Needs Assessment

Super Seal: Adding a 2nd Stage Sealing Device To Recapture Oil From Seal Leaks

Team 1 Members:

Project Lead: Christian Milione – cam11w@my.fsu.edu

Lead ME: Kyle Brooks – kwb13c@my.fsu.edu

Financial Advisor: Jonathan Strickland – jbs12d@my.fsu.edu

Research/Chronicler: Olaniyi Ogunbanwo – olaniyi1.ogunbanwo@famu.edu

Faculty Advisor

Dr. William Oates

Sponsor

Terry Shaw, Cummins Technical Center

Instructor

Dr. Nikhil Gupta

Date Submitted:

September 30, 2016

Table of Contents

Table of Figures

ABSTRACT

The goal of the Cummins Inc. sponsored project is to design a device that will capture oil that leaks out of a crankshaft seal. The collected oil is to be transferred to a holding reservoir enabling future reinsertion into the crankcase. This objective will be obtained through the application of various engineering design methods, coupled with collaboration between the college and industry appointed sponsors. The overall effectiveness of this device will be assessed through a 24-hour simulation across various operating regimes proposed by Cummins, and carried out through a custom test rig for which the group must also design and fabricate. Team 1 has done preliminary research into the problem to better understand the gap between the current and ideal situation, as well as the concept of the product needed to achieve success with the objective.

ACKNOWLEDGEMENTS

The group would like to make a point to thank Dr. Shih for his hard work in gathering the available projects for the entire semester. In addition, an acknowledgement must be made for the course instructor, Dr. Gupta, seeing as how he has been (and will continue to be) the main source of information pertinent to the course. Furthermore, a note of gratitude would like to be made for the sponsor engineer, Terry Shaw, for his time and effort spent with the team thus far.

1. Introduction

Due to the ever-increasing demand of goods and services, modern powertrain systems used for their conveyance are being repeatedly held to higher and higher operational standards. As such, the schedule for routine engine overhauls are being delayed to the point where the industry is beginning to push the boundaries of what is currently possible. To illustrate this, current semi-trucks being used to deliver automotive parts are expected to adhere to a life of 80,000 hours of operation before a rebuild is necessary. [1] If that 80,000 hours target is assumed to be nonstop, that is just over 9 years of continuous function. It is important to note that performance for that duration without any stopping is highly unrealistic in this application, but rather was used as to help gauge just how high the target for modern machinery is. To meet these inflating targets, innovations in design and manufacturing are, and will continue to be, necessary

As with everything, the primary driving factor is cost. Engine overhauls across the wide range of models in current production yield extremely high numbers when it comes to repairs. For example, the replacement of a rear crank seal for the Cummins 95 liter locomotive engine is $21,000. [2] This is due to the extreme amount of labor involved; these type of engines have such little clearance between parts, that to access anything that is not located directly on the exterior requires a large amount of component disassembly merely to access what needs replacing. If this repair cost is then coupled with the opportunity cost of lost productivity, the expenses for this seal failure begin to accumulate rapidly. This notion can be extrapolated to most large-scale power generation systems in use today. Ultimately, fixing issues as they fail is not an option for the companies that operate them.

With this in mind, the prevention of premature component failure is highly important. Not to mention, the concept of what is considered to be a "failure" has evolved over the years. In modern times, customers are becoming more sensitive to what is perceived as a failure. A large segment of this sensitivity increase concerns leaks. Historically, leaks were tracked through dripping, spraying, or fluid actively running from whichever aspect of the motor it was contained in. However, current customers perceive a leak as an instance when a component is not “dusty dry”. [2] Interestingly enough, the customer is technically correct with this assertion.

Therefore, to continue to align themselves with increasing customer expectations for both engine performance and evolving classifications of failure, Cummins Inc. (Cummins) is looking for a method to recapture oil that has managed to work its way past the rear seal of a crankshaft. This oil is to be collected as thoroughly as possible and deposited into an accessible reservoir where it will remain until a powertrain technician can reinsert the oil back into the crankcase.

2. Background

2.1 The Role Of Engine Oil

Simply put, engine oil is the lifeblood of a motor. Most notably, engine oil serves the main function of providing lubrication between components of the motor as it performs under high pressures and temperatures. By reducing friction, and therefore wear, motor oil aids in prolonging the life of vital parts.

