Determining the Effectiveness of Oleophobic Gaskets

Design Review 1 Presentation

Sponsor: Cummins Inc.

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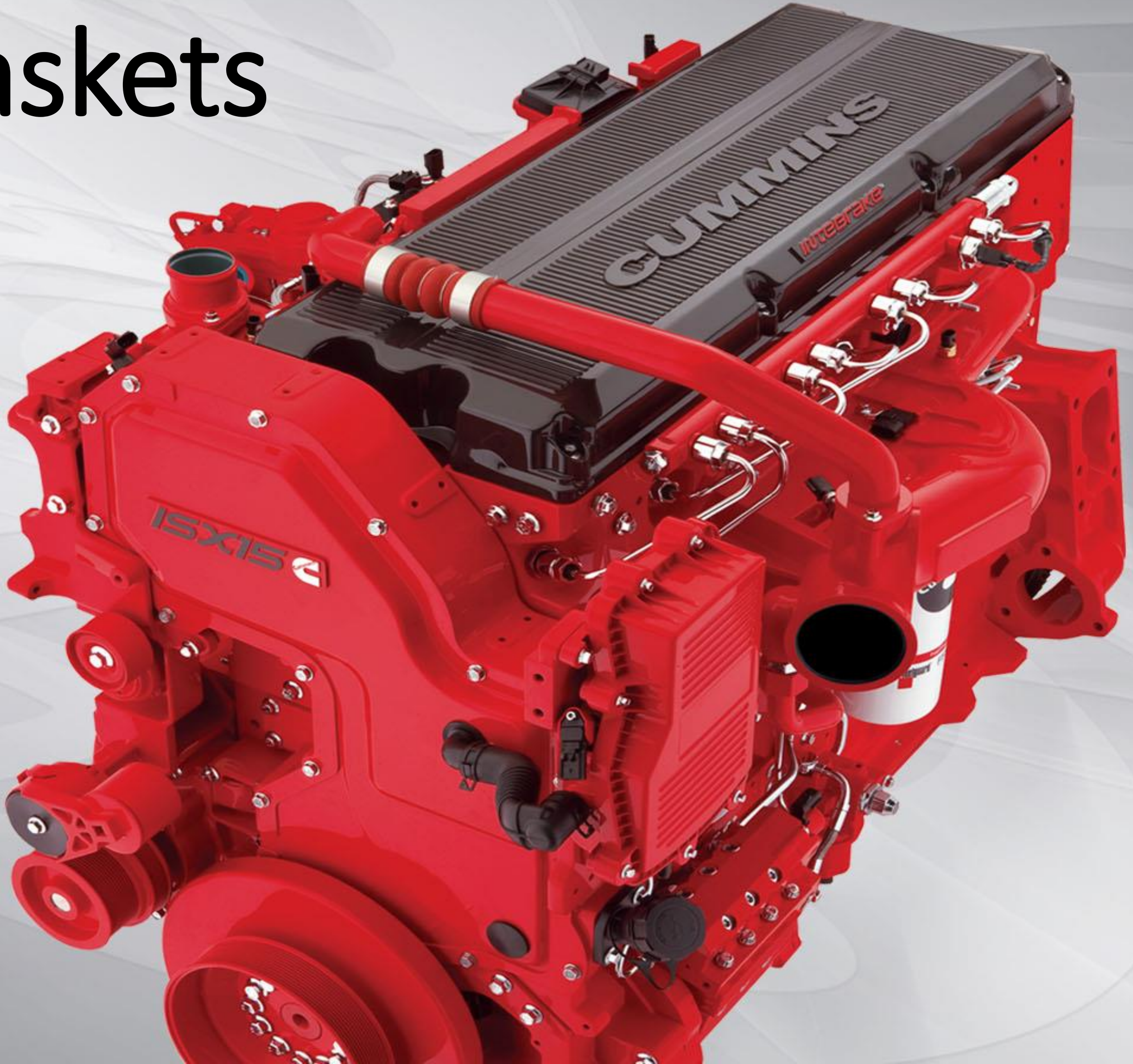
Date: 2/18/2016



Agenda

- Project Background Recap
- Test Rig Design/Fabrication
- Gasket Testing
- Experiment Preparations
- Procurement and Budget Update
- On Going Work
- Summary

Presenter: Norris McMahon

Background Information

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

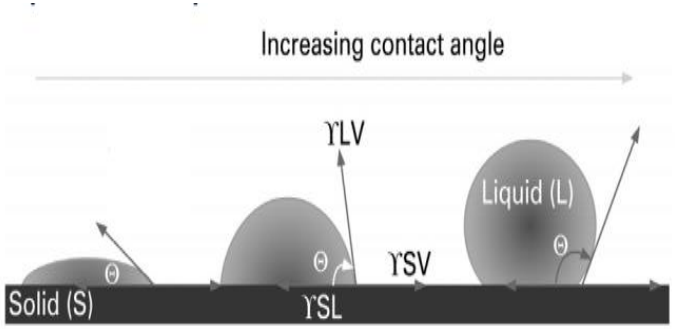


Figure 1. Substance beads up with a high contact angle[1]

Figure 2. Paper and a rubber coated metal gasket[2]

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.

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Objectives and Scope

Objective Number	Objective
1	Research what causes items to become oleophobic
2	Create oleophobic gaskets using current market products
3	Create oleophobic gaskets using non conventional gasket materials
4	Design and build the test rig to determine leak rate at different temperatures and clamping pressures at a stipulated pressure (2.5 psi)
5	Test new oleophobic gaskets and currently used gaskets for leak rate and compare results

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Test Rig Product Specifications

- Design Specifications:

Design Specifications	Value
Test Rig Dimensions	Inner Diameter: ≤ 55 mm
Test Rig Stress Capacity	Minimum of bottom flange: 4.94 mm Vessel thickness not critical as pressure difference nearly negligible.
Flange Dimensions	Inner Diameter: ≤ 55 mm Outer Diameter: > 140 mm
Clamping Pressure	Minimum: 0.5 MPa Maximum: 10 MPa

- Performance Specifications:
  - Measure temperature: 22-120°C ± 2°C
  - Measure internal pressure: 0-5 psi ± 0.01 psi
  - Simulate actual seal

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How to Measure Leak Rate

- Ideal Gas Law
  - PV = nRT
    - 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

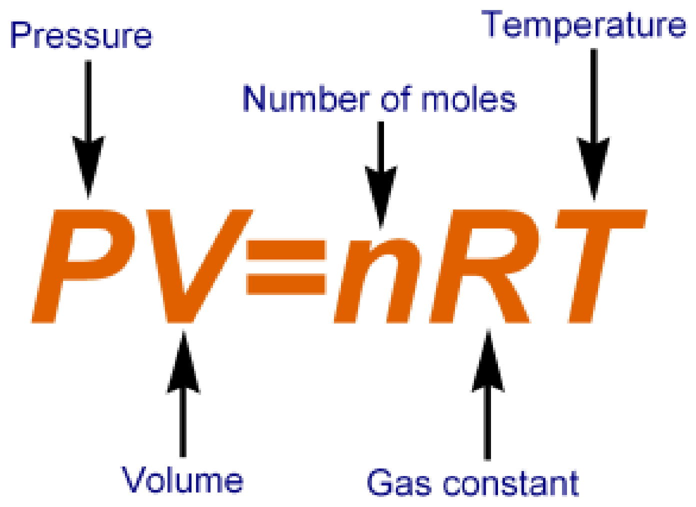

Figure 3. Ideal gas law[3]

