Restated Project Scope and Plan:

Sealing Ring Testing and Characterization

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TEAM 1 BIOGRAPHY

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Richard is a senior Mechanical Engineering student at Florida State University with a focus in Mechanical systems. He recently interned for Cummins, Inc. as a product validation engineer for the QSK 23L engine family in Seymour, IN.

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Kenneth is a senior Mechanical Engineering student at Florida State University with a focus on Thermal Fluids. He is interested in working on the research and development of renewable energy sources.

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Tawakalt is an exchange student at Florida Agricultural and Mechanical University from Federal University of Technology Akure, Nigeria. Her main focus is in Materials Engineering. She obtained a Diploma in Metallurgical and Materials engineering and had an industrial training at Tower Aluminum Roofing Company, Nigeria. She plans to get a master's degree in Materials Engineering after graduating with a B.S. in Metallurgy and Materials.

Erin Flagler

Project Planner

Erin is a senior Mechanical Engineering student at the Florida State University with a mixed focus in Energy Systems and Materials. Erin interned for Black and Veatch this past summer as a Mechanical Engineer in the Energy Division in Overland Park, KS. After graduation, Erin plans to pursue an engineering career in the energy sector.

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ABSTRACT

The aim of the Sealing Ring Testing and Characterization project is to create a method that approximate the geometrical dimensions needed in a given mechanical application. The current design process for sealing ring application requires numerous iterations of finite element analysis, which is costly in both time and money. Team 1 will streamline this long process by essentially developing a shortcut using data collected from testing various sealing rings under compressive loads at varying percent crush. From these tests, one can attain a sealing pressure using pressure sensitive film and the force needed to compress the sealing ring to that pressure. With these values, a geometric shape factor will be devised in order to correlate the cross section of a sealing ring with a sealing pressure and percent crush. A test fixture was designed last semester and is currently being fabricated. A new strategic plan has been devised and will be put into place once testing begins. It consists of splitting testing into two main groups in order to expedite the Fujifilm scanning.

I. Introduction

The current sealing ring selection process used by Cummins, Inc. requires extensive analysis to examine and consider a variety of unique and applicable designs. The team's goal is to decrease the time needed for the sealing ring selection process by creating a method in which extensive finite element analysis is not required. Lowering the time required to select the proper sealing ring for a specific process ultimately reduces the cost of the analysis in multiple departments throughout the company. During the duration of the project, Team 1 will examine 23 uniquely shaped sealing rings in face-compression tests to search for a correlation between the physical geometry of the sealing rings, the pressure required to produce a complete seal, and the amount or percentage that the ring was crushed to achieve the seal. This correlation is referred to as a shape factor. Once the shape factor(s) is or are identified, the team will use these correlations in order to create a user interface that can output dimensions for a sealing ring, if given application parameters. These parameters will be the percent crush and sealing pressure.

II. Project Scope

A. Goals and Objectives

The goal of this Senior Design project is to provide an efficient method to select sealing rings by defining key relationships called "shape factors" between the cross section geometry of a sealing ring and the sealing pressure at a given percent crush. In order to accomplish this goal, data and analysis will be done on 23 different cross sections. Then, software like Matlab will be applied to create the user interface and contour plot with the correlations.

B. Challenges Encountered

The first issue encountered this semester came in the form of delays in the machine shop. The original schedule accounted for the test fixture to be completed and ready for testing upon the return of the team from vacation. This way the pressure sensitive film sensitivities could be assessed and a sufficient amount ordered so that testing could begin within the first two weeks. A computer malfunction caused the completion of the fixture to be delayed a matter of weeks. This schedule delay set back the assessment of pressure film sensitivities and of course running the tests.

Challenges currently being faced include determining the sensitivities and amount of pressure sensitive film needed. A range of expected pressures between about 30 psi and 400 psi was calculated using theoretical data, but the penalty of ordering the incorrect sensitivities would be too severe to rely solely on the theoretical data. The team had hoped to calculate using some experimental data, since pressure range would call for three different sensitivities of film. Various film pressure sensitivity options are shown below in Table 1.

