Super Seal:
Development of a Robust 2nd Stage Oil Sealing Device for Heavy Duty Engines.

Midterm Presentation 1

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Cummins' Heavy Duty Truck engine, the ISX 15 @ 15 Liters, 600 HP

Presentation Overview

- **Project Background**
  - Background Information
  - Project Scope
- **Concept Generation**
  - Cummins Technical Drawings
  - Macroscopic Ideation
  - House of Quality
  - Conceptual Sealing Design
- **Future Considerations**
  - Challenges
  - Projected Schedule
- **Conclusion**

Project Background

What's The Problem?

- **Motor oil is repeatedly leaking past the rear crankshaft seal.**
  - **Liquid Oil**
  - **Oil Vapor**

Research Dictates:

- "Go to" cause of an oil leak is a failed gasket or seal.[1]
- Material fluctuations due to thermal transients.

Figure 1: Depiction of rear crank seal leaking oil.[2]

Project Background

Driving Factors For Solution:

- Cost
  - Market demands for increased life before engine overhaul
    - ISX15 target: 30,000 hours of life
      - ~3.5 years of continuous operation

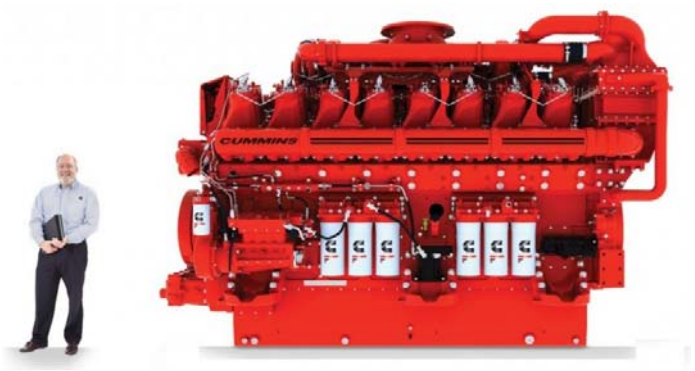


Figure 2: Cummins' newest engine, the Hedgehog @ 95 Liters, 4500 HP
Cost for crank seal replacement: $21,000.[3]

- Increased Customer Sensitivity
  - Evolving perceptions of part 'failure'

Project Scope

Goal Statement

- Design a device to capture leaking oil from a rotating test crankshaft and deposit it into a reservoir so that is can be reintroduced to the engine. Additionally, a test rig must be fabricated in order to assess the functionality of the design.

Objectives

- Design a capturing device to collect oil.
- Design a rig that can be used to test the recapture device.
- Determine feasibility of each design with technical proof.
- Construct the oil recapture device and test rig.
- Perform the 24-hour trial, and assess overall project success.

Concept Generation

Technical Drawings – ISX 15

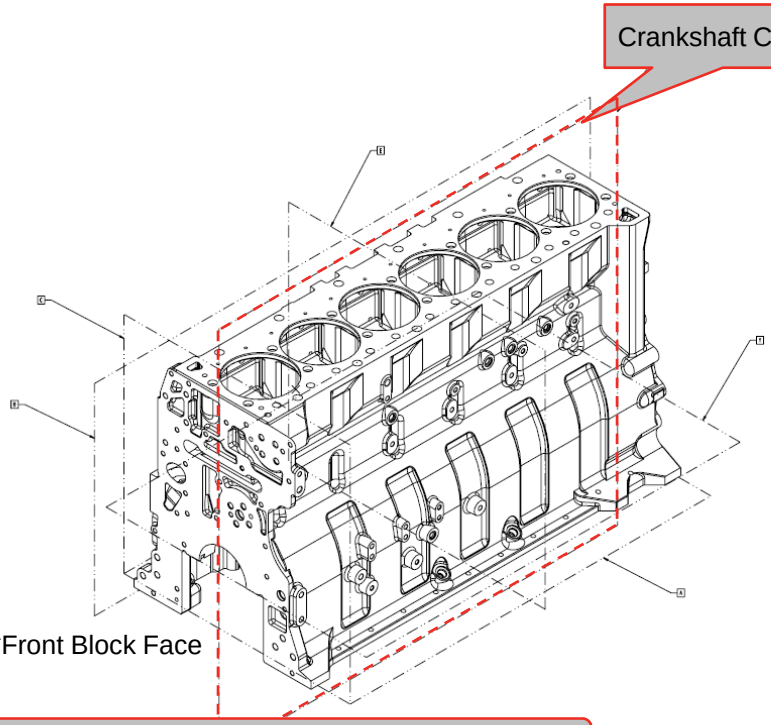


Figure 3: CAD drawing of the ISX 15 engine block.[4]

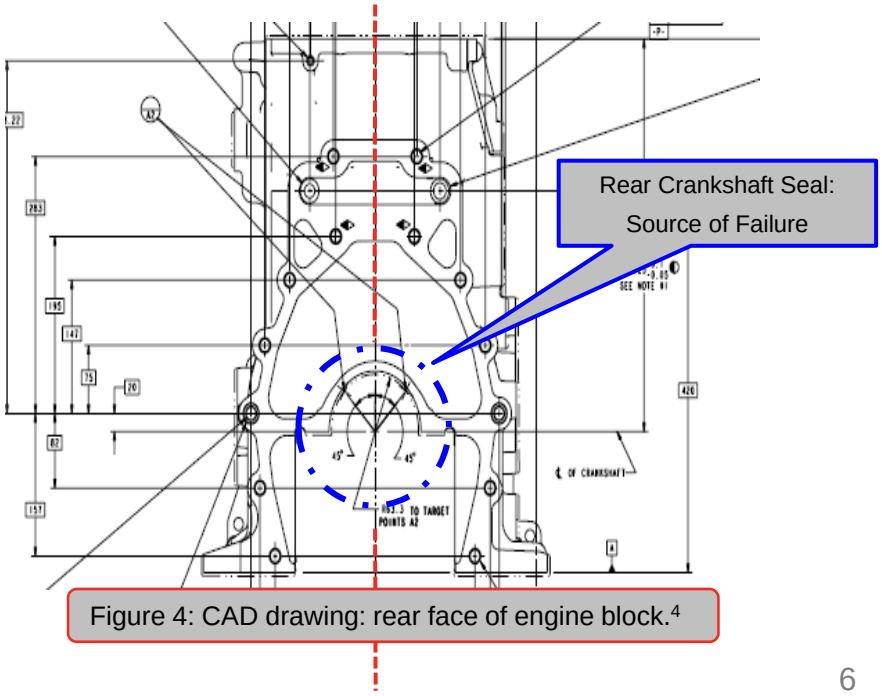
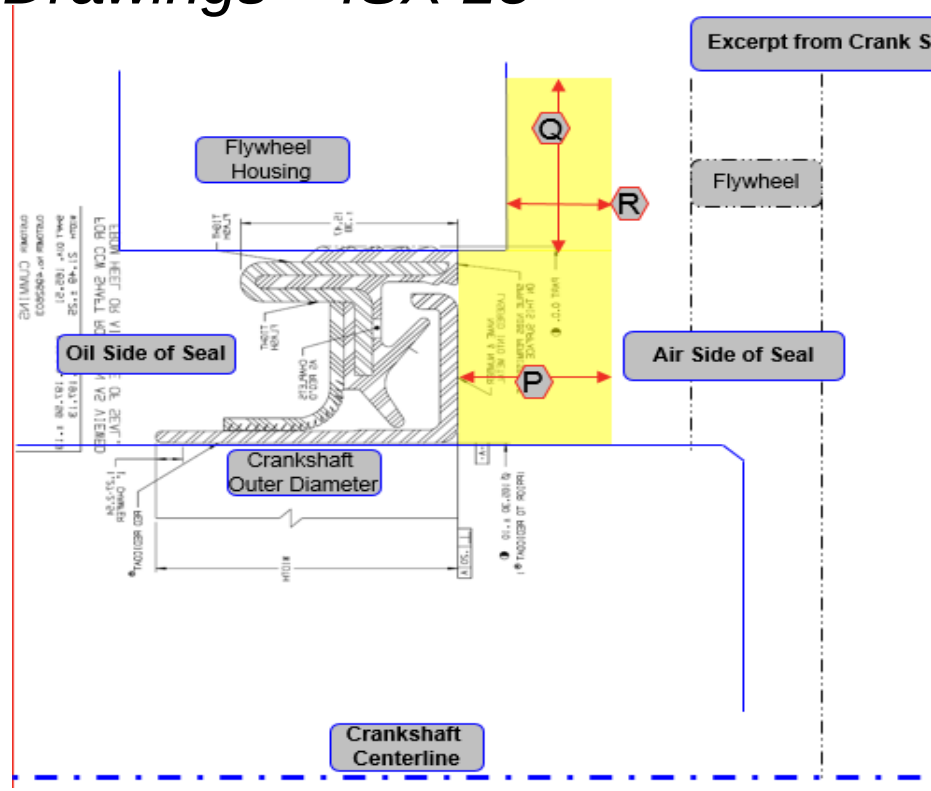


Figure 4: CAD drawing: rear face of engine block.[4]

Concept Generation

Technical Drawings – ISX 15



Area available for leak capture hardware

P max = R + 10 mm, +5 mm desired
Q max = 25 mm, 10 desired
R Max = 15 mm, 10 desired

Figure 5: Cross section of rear crankshaft seal assembly.[3]

Concept Generation

Macroscopic Ideation

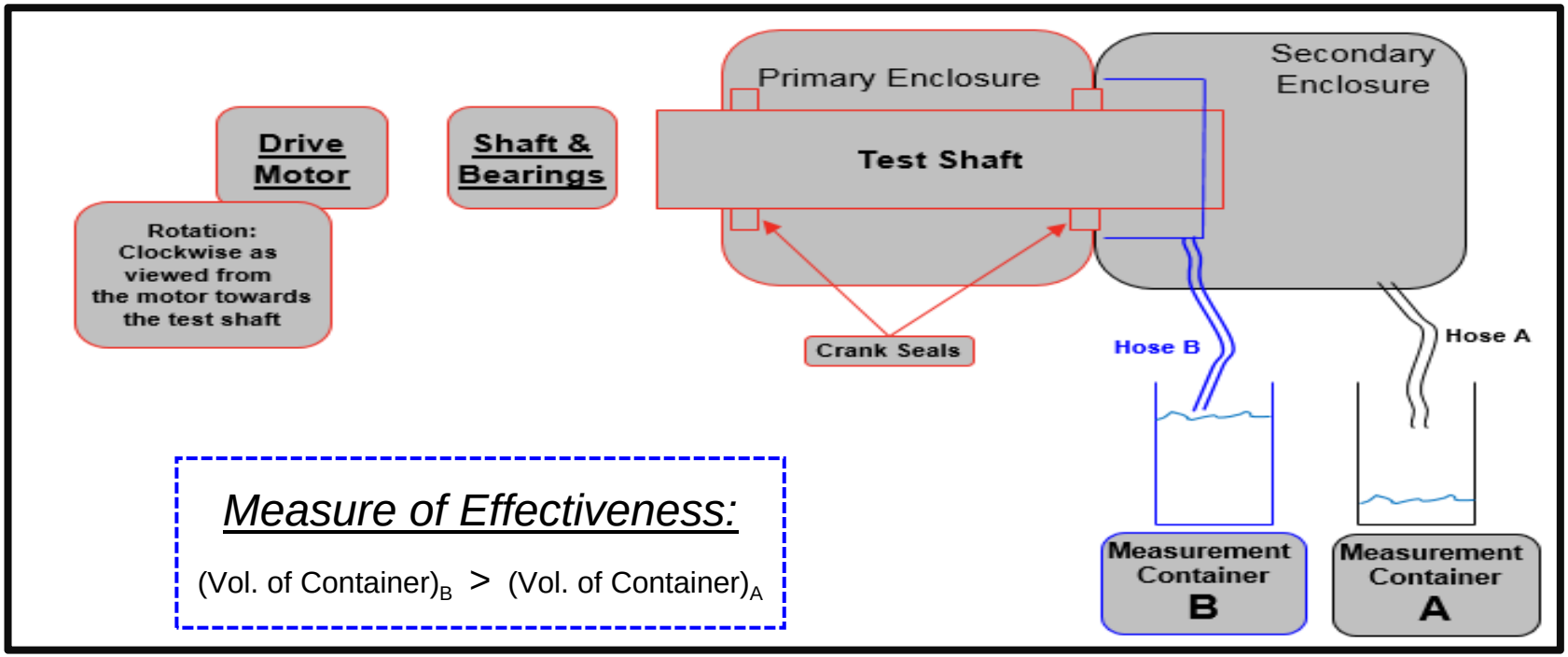
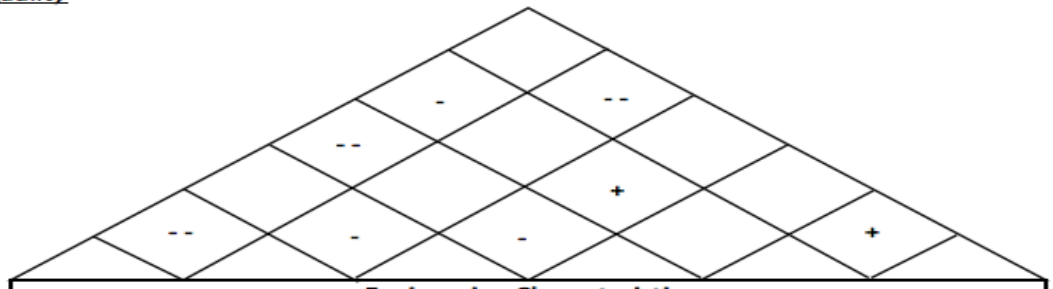


Figure 7: Concept of entire product; capture device couples to test rig.[3]

House of Quality

Super Seal: House of Quality

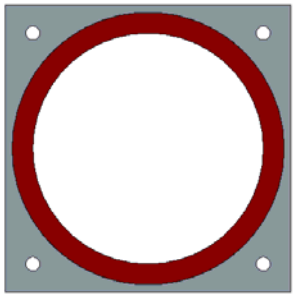
Roof Correlations	
+ +	Strong Positive
+	Positive
-	Negative
- -	Strong Negative



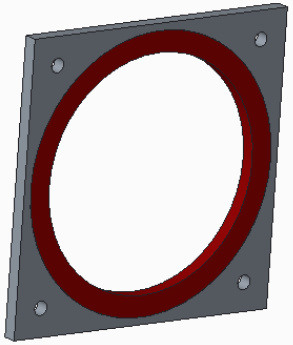
		Engineering Characteristics					
Customer Requirements	**C.I. (1-5)**	Size	Cost	Durability	Weight	Versitility	Efficiency
Device/Rig Operate Safely	5				3		1
Device Fits Size Constraint	4	5	3		3	2	3
Device Collects More Oil Than Surroundings	5	2		3		2	5
Device Operates in "Normal" Regimes	3		3	4		3	3
Design/Fabrication of Test Rig	5	3	4	2		3	
Collected Oil Can be Returned Into Engine	3	4	3	5		3	4
		1 - Low Correlation			*5 - High Correlation*		
Calculations	**Score**	57	50	52	27	51	63
	Rank	**2**	**5**	**3**	**6**	**4**	**1**

Figure 6: Super Seal House of Quality.

Initial CAD Renderings

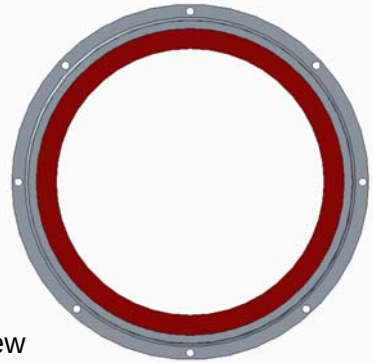


-Front view

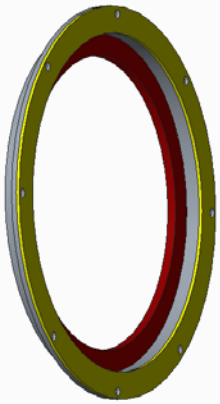


-Rear view

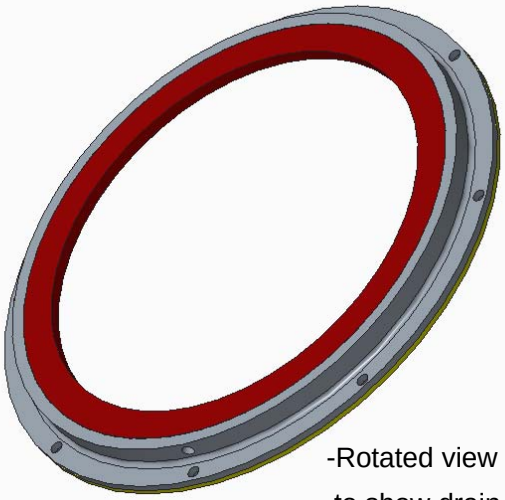
Figure 12: Device concept, version 1



-Front view



-Rear view



-Rotated view
to show drain hole

Figure 13: Device concept, version 2.

Seal Comparison

Contact Seals:

- Short lifespan.
- Limited operating speeds.
- Controlled fluid cavity isolated from environment.

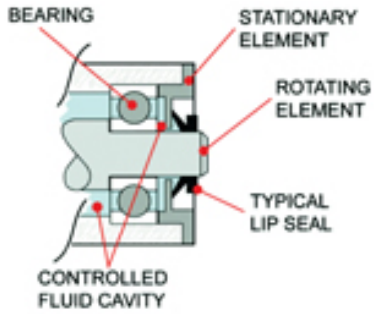


Figure 9: Illustration of a contact seal.[5]

Non-contact Seals:

- Longer lifespan when compared to contact seals.
- Operable at various speeds.
- Controlled fluid cavity is partially open to environment in some stages.

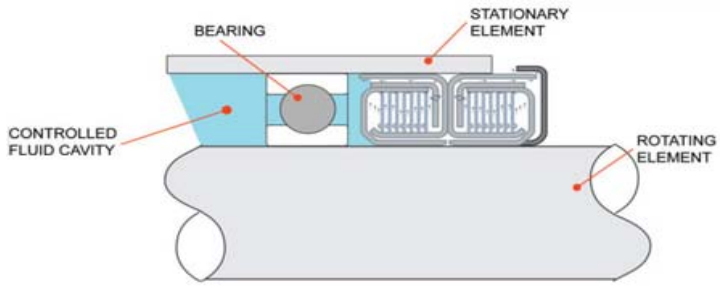


Figure 10: Illustration of a centrifugal pressure non-contact seal.[5]

Pugh Matrix

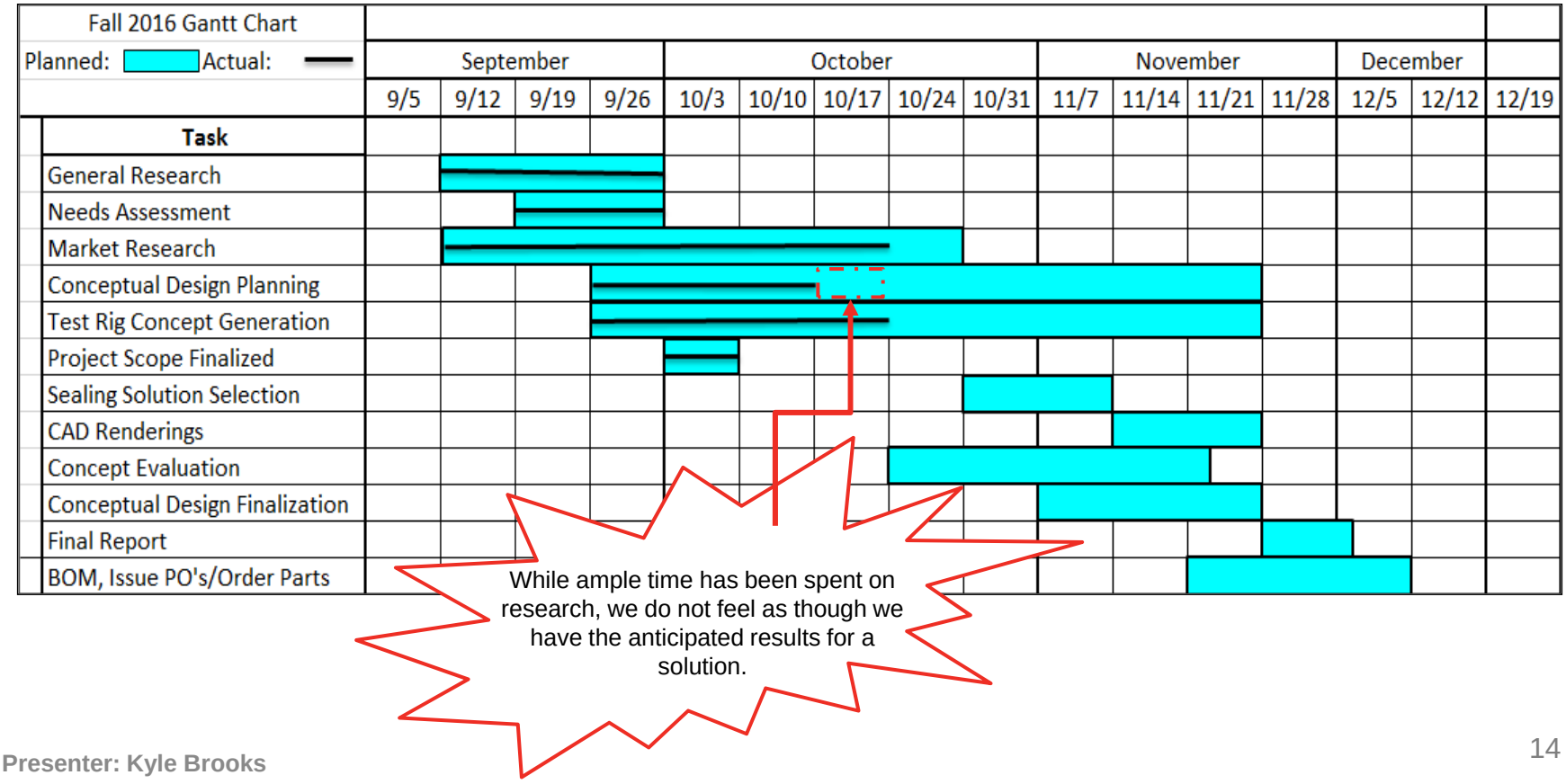
Engineering Characteristics	Sealing Options			
	Labyrinth	**Hybrid Labyrinth**	**Centrifugal Pressure Seal**	**Secondary Crankshaft Seal**
Efficiency	**1**	**2**	**2**	**1**
Durability	**1**	**2**	**2**	**0**
Size	**1**	**1**	**1**	**1**
Total	**3**	**5**	**5**	**2**

Figure 11: Pugh Matrix of different sealing options for an oil capturing device.

Challenges

- **Sealing**
  - Each sealing method explored theoretically fails some customer requirement.
  - No “1” solution.
    - Solution = Idea(A) + Idea(B) + …
- **Innovation**
  - Use of innovative design techniques/materials.
  - “Exciters” in addition to “expected”
- **Space**
  - Tight tolerances on spatial availability for device.
    - Keep in mind the customer’s customer.
- **Test Rig**
  - Design and fabrication of a viable testing platform.

Schedule


Fall 2016 Gantt Chart
Planned:
Actual:
September
October
November
December
9/5
9/12
9/19
9/26
10/3
10/10
10/17
10/24
10/31
11/7
11/14
11/21
11/28
12/5
12/12
12/19
Task
General Research
Needs Assessment
Market Research
Conceptual Design Planning
Test Rig Concept Generation
Project Scope Finalized
Sealing Solution Selection
CAD Renderings
Concept Evaluation
Conceptual Design Finalization
Final Report
BOM, Issue PO's/Order Parts
While ample time has been spent on research, we do not feel as though we have the anticipated results for a solution.

Conclusion

- **Project Goal:**
  - Develop a device to capture oil and increase overall robustness of crankshaft seal. Prove effectiveness of concept through a fabricated test rig operated at sponsor designated parameters.
- **Current Obstacles Hindering Progress:**
  - Effective seal countermeasure
  - Spatial availability
- ***What's Next?***
  - Select viable sealing option
  - Concurrently engineer test rig and secondary seal device

References

- **1.** "Symptoms of a Bad or Failing Crankshaft Seal." *Your Mechanic*. N.p., n.d. Web. 28 Sept. 2016.
- **2.** Pawlik, Bernie. "2004 Lexus RX330: Front Crankshaft Seal And Timing Belt Replacement." *2004 Lexus RX330: Crankshaft Seal, Timing Belt Replacement*. N.p., 27 Sept. 2013. Web. 19 Oct. 2016
- **3.** Shaw, Terry. *Project 1*. N.p.: Cummins Inc., n.d. PPT.
- **4.** Shaw, Terry. Cummins Technical Drawings, ISX15.
- **5.** Jun 1, 2012 Michael E. Gamache President The Carlyle Johnson Machine Co. Bolton, Conn. | Motion Sy. "Engineering a Better Noncontact Seal."*Machine Design*. N.p., n.d. Web. 19 Oct. 2016.

Questions?