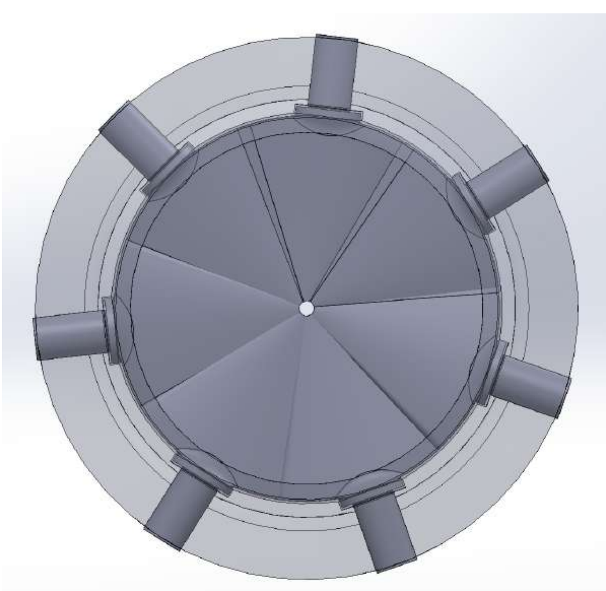
Test & Simulation on an Inlet Guide Vane for a B2B Compressor

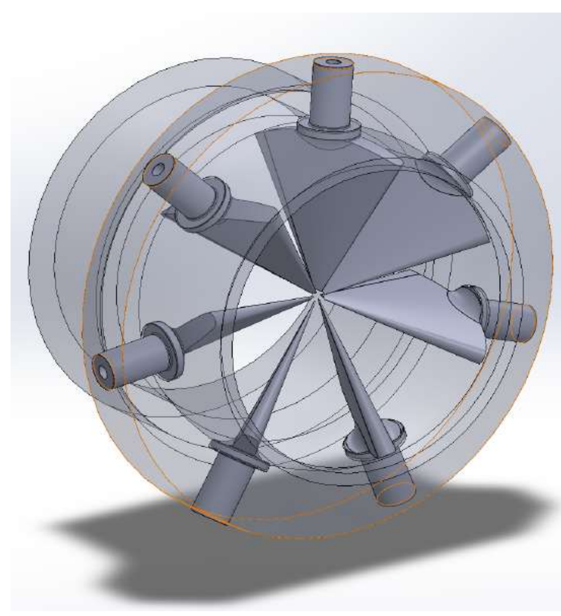
Project Description:

Companies are relying on model-based design to bring their products to market faster without building test setups which are costly and take time. Even the most advanced modeling techniques can't be used without some amount of experimental validation that provide confidence in the analysis results.

A methodology is required to estimate the torque induced by the flow on the inlet guide vanes, a value necessary to properly size the actuator controlling the uniform rotation of all vanes.



IGV in closed position

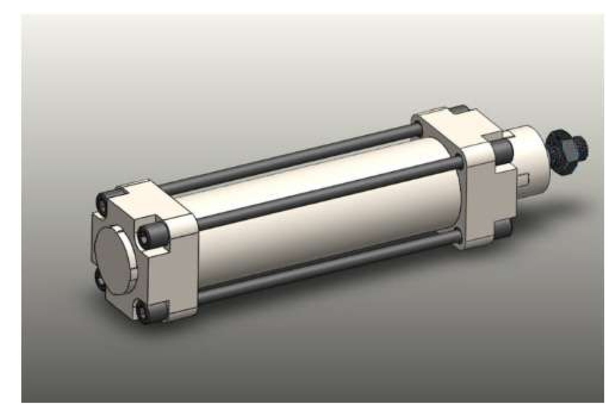


IGV in open position

Background:

For new product development, specifically new compressor development, the actuator of the IGV must be specified prior to the testing of the compressor. To properly size and select an actuator, a testing methodology is required to estimate the torque induced by the flow on the IGV.