Selected Sensors

- Omega Resistance Temperature Detector (RTD) Sensor
  - Required range: 22 – 120°C
  - Accuracy: ± 2°C
  - Length probe restriction (<55 mm)
  - Compression fitting
- Kulite Pressure Transducer
  - Required range : 0 – 5 psi
  - Accuracy: 0.005 psi
    - Used in further leak measurement calculations

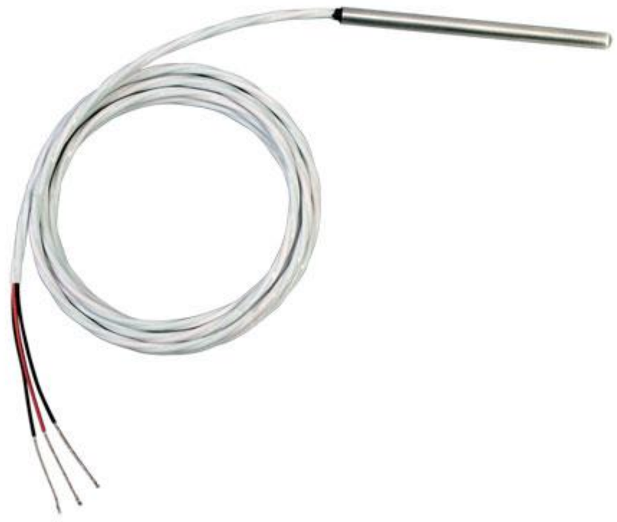

Figure 4. Short RTD probe (PR-20-2-100-3/16-2-E-T)[4]

Figure 5. Pressure Transducer (XT-123B-190-5G)[5]

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Test Rig Final Design

- Oil inlet valve and pressure relief valve on top surface
- RTD temperature sensor, pressure transducer, and air valve are mounted to the side face
- Bottom flange (red) will be interchangable
- Four M10 bolts with strain gauges used to create a clamping load on the gasket

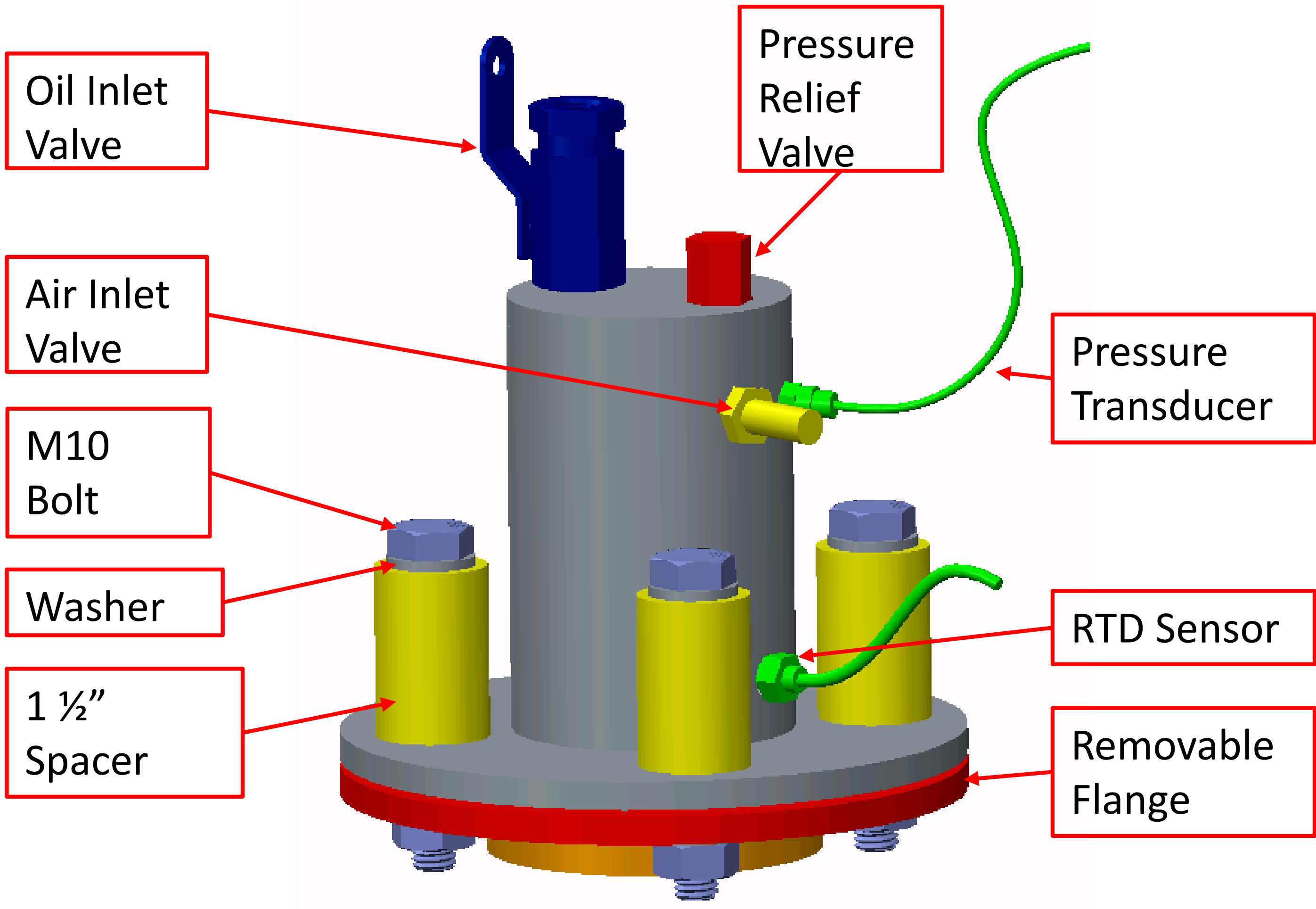

Figure 6. Final Test Rig Concept

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Internal Features of Test Rig

- RTD sensor completely submerged in oil
- Pressure transducer and air valve open to air cavity
- All material is 6.34 mm (0.25 in)

