Integrated Data Acquisition

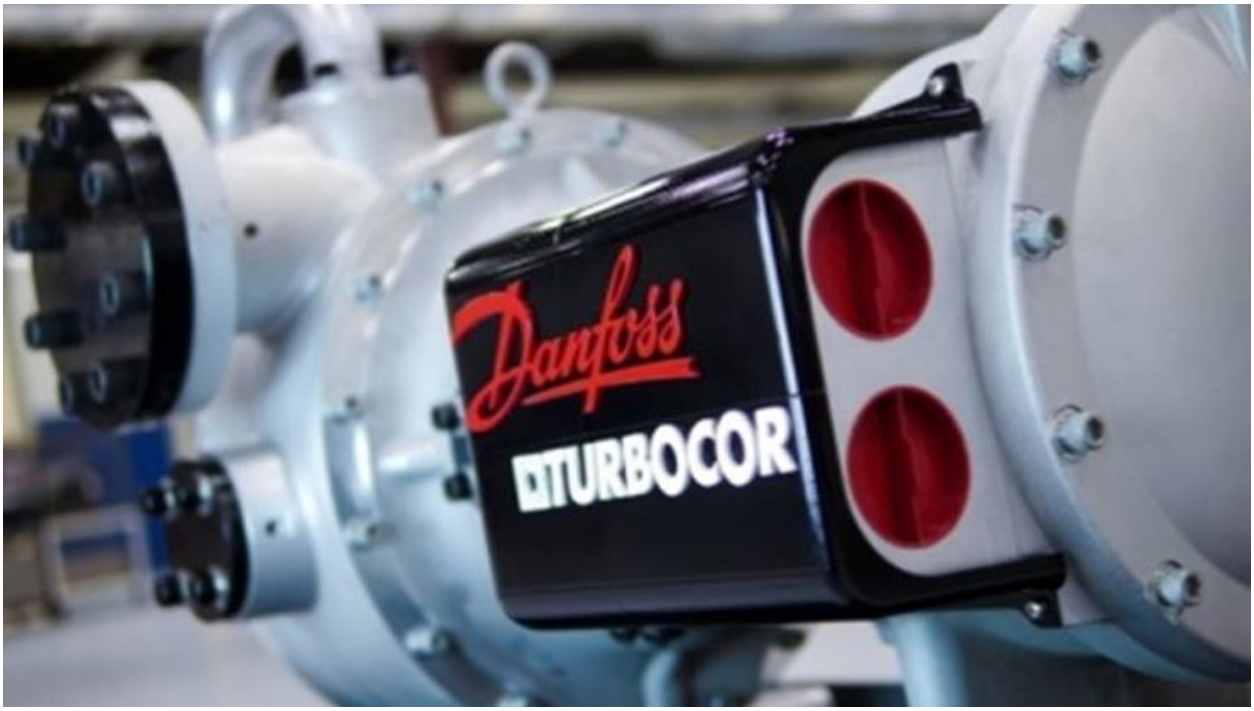

Figure 1: Danfoss Turbocor Centrifugal Compressor

Team Number: 5

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Abstract

The team's first meeting with Turbocor and its engineers proposed developing an algorithm based method to determine failure modes. After the first bi-weekly meeting with Dr. Shih and Dr. Gupta it was proposed to design a test platform with integrated compressor sensors so different ranges could be tested without having to subject compressors to their physical limits. After proposing this new project aim provided by Dr. Gupta and Dr. Shih, Mr. Robert Arnold at Turbocor proposed a third refined project definition of exactly what the company aimed to develop as a long term goal. Mr. Arnold proposed an integrated real time data acquisition and storage device for the newly developed larger "VTT" compressor model. Again it was determined that this proposed goal did not satisfy the mechanical design aspect of the project and was altered. The most recent meeting with Dr. Shih and with Turbocor Engineers has determined that the aim of this design project is to provide the company with a means to measure the efficiency of the compressors via integration of an externally mounted mass flow sensor package. The team is thoroughly satisfied with this goal and project need as Turbocor plans to implement this design no later than 2017. Going forward the team plans to meet with Turbocor's failure analysis group and understand the mechanics and specifications of the compressor in great detail.

