Determining the Effectiveness of Oleophobic Gaskets

Midterm Presentation 1

Sponsor: Cummins Inc.

Advisor: Dr. William Oates

Instructors:

Dr. Nikhil Gupta

Dr. Chiang Shih

Team #1:

Heather Davidson
David Dawson
Aruoture Egoh
Daniel Elliott
Norris McMahon
Erik Spilling

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- Summary

Presenter: Norris McMahon

Figure 1. Nonoleophobic vs Oleophobic surface[1]

Figure 2. Typical gaskets found on an engine[2]

Background Information

- Oleophobicity is a physical property of a molecule that causes it to repelled from oil
  - Must have lower surface energy than oil
- Gaskets
  - Mechanical seal which can be created using a variety of materials and shapes
  - Placed in a space between two surface and will create a seal while under compression between the two surfaces
- Four most common gaskets types:
  - Paper
  - Molded Elastomeric (O-rings)
  - Rubber Coated Metal
  - Formed in Place Gasket

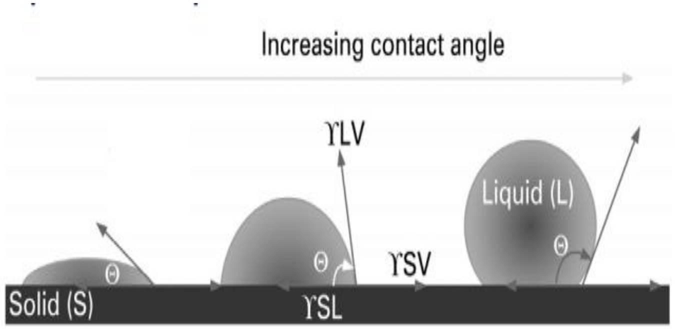


Figure 3. Increasing the contact angle will cause substance to bead up instead of lay flat[3]

Figure 4. Paper, o-ring, and a rubber coated metal gasket[4]

Project Needs and Goals

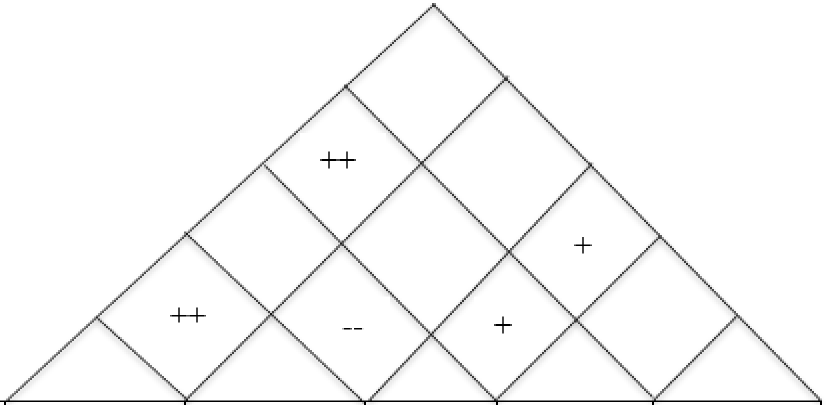
- Needs Statement:
  - Gaskets used at large joints where the oil is at low pressure leak more oil than desired.

- Goal Statement:
  - Determine the effectiveness of oleophobic gaskets through the use of a test rig designed by the team.

Objectives

Objective Number	Objective
1	Research what causes items to become oleophobic.
2	Create oleophobic gaskets using on market products.
3	Create oleophobic gaskets using non conventional gasket materials
4	Design and build the test rig to be capable of varying pressure and temperature
5	Test oleophobic gaskets and currently used gaskets for leak rate and compare results

House Of Quality



Direction of Improvement		Down	N/A	Down	N/A	Up
		Engineering Characteristics				
Customer Requirements	**Customer Importance**	Gasket Leak Rate (sccm)	Flange Surface Roughness (µm)	Project Budget ($)	Test Rig Pressure (psi)	Oil Temperature (°C)
$2,000 budget	8	Δ	Δ	•	○	○
Test various pressures	7	○		○	•	
Test various roughnesses	6	○	•	○		
Comparable performance	9	•	Δ		○	○
Test various oil temp.	7	○		○		•
Absolute Importance		225	145	192	165	165
Relative Importance		0.26	0.16	0.22	0.18	0.18
Rank Order of ECs		1	4	2	3	3