Table 1: Pressure sensitive film sensitivities available

Film Sensitivity	**Pressure Range** (PSI)
Extremely Low	7.2 - 28
Ultra Low	28-85
Super Low	70 – 350
Low	350 - 1,400
Medium	1,4000 - 7,100
High	7,100 - 18,500

To manage this delay issue, free samples of a few film sensitivities were ordered from Fujifilm. These samples should arrive before the test fixture is completed and will be assessed using a generic flat plate fixture mounted in the MTS machine. Once the sample sheets of film have been tested, sheets of the correct sensitivities can be ordered, with expedited shipping if necessary, to ensure they arrive near the time the test fixture is completed.

Another challenge to be faced is the main challenge of the project: what to do with the data once it has been collected. The pressure sensitive film will be sent to either Cummins, Inc. or back to Fujifilm to be scanned, but there will still be the data collected from the MTS machine itself that will need to be analyzed. The same set of theoretical data mentioned earlier was created in order to determine a method to find a correlation between percent crush, cross section geometry, and sealing pressure. Until actual data is collected, an analysis method may not be determined. Advisors Dr. Oates and Dr. Alvi have been consulted for assistance in determining the data analysis method.

C. Changes to Project Strategy

While the design of the test fixture has not changed since it was finalized, the strategy to be used in acquiring data has. Changes were made to the testing procedure and approach once certain aspects of the procedure were realized, such as the amount of pressure sensitive film and magnitude of time needed to perform tests on each sample. The main change to the strategy of the project is to test three samples from each of the three seal cross section categories circular, rectangular, and irregular. The three samples in each category were chosen based on size since size is the main variable within each shape category. These nine samples should be a good representative of the overall set of data due to the range of sizes chosen and will be known as the preliminary set of samples. Testing these samples first and beginning analysis on the data gathered will allow the team to get a jump start on a set of data representative of the entire set while the rest of the samples are being tested. Resource allocation will be assessed once testing and data gathering has commenced so that part of the team will be devoted towards data analysis and the others will continue to test the remaining samples.

Approaching the data acquisition and analysis tasks in this manner, will allow the team to get an idea for how the entire set of data should behave and therefore be able to finalize the data analysis method before being overwhelmed with a large magnitude of data all at once. This method should also act as a failsafe in that results could be deduced from this representative set of data if time does not permit all of the data to be analyzed successfully due to unforeseen delays. A major delay could arise from the need for the pressure sensitive film to be sent either to Cummins, Inc., or the provider, Fujifilm, to be scanned and the data returned to the team. The set of film from the preliminary nine samples should be processed and returned relatively quickly compared to the entire set being sent at once or even in batches.

III. Project Plan

A. Procurement Process

Team 1 started with a budget of $2000 to purchase raw materials. After raw Aluminum 6061 was ordered for the creation of an MTS-compatible test fixture and sampling test grooves, the remaining budget was $1869.29. This figure included the taxes and shipping costs of the material. The materials are currently in the machine shop, and the test fixtures and groove plates should be completed within a few weeks of schedule. The remaining budget will be put towards the purchase of Fujifilm Prescale pressure sensitive paper. A range of film samples with varying sensitivities have been ordered to assist in the confirmation of the sensitivities required. The necessary sensitivities were discovered through calculation before large amounts of film was ordered to prevent a waste of budget. The other resources utilized for this project, the MTS machine and the sealing ring samples, were obtained without having to reduce the budget through the cooperation of FCAAP and Cummins, Inc.

B. Scheduling

A workflow breakdown structure, Figure 1, was created in order to illustrate the main tasks that must be completed in order to complete this project. This project can be broken down into three main tasks: testing, data analysis, and creating the user interface. In order to complete this project in a timely fashion, a Gantt chart, which can be seen in the Appendix, must be followed. Before we begin testing, we must finalize the testing preparations. The testing fixture is still being fabricated and the Fujifilm has been ordered, but has not yet arrived. Preparations are due to be completed by the end of January.

