HIGH SPEED MOTOR TEST RIG

TEAM 5

NEEDS ASSESSMENT

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ABSTRACT

This is the Senior Design Team 5 Needs Assessment report. Team 5 is partnered with Danfoss Turbocor and has been tasked with the continuation of Senior Design Team 4's project in 2015-2016. Their objective transitioned multiple times giving them incomplete results. The task for our group is to complete the design and build a system that can support the vibrations from two compressors with shafts adjoined with a coupler. We must purchase the coupler, shafts, alignment tool, and design the stand that will be built in the machine shop. The previous design team had a working stand that we will be building off of. The goal is to be able to add a torque transducer and run the compressors at very high speeds, ranging from 13,000 rpm to 40,000 rpm, to analyze the forces in the system.

1. Introduction

Senior Design Team 5 has been tasked with redesigning the High-Speed Motor Test Rig by Danfoss Turbocor. This project is a continuation from last year, which was lead by Senior Design Team 4. Danfoss Turbocor separates itself from other companies by being able to attain high speed rotation, up to 40,000 rpm, in their compressors. The compressor can't use regular bearings at such high speeds due to the high heat that is caused by friction, low lifecycle caused by fatigue, and the magnitude of the strains. As such, the company was able to find a solution by using magnetic bearings. This resulted in the system reducing friction significantly.

Danfoss Turbocor is still looking for a way to be able to test their compressor models at very high speeds along with maintaining the speed for longer periods of time. This project is currently undergoing a redesigning phase. This boils down to what Turbocor wanted changed from last year's High-Speed Motor test Rig.

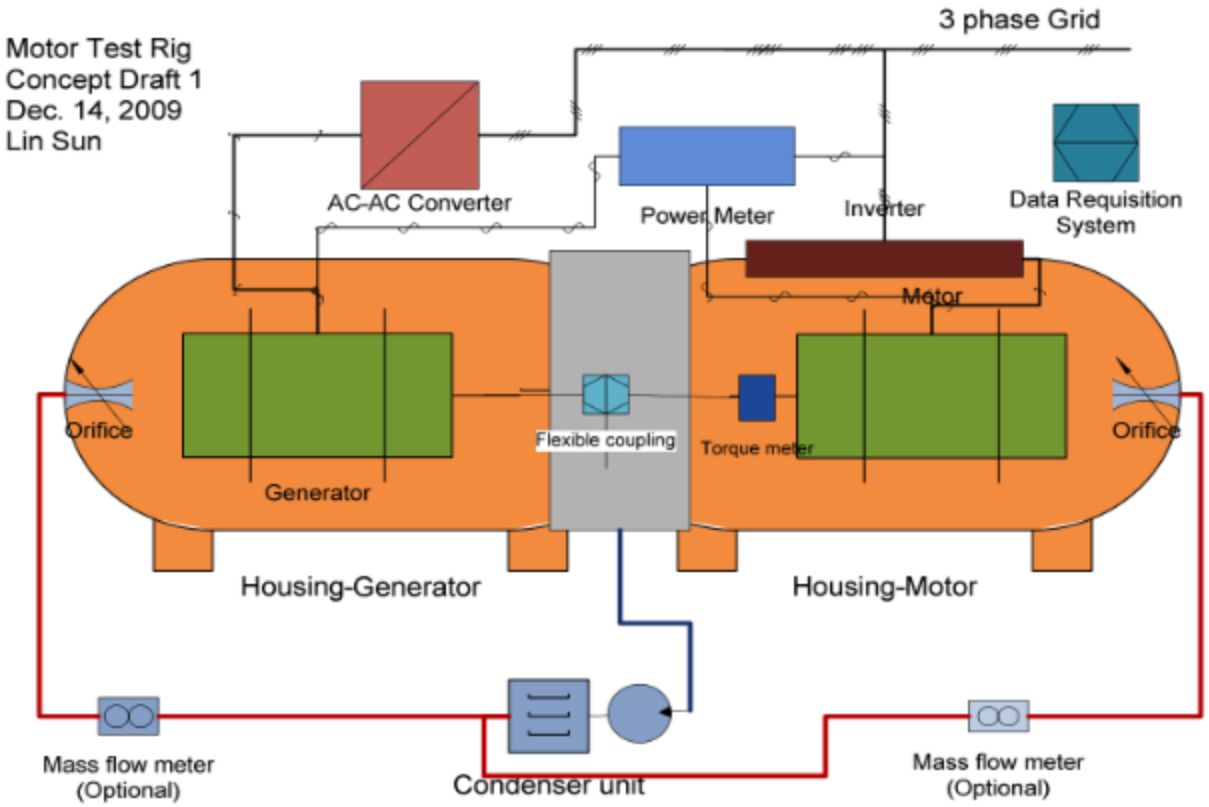


Figure 1: Motor test Rig [1]