Acknowledgements

We would like to acknowledge and thank Dr. Gupta, Dr. Shih and the many engineers at Turbocor thus far for helping to define the scope of this design project. We are grateful for Turbocor engineers that have taken time away from their projects in order to guide this design team in a productive direction and for the opportunity provided to us through both or faculty advisor and the Danfoss Turbocor company. Furthermore, we are extremely excited and thankful for Turbocor's willingness to grant the entire design team access to their on-site testing facilities and resources.

1 Introduction

Turbocor is a Tallahassee, FL based company that designs, develops, and manufactures high efficiency compressors to be used in HVAC chiller systems using innovative proprietary “mag-lev” technology. The company started in Australia in 1993 then moving to Montreal Canada in 1999. Turbocor brought their high efficiency compressors to market in 2002. Eventually being acquired by their now parent company, Danfoss in 2006, they moved to the purpose built facility in Tallahassee to cope with growing demand for their product.

Although the Turbocor compressors are known to be very reliable, to provide long-term customer satisfaction Turbocor hopes to develop methods of failure modes predictions. As more companies discover their own versions of “mag-lev” technology Turbocor is turning its attention to the end users satisfaction to create a strong and loyal customer base. Turbocor is already competitive in customer service through their proactive efforts in assuring the highest manufacturing quality but want to add another level of service through remote monitoring and diagnostics of their compressors as a means by which to increase product uniqueness and value. Many companies like General Electric and Siemens have already taken this step and integrated the necessary mechanical components into their turbines. Thus to provide stepping stones toward achieving this end goal, our team is to analyze the existing systems and determine mechanical changes that can aid in the possible incorporation of additional hardware. Possible hardware includes, but is not limited to extra sensors and mass-storage devices.

2 Project Definition

2.1 Background Research

In current industry markets for mass flow measurements of compressed fluids, there are a variety of methods available and in use. The most prominent of these methods is based off of Loui Vesso King's hot-wire anemometer. This relates mass flow rate to the amount of current required to maintain a constant temperature gradient between two probes placed within the flow. The underlying thermodynamic principles behind these devices have been thoroughly studied and defined[1]. Many companies such as Sierra, Elektronik, and Sage Metering Inc. have developed robust sensors that can read mass flow rates of a closed system with great accuracy. Similar to the current goal of this design project, these sensors are external add-ons to a closed loop system but must be purchased by a separate vendor. This project intends to simplify the necessity of having to purchase meters from external venders by developing a mass flow sensor that can be attached directly to the compressor itself and be calibrated to exact specifications of the end user in house. Because compressed fluid flows can account for up to 1/3 of the overall power cost, the overall goal of these companies are similar in that they intend to increase product life span and health, while reducing the cost of leaks, malfunctions, and bad operating conditions of the compressors[2]. Turbocor strives to be a leader and innovator in their field by implementing and improving mass flow sensors for increased customer asset value.

2.2 Need Statement

The design team sponsor, Turbocor, has proposed a project outline. Current variations of Turbocor compressors do not have a real time method for measuring efficiency. Additionally, there aren't any current sensors on board internally or externally that can measure mass flow rate specifically. This hinders the company from achieving its long term goals of providing increased asset value for their line of compressors. Since customer satisfaction is a priority, Turbocor would eventually like to offer a separate package that will be able to integrate with the technology and systems that are already present on the compressors. The need for this project is to develop a mechanically integrated, operating mass flow sensor for the Turbocor "VTT" model compressor.

2.3 Goal Statement & Objectives

Goal Statement: Design an integrated compact mass flow rate sensor with the ability to measure efficiency of the “VTT” model compressor.

