MET 335

Module 3 – Measurement of Viscosity

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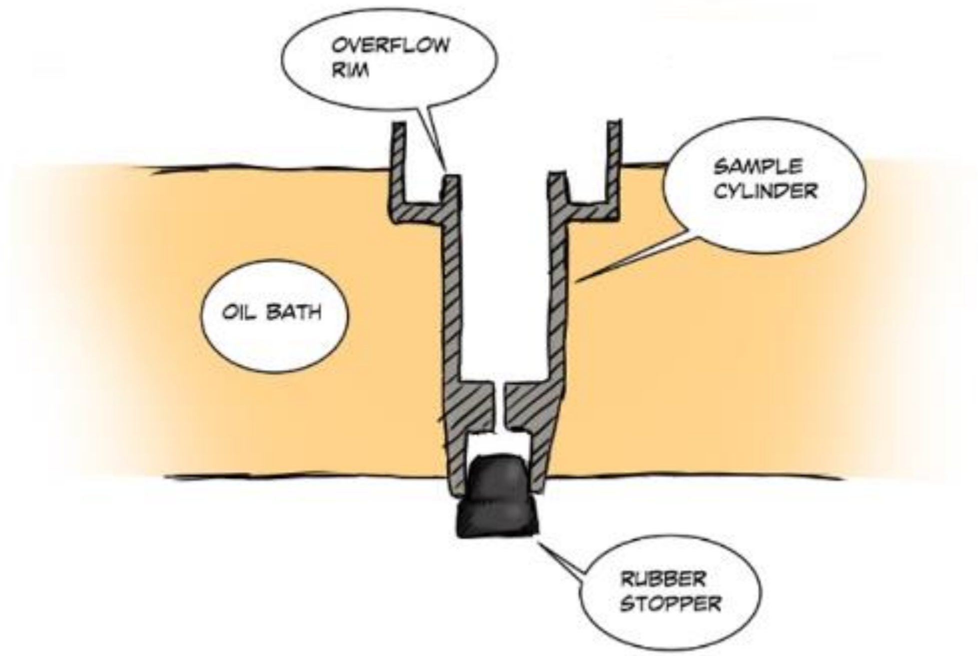
Purpose, Theory, and Procedure

1. **Experiment Title**
    a. Measurement of Viscosity
2. **Purpose**
    a. The purpose of this lab is to understand how to use the Saybolt method of viscosity testing as well as how temperature effects viscosity for oils. Students will learn about the ASTM Standard D-88 and will take samples to be tested and placed inside a machined container. Once samples are placed, the students will then set a temperature for the oil bath to then pour 60 mL of the oil through a 0.1795" diameter orifice. Doing just this is called the Saybolt Universal Viscosity. The student will calculate the viscosity of each oil with increasing temperature and then graph the fluid viscosity versus the temperature for each oil on the same graph. Finally, the student will discuss the curves of the graph, compare the viscosities of the two oils, and then discuss any sources of error.
3. **Theoretical Considerations**
    a. Theoretical considerations to take notice of are the temperature as which we choose to put the oil bath. Another consideration is the timer we choose to use when counting the time that it takes for the 60 mL of oil to fill the orifice. Lastly, a consideration students will want to account for is the type of oil they are using since there are many types such as 5W-30 or 10W-30.

4. **Drawing or Sketch**



a. *Figure 2 - Oil Bath and Container Details*

b. *Figure 3 - Temperature Controls*

c. Figure 2 shows the Oil Bath and Container Details

d. Figure 3 shows the Temperature Controls

5. **Verbal Description**

   a. The student will use a 60mL glass flask that is placed under one of two containers. Each of these containers have a cork stopper made of rubber or other material. A thermometer is then placed inside the container to verify the temperature of the oil that is to be tested. The student has the capability to control certain variables of the machine such as time and temperature. These controls are situated under the platform on which the two containers are placed. Temperature values are set in Celsius. The student will pour the oil into a carefully machined container that is inside an oil bath. This oil bath will then heat up to the required temperature setting. Once the temperature has been achieved, the student will then time how long it takes that same oil to pour out of the carefully machined container that has a 0.1795” diameter opening into the 60mL flask.

