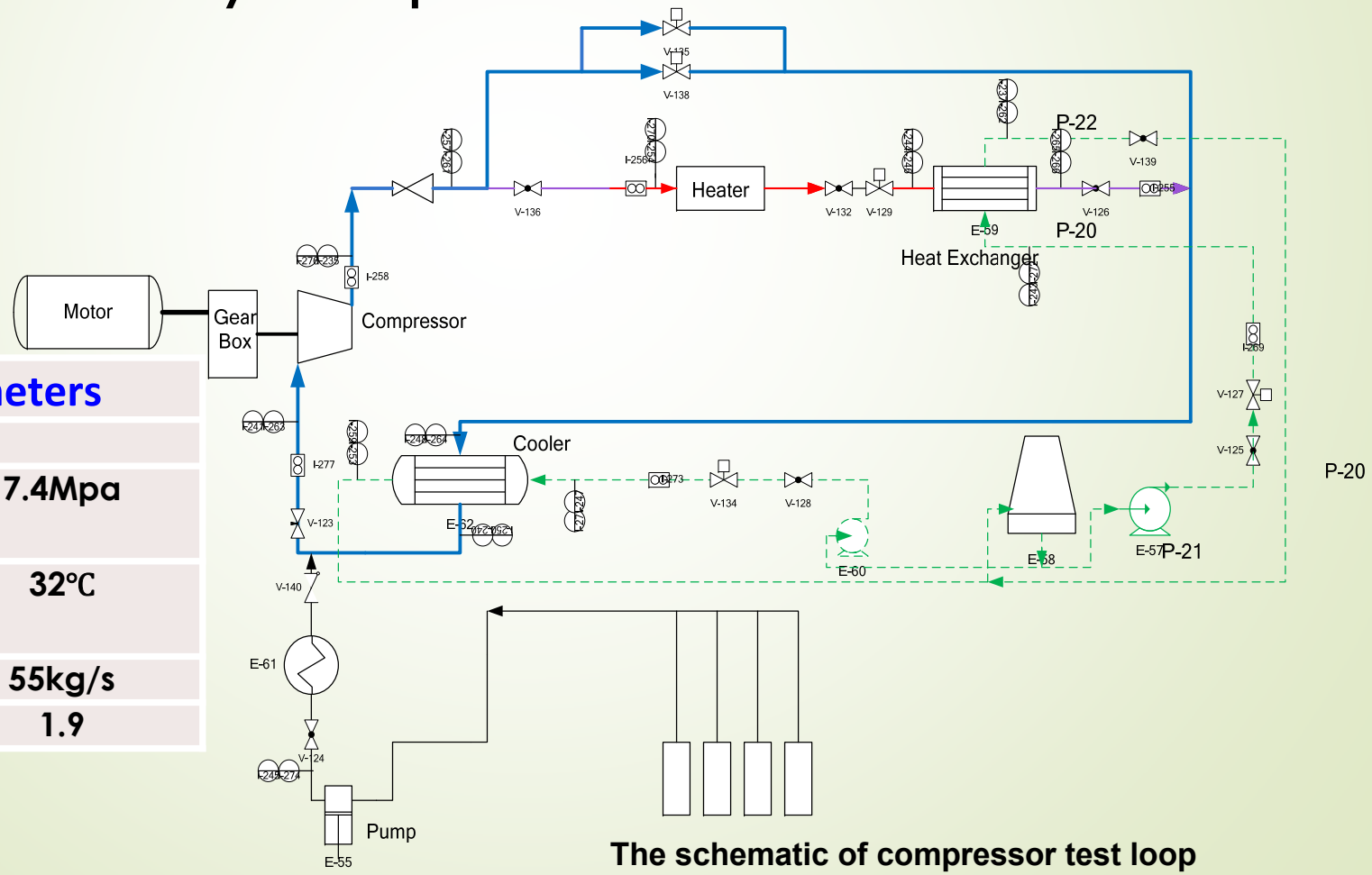
- SARI has been working on the key technologies of closed-cycle gas turbine for Gen IV Nuclear. A multi-purpose helium closed brayton cycle test loop has been developed for TMSR.
- A 2MW rated sCO2 compressor test loop is under implementation aiming at improving the prediction of the performance near critical point.
- The scale is big enough for the measurement of flow field which is important to modify the design methods.
- The heat sink, drive motor, lubrication oil station and part of measurement system are ones which are also used in the Helium Turbine test loop