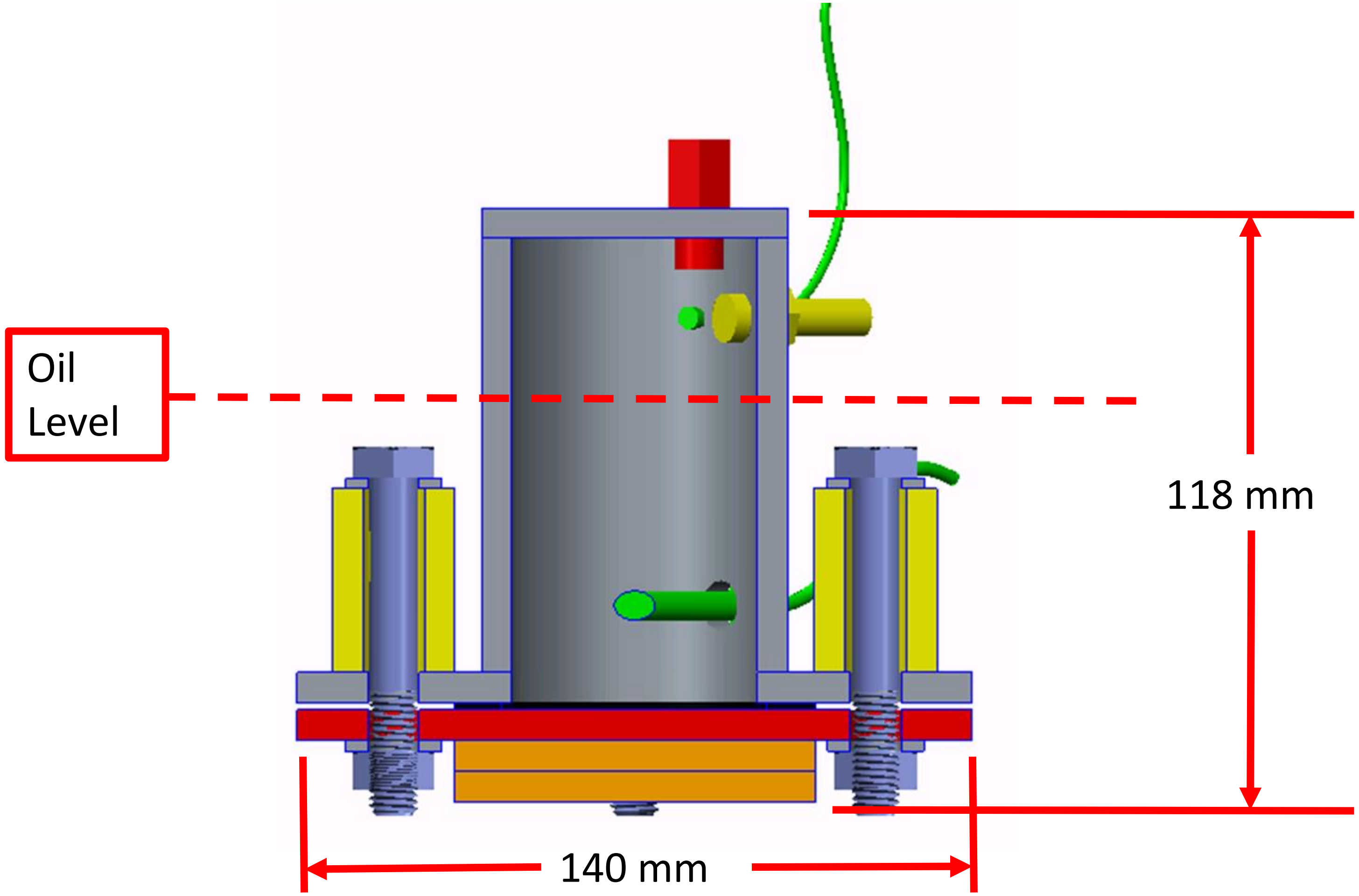

Figure 7. Internal Configuration of the Test Rig

Test Rig Mock Up

- Test rig fabrication has been completed
- All hardware has been received
- Hot plate has been acquired
- Waiting on arrival of strain gauged bolts from Cummins Inc.

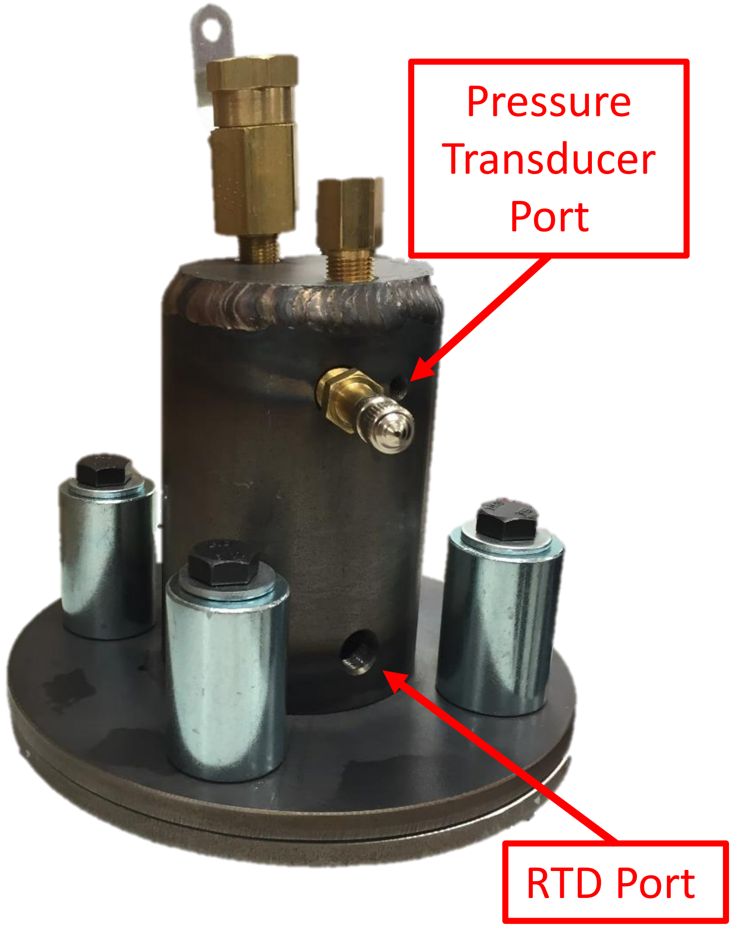

Figure 8. Test rig mock up assembly

Fabricated Components

- Test rig had to be resent to the COE Machine Shop to fix a welding issue
  - No delay in the schedule
- Cummins Inc. requires less than 3.2 microns RA
- Coherix -- ShaPix S150 Sensor
  - HPMI – Dr. Hui Wang
  - Mounted on XY gantry system
  - Creates 3-D image of surface