6. Step-by-Step Procedure

1. Identified the components used for the lab
    i. Oil Bath
    ii. Oil Bath Thermostat
    iii. Thermometers
    iv. Oil Bottles
        1. Oil Bottle 1 = (20W-50)
        2. Oil Bottle 2 = (5W-30)
    v. Vial Section
    vi. Vials
    vii. Stoppers
    viii. Cylinders
2. Turned on the power for the viscosity unit
3. Turned on the light for the viscosity unit
4. Prepared to add oil from bottle 1, black bottle 20W-50
5. Lifted back left cylinder cap
6. Prepared to add oil from bottle 2, green bottle 5W-30
7. Lifted back right cylinder cap
8. Poured 20W-50 oil into back left cylinder
9. Poured 5W-30 oil into back right cylinder
10. Prepared to record temperature of the 20W-50 sample
11. Placed thermometer in back left cylinder
12. Prepared to record temperature of the 5W-30 sample
13. Placed thermometer in back left cylinder
14. Determined the oil bath temperature for first test case (35°C)
15. Increased temperature button until setting was 35°C
16. Waited 15 minutes for oil bath to reach 35°C temperature setting
17. Recorded 20W-50 oil temperature at 32°C
18. Unplugged stopper for 20W-50 oil
19. Observed dripping oil into back left vial to 60mL
20. Recorded the time needed for 20W-50 oil at 32°C to fill a 60mL vial (621 seconds)

21. Recorded 5W-30 oil temperature at 32°C
22. Unplugged stopper for 5W-30 oil
23. Observed dripping oil into back right vial to 60mL
24. Recorded the time needed for 5W-30 oil at 32°C to fill a 60mL vial (368 seconds)
25. Prepared to pour both samples of oil back into the oil bath cylinders
26. Released the stopper to block both the left and right cylinder drains
27. Poured 20W-50 oil back into back left cylinder
28. Poured 5W-30 oil back into back right cylinder
29. Placed 20W-30 vial back into vial station
30. Placed 5W-30 vial back into vial station
31. Determined the oil bath temperature for first test case (60°C)
32. Increased temperature button until setting was 60°C
33. Waited 15 minutes for oil bath to reach 60°C temperature setting
34. Recorded 20W-50 oil temperature at 54°C
35. Unplugged stopper for 20W-50 oil
36. Observed dripping oil into back left vial to 60mL
37. Recorded the time needed for 20W-50 oil at 54°C to fill a 60mL vial (280 seconds)
38. Recorded 5W-30 oil temperature at 55°C
39. Unplugged stopper for 5W-30 oil
40. Observed dripping oil into back right vial to 60mL
41. Recorded the time needed for 5W-30 oil at 55°C to fill a 60mL vial (252 seconds)
42. Prepared to pour both samples of oil back into the oil bath cylinders
43. Released the stopper to block both the left and right cylinder drains
44. Poured 20W-50 oil back into back left cylinder
45. Poured 5W-30 oil back into back right cylinder
46. Placed 20W-30 vial back into vial station
47. Placed 5W-30 vial back into vial station
48. Determined the oil bath temperature for first test case (80°C)
49. Increased temperature button until setting was 80°C
50. Waited 15 minutes for oil bath to reach 80°C temperature setting
51. Recorded 20W-50 oil temperature at 78°C
52. Unplugged stopper for 20W-50 oil
53. Observed dripping oil into back left vial to 60mL
54. Recorded the time needed for 20W-50 oil at 78°C to fill a 60mL vial (125 seconds)
55. Recorded 5W-30 oil temperature at 79°C
56. Unplugged stopper for 5W-30 oil
57. Observed dripping oil into back right vial to 60mL