Multi-purpose Helium Closed Brayton Cycle Test Loop

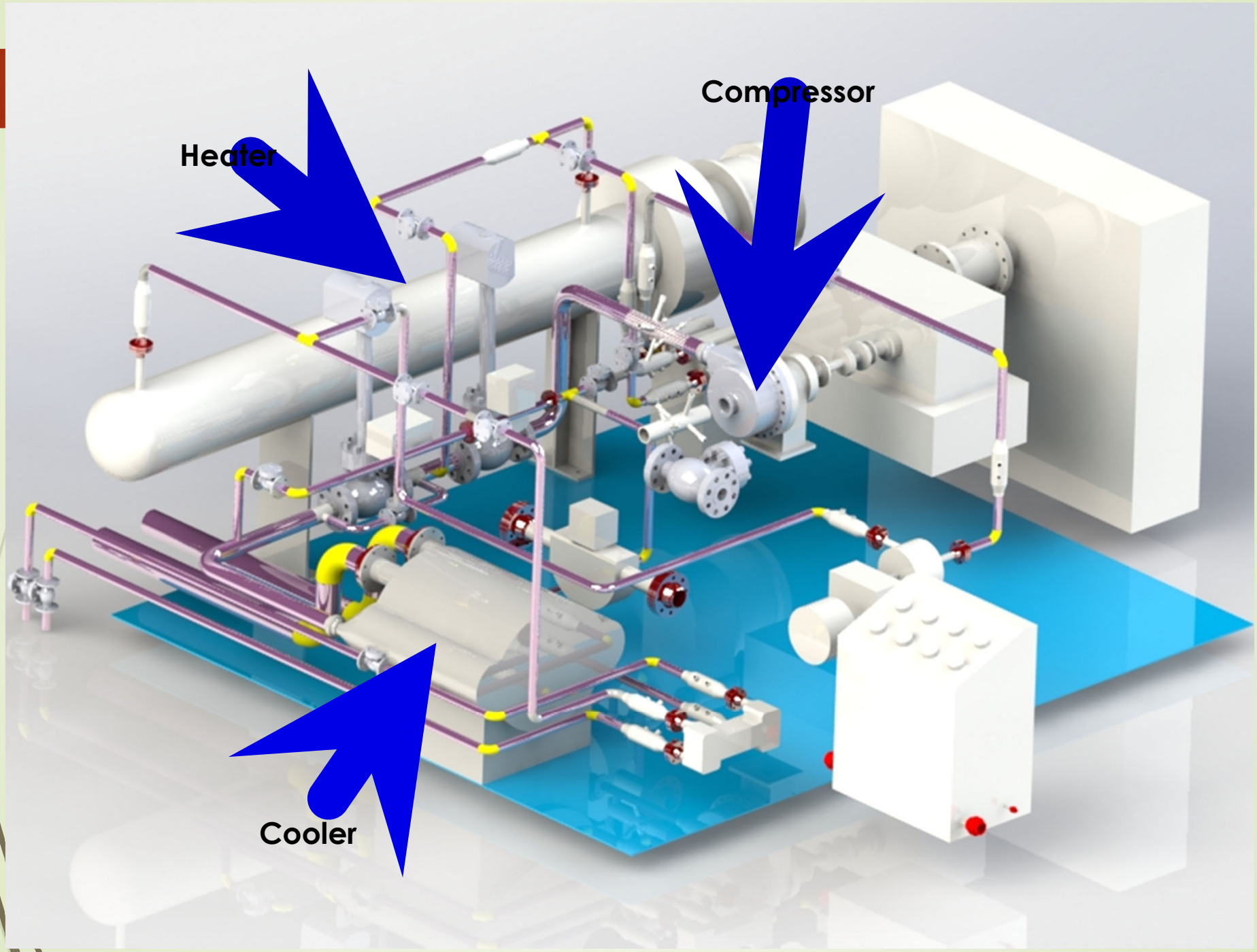
Description of Compressor Test Loop

- An in-house MATLAB code is applied to calculate the thermodynamic parameters

Design Parameters	
Inlet Total Pressure	7.4Mpa
Inlet Total Temp.	32℃
Mass flow rate	55kg/s
Pressure ratio	1.9