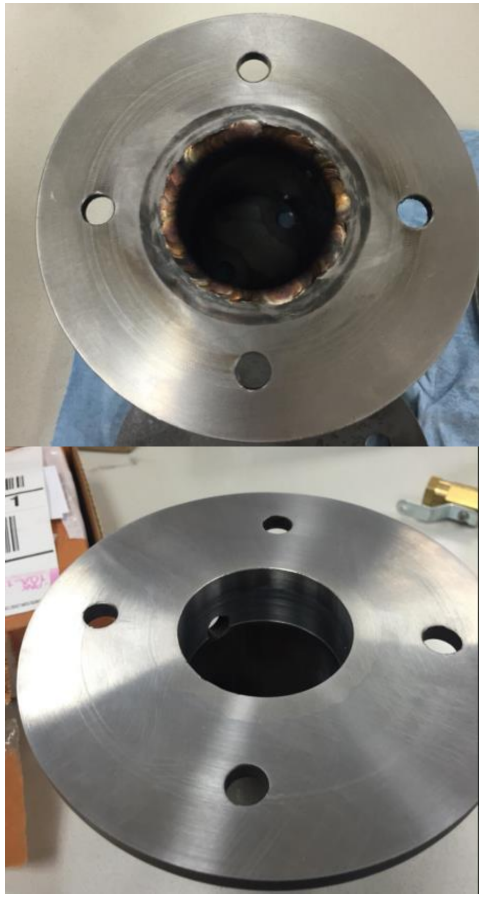

Figure 9. Fabricated top flange from the machine shop

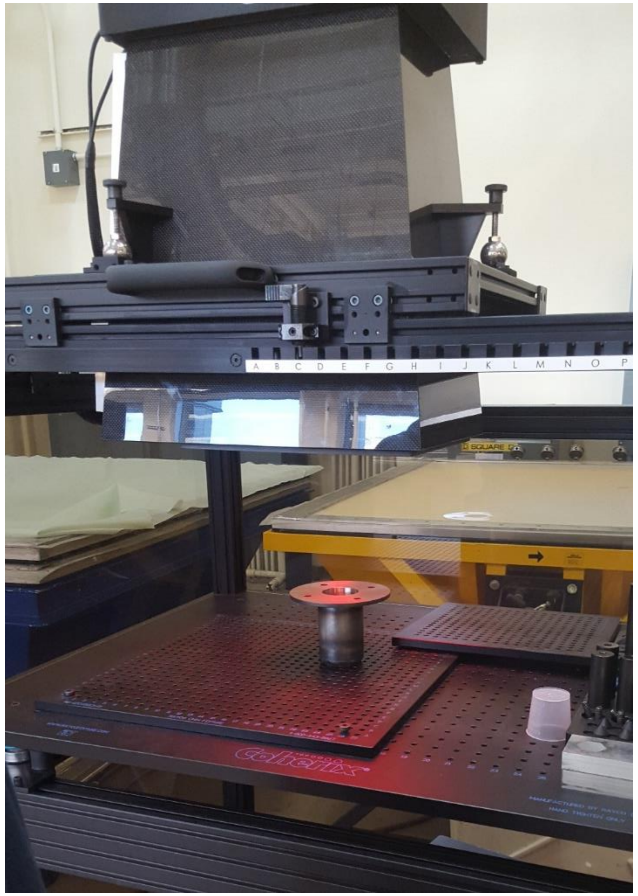

Figure 10. Surface roughness measurement of flange

Surface Roughness Results

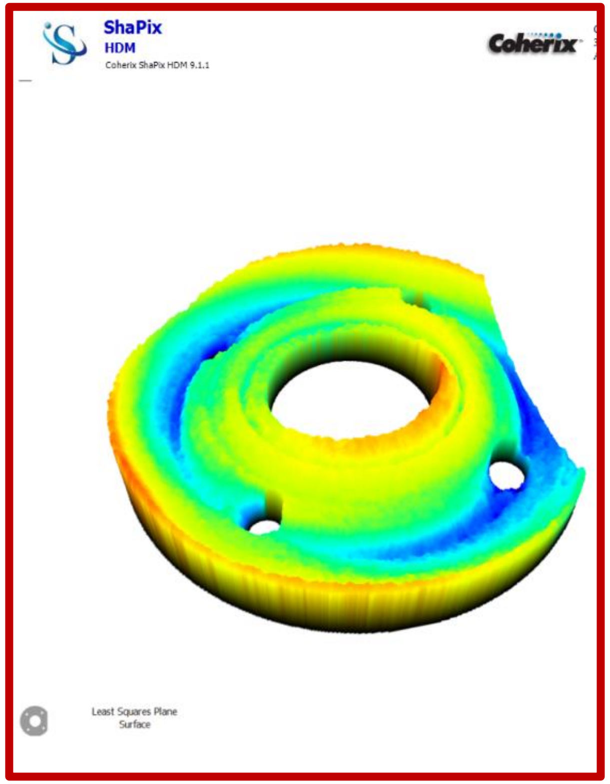

Figure 11. Welded Flange
2.9 microns RA

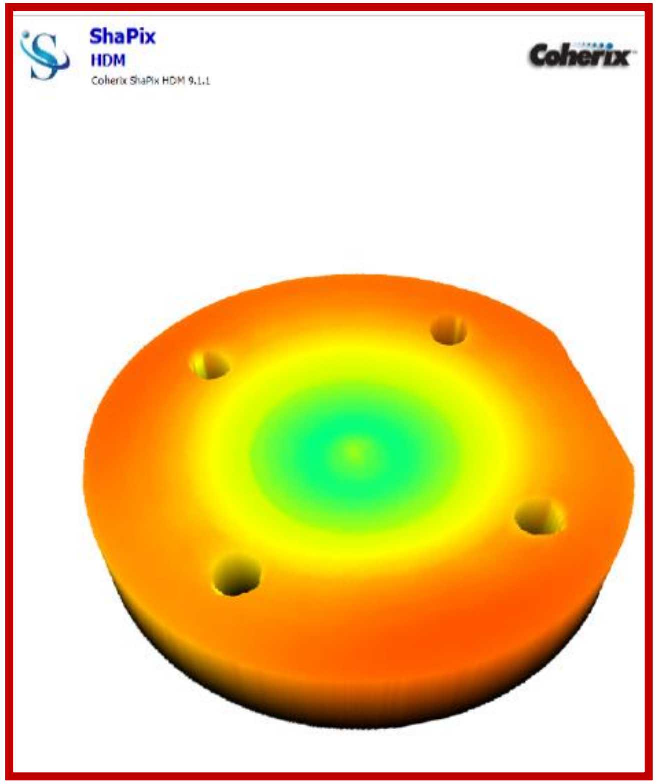

Figure 12. Bottom Flange 1
12.5 microns RA

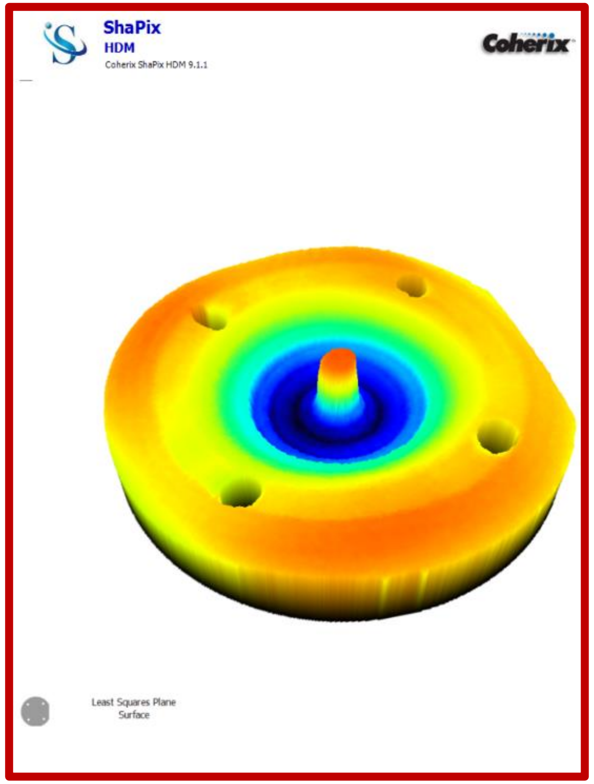

Figure 13. Bottom Flange 2
22.2 microns RA

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Making Oleophobic Gaskets

- Standard methods of making oleophobic surfaces
  - Spray
    - Using a sprayer such as an air brush or paint gun to apply a consistent and constant 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