58. Recorded the time needed for 5W-30 oil at 79°C to fill a 60mL vial (80 seconds)
59. Prepared to pour both samples of oil back into the oil bath cylinders
60. Released the stopper to block both the left and right cylinder drains
61. Poured 20W-50 oil back into back left cylinder
62. Poured 5W-30 oil back into back right cylinder
63. Placed 20W-30 vial back into vial station
64. Placed 5W-30 vial back into vial station
65. Determined the oil bath temperature for first test case (110°C)
66. Increased temperature button until setting was 110°C
67. Waited 15 minutes for oil bath to reach 110°C temperature setting
68. Recorded 20W-50 oil temperature at 105°C
69. Unplugged stopper for 20W-50 oil
70. Observed dripping oil into back left vial to 60mL
71. Recorded the time needed for 20W-50 oil at 105°C to fill a 60mL vial (68 seconds)
72. Recorded 5W-30 oil temperature at 104°C
73. Unplugged stopper for 5W-30 oil
74. Observed dripping oil into back right vial to 60mL
75. Recorded the time needed for 5W-30 oil at 104°C to fill a 60mL vial (55 seconds)
76. Prepared to pour both samples of oil back into the oil bath cylinders
77. Released the stopper to block both the left and right cylinder drains
78. Poured 20W-50 oil back into back left cylinder
79. Poured 5W-30 oil back into back right cylinder
80. Placed 20W-30 vial back into vial station
81. Placed 5W-30 vial back into vial station
82. Determined the oil bath temperature for first test case (130°C)
83. Increased temperature button until setting was 130°C
84. Waited 15 minutes for oil bath to reach 130°C temperature setting
85. Recorded 20W-50 oil temperature at 126°C
86. Unplugged stopper for 20W-50 oil
87. Observed dripping oil into back left vial to 60mL
88. Recorded the time needed for 20W-50 oil at 126°C to fill a 60mL vial (52 seconds)
89. Recorded 5W-30 oil temperature at 125°C
90. Unplugged stopper for 5W-30 oil
91. Observed dripping oil into back right vial to 60mL
92. Recorded the time needed for 5W-30 oil at 125°C to fill a 60mL vial (45 seconds)
93. Prepared to pour both samples of oil back into the oil bath cylinders

94. Released the stopper to block both the left and right cylinder drains
95. Poured 20W-50 oil back into back left cylinder
96. Poured 5W-30 oil back into back right cylinder
97. Placed 20W-30 vial back into vial station
98. Placed 5W-30 vial back into vial station
99. Completed lab and recorded all necessary data

Recorded Data Table(s)

Oil Number 1 Description: 20W-50, black bottle		
Temperature Setting	Temperature (°C)	Time (seconds)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Oil Number 2 Description: 5W-30, green bottle		
Temperature Setting	Temperature (°C)	Time (seconds)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Sample Calculations

For times greater than 100 seconds, where SSU stands for time in seconds for oil to reach 60 milliliters.

$$v = (2.33 * 10^{-6})(SSU)$$

$$v = (2.33 * 10^{-6})(280) = \boxed{0.000652 \frac{ft^2}{s}}$$

For times less than 100 seconds, where SSU stands for time in seconds for oil to reach 60 milliliters.

$$v = [(0.226 * SSU) - \frac{195}{SSU}](10.76 * 10^{-6})$$

$$v = [(0.226 * 55) - \frac{195}{55}](10.76 * 10^{-6}) = \boxed{0.000096 \frac{ft^2}{s}}$$

Calculated Data Table(s)