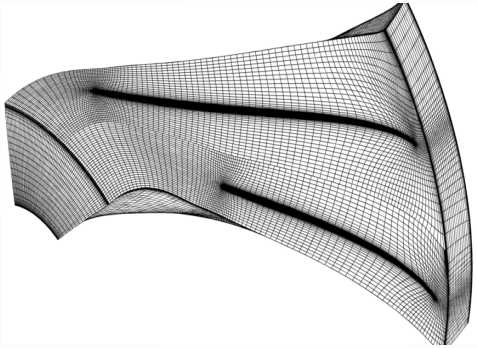


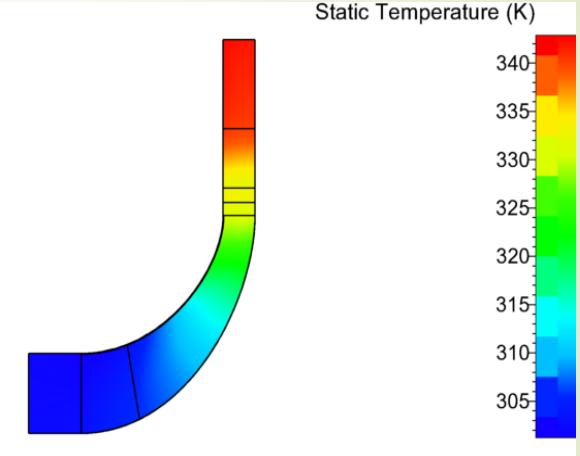
The schematic of compressor test loop

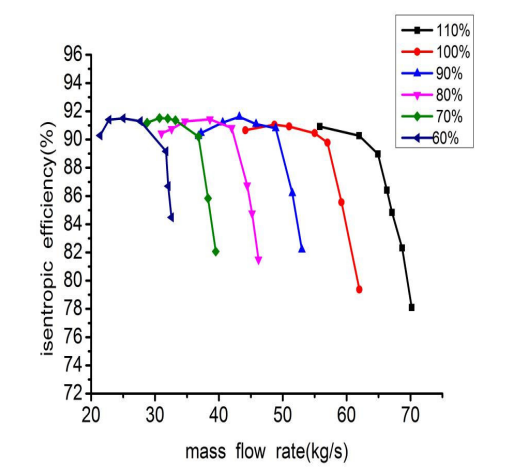

Heater
Compressor
Cooler

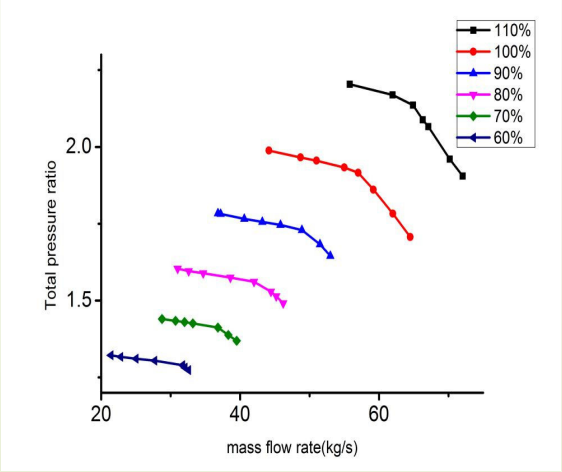
Compressor Aerodynamic Design

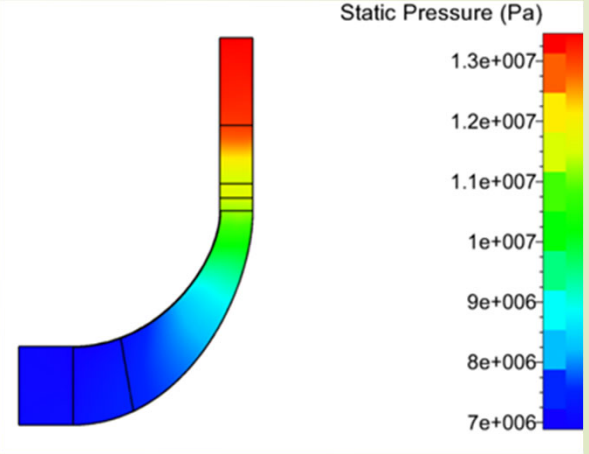
- The AxCent is used for the flow-path design and NUMECA is used for the CFD analysis.





