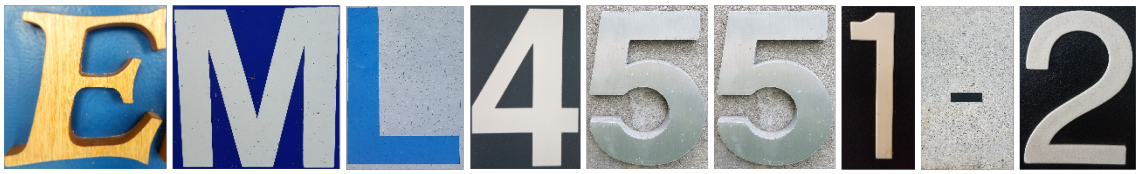
10/13/2017



Team 04: Danfoss IGV Monitoring System

Author1 Name: Travis J. Carter; Author2 Name: Peter R. House;

Author3 Name: Brandon A. Klenck; Author4 Name: Arnold M. Schaefer

FAMU-FSU College of Engineering 2525 Pottsdamer St. Tallahassee, FL. 32310

Abstract

Disclaimer

Acknowledgement

Table of Contents

List of Tables

List of Figures

Notation

IGV	Inlet Guide Vane

Chapter One: EML 4551C

1.1 Project Scope

Danfoss is currently redesigning and testing new inlet guide vanes (IGVs) to use in their TT series of compressors. The compressors use IGVs to manage inlet refrigerant mass flow and flow direction by changing the angle of the vanes. They are currently testing how the different IGV angles impact the mass flow rate and pressure ratio of the compressor; however, there are limitations to what Danfoss can analyze about the IGVs using their current equipment. Danfoss would like to have a better understanding of how the IGVs react in the flow of the refrigerant, and to have a more accurate reading of the current IGV angle. Danfoss has asked our team to build a device that can provide a visual of the IGVs, and that has an angle reading that is more accurate than the stepper motors currently in use.

Our team has come up with the following project scope using the information from the initial sponsor meeting with Danfoss and the project background they provided (W. Bilbow, personal communication, September 22, 2017).

Description:

A system for real-time visual and position monitoring of the compressor inlet guide vanes

Goals:

- True Angle Measurement
- Detailed Visual Monitoring
- Minimize the impact on the fluid flow

Primary Market:

- Danfoss Research and Development Testing Labs

Assumptions:

- Monitoring and sensing equipment will need to be purchased by the group
- System will be used on the TT series of Danfoss compressors

Stakeholders:

- Danfoss Test Lab
- Aero-Thermal Design Team
- Sales
- Manufacturers utilizing the compressor

1.2 Customer Needs

Our initial meeting with Danfoss provided a lot of useful information about the individual needs that their test lab has for this monitoring device (W. Bilbow, personal communication, September 22, 2017). Using the information gained from this meeting and the needs outlined in the project description, our team came up with a list of customer statements given in table 1.

Our team then rewrote the customer statements as interpreted need statements. We wanted to remove some of the implied solutions to our project given in the statements so that we have a list of needs which outline what our final system needs to accomplish rather than how it

should be accomplished. We also wanted to reword the negative customer statements into positive needs. The table below shows the customer statements and our team's interpreted need.

Table 1
List of Customer Statements and Interpreted Needs

#	CUSTOMER STATEMENTS	INTERPRETED NEED
1	We want a visual of the inlet to monitor guide vane, slip, impedance, flutter and vane loss	Visual monitor allows for qualitative analysis of inlet guide vanes
2	We need an angle reading of the IGV that is better than the stepper motor	The angle reading is more accurate than that of the stepper motor
3	The camera needs to be in the center	The view of the vanes is from the center of the inlet
4	The device cannot break and have parts enter the compressor	System malfunction will not damage compressor
5	Compressor inlet flow should not be impacted	Allows for normal flow into the compressor
6	Device components like the camera and sensors need to be serviceable	Components can be replaced or serviced
7	To avoid interference with the rest of the compressor, don't use sonic or magnetic sensors	Allows for normal operation of the compressor's electronic subsystems
8	The vanes need to be illuminated to see them	The vanes are clearly visible

These new interpreted need statements will allow our group to focus on the main customer needs of the project without narrowing the possible solutions to those implied in the customer statements.