Figure 5. HOQ

++	Strong positive
+	Positive
-	Weak
--	Strong weak

•	Strong (9)
○	Medium (6)
Δ	Weak (3)

Making Oleophobic Gaskets

- Standard methods of making oleophobic surfaces
  - Coat
    - Submersing the surface in the liquid for a uniform coat on both sides
  - Spray
    - Using a sprayer such as an air brush or paint gun to use a consistent and constant applied spray
  - Impregnator solution
    - Sealer that penetrates the surface to allow for protecting from dense liquids such as oil
- Non-traditional gaskets
  - Teflon gaskets
    - Naturally has oil repellent properties
  - Coat a high density fabric or other material with an oleophobic solution to create a unique oleophobic gasket

Product Specifications

- Design Specifications:

Design Specifications	Value
Test Rig Dimensions	Inner Diameter: 55 mm
Test Rig Stress Capacity	Dependent upon analysis. Must withhold maximum pressure of 50 psi.
Flange Dimensions	Inner Diameter: 55 mm Outer Diameter: > 120 mm
Clamping Pressure	Minimum: 1 MPa (Molded Elastomer) Maximum: 20 MPa (Paper)

- Performance Specifications:
  - Measure temperature: 22-125°C ± 2°C
  - Measure pressure: 0-50 psi ± 0.1 psi
  - Simulate actual seal

Test Rig Concepts

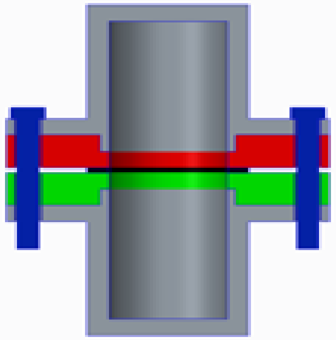
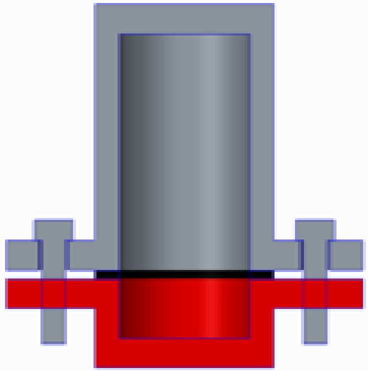
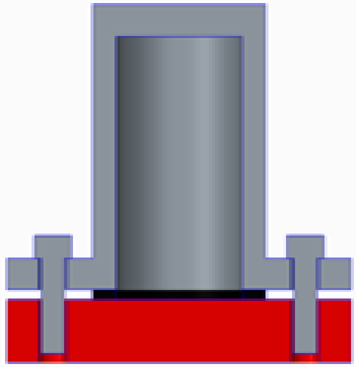
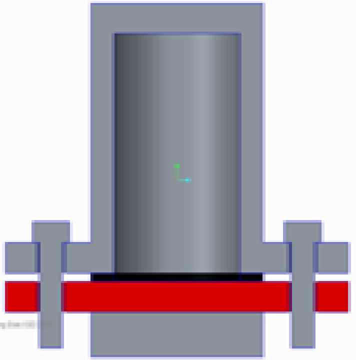
			NPT Threaded Removable Flanges			
	Weight	#1	#2	#3	#4	#5
Number of Leak Paths	0.25	0	0.3	1.3	2.0	2.0
Ease of Assembly	0.1	0	-0.3	1.0	1.3	1.0
Machinability	0.1	0	-0.7	1.3	1.7	1.7
Temperature Variation	0.2	0	0.0	0.3	0.7	1.0
Pressure Variation	0.2	0	0.0	0.0	0.3	0.7
Durability	0.1	0	-0.3	1.0	0.0	1.0
Cost	0.05	0	-0.3	1.0	1.3	1.7
Total	1	0	-0.1	0.8	1.1	1.3
Rank		4	5	3	2	1