Baseline Gasket Material Testing

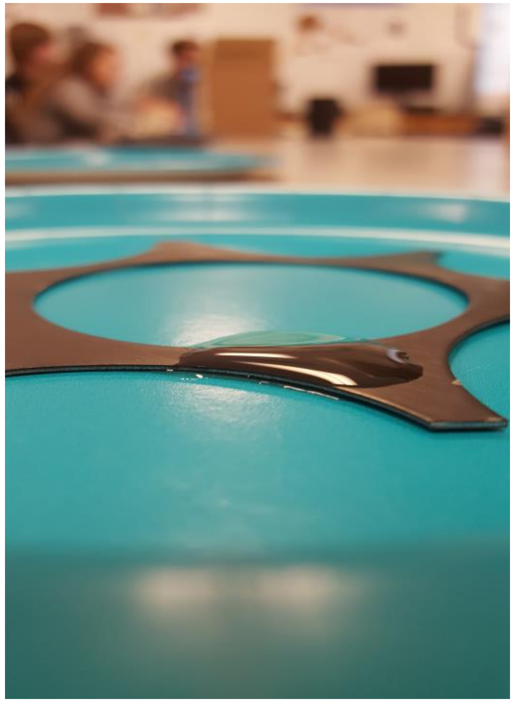


Figure 14. RCM gasket without any solution

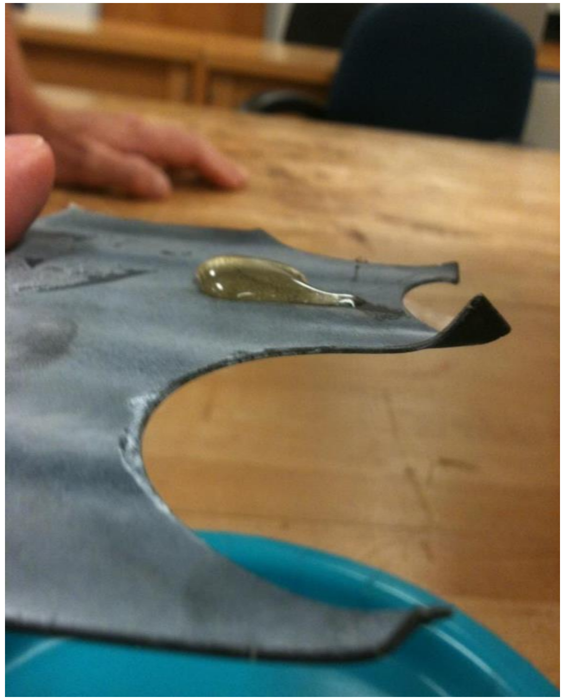


Figure 15. RCM gasket after spray and oil droplet dispersed

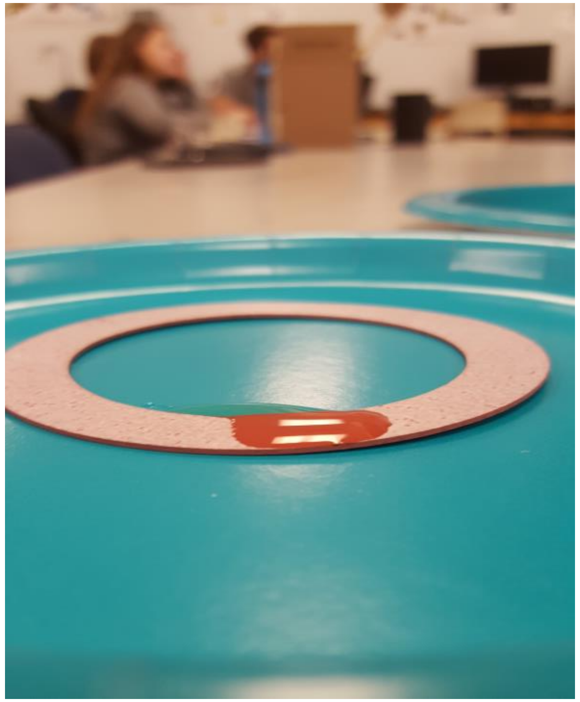


Figure 16. Paper gasket without solution

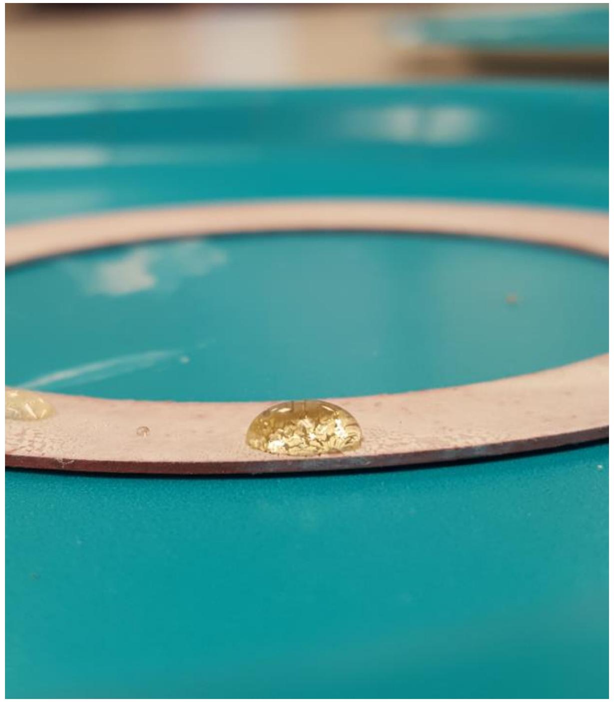


Figure 17. Paper gasket after impregnation and oil droplet dispersed

Baseline Gasket Material Testing

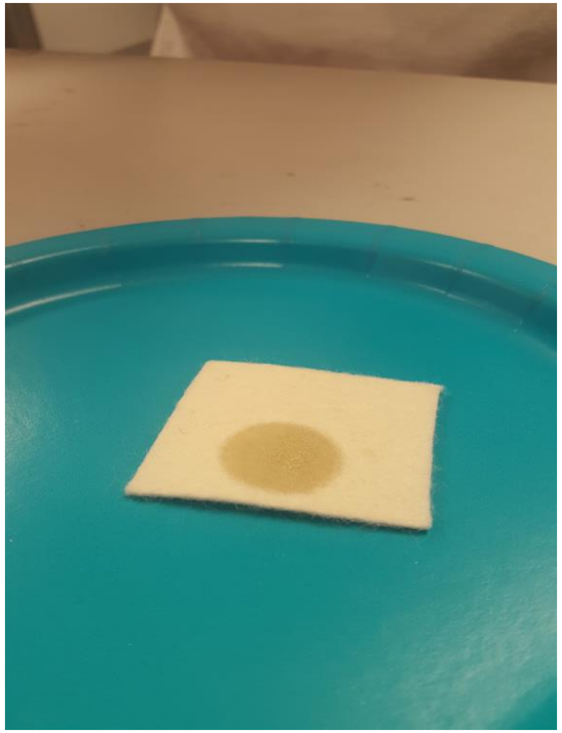


Figure 18. Top view of fiber felt without any solution

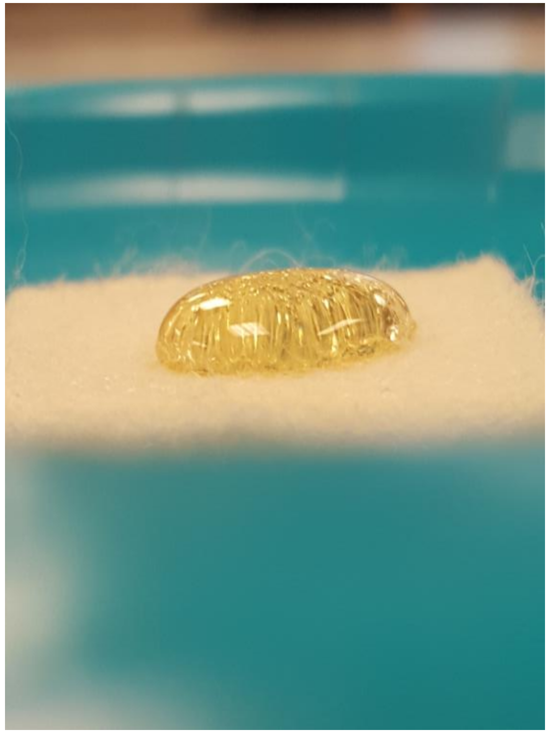


Figure 19. Fiber felt after impregnation and oil droplet dispersed

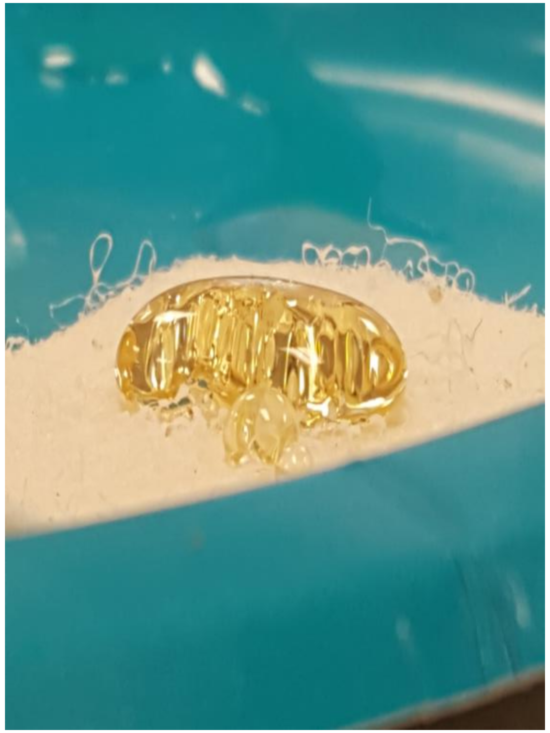


Figure 20. Fiber felt after spray application and oil droplet dispersed

Baseline Gasket Material Testing

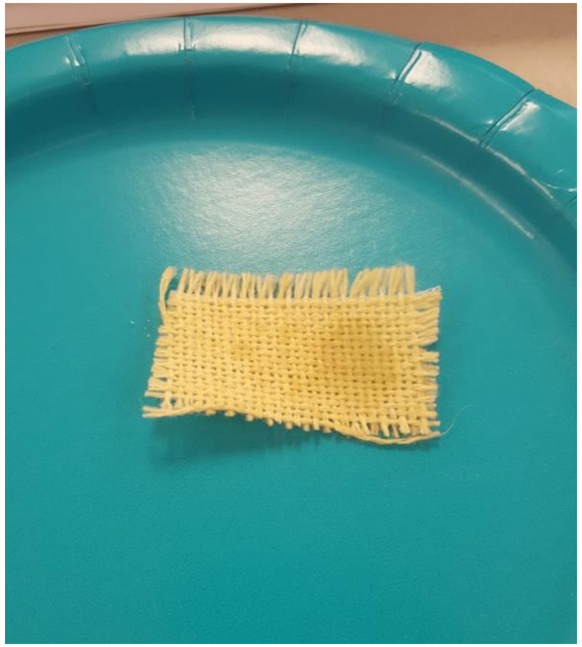


Figure 21. Top view of fiber cloth without solution