1.3 Functional Decomposition

Our team used the project scope and interpreted customer needs to come up with a list of functions that our system needs to accomplish in order meet the goals outlined in the project scope. The list of functions shown below acts as a guideline for our concept generation and selection which takes all the system requirements into account.

- Sense IGV Position
- Provide Power to Position Sensor
- Relay Position Signal to System
- Convert IGV Position Sensor Reading to IGV Percentage
- Send IGV Percentage to Indicator
- Indicate Percentage of IGV to User
- Provide Power to Indicator
- Capture Visual of IGVs
- Provide Power to Visual Sensor
- Relay Visual Signal to System
- Process IGV Visual Signal into a Video Feed
- Send Video Feed to Display
- Provide Power to Monitor
- Display Video of IGV to User
- Get Power from Source

Our team also created a graphical representation using the previously listed functions in order to create a better visualization of the system's main operating requirements. This diagram is included below.

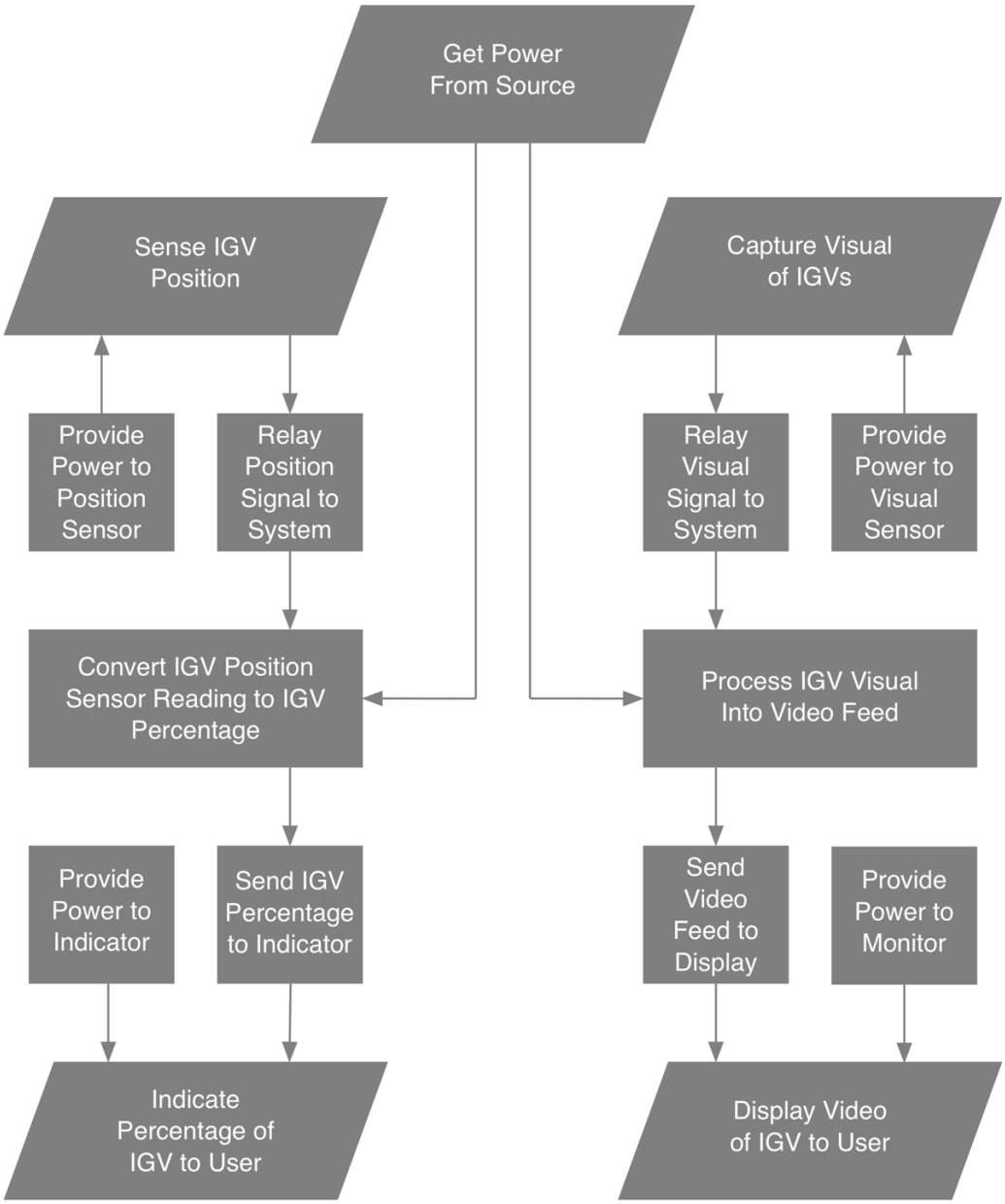


Figure 1. Flow diagram of all items in the functional decomposition.