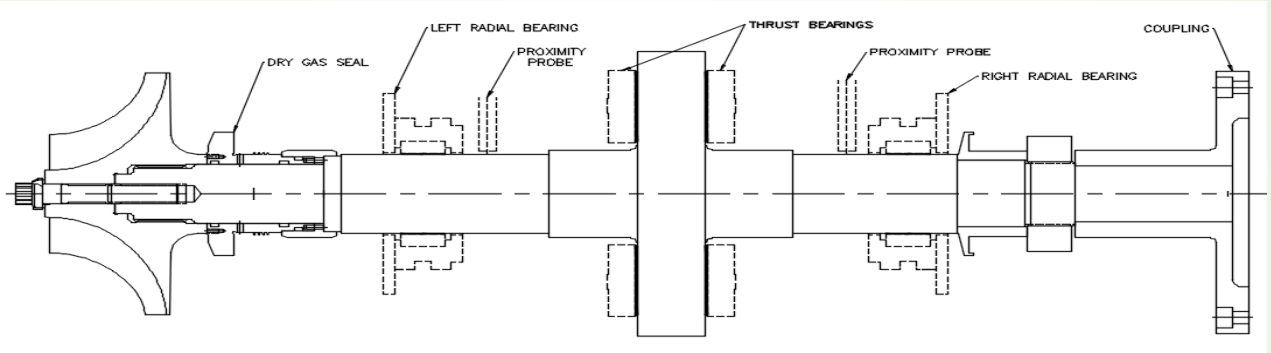


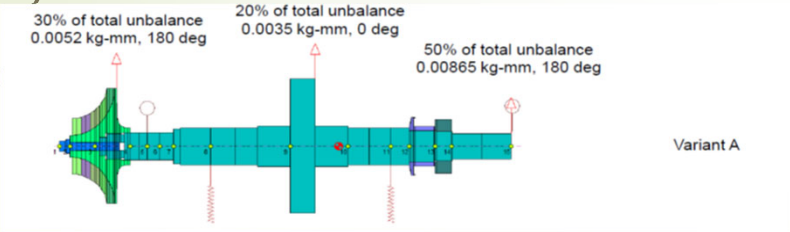


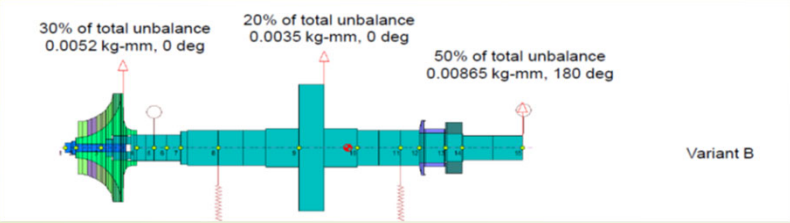


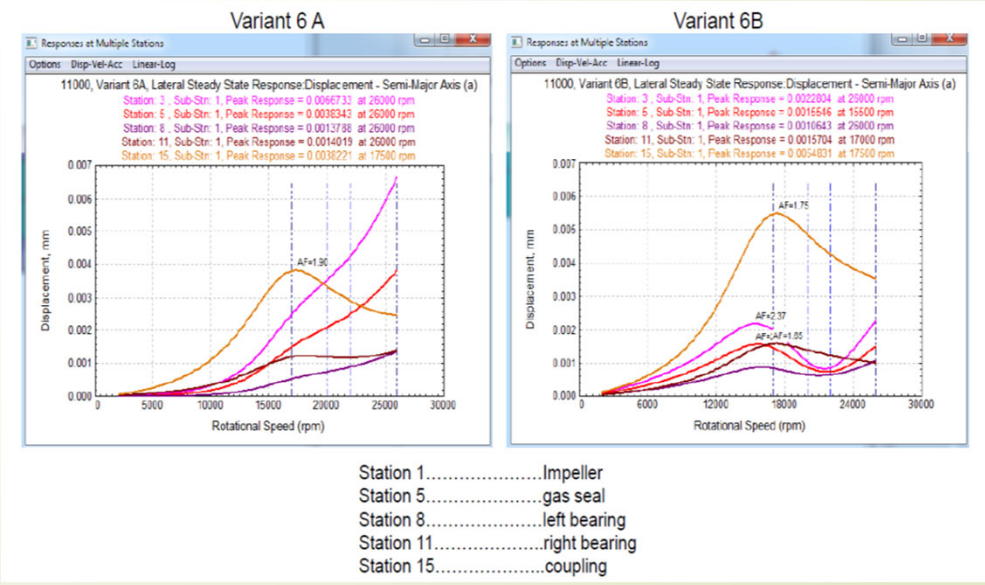
Rotor Structure Design

- **Rotor Dynamics Analysis（ISO 1940 G2.5）**