However, advances in technology have provided the opportunity for oil to do more than just lubricate parts through their additives. Modern motor oil removes dirt and debris buildup within the engine and suspends it within the fluid until it can be removed during the next oil change; effectively working to clean your engine. Furthermore, todays oil supports increased fuel economy, protects the vehicles emissions system, works to assist with hydraulic operations for variable valve timing (VVT), and maintains components at cooler temperatures, all while possessing the ability to perform these task across a extensive range of temperature spectrums. [3]

2.1.1 Why is Engine Oil Especially Important Today?

Consider the trend of engine design in today’s market. To meet rising demand for better fuel economy, original equipment manufacturers (OEM) are transitioning into motors with smaller and smaller volumetric output. However, this typically comes with the sacrifice of power. To offset that sacrifice, turbochargers are commonly installed. The shaft inside of said turbocharger can rotate at speeds of up to 200,000 revolutions per minute. As a result, it is imperative that oil can reach these components quickly, while providing an effective form of lubrication and cleaning. Otherwise, the entire system fails producing an inability to reach OEM targets and costly customer repairs. [4] Figure 1 displays a photograph of a turbocharger during operation.

Figure 1: Depiction of a turbocharger during operation. The intense heat generated can be seen by the color change.

2.2 Oil Leaks

The “go to” cause of an oil leak is the result of a failed gasket or seal, most commonly being an issue with the crankshaft seal. [5] Depending upon the operating conditions of the vehicle, the seal can dry rot, crack, break, tear, or some combination of them all. However, there are also instances in which oil can escape past seal that is in perfect working condition. For instance, during normal operation both the oil within the crankcase and the crankshaft seal become heated. While heated, the oil can become a mist, and the seal experiences thermal expansion. After operation, the subsequent cooling process allows oil mist to discharge past the crankshaft seal as a result of differences in cooling rates between the two, often collecting along the underside of the vehicle. In either case (faulty or non-faulty seal), this is still considered to be a component failure due to the fact that the oil is no longer completely contained within the crankcase.

2.3 Current Recapture Methods

Preliminary research conducted indicates there is no widespread device with the sole purpose of recapturing oil that has leaked out of a vehicle. This statement (and research) applies to any mechanical device or piece of hardware that is fitted to a vehicle, either in the OEM or aftermarket segments. Rather, the main option is to use a drip pan to catch large oil leaks while the vehicle is stagnant for large periods of time (where possible).

Instead, the aim of current line of products is to prevent the oil from continuing to leak through the use of a “stop leak” additive/sealant. These products are design to be mixed with your engine oil and circulate throughout the motor. During their circulation, these additives seep into seals to try and recondition them back to their original characteristics; softer, more flexible, and proper shape. [6]

Ultimately, this means that there is a gap in the current market. If successful, this project could have a large impact to the current design, manufacturing, assembly, and repair processes. Additionally, it could save customers and technicians both time and money.

3. Project Scope

3.1 Need Statement

A current industry setback is that engine oil commonly leaks past the rear crankshaft seal. This particular failure is becoming more paramount in the eyes of the customer.

3.2 Goal Statement

"Design a device to capture leaking oil from a rotating test crankshaft and deposit it in a reservoir so that it can later be reintroduced to the crankcase. Additionally, a test rig for the device must also be fabricated in order to assess the functionality of the design."

3.3 Objectives

- Design a capturing device to collect oil that has leaked from a rear crankshaft seal.
- Design a rig that can be used to test the recapture device in order to determine its overall effectiveness.
- Determine feasibility of each design with technical proof (calculations, drawings, etc.).
- Order, obtain, or manufacture components for each design.
- Construct the oil recapture device.
- Construct the test rig; ensuring it can adhere to the operating regimes given by Cummins.
- Perform the 24-hour trial, and assess overall project success.

3.4 Constraints

The project must adhere to multiple constraints. They include, but are not limited to:

- A budget of $2,000 is not to be exceeded.
- The oil recapture device must work with a Cummins OEM 165mm rear crank seal.
- The oil recapture device must be able to hold oil that has been heated to 125°C.
- The oil collected must be deposited in a reservoir that can be emptied by a technician.
- The oil recapture device must fit in the space between the rear crank seal and flywheel housing.