Figure 22. Fiber cloth material after impregnation and oil droplet dispersed

Figure 23. Teflon gasket with oil

Figure 24. Teflon gasket after oil removal

Presenter: Heather Davidson

Number of Experiments

Gasket Types	RCM
	Paper
	Coated RCM
	Impregnated Paper
	Felt
	Woven
	No Gasket
	Teflon
Alternative Gasket Types	Felt with other solution
	Woven with other solution
	Teflon with solution
	Paper with coat solution

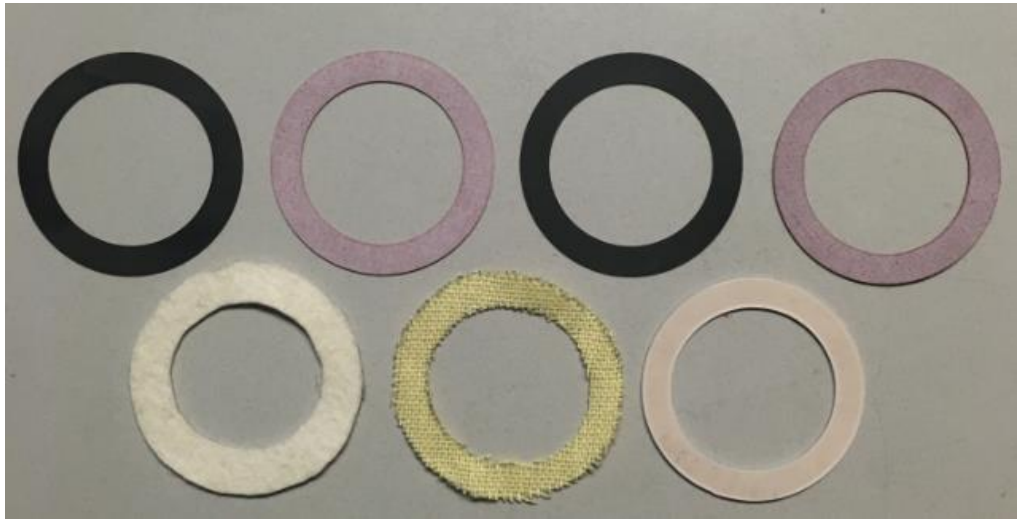


Figure 25. Gasket testing specimens

	Planned Gaskets	**With Alternative Gaskets**
Number of Gasket Types	8	12
Number of Temperatures	2	2
Number of Clamping	3	3
Total Test	48	72
Number of test with 2 trials	96	144

Clamping Load	0.5 MPa
	2 MPa
	10 MPa

Temperatures	22°C
	120°C

Testing Schedule

- Each round is composed of 8 gasket samples
- Planned Start Date: Feb. 24th
- Planned End Date: March 17th
  - Accounting for Spring Break
- Start date is dependent upon arrival of bolts from Cummins Inc.