Objectives:

- Mechanically integrate a mass flow sensor
- Keep the sensor compact lightweight and nonintrusive
- Must be durable preferably with minimum moving parts if any
- Must provide added value to the customer featuring equipment health and reliability
- Must be simple to obtain and understand without extensive prior knowledge required

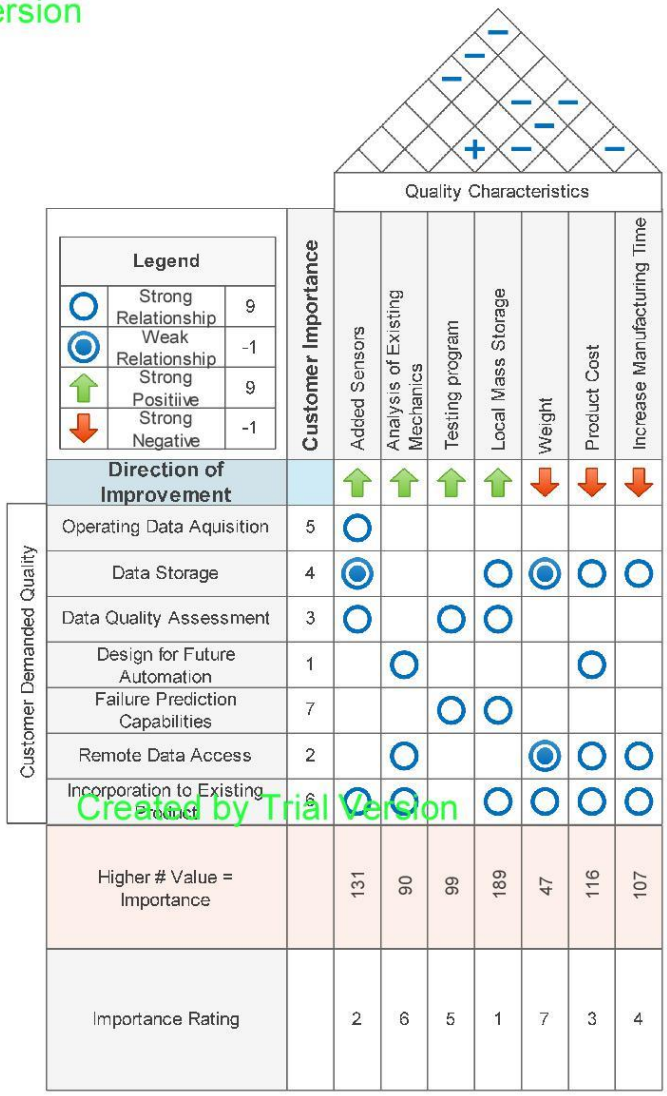


Figure 2: HOQ based on current knowledge of Turbocor specifications

2.4 Constraints

Current constraints include but are not limited to the following:

- Low price range with current technology ranging from 50 to 5000 dollars
- Must be compact and light weight, no more than a few pounds
- Must be compatible with the current control board on the compressor
- Must comply with the geometry and specifications of the existing compressor

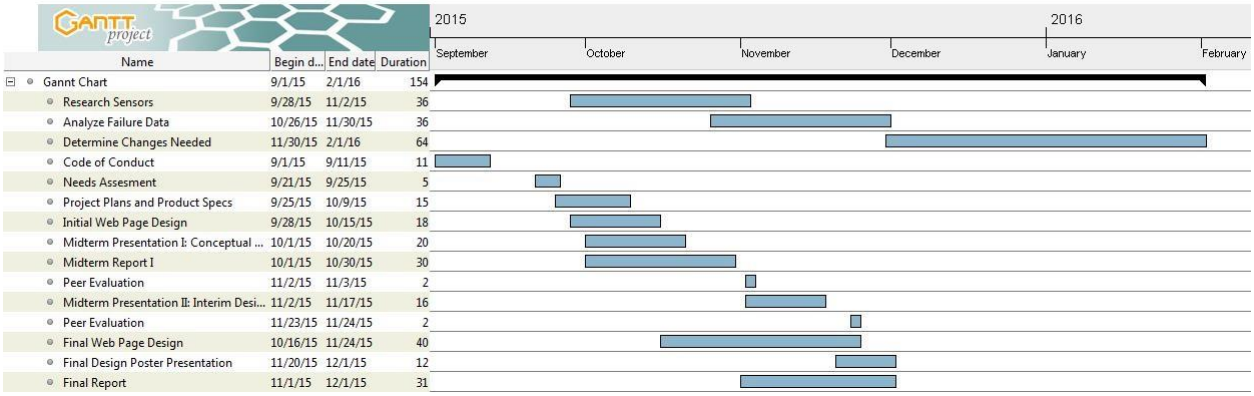
2.5 Methodology

This project consists of three distinct phases. Each one will require coordination with different members of the Turbocor staff along with utilization of the various tools available to us.