Appendices

Appendix A: Code of Conduct

Mission Statement

Team 4 is dedicated to ensuring a positive work environment that supports professionalism, integrity, respect, and trust. Every member of this team will contribute a full effort to the creation and maintenance of such an environment to bring out the best in all of us as well as this project.

Roles

Each team member is assigned one of the following roles based on their previous experiences and skill set and is responsible for completing the following actions. All team members must contribute to the project in the following ways:

- Must work on their certain tasks for the project
- Must work toward the project goals and its success
- Deliver any commitments on time
- Work as an effective team member with team spirit

Arnold M. Schaefer - Team Leader

Manages team as a whole; develops a plan and timeline for the project; delegates tasks among group members according to their skill sets; finalizes all documents and provides input on other positions where needed. The team leader is responsible for promoting synergy and increased teamwork. If a problem arises, the team leader will act in the best interest of the project.

The team leader keeps the communication flowing, both between team members and the sponsor. The team leader takes the lead in organizing, planning, and setting up all of the meetings. The team leader will also be responsible for editing the evidence manual and keeping it up to date. The team leader is responsible for the overall project plans and progress.

Brandon A. Klenck - Lead Mechanical Engineer

Takes charge of the mechanical design aspects of the project. Lead ME is responsible for knowing the details for the design, and presenting the options for each aspect to the team for the decision process. Keeps all design documentation for record and is responsible for gathering all reports and maintains product quality and safety. In addition, the lead ME is responsible for keeping a record of all correspondence in group meetings.

Peter R. House – Lead Efficiency Engineer

Takes charge of the efficiency of the project design. Will work in conjunction with the Lead ME to identify problem areas and to work on smaller improvements and iterations leading to a more streamlined final product.

Will also work to identify problematic areas in the rest of the team to try and implement solutions to increase the team's overall workflow. Will finally be responsible for aggregating documentation and working on final presentations.

Travis J. Carter – Operations Officer

Manages the orders and budget and maintains a record of all credits and debits to the project account. Any product of expenditure requests must be presented to the advisor, whom is then responsible for reviewing and the analysis of equivalent/alternative solutions. They then relay the information to the team and if the request is granted, order the selection. A record of all these analyses and budget adjustment must be kept.

Additionally, the Operations Officer will build and maintain the team website to ensure that all relevant information is posted and up to date and maintain the group's one page project manager.

Team Role Matrix

Team Member:	Team Leader	Lead ME	Lead Efficiency Engineer	Operations Officer
Travis Carter				X
Brandon Klenck		X		
Peter House			X	
Arnold Schaefer	X			

Communication

All remote team communication will occur in two main places, GroupMe and email. GroupMe will be used for casual conversations and planning while email will be used for more official purposes such as document preparation, review and submission. Therefore, all team members must have access to a working email account, access to GroupMe and regularly check all accounts to keep up with group progress. All files transferred via email to Danfoss or the instructors should have the rest of the team members carbon copied, while files emailed between

team members should only have the rest of the team members carbon copied if their input is needed.

The team will also conduct weekly meetings on Tuesdays and Thursday from 12:30PM to 2:00PM to discuss all progress and further actions. Team members must all be present for this meeting. 24 hour notices should be given if a member cannot make the meeting in time. Repeated absences will not be tolerated. All members of the team must also attend all meetings with the sponsor. 24 hour notices should be given if a member cannot make the meeting in time. Repeated absences will not be tolerated.

All team members must be present for presentation practice sessions in the week leading up to the due date. Practice times will be decided a week in advance at the weekly team meeting.

Team Dynamics

All team members will work with a team dynamic allowing the others to make comments and suggestions without fear of embarrassment or ridicule. If any team member finds their given task too difficult or they face a roadblock, they should inform the rest of the team members and ask for help so that the tasks can be completed with the quality and timeliness expected of our team. If any team member feels that they are not being respected or taken seriously, they should address the issue with the team so that a resolution can be found. Everything is done for the benefit of all members and no individual member should suffer an unequal burden.