Table 1. Pugh Decision Matrix for Test Rig Design

Final Concept

- Pressure transducer, air valve, and oil inlet valve on top surface
- RTD temperature sensor mounted to the side face
- Bottom flange (red) will the interchanged to vary surface roughness
- Four M8 bolts used to create a clamping load on the gasket

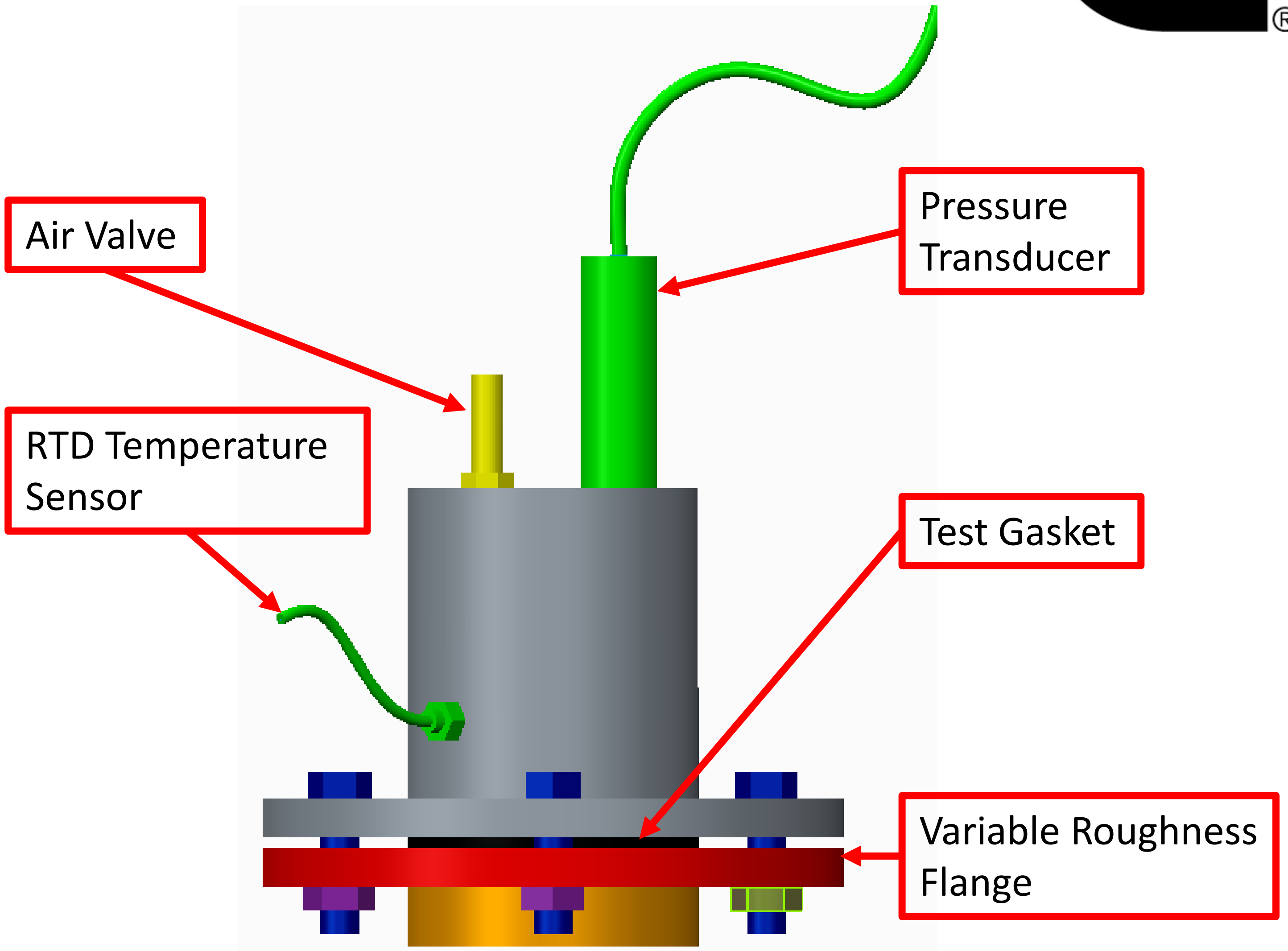


Figure 6. Final Test Rig Concept

Internal Features of Test Rig

- Gasket geometries capable of testing:
  - O-ring
  - Flat Gaskets
- RTD Sensor completely submerged in oil
- Pressure transducer open to air cavity