In addition to the constraints of the recapture device, the rig with which it will be tested be designed around some constraints. These include but are not limited to:

- Rig must be able to operate continuously at variable speeds between 500 and 2000 RPM.
- Rig must rotate the appropriate size "crankshaft" across the provided operating regimes.

- Test fixture must be enclosed and properly grounded to ensure safe operation.
- Rig must be able to shutdown from full operation without any issues.

Please reference Figure 2 below for a schematic of what it the system might look like to better understand some constraints.

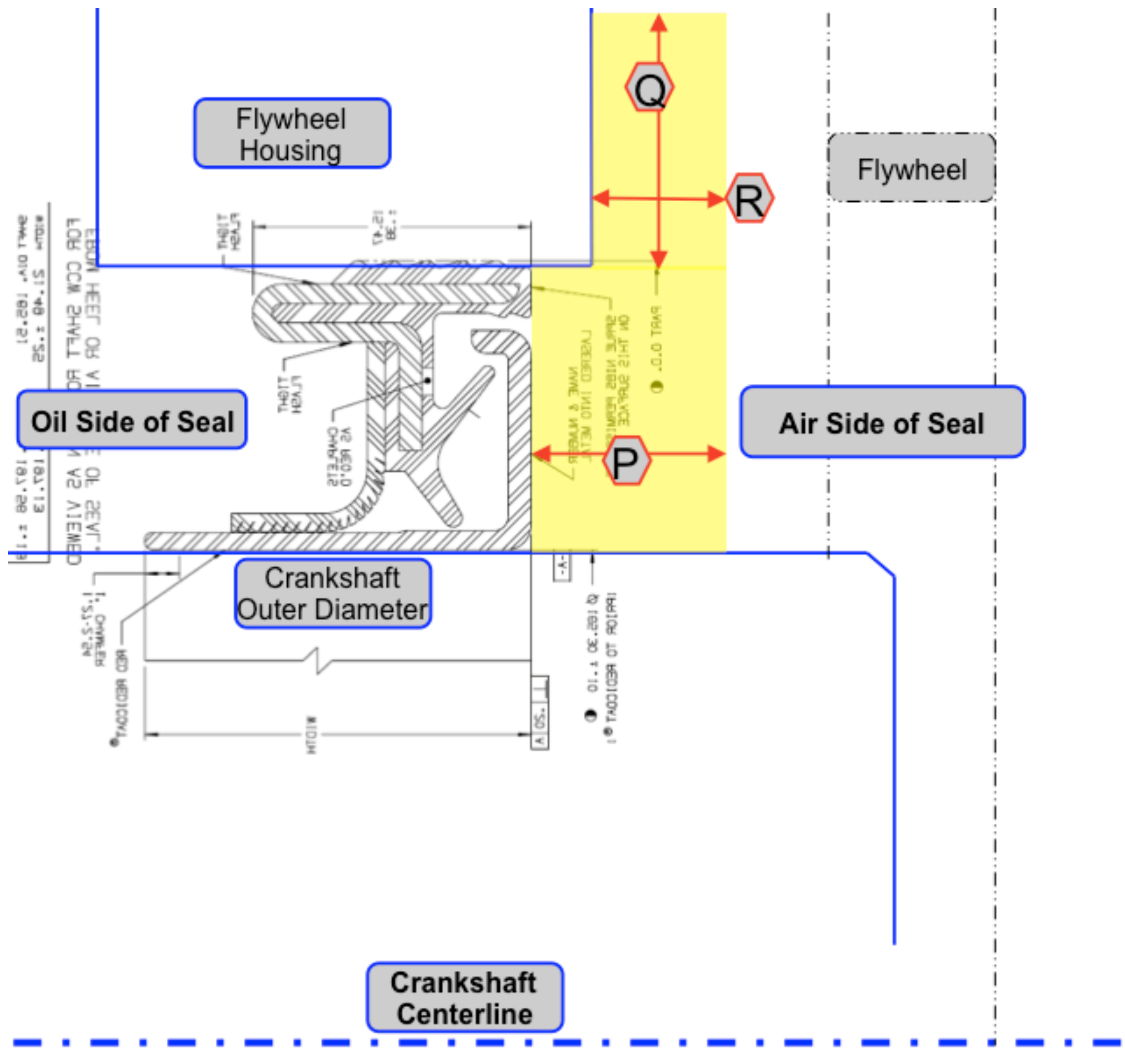


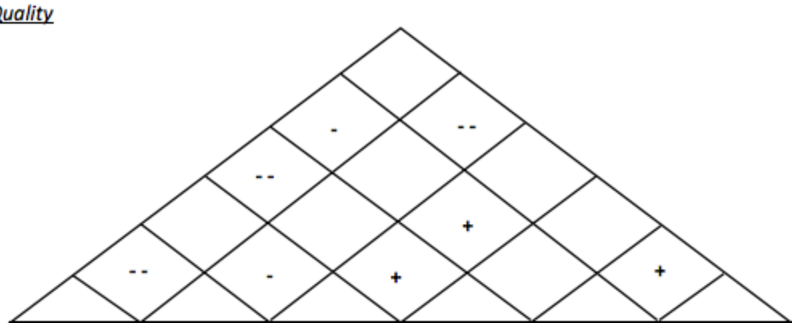
Figure 2: Schematic of rear crankshaft seal and its adjacent components.

3.5 House of Quality

Please reference Figure 3 below for the House of Quality that has been generated for this project.

Super Seal: House of Quality

Roof Correlations	
+ +	Strong Positive
+	Positive
-	Negative
- -	Strong Negative



		Engineering Characteristics					
		Size	Cost	Durability	Weight	Versitility	Efficiency
Customer Requirements	**C.I. (1-5)**						
Device/Rig Operate Safely	5				3		1
Device Fits Size Constraint	4	5	3		3	3	3
Device Collects More Oil Than Surroundings	5	2		3		2	5
Device Operates in "Normal" Regimes	3		3	4		3	3
Design/Fabrication of Test Rig	5	3	4	2		3	
Collected Oil Can be Returned Into Engine	3	4	3	3		3	4
		1 - Low Correlation			*5 - High Correlation*		
Calculations	**Score**	57	50	46	27	55	63
	Rank	**2**	**4**	**5**	**6**	**3**	**1**

Figure 3: House of Quality for the project.

4. Methodology

For this project, there are a few different distinct phases. Each stage serves its own purpose in order to develop a quality product that will meet all of Cummins requirements. The first stage of this project will require continued research into the problem to gain a better understanding of how the gap between the current and ideal condition arises. In this stage it is important to work directly with the sponsor engineer, Terry Shaw, to learn from his experience and expertise regarding this system that the group is being asked to address. Furthermore, benchmarking will prove to be a key element in order to ensure that Team 1 is measuring up well to other competitors, as well