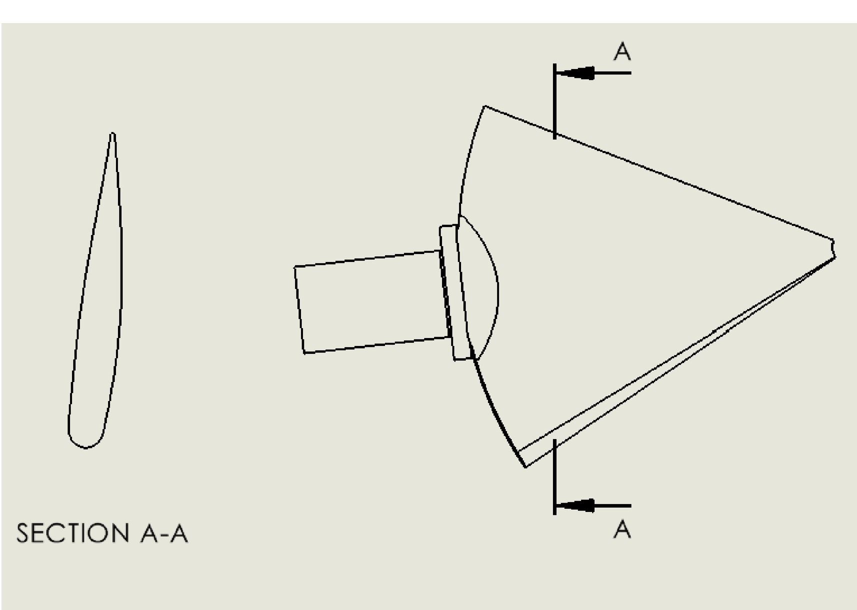
Successful development and documentation of the test methodology will provide a practical and repeatable testing procedure that yields results consistent with those of a computational fluid dynamics simulation. Achieving this will enable any centrifugal compressor to reduce its energy footprint. As well as, improving the efficiency of the testing process of a compressor by accelerating the selection of the actuator.



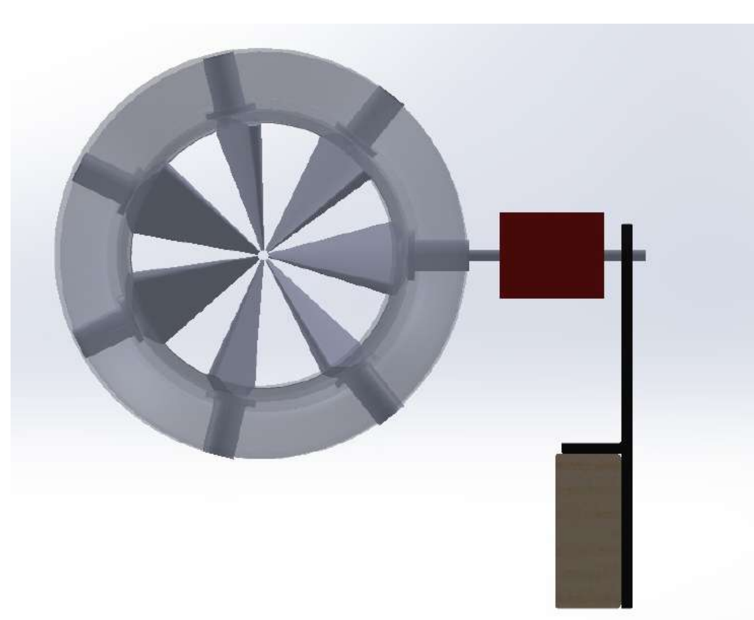
Actuator

The Inlet Guide Vane:

The inlet guide vane (IGV) on a centrifugal compressor is a device used to control and manipulate airflow at the inlet, where vapor enters the system. The use of an IGV contributes to improved overall efficiency by enabling stable operation at flow rates below 25% of system capacity — a range that is typically unattainable without it. The design of an IGV can vary, but it typically consists of several airfoil-shaped vanes arranged within a specific diameter and mounted on individual shafts. These shafts are linked together and rotated uniformly by an actuator.