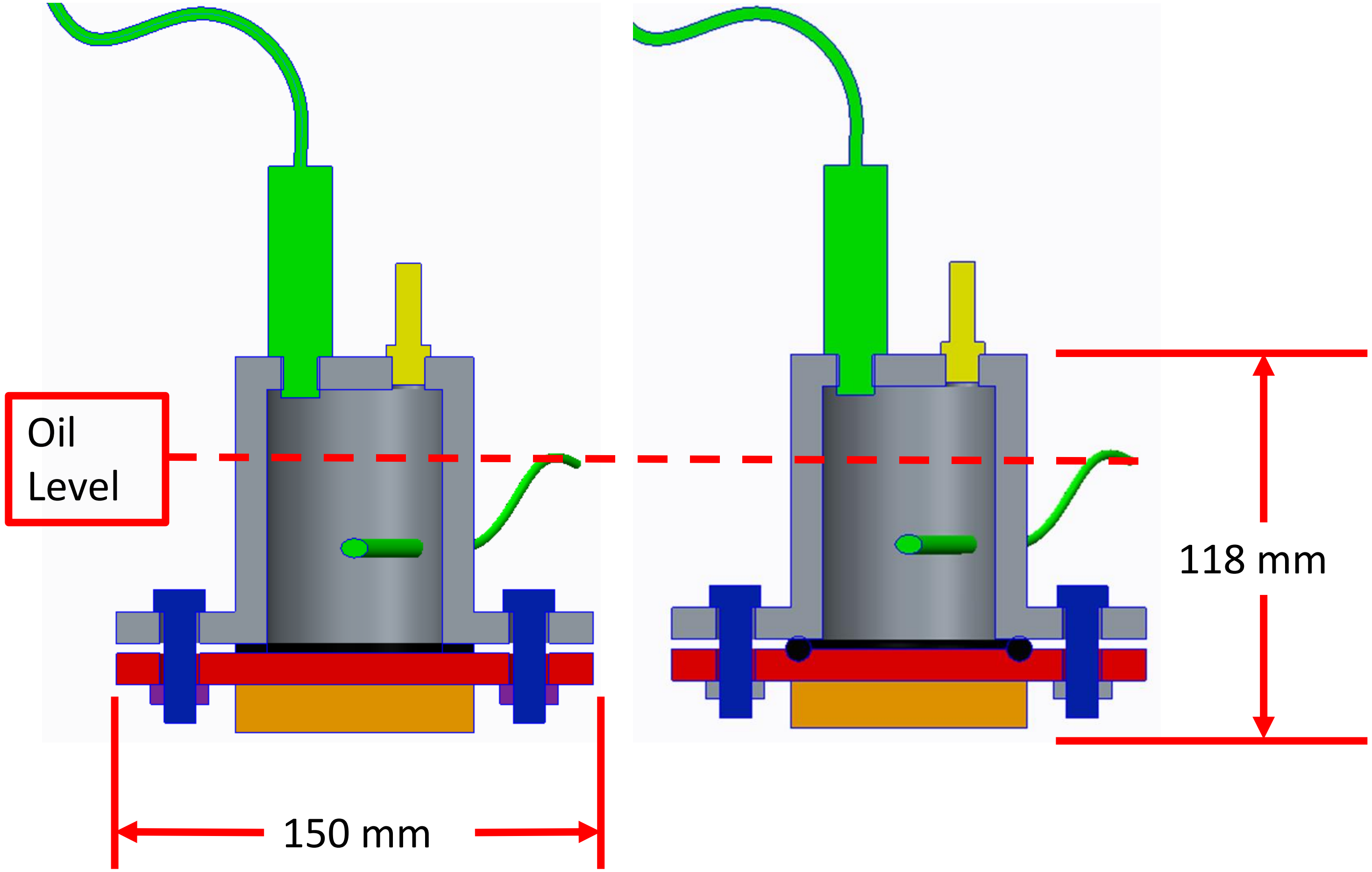


Figure 7. Comparison of Flat Gasket (left) to O-Ring Gasket (right) within Test Rig