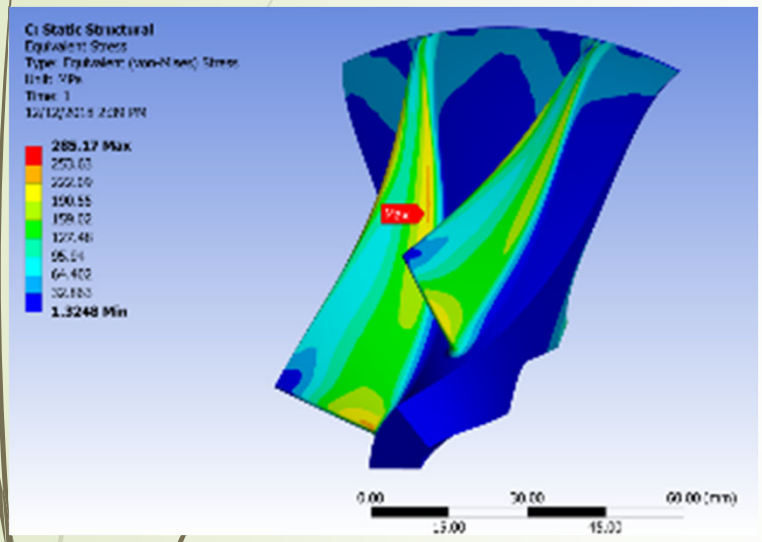


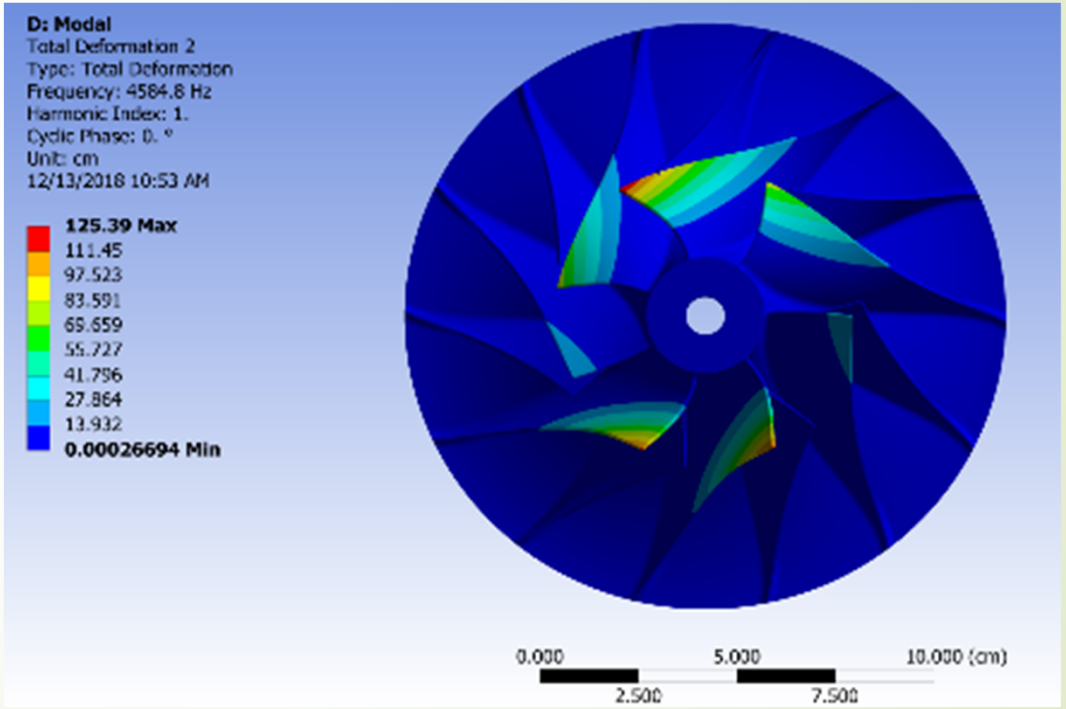




Rotor Structure Design

- Compressor Impeller Structural Design and Modal Analysis



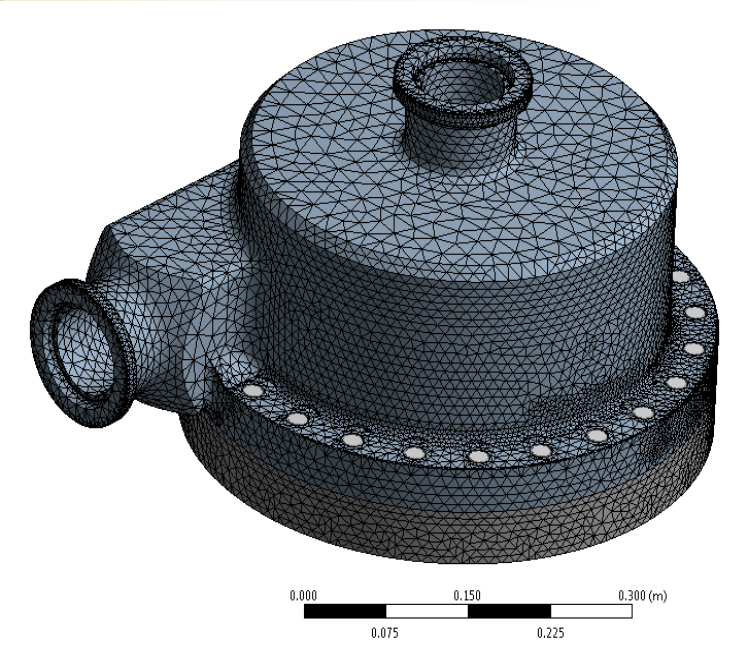


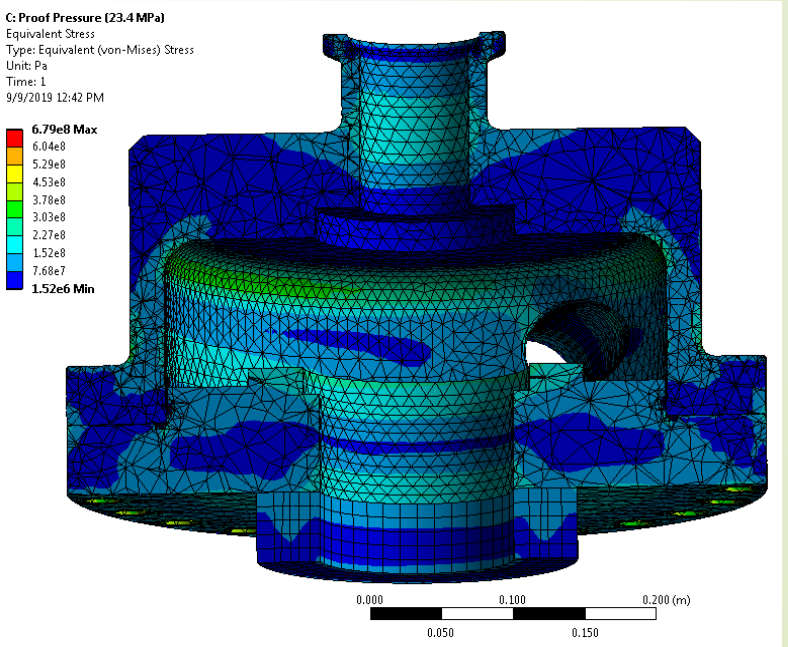
Quantity	Value
s_{von} (max)	285 MPa
s_Y (~50°C)	370 MPa
Max von Mises stress as % of Yield Strength	77%

Modal Analysis on compressor impeller indicating a possible blade flapping concern at 4,585 HZ (equal to 13 x diffuser vane passing frequency)