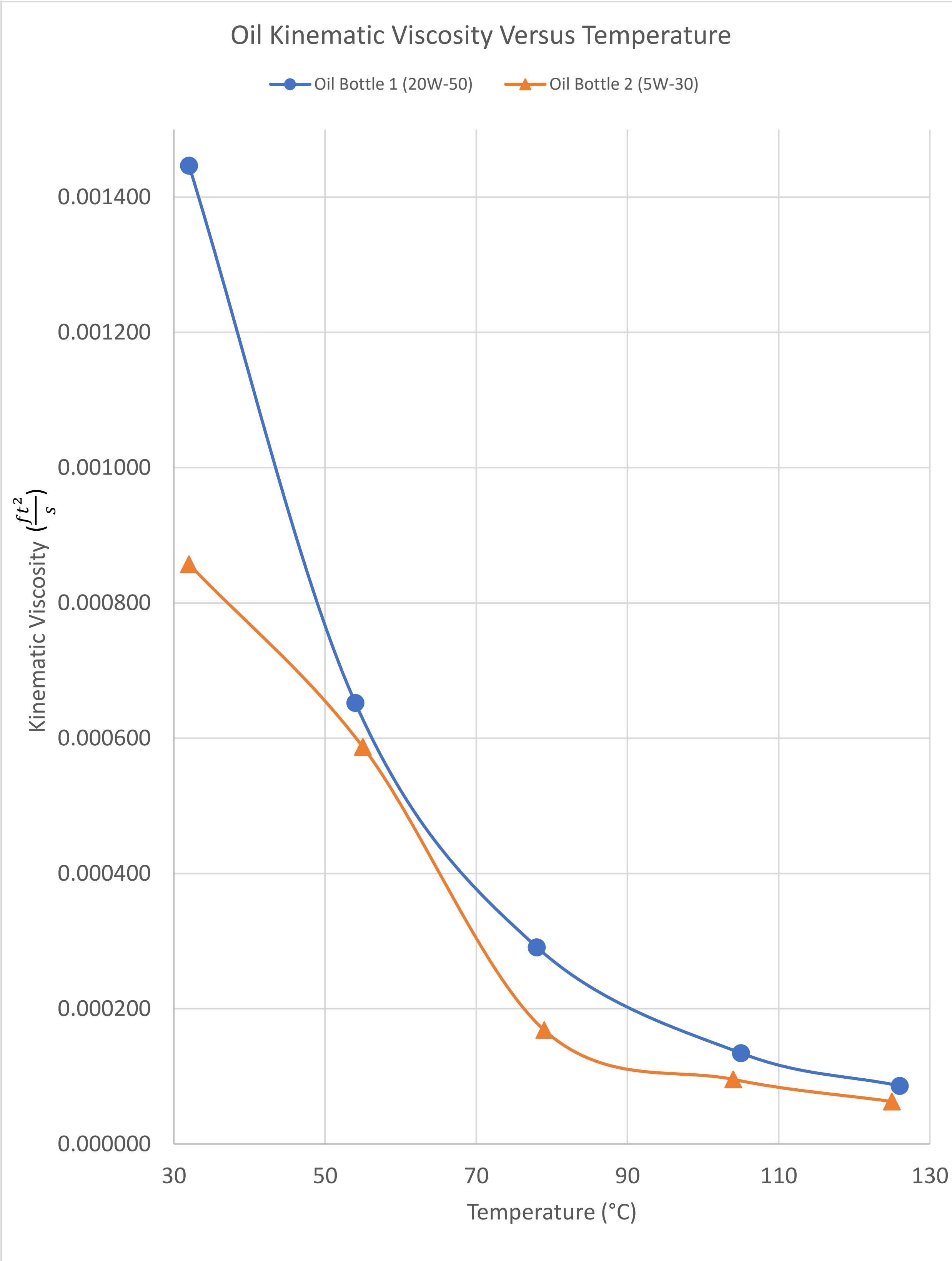
Oil Number 1 Description: 20W-50, black bottle		
Temperature Setting	Temperature (°C)	Time (seconds)
1	32	621
2	54	280
3	78	125
4	105	68
5	126	52

Oil Number 1 Description: 20W-50, black bottle		
Temperature Setting	Kinematic Viscosity v $\frac{ft^2}{s}$	Kinematic Viscosity Formula
1	0.001447	*(=(2.33*(10^-6))*(621))*
2	0.000652	*(=(2.33*(10^-6))*(280))*
3	0.000291	*(=(2.33*(10^-6))*(125))*
4	0.000135	*(=((0.226*68)-(195/68))*(10.76*(10^-6)))*
5	0.000086	*(=((0.226*52)-(195/52))*(10.76*(10^-6)))*

Oil Number 2 Description: 5W-30, green bottle		
Temperature Setting	Temperature (°C)	Time (seconds)
1	32	368
2	55	252
3	79	80
4	104	55
5	125	45

Oil Number 2 Description: 5W-30, green bottle		
Temperature Setting	Kinematic Viscosity v $\frac{ft^2}{s}$	Kinematic Viscosity Formula
1	0.000857	*(=(2.33*(10^-6))*(368))*
2	0.000587	*(=(2.33*(10^-6))*(252))*
3	0.000168	*(=((0.226*80)-(195/80))*(10.76*(10^-6)))*
4	0.000096	*(=((0.226*55)-(195/55))*(10.76*(10^-6)))*
5	0.000063	*(=((0.226*45)-(195/45))*(10.76*(10^-6)))*

Graph(s)



Oil Kinematic Viscosity Versus Temperature
Oil Bottle 1 (20W-50)
Oil Bottle 2 (5W-30)
Kinematic Viscosity $\left(\frac{ft^2}{s}\right)$
0.001400
0.001200
0.001000
0.000800
0.000600
0.000400
0.000200
0.000000
30
50
70
90
110
130
Temperature (°C)

Discussion of Results and Conclusions

The above graph shows the kinematic viscosity ($\frac{ft^2}{s}$) on the coordinate *versus the temperature reading (°C) on the abscissa for two different oils. The first oil being 20W-50 