How to Measure Leak Rate

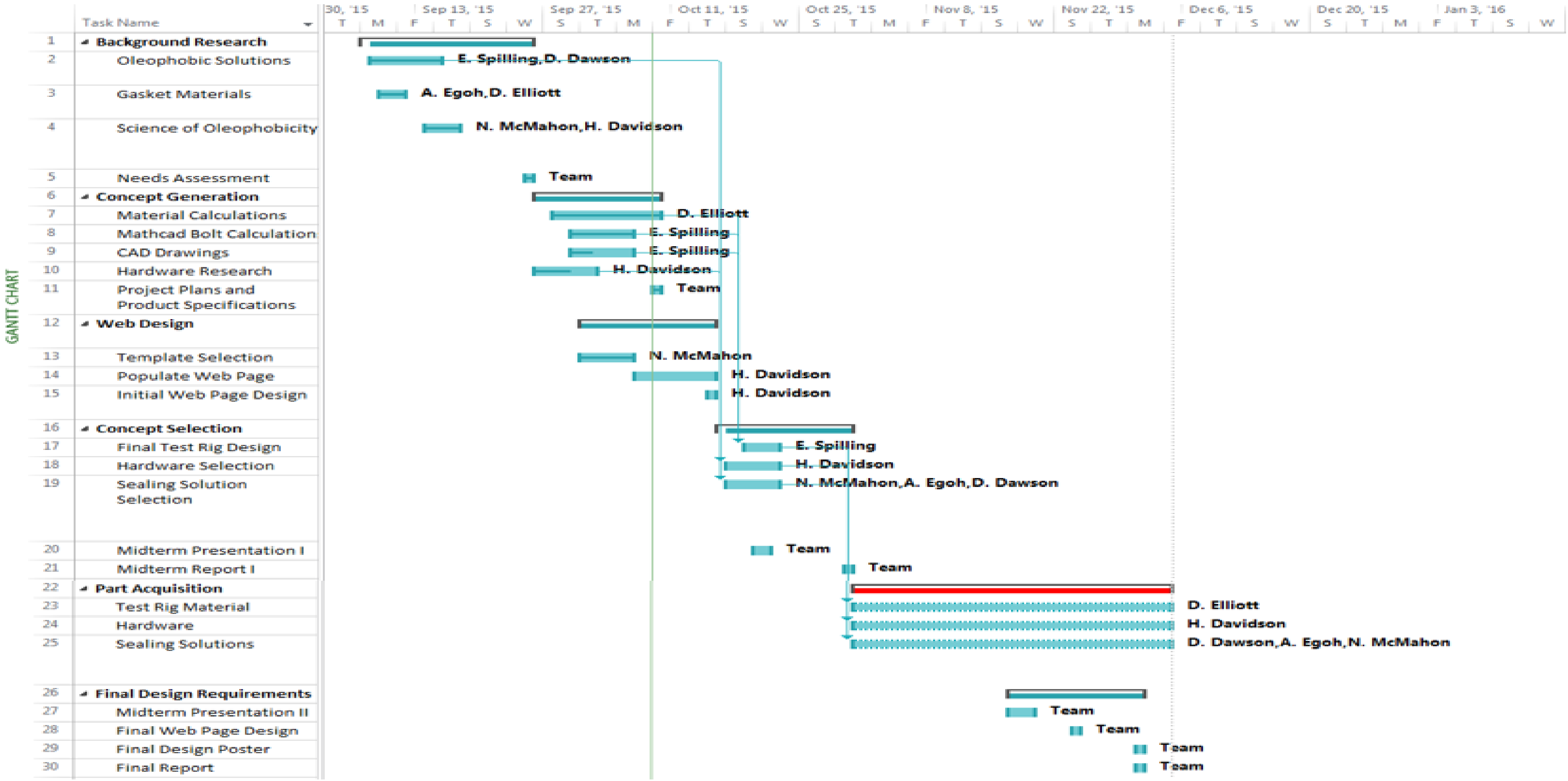
- Ideal Gas Law
  - PV = nRT
    - Knowns: initial pressure and volume of the air (oil volume is constant because oil is incompressible)
    - nRT will remain constant throughout test
    - Therefore $P_1V_1 = P_2V_2$
    - Solve for final volume V_2
    - Change in volume/time = leak rate
- Compressed air used to increase initial pressure
- Hot plate used to vary oil temperature