as to ensure that no time is lost on a portion of the project that someone else has already solved. Once sufficient knowledge has been gained on the problem and system/components, the secondary phase is to then begin designing the two vital components to this entire project: the oil recapture device that is to be the solution of the problem, as well as a rig that will be used to test the solutions ability to perform across a range of operating regimes provided by Cummins. It is important to keep a keen eye on time management for both aspects of the project in order to deliver a quality product in a timely manner. In addition, with the project sponsor being located so far away, effective information sharing and various communication between the group and sponsor will be vital, and must be performed as efficiently as possible. This will help the project flow more efficiently throughout the year. The design phase of the project should prove to be the most challenging, yet rewarding portion of the project. This is where the background research and knowledge gained from the sponsor are put into motion. An important note to make is that the design of our solution and test rig should be developed using concurrent engineering, in an effort to minimize any lack of correlation between the two. Once viable designs have been selected, the necessary parts must be ordered as soon as possible to give the supplier a reasonable amount of time to process the request (and make any adjustments if need be). A close watch will be kept during this phase in order to ensure that the budget of $2,000 is not exceeded. Once all parts have been ordered or machined, the actual construction of the project will begin. It will be extremely important that this stage not be taken lightly, as any shortcoming or overlooked detail could result in a failure of the entire system. Once the construction phase is complete, the final stage of the project is to test the device under operating conditions to which Cummins has provided so that the overall effectiveness of the design can be analyzed. By using this methodology, the group hopes to exceed the expectations set forth by the project sponsor, Cummins.

4.1 Tentative Project Schedule

Figure 4 below represents the tentative schedule for the fall semester.