IGV profile

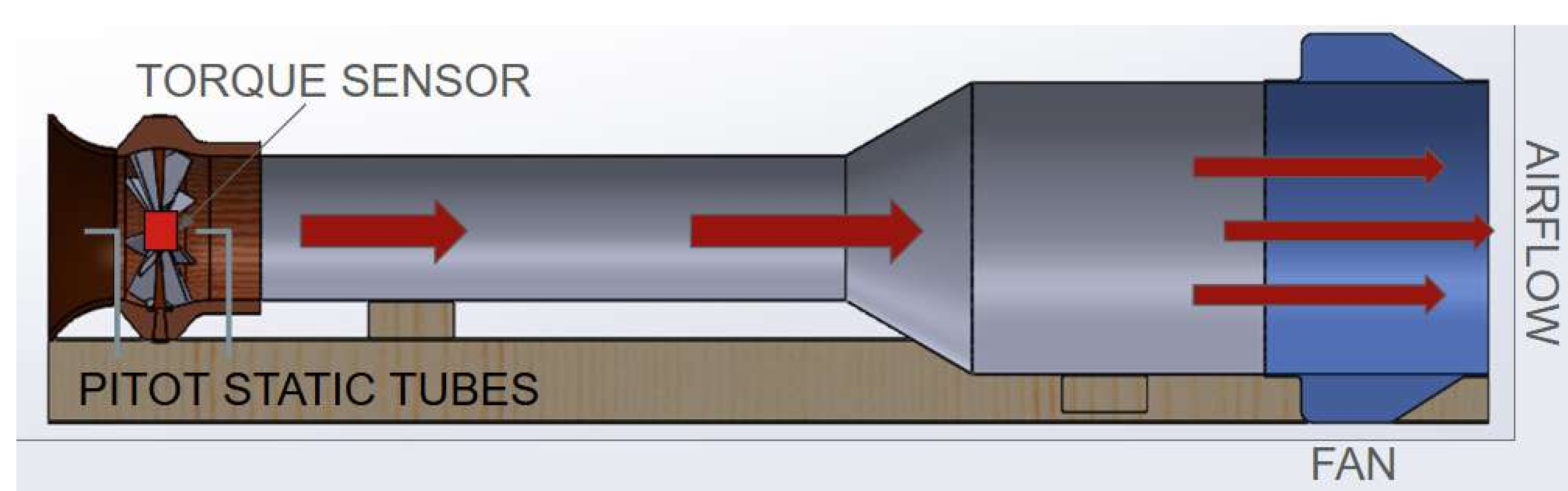


Torque sensor attachment on singular vane

Test Setup:

To accomplish this, we will develop a physical testing environment consisting of an axial fan, ducting, and the Inlet Guide Vane (IGV) assembly. The axial fan will be placed at one end of the duct, with airflow pointing outwards to promote laminar flow within the duct. Then, the IGV will be installed at the opposite end with the converging duct unifying them both.

To measure torque, we will attach the torque sensor to one of the IGV flaps. Additionally, dynamic pressure and pressure drop will be recorded using two pitot static tubes. A thermocouple will also be used to measure air temperature within the duct. This measurements will be collected by a data acquisition device that will be programmed using Python.



Early testing setup design concept

Project Objectives and Goals:

This project comes along with several specific goals that fall under the team's scope of work. Carrier has asked the team to accomplish three main objectives:

- CFD simulation
  - IGV tested in 15º increments from 0º to 90º Whitepaper 3
- Design and execute a physical test setup
  - Replicate CFD simulation, testing IGV in 15º from 0º to 90º
  - Develop a detailed procedure on how to design and run the experiment
- Comparison of results from simulation and test setup
  - Use CFD results and measured torque values to validate the effectiveness of the designed testing method