As mentioned in the project strategy, samples will be divided into two batches in order to expedite the Fujifilm analysis process. Following preparations, the testing on the first half of cross sections will begin and is scheduled to be completed by February 8th semester in order to ship the Fujifilm to Cummins, Inc. for processing. The second half of testing will then commence and be completed by the week of February 22nd, followed by the mailing of its Fujifilm results to Cummins, Inc. Following testing, analysis must be done on the collected data from the testing. Data with varying cross sections will be plotted against each other in order to find the correlation. Finally, the correlations will be coded in Matlab in order for users to be able to input certain parameters and the algorithm to output various cross sections that will work at the given situation. This will also allow for the 3-D rendering of our results to be created in the form of a contour plot. This should be completed by the end of March, leaving plenty of time for unexpected delays.

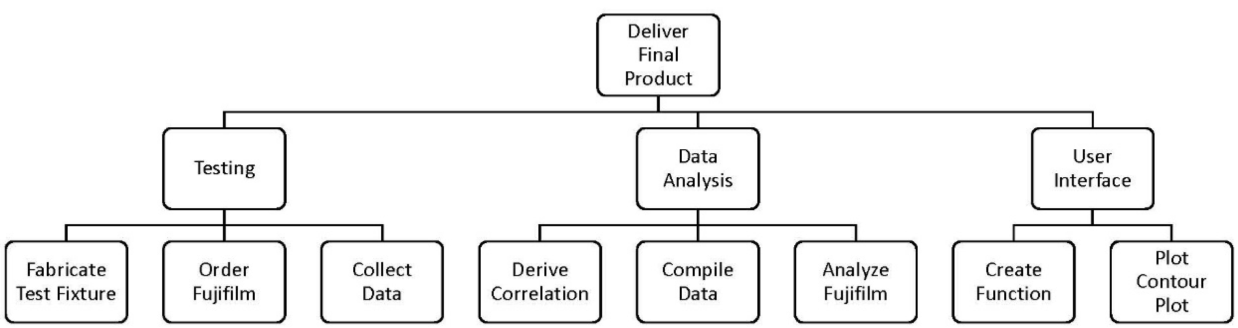

Figure 1: Workflow Breakdown Structure

IV. CONCLUSION

The first half of the project consisted of the team conducting research, theoretical calculations, and preparing to begin the sealing ring testing process of the project. The fluoroelastomeric material to be tested was selected, as were the size and cross sectional geometry testing ranges, resulting in 23 unique sealing rings to test. The different sealing rings or testing samples have been received from Cummins, Inc., along with their specifications in the form of mechanical drawings. The testing method of the samples was selected as a MTS (Measuring, Testing, and Sensing) machine to conduct face compression tests on linear sealing ring sections. The MTS machine was located in the FCAAP wing of the Aeropropulsion, Mechatronics, and Energy (AME) Center. Pressure sensitive film was chosen as a method to measure pressure felt by the samples and will be placed between the sample and the load piece. Testing grooves were designed for each individual sample following existing standards but modified from the drawings in order to accommodate a seal being compressed to 40 percent crush as requested by Cummins, Inc. A custom test fixture compatible with both the grooves and MTS machine was designed and analyzed for stress and deflection to ensure useable data would be produced. Aluminum 6061 was decided as the raw material and is currently being machined into the test fixture and grooves. A theoretical data set was developed to help determine what type of data analysis methods would be viable and predict the sensitivities pressure sensitive film would be needed.

The second half of the project began with scheduling delays originating in the machine shop in the form of computer malfunctions but the schedule and project strategy has been adjusted to account for this and other possible setbacks. A modification to the project strategy that consists of testing a smaller number of samples representative of the entire set was developed to ensure if time was running short and not every sample could be tested, the team would at least have a data set to work with that could produce results and be representative of the entire data set. While multiple challenges are being faced, they each are being met with plans of attack. The first and foremost being which sensitivities of pressure sensitive film are needed because testing cannot begin until data acquisition materials have been received. The next challenge is of great magnitude in that a method of data analysis has yet to be determined but the team advisors who are experts in the field are being consulted.