Round	Clamping Pressure (MPa)	Bolt Load (kN)	Temperature (°C)	Est. Time (days)
1	0.5	0.255	22	1
2	0.5	0.255	120	1
3	2	1.021	22	2
4	2	1.021	120	2
5	10	5.015	22	4
6	10	5.015	120	4
			Total Days	**14**

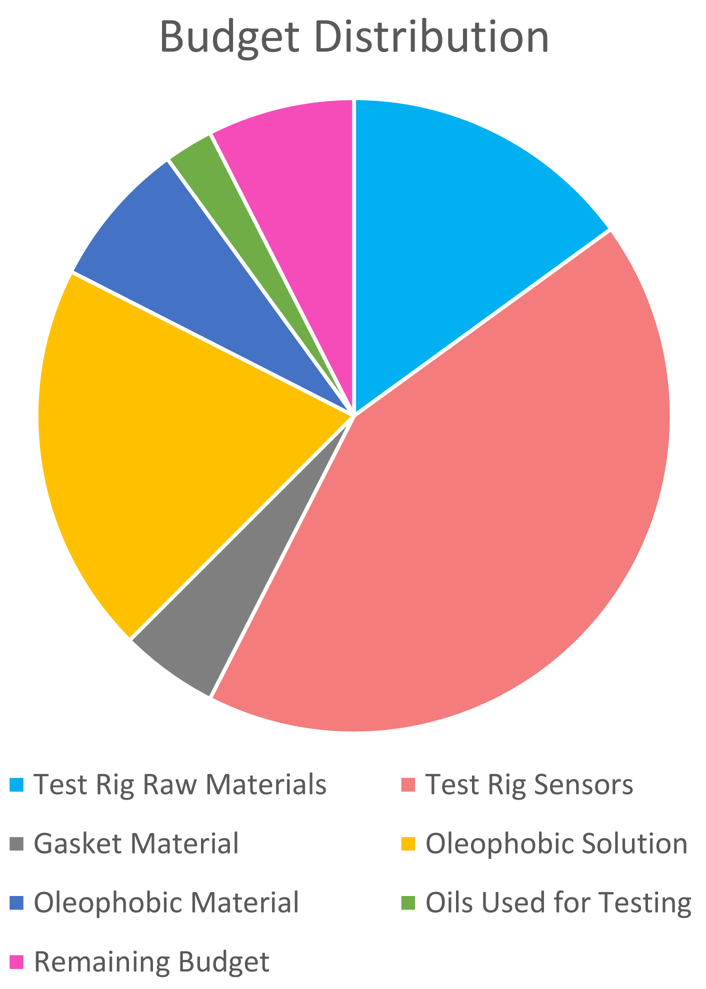
Preliminary Testing Procedure

- Rough draft of the testing procedure has been created
- Overview of Procedure:
    1. Install gaskets and hardware to test rig
    2. Tighten bolts to specified bolt load
    3. Add oil
    4. For hot oil testing, heat the system with the hot plate
    5. Pressurize the test rig to 2.5 psi using compressed air
    6. Begin collecting data on the DAQ system
    7. Upon test completion, remove internal pressure and drain remaining oil
    8. Clean the inside of the test rig

Budget Forecast

- Budget provided: $2,000
- Total estimated cost: $1,850

Item	Maximum Estimated Cost
Test Rig Raw Materials	$300.00
Test Rig Sensors	$850.00
Gasket Materials	$100.00
Oleophobic Solutions	$400.00
Oleophobic Material	$150.00
Oils Used for Testing	$50.00
Remaining Budget	$150.00