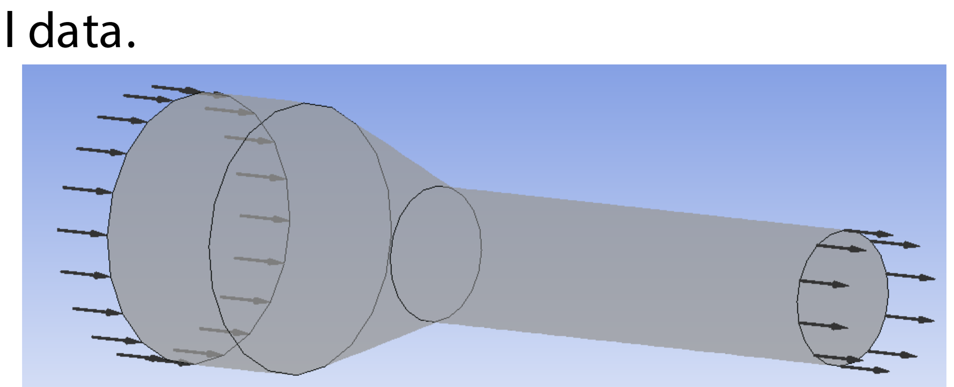
Measured IGV torque data from physical testing matches ANSYS simulation results within ±10% error

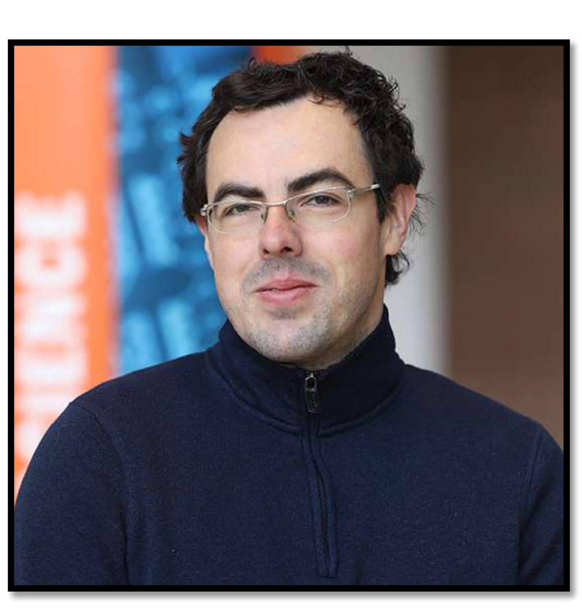
Methodology:

Our road to success begins by performing hand calculations to determine the pressure drop across the duct and moment acting on the vane shaft due to fluid pressure forces. The goal of these calculations is to estimate boundary conditions and the required resolution of selected sensors.

$$P_d = \frac{1}{2}\rho v^2 \qquad C_m = \frac{M}{\frac{1}{2}\rho V^2 c S}$$

Following these calculations, we will compare our findings from the ANSYS simulation data using the CFX testing profile with our physical test results, with the aim of validating the simulation data with our experimental data.





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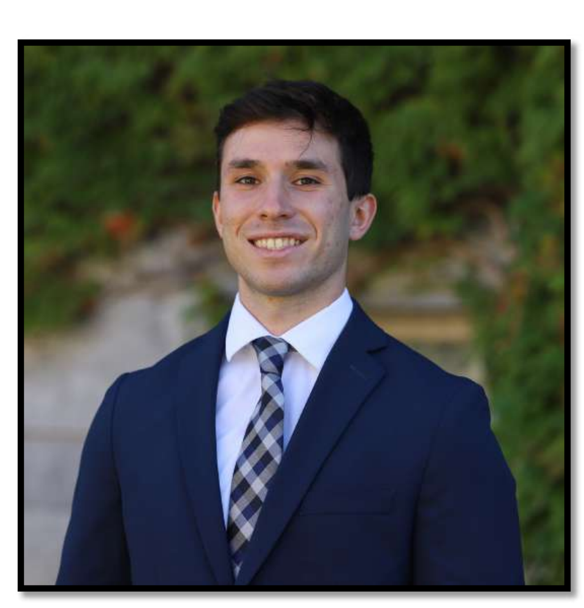

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