Rotor Structure Design

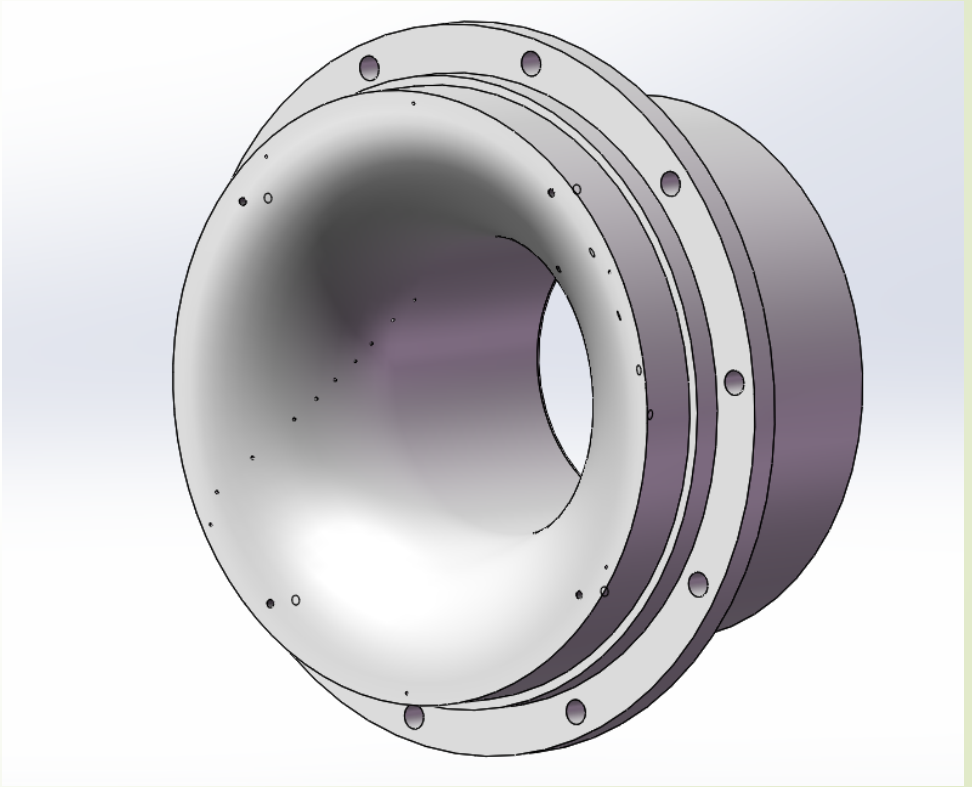
- **Compressor Casing Conceptual Design**