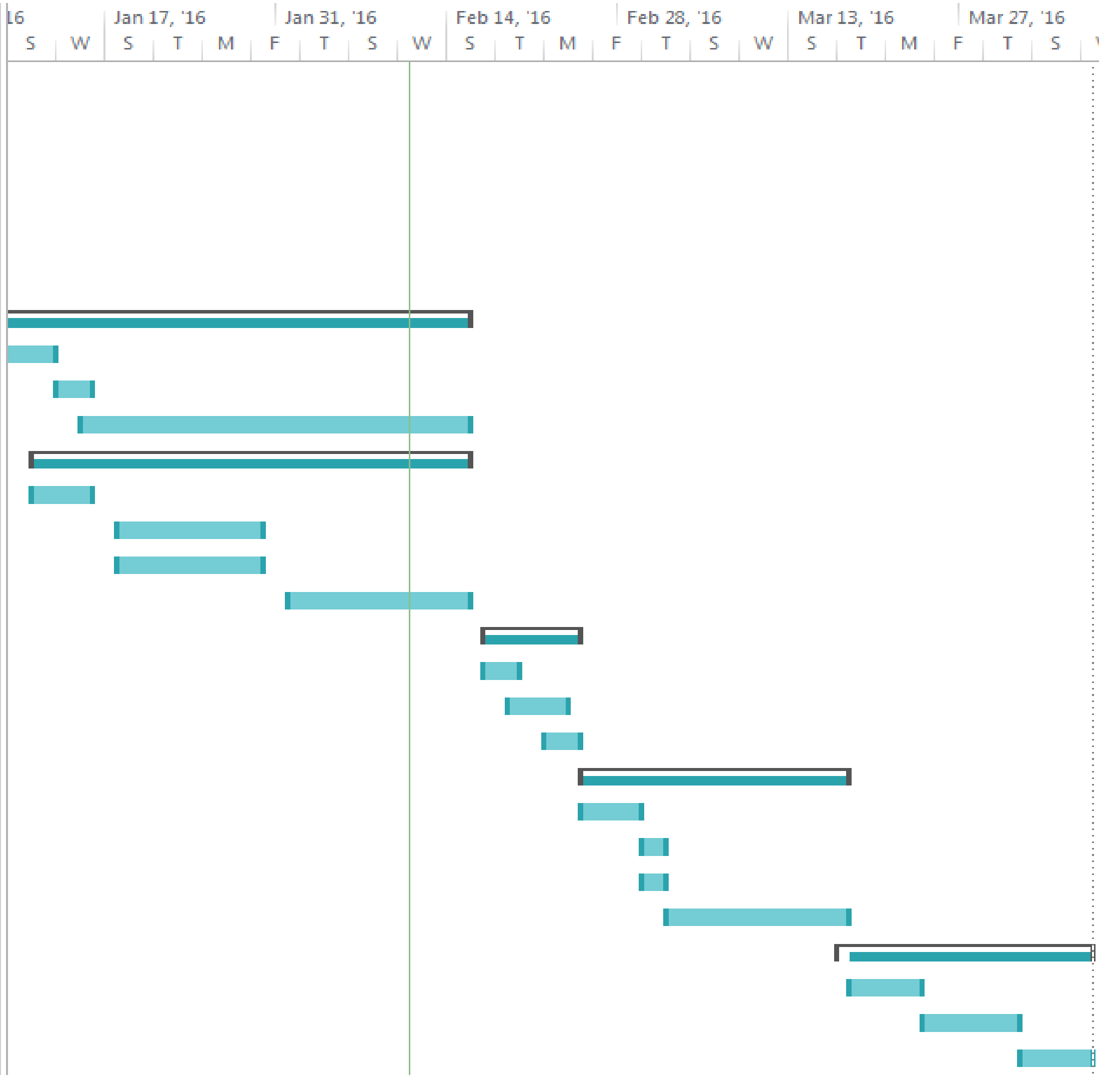


Updated Purchased Items

Budget Category	Item	Quantity	Cost
Test Rig Material	M8 Class 10.9 Cap Screw	1(Pack of 25)	$7.91
Test Rig Material	M8 General Purpose Steel Washer	1 (Pack of 100)	$6.09
Test Rig Material	M8 Class 10 Steel Nut	1 (Pack of 100)	$10.48
Test Rig Material	M10 General Purpose zinc plated steel washer	1 (Pack of 100)	$4.36
Test Rig Material	M10 Class 8 Zinc Plated Steel Hex Nut	1 (Pack of 100)	$10.48
Test Rig Material	Zinc-Plated Steel Unthreaded Spacer	4	$55.32
Test Rig Material	M10x1.5 70mm long class 8.8 cap screw	1 (Pack of 10)	$8.58
Test Rig Material	Pressure Relief Valve	1	$48.00
Test Rig Material	Compact High-Pressure Brass Ball Valve	1	$11.34
Test Rig Material	Brass Air Fill Valve Straight	1	$4.40
Test Rig Material	1ft x 1ft x ¼ in Thick A36 Steel Plate	1	$15.41
Test Rig Material	1ftLong 2-1/2 OD x 2 ID Round Steel Tube	1	$36.04
Test Rig Sensors	Short RTD Probe	1	$66.00
Test Rig Sensors	Compression Fitting	1	$20.00
Test Rig Sensor	Pressure Transducer	1	$618.00
Oleophobic Material	Teflon Gaskets	20	$170.00
Oil Used for Testing	T Triple Protection CJ-4 15W-40 Motor Oil	1 (Gallon)	$13.44
Purchased	**Total**		**$1,105.85**

Spring Projected Schedule

	Task Name	Start	Finish
1	**Background Research**	**Mon 9/7/15**	**Fri 9/25/15**
6	**Concept Generation**	**Sat 9/26/15**	**Fri 10/9/15**
12	**Web Design**	**Thu 10/1/15**	**Thu 10/15/15**
16	**Concept Selection**	**Fri 10/16/15**	**Fri 10/30/15**
22	**Fall Semester Part Acquisition**	**Sat 10/31/15**	**Fri 12/4/15**
26	**Final Design Requirements**	**Tue 11/17/15**	**Tue 12/1/15**
31	**Test Rig Fabrication**	**Mon 11/2/15**	**Mon 2/15/16**
32	Create CAD drawings	Mon 11/2/15	Tue 1/12/16
33	Submit CAD drawings	Wed 1/13/16	Fri 1/15/16
34	Obtain machined test rig	Fri 1/15/16	Mon 2/15/16
35	**Final Gasket Preparation**	**Mon 1/11/16**	**Mon 2/15/16**
36	Cut out nontraditional gaskets	Mon 1/11/16	Fri 1/15/16
37	Apply spray sealing solution	Mon 1/18/16	Fri 1/29/16
38	Apply impregnator solution	Mon 1/18/16	Fri 1/29/16
39	Gasket quality control check	Mon 2/1/16	Mon 2/15/16
40	**Test Rig Assembly**	**Wed 2/17/16**	**Wed 2/24/16**
41	Install hardware/electronics	Wed 2/17/16	Fri 2/19/16
42	Set up heating component	Fri 2/19/16	Tue 2/23/16
43	Set up wire configuration	Mon 2/22/16	Wed 2/24/16
44	**Experimentation**	**Thu 2/25/16**	**Thu 3/17/16**
45	Set up experimentation area	Thu 2/25/16	Mon 2/29/16
46	Implement saftey precautions	Tue 3/1/16	Wed 3/2/16
47	Establish DAQ system	Tue 3/1/16	Wed 3/2/16
48	Run experiment	Thu 3/3/16	Thu 3/17/16
49	**Analysis**	**Thu 3/17/16**	**Wed 4/6/16**
50	Organize recorded data	Fri 3/18/16	Wed 3/23/16
51	Analyze trends	Thu 3/24/16	Thu 3/31/16
52	Draw conclusions	Fri 4/1/16	Wed 4/6/16



Future Work

- Resolve surface roughness issue
- Setting up the lab for experimentation
- Collection, manipulation and analysis of data
- Final experimental comparison/deduction

Summary

- Goal:
  - Determine the effectiveness of oleophobic gaskets through the use of a designed test rig
- Completed Tasks:
  - Fabrication of test rig
  - Initial surface roughness measurement
  - Creation of oleophobic gaskets
  - Experimental procedure/schedule
- Key next steps:
  - Assemble the test rig with the strain gauge bolts
  - Perform experiments

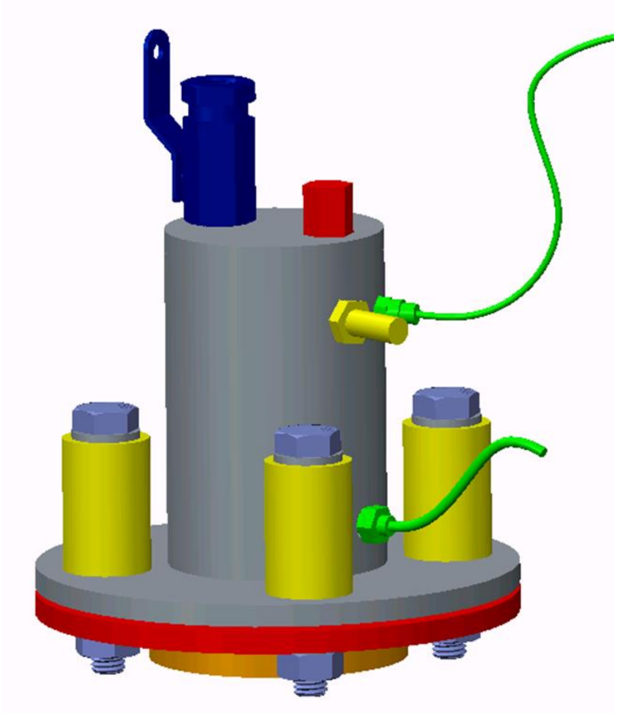


Figure 26. Test Rig Design

Presenter: Aruoture Egoh

References

[1]http://pubs.rsc.org/en/content/articlehtml/2014/cs/c3cs60415b

[2]http://store.jamesgaskets.com/product_info.php?products_id=742&osCsid=4s6r9tgqtdt3s1tfi5q7puf9t2

[3] http://www.calctool.org/CALC/chem/c_thermo/ideal_gas

[4]http://www.omega.com/pptst/PR-20.html

[5]http://www.kulite.com/products.asp?p=4-1