Ethics

Team members are required to be familiar with the NSPE Engineering Code of Ethics as they are responsible for their obligations to the public, the client, the employer, and the profession. There will be stringent following of the NSPE Engineering Code of Ethics.

Dress Code

Team meetings will all be held in casual attire. Meetings with the sponsor will be held in business casual attire (i.e. pants & button down shirts). Team presentations will be held in formal attire (i.e. suits). Color coordination will be decided on a case by case basis at team meetings.

Weekly and Biweekly Tasks

Team members will participate in all meetings with the sponsor, adviser, and instructor. During said times ideas, project progress, budget, conflicts, timelines and due dates will be discussed. In addition, tasks will be delegated to team members during these meetings. Repeat absences or incomplete tasks will not be tolerated.

Decision Making

It is conducted by consensus and the majority of the team members. Should ethical or moral reasons be cited for dissenting reason, then the ethics or morals shall be evaluated as a group and the majority will decide on the plan of action. At least 3 team members must participate in the vote. In the case that the vote ends up in a tie, the advisor to the team will be given a vote. Individuals with conflicts of interests should not participate in decision-making processes but do not need to announce said conflict. It is up to everyone to act ethically and for the interest of the group and the goal of the project. Achieving the goal of the project will be the top priority for each group member. Below are the steps to be followed for each decision-making process:

- Problem Definition – Define the problem and understand it. Discuss among the group.
- Tentative Solutions – Brainstorm possible solution. Discuss among most plausible group.

- Data/History Gathering and Analyses – Gather data required for implementing tentative solution. Re-evaluate tentative solution for plausibility and effectiveness.
- Design – Design the tentative solution product and construct it. Re-evaluate for plausibility and effectiveness.
- Test and Simulation/Observation – Test design for tentative solution and gather data. Re-evaluate the testing phase and determine its level of success. Decide if design can be improved and if time/budget allows for it.

Conflict Resolution

In the event of discord amongst team members the following steps shall be employed:

- Communication of points of interest from both parties which may include demonstration of active listening by both parties though paraphrasing or other tools.
- Administration of a vote, if needed, favoring majority rule.
- Team leader intervention.
- Instructor will facilitate the resolution of conflicts.

Work Schedule Prioritization

The team will attempt to organize tasks and meetings in a way that time spent working during the weekend is minimized. In addition, federal, university and religious holidays will be observed and no work will be required of any team member during that time.

Individual Work Schedules

In addition to the weekly team meetings and sponsor meetings, each team member is required to commit to at least 15 working hours per week, and more if needed. This working

time can be completed by working on individually assigned tasks or working with others in the team.

Amendment Procedure

In the case that a change is required to be made to this document, the following amendment process will be followed. Any team member can present an amendment in a written email or text message to the group. Following the proposal, each team member must vote on the issue before a decision is made. One vote will be given to each team member with the option to vote for the amendment, vote against the amendment, or to voluntarily abstain from the vote. To pass, the proposal must receive at least 3 votes for the amendment. If the vote is 3 to 1 for the amendment, the change will be made effective one week after the decision is made. A unanimous vote for the proposal will leads to immediate effective implementation. A new code of conduct will then be written and re-signed by all members.

Statement of Understanding

By signing this document, the following members of team 4 agree to all of the above and agree to abide by the code of conduct set forth by the group.

Peter R. House:

Sign:  Date: 10/5/17

Travis J. Carter:

Sign:  Date: 10/5/17

Brandon A. Klenck:

Sign:  Date: 10/05/17

Arnold M. Schaefer:

Sign:  Date: 10/5/17

Amendments

10/5/17

- Changed team meetings from Thursdays after senior design lectures to Tuesdays and Thursdays from 12:30PM to 2:00PM
- Added team leader responsibility of maintaining the evidence manual
- Added operations officer responsibility of maintaining the one page project manager

Appendix B: Functional Decomposition

WORK IN PROGRESS. THIS SECTION WILL BE COMPLETED AT A FUTURE TIME.

Appendix C: Target Catalog

WORK IN PROGRESS. THIS SECTION WILL BE COMPLETED AT A FUTURE TIME.

References

There are no sources in the current document.