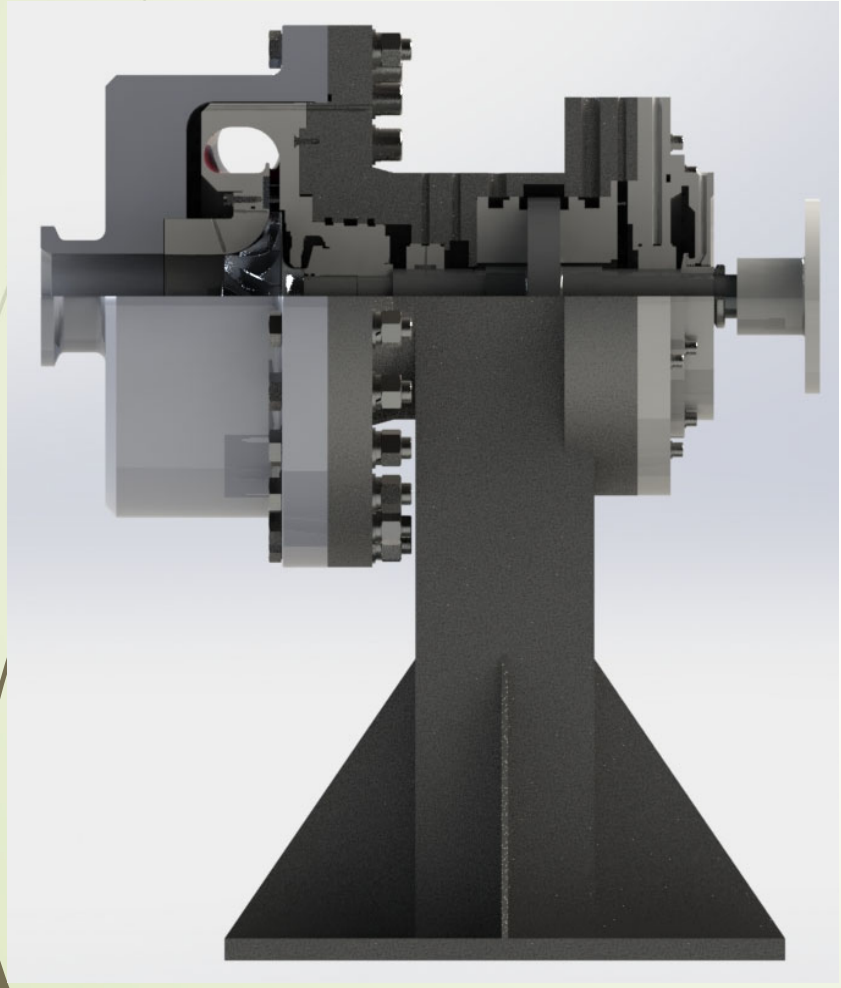
Instrumentation Plan

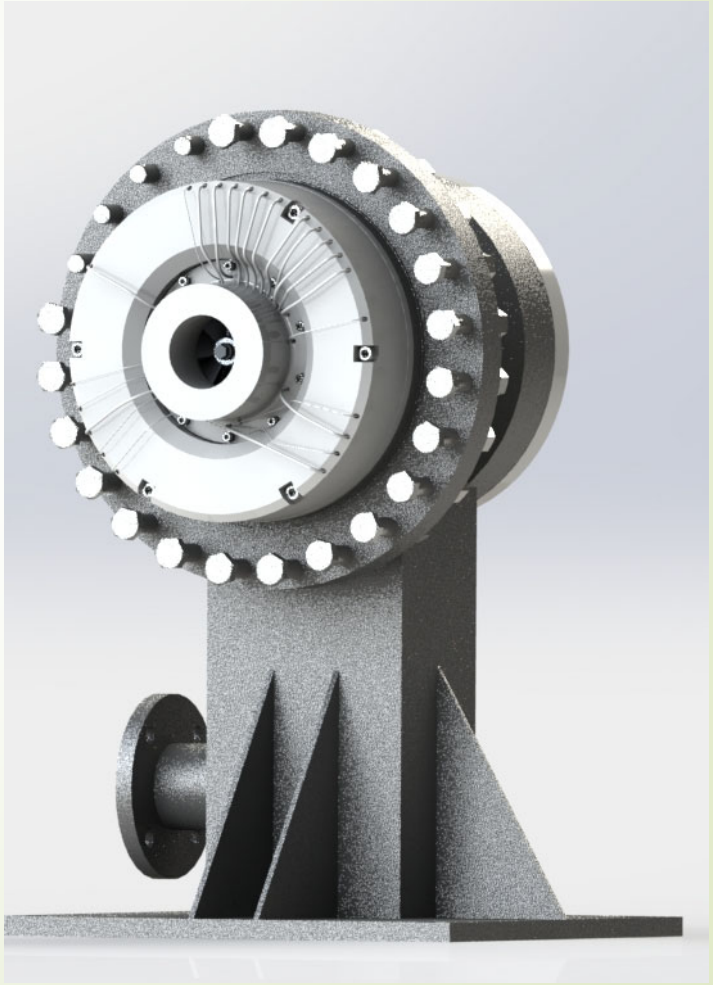
Parameter	Instrumentation Type
Mass flow rate	Coriolis Mass flowmeter
Torque	Torque Flange
Total Pressure	Kiel Probes
Static Pressure	Wall Static Pressure Taps
Temperature	Thermocouple
Unsteady Pressure	Kulite Transducer



Measure positions of static and unsteady pressure on shroud

Final Design





Future work

- SARI is proceeding to the fabrication of the Compressor.
- The compressor and instrumentation will be assembled before June, 2020.
- Testing will proceed immediately and continue to gather performance data to determine the actual static to static and static to total efficiencies of the compressor and the mechanical operation of the shaft seal.

Thank you for your attention