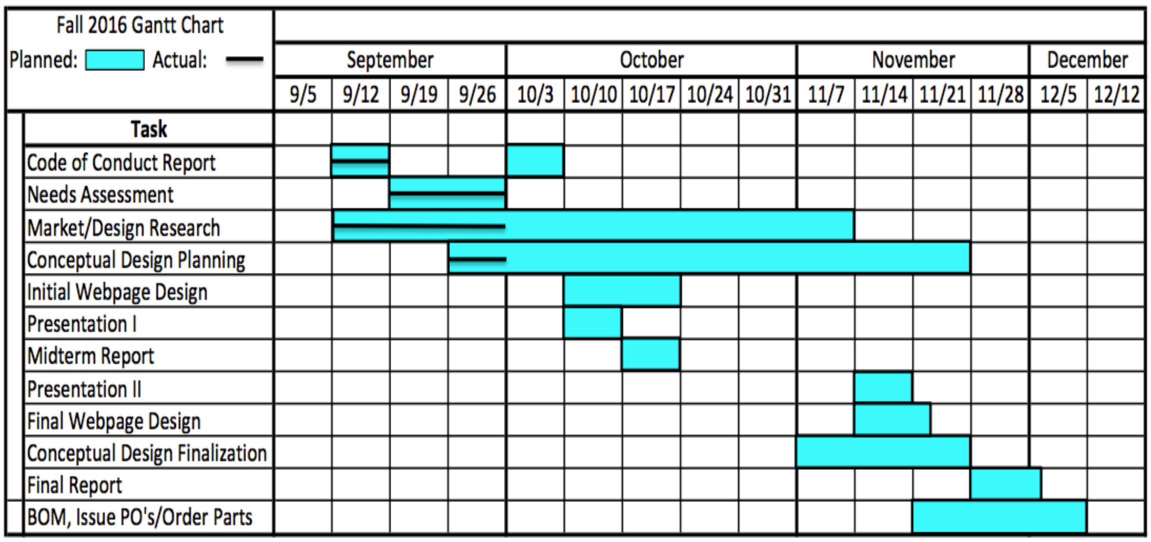


Figure 4: Gantt chart to be tentatively used for the fall semester.

5. Conclusion

The purpose of this project is to design a device that captures oil that has leaked from a rear crank seal for a Cummins diesel motor. This leakage is considered to be a failure in the eyes of customers. In addition, Team 1 is tasked with the challenge of also designing and building a test rig to determine the effectiveness of the oil capturing system. This custom test rig must be able to rotate a replicated crankshaft continuously at a steady speed of 500 RPM and 2000 RPM in order to gain the most knowledge on how the system works. The test is to last a total of 24 hours, afterwards the oil in the capturing device will then be measured. The results of the measurement will then yield the effectiveness of the device. In order to complete this task, Team 1 must first familiarize with the Cummins engine system, especially the rear seals and crankshaft, to get a better understanding of the problem at hand. Once the research has been completed, the team will then use this knowledge while also applying design skills learned throughout our young engineering careers to develop a product that will satisfy and exceed Cummins Inc. expectations.

Moving forward, Team 1 will continue to hold weekly meetings with our sponsor Terry Shaw and also weekly team meetings in order to give updates on the project and its progress. A Gantt chart was also developed to help Team 1 be aware of important dates and deadlines for the duration of this project. Team 1 knows that there is much work to be done but is up for the challenge ahead.

References

1. Shaw, Terry. "Sponsor Meeting." Interview.

2. Shaw, Terry. *Project 1*. N.p.: Cummins Inc., n.d. PPT.

3. "Education: What Is Motor Oil?" Pennzoil, n.d. Web. 28 Sept. 2016.

4. "Synthetic vs. Conventional Oil." *Mobil Oil*. Mobil, n.d. Web. 28 Sept. 2016.

5. "Symptoms of a Bad or Failing Crankshaft Seal." *Your Mechanic*. N.p., n.d. Web. 28 Sept. 2016.

6. Pro, By BD Auto. "Best Oil Stop Leak & Oil Leak Sealant | BlueDevil Products." *BlueDevil Products Best Oil Stop Leak Comments*. N.p., 11 Apr. 2016. Web. 30 Sept. 2016.