The primary phase of the project requires us to learn about the sensors that are currently embedded in the system. In order to fulfill this need, we will be communicating with Application Engineers Kit Kennedy and Heath Widdon to learn from their expertise. We will then conduct research on our own to better understand the "VTT" compressor system in addition to general compressor basics. Furthermore, we will utilize the Turbocor testing facilities available to us so that we can monitor the real time output of the system as it currently operates. Through these means we will develop a working knowledge of the sensors and the data they produce. We will utilize the experience of the forensic investigators they have currently inspecting all failed devices, Kevin Dodson and Peggy Sue Blondheim to gain further knowledge of the systems. In addition we are able to speak with Francis Champagne, Failure Analysis Engineer, and Kevin Gehrke, Director of Reliability. After we acquire the information needed we will begin to design a mass flow sensor and integration method of the sensor onto the compressor. We are aiming for a "plug-n-play" applicability of this mass flow rate sensor. Throughout the project we will be coordinating with software engineers Jason Eick and Robert Arnold. They are coordinating the project and concerned with the end result, a sensor that can monitor system efficiency for the end user of their compressors. By coordinating with them consistently we will be able to keep our project on track to fulfill the expectations and desires of Turbocor.

2.6 Schedule

The current projected schedule has been broken up into three larger blocks each of which include smaller meetings, deliverable dates, and other minor dates. The three larger task under which all minor task fall includes researching sensors, Analyzing failure data, and Determining mechanical modifications needed as can be seen below in figure 2.



Name	Begin d...	End date	Duration
Gannt Chart	9/1/15	2/1/16	154
Research Sensors	9/28/15	11/2/15	36
Analyze Failure Data	10/26/15	11/30/15	36
Determine Changes Needed	11/30/15	2/1/16	64
Code of Conduct	9/1/15	9/11/15	11
Needs Assesment	9/21/15	9/25/15	5
Project Plans and Product Specs	9/25/15	10/9/15	15
Initial Web Page Design	9/28/15	10/15/15	18
Midterm Presentation I: Conceptual ...	10/1/15	10/20/15	20
Midterm Report I	10/1/15	10/30/15	30
Peer Evaluation	11/2/15	11/3/15	2
Midterm Presentation II: Interim Desi...	11/2/15	11/17/15	16
Peer Evaluation	11/23/15	11/24/15	2
Final Web Page Design	10/16/15	11/24/15	40
Final Design Poster Presentation	11/20/15	12/1/15	12
Final Report	11/1/15	12/1/15	31

Figure 3: Turbocor Project current Gantt chart.

3 Conclusion

At this point, the need assessment and future goals are clearly defined. The team is tasked with mechanically modifying the current "VTT" Turbocor compressor with an attachable mass flow rate sensor. This in turn will give added value to the customer and company. The design will be incorporated into the "VTT" compressor no later than 2017. The Gantt chart is utilized as a visual aid to view upcoming events and their relative timelines. Researching current mass flow sensor technology, familiarizing with the "VTT" compressor model, and determining limiting constraints are of the greatest importance at this stage of the project. The house of quality is also utilized to correlate customer demand with customer importance. Although it is early and the team has yet to meet with failure analysis technicians, it was completed with information from Rob Arnold and Heath Widdon during the most recent Turbocor visit.

4 References

Danfoss. n.d. 24 9 2015. <http://industrialrefrigeration.danfoss.com/assets/0/114/137/138/17179871081/17179873132/42913673-264d-4750-8c9b-484debe90f4f.jpg?n=1124>.

Lomas, Charles G. *Fundamentals of Hot Wire Anemometry*. Cambridgeshire: Cambridge University Press, 1985.

Power Generation. n.d. 24 9 2015. <https://powergen.gepower.com/service-optimize/services/gas-turbines/software-analytics/monitoring-and-diagnostics.html>.