Inlet Guide Vane Monitoring System

FAMU-FSU College of Engineering

Team: Travis Carter, Peter House, Brandon Klenck, Arnold Schaefer

Sponsor: Danfoss Turbocor represented by William Bilbow

TEAM 4

PROJECT BACKGROUND

Danfoss Turbocor's TT Series compressors use Inlet Guide Vanes (IGVs) at the inlet of the compressor to regulate refrigerant mass flow and direction.

Figure 1: Position of the IGVs on the compressor

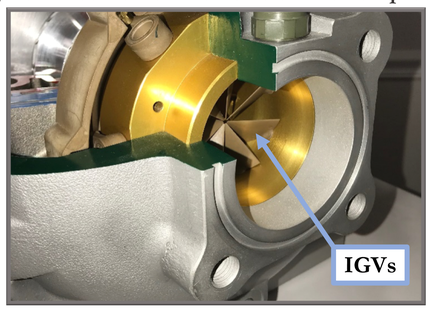
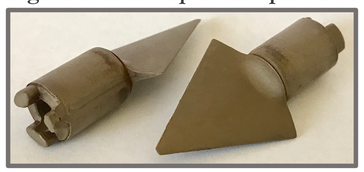


Figure 2: Close-up of sample IGVs



These IGVs are prone to break in the following ways:

- Breaking due to Flow Pressure
- Latching due to Geometrical Interference
- Breaking due to Vane Vibrations

We were tasked with building a monitoring device that can be used by the Danfoss Testing Department to monitor the integrity of the vanes during operation.

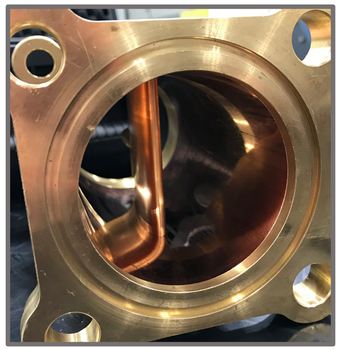
OBJECTIVES

In order to meet the customer needs, the project must accomplish the following objectives:

- Display a live video of the compressor inlet which can be used to determine if all IGVs are present and functioning
- Illuminate the compressor inlet evenly so that the camera can clearly see every IGV
- Provide angle measurements of each IGV to determine if any IGVs are stuck or not moving

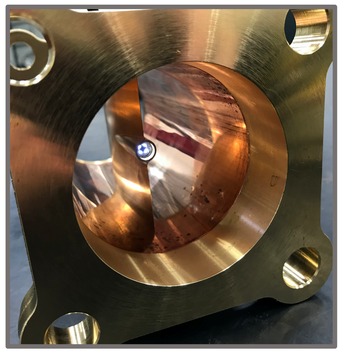
PRODUCT RESULTS

Figure 3: Different Views of Final Assembly



Front View

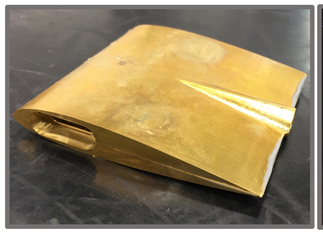
Top View



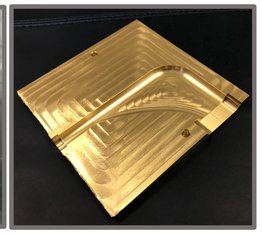
Back View

Our team engineered an aerodynamic airfoil spanning the pipe diameter with a custom channel to guide the camera into place to sit perfectly in the pipe center so that the incoming flow is not heavily impacted.

Figure 4: Central Body Design Details



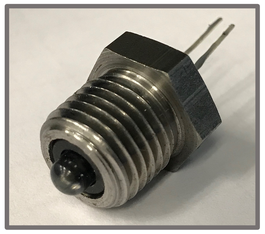
Assembled Housing



Camera Channel

Our team also designed lights that are pressure sealed to screw into the pipe flange so the Inlet Guide Vanes can be clearly seen by the camera. These lights can be removed for maintenance and replacement.

Figure 5: Lighting and Camera Overview



Sealed LED Light

Inlet View

TARGETS

The targets and metrics outlined in the table below indicate the minimum performance requirements to successfully fulfill the needs of the customer.

Min. Angle Sampling Rate	1 Hz
Min. Angle Measurement Accuracy	9 Degrees
Allowable Flow Impact	No Flow Turn
Min. Camera Resolution	240 x 240 pixels

BUDGET USED

Total Budget: $3,000	
Spent: ~$1,600	Remaining: ~$1,400

- Produced a product at a fraction of the total budget
- Camera was most expensive item ($1,0032.30)
- Danfoss purchased some off-the-shelf items that are not included in this budget including stock metal, and pluming equipment

TESTING CONDUCTED

Two main categories of testing were conducted for our project. One was to evaluate the resistance to the environmental conditions in the refrigerant loop and the other was to test the actual functionality of the monitoring system. The results of these tests are given below.

ENVIRONMENTAL TEST RESULTS

AprilTag Refrigerant Resistance	PASS
Sightglass Refrigerant Resistance	PASS
Sightglass Pressure Resistance	PASS
Sightglass Epoxy Seal Test	PASS
Central Vane Epoxy Seal Test	PASS

PERFORMANCE TEST RESULTS

IGV POSITION	VANES VISIBLE	APRILTAGS READABLE	ANGLE ERROR (%)
0-29%	PASS	FAIL	N/A
30-110%	PASS	PASS	±2%

FUTURE WORK

- Conduct more long term testing on refrigerant compatibility with IGV paints
- Redesign sight glass to reduce reliance on the epoxy as the refrigerant seal
- Source a higher quality camera

ACKNOWLEDGEMENTS

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