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V. APPENDIX

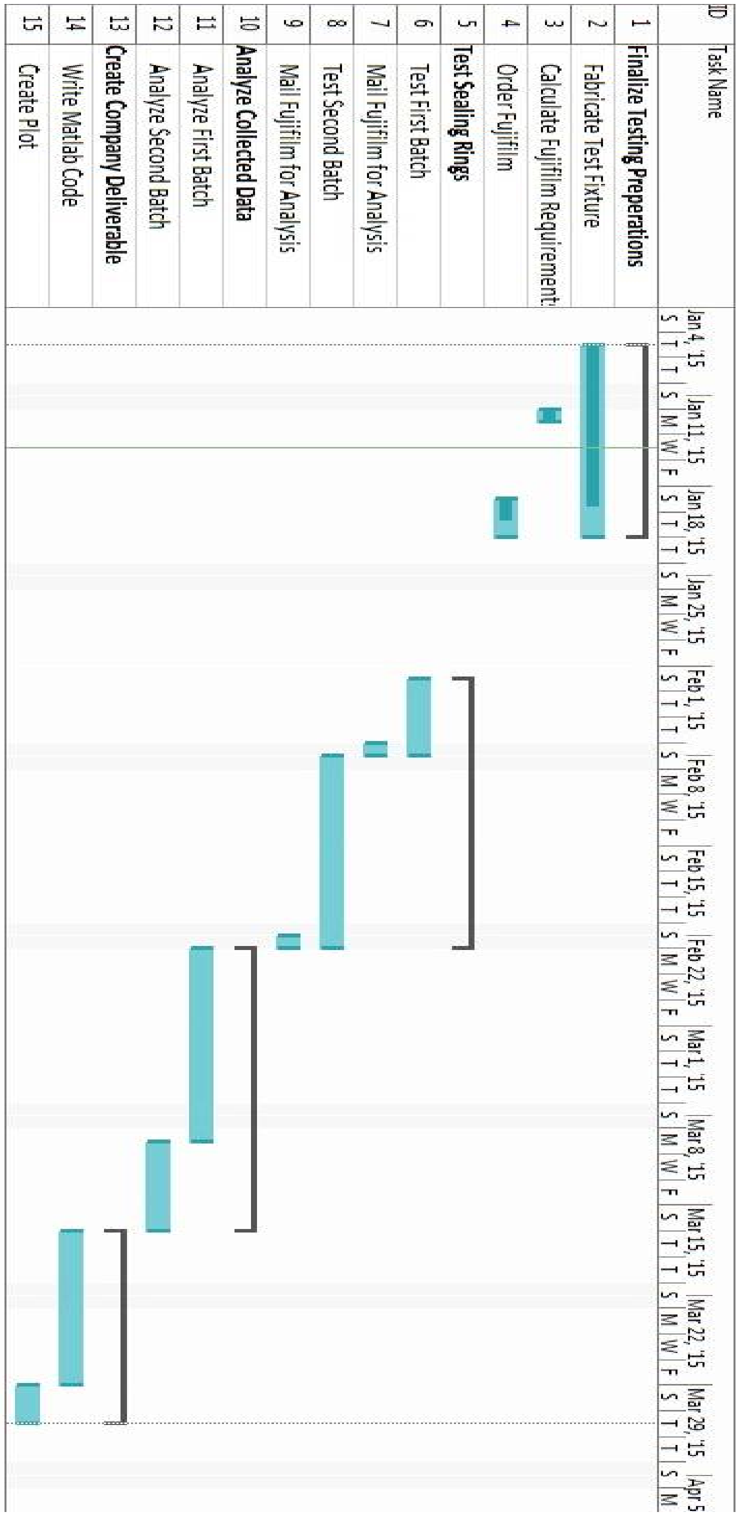

Figure 2: Gantt chart