The figure above was provided to last year's team by Danfoss Turbocor. It is a rough sketch of the initial plan that they wanted to incorporate. Team 5 has had one meeting with the sponsor, represented by Mr. William Sun and Mr. Kevin Lohman and, so far, what has been asked of the team at this time was to fix certain aspects of the test rig from last year. Which would include redesigning the coupler, stabilizing the stand, acquiring a suitable laser alignment system, and acquiring a torque transducer, which will ultimately fix vibration and alignment issues for a High-Speed Motor Test Rig. After taking a look at the actual compressor while taking a tour of the facility, it was then known that it would consist of two compressors. One of the compressors would act as the motor while the other would act as the generator. The team is currently researching different laser alignment tools that best suits the conditions that are given. Last year's team ended up having to use a dial indicator for alignment due to budget constraints that were placed on them.

Along with that, research on high-speed couplers that are flexible that can withstand high speed rotation. This was another issue that Danfoss put emphasis on. The couple that was used last year was not flexible enough resulting in vibrations occurring as soon as the Rig powered up. This is due to the sensors, nine in total, in each compressor moving the shafts resulting in the compressors fighting each other. After meeting with the sponsor and reviewing the previous Senior Design Team's reports, requested by the sponsor, the focus on what needs to be done is clear. Team 5 is taking the necessary steps in order to resolve the issues at hand.

2. Project Definition

2.1 Background Research

High-Speed couplers are mainly used in high tech products. For example, General Electric has their Wind Turbines that vary from 6,000 rpm up to 22,000 rpm depending on what model is used [2]. There are many different types of couplers available nowadays such as flexible, fluid, and magnetic couplers.

The type of coupler that was chosen from last year was the flexible coupler. This can seen on their Final Report from last year [3]. The reason for this was due to the fact that some types of flexible couplers are able to withstand high rotation speeds with low levels of misalignment and low levels of torque. There are other commercial high-speed flexible couplers for sale that may be researched. This will be done in case that last year's coupler is deemed no good for the project this year. Finite Element Analysis (FEA) will be done in order to see if the coupler along with other aspects of the test rig are in line with what Turbocor wants.

2.2 Needs Statement

Danfoss Turbocor requires a high-speed motor test rig that is capable of measuring efficiency and power/heat management more accurately while utilizing little power consumption. The motors that are going to be analyzed have rotation speeds that range from 13,000 rpm to 40,000 rpm. Having such a wide range for rotation will result in misalignment between the shafts that the coupler is connected with. Improvements are expected to be made from the design that was presented last year. This includes adjusting the current coupler or using a different coupler. A torque transducer to actually be added into the rig itself. Trying to fix the alignment issues that occurred last year will also be required in order to fulfill the needs of Danfoss Turbocor.

2.3 Goal Statement & Objectives

The main goal for Team 5 is to improve upon the design that last year's team 4 made for Danfoss Turbocor. The main focus being on choosing a more proper coupler and alignment system. This is in order to reduce the amount of mechanical vibrations that occurred when trying to run the test rig last year. The objectives are as follows:

- Compressor alignment working at high speeds

- Stability in the stand to reduce vibration
- Acquire a more efficient coupler
- Introduce a torque transducer into the test rig

2.4 Constraints

Foreseen requirements that still remain in the motor test rig pertain to the shaft alignment between the two compressor, coupler, and torque transducer. This year a budget constraint was given in the amount of $20,000. The sponsor also seemed adamant in meeting any financial demands this year compared to last year. Given such a high budget, the early purchase of a laser alignment tool will allow experimentation to begin, which will give information on how to adjust the problems that stemmed from last year.

Last year's team worked mainly in the senior design lab which limited their resources. This year the stand will remain at Turbocor giving the support and knowledge of the staff. Last year's team had to start the project from scratch, where this year previous deliverables are accessible, which will show what needs to be enhanced and newly implemented. This is all on top of having the motor test rig run from a rpm range of 13,000 to 40,000.

3 Methodology

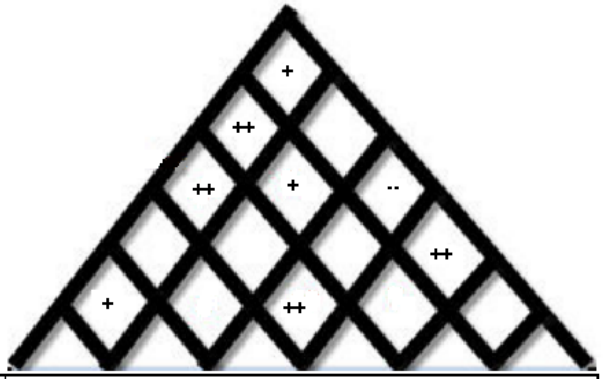
Frequent visits will be made to the sponsor company, Danfoss Turbocor, to keep in touch with the contact person, Mr William Sun, and intimate him about every development that arises regarding the design of the Test Rig. Also, most of the machining works for the design of the Test Rig will be carried out at Turbocor's machine shop, mainly because of the high level of precision required. Mr Kevin Lohman, who is in charge of the machine shop, promised to help us out with the machining processes. Already a meeting has been held with the team's advisor, Dr Hollis, but more meetings would be held with him to intimate him about the progress of the project and to seek advice from him at certain points in the project.

The team's code of conducts will be upheld throughout the period of this project, and the opinion of each member of the team will always be respected and considered. Through judicious compliance with the schedule given in the Senior Design course for the submission of deliverables, the team will gradually and actively realize the goals of the sponsor. At the moment, the team is working to reach out to the suppliers of torque transducers, and seeking to

get a transducer that accommodates a torque of 100Nm and speed of 50,000 rpm, instead of two torque transducers offering various speeds and rpms, as decided by the last senior team that worked on this project [1].

Through brainstorming and from last year's project, the team created a House of Quality that represents and ranks Danfoss Turbocor's requirements. It also shows what engineering characteristics will be used in order to meet the needs of the customer. This House of Quality goes with all aspect of the High Speed Motor Test Rig.

Table 1: House of Quality



		Customer Priority	Engineering Characteristics					
			Price	*Efficiency*	*Weight*	*Material*	*Tolerance*	*Strength*
Customer Requirements	*Safety*	2	1		4	7	4	10
	Durability	6	4	4	7	7	1	7
	Within Budget	3	10		1	10	7	4
	Reliability	4	4	4		4	10	7
	Functionality	1	1	4	4	4	10	7
	Mobility	5			10	7		4
	Importance Rating							
	Σ(Customer Priority X Relationship Value)		73	44	107	141	85	129

Correlations	
++	*Strong Positive*
+	Positive
-	Negative
--	Strong Negative

Relationships	
10	*Strongest*
7	Strong
4	Fair
1	Weak

3.1 Schedule

With the help of a Gantt chart, the schedule for the fall semester for the team has been organized. All of the deliverables with the amount of time each will take has been inputted. In addition to the deliverables, the addition of "Market Research" shows the main nodes for work for the fall semester. Market research will include further research into the industry in order to find supplies and tools that would meet the requirements of Turbocor.

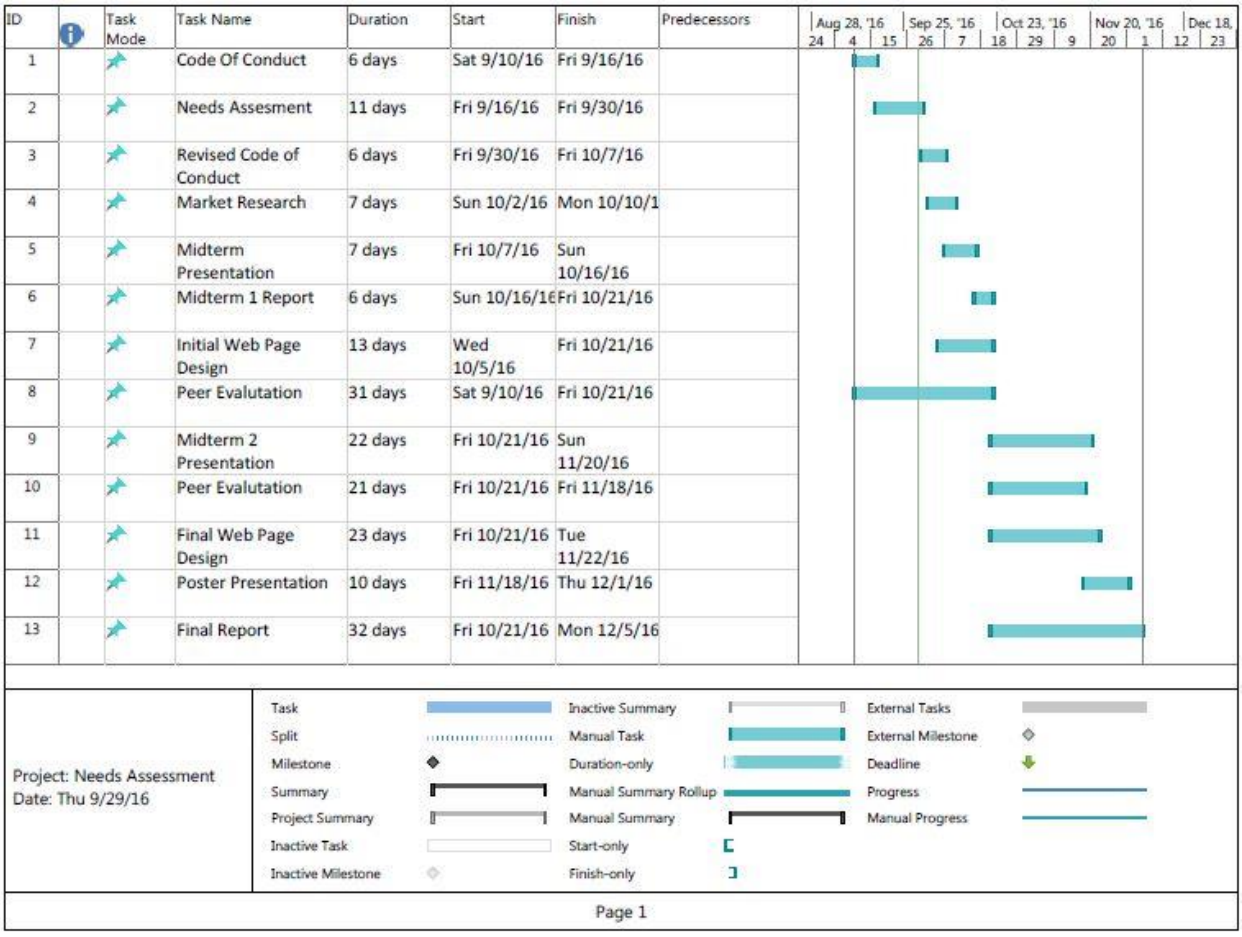


Figure 2: Gantt Chart

4 Conclusion

Based on the advice from last year's report, advisers, and sponsors, the recommendation was to set a clear budget in order for the project objective to not transition as often as last year. Last year's budget was cut by $19,500 resulting in an insufficient product that couldn't meet Turbocor's original standards and design goals.

The main focus right now that will need to be addressed will be whether or not the same coupler will be used again this year. On top of the conditions that the coupler needs to be able to perform in the coupler that is chosen this year, whether by adjusting the current one or finding a new one altogether, will need to be able to keep vibrations down to a minimum while the test rig will be running at high speeds.

The team is currently unaware of a torque output that will be needed for the torque transducer, but will inquire about it to Mr.William Sun and Mr.Kevin Lohman. The team will also be in contact with Dr.Hollis in order to have some guidance in regards to the alignment system, options on the coupler, and other mechanical components of the test rig. Taking into consideration the constraints and projected goals that the team has, a final design is to be completed and submitted by December 5, 2016 in order to be able to do some testing the following semester.

References

1. http://eng.fsu.edu/me/senior_design/2016/team04/NA.pdf
2. http://www.aweo.org/windmodels.html
3. http://eng.fsu.edu/me/senior_design/2016/team04/Final%20Report%20-%20Team%204.pdf
4. Sekhar, A.S., Prabhu, B.S., Effects of Coupling Misalignment on Vibrations of Rotating Machinery, 1994

Appendix A

Type or paste your appendices here. Appendices are a place to organize and include all of the "extra" material that is important to your research work but that is too detailed for the main text. Examples can include: specific analytical methods, computer code, spreadsheets of data, details of statistical analyses, etc. But, these materials do not speak for themselves. There should be a reference to these materials from the main section (complete details included in Appendix A) and there should be some text at the beginning of each appendix to briefly explain what the information is and means that is included in that appendix.

*Biography

Each report should have the group member's small introduction (short bio – maximum of 50 words) at the end of the report.

*Only applicable to mid-term and final report.