Figure 8. Pressure transducer[5]

Challenges

- Overcame Challenges:
  - Minimizing unwanted leak paths in design
  - Obtaining a measurable leak rate
  - Varying the surface roughness of test rig
  - Cylindrical vs Rectangular Cross Section test rig
  - Identified best heating method
  - Identified best method to inducing elevated pressure
- Anticipated Challenges:
  - Measuring the flange surface roughness
  - Obtaining gaskets of each type which are similar in shape and dimensions
  - Recently given additional objective of creating a gasket with non-traditional materials
  - Obtaining consistent bolt loads based on torque input

Projected Schedule



Future Work

- Determine test rig material
- Determine a method to create flanges with different surface roughness
- Calculate required wall thickness of test rig
- Purchase oleophobic solutions for gaskets
- Create non-conventional oleophobic gaskets
- Create detailed test rig CAD drawings
- Purchase test rig raw materials and sensors

Summary

- Goal
  - Determine the effectiveness of oleophobic gasket through the use of a designed test rig
- In order to accomplish this:
  - Design a test rig
  - Coat the gasket with an oleophobic solution
  - Vary the temperature and pressure in the test rig
  - Measure the leak rate
- Challenges
  - Varying surface roughness
  - Minimize unwanted leak path
  - Obtaining a measurable leak rate
- Key next steps:
  - Defining detailed final design
  - Purchase test rig raw materials and sensors
  - Inducing surface roughness

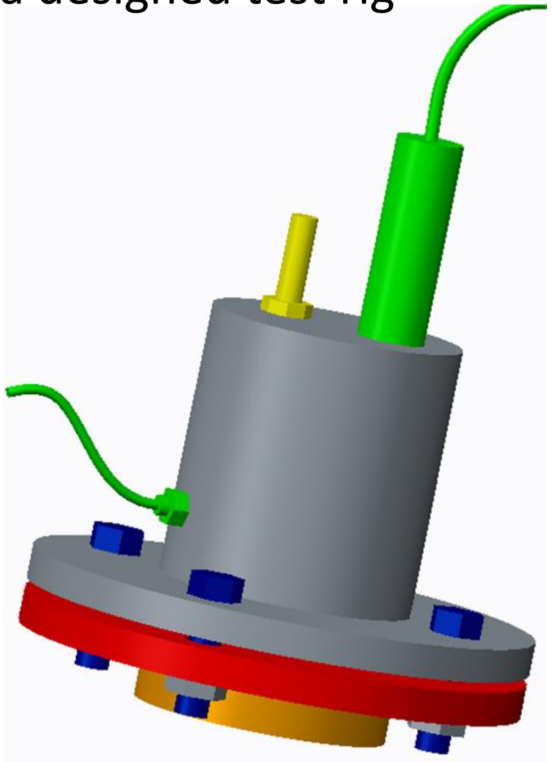


Figure 9. Selected test rig concept

Reference

[1] http://www.spigen.co.uk/galaxy-s4-screen-protector-glas-t-nano-slim-premium-tempered-glass-oleophobic-coating.html#.VifZv36rS70

[2] http://www.discountcarpartsonline.co.uk/car-parts/engine-parts.html

[3] http://www.astp.com/wp-content/uploads/2010/06/VCA-Blog-1C.jpg

[4] http://www.sjscycles.co.uk/images/products/medium/15601.jpg

[5] http://www.omega.com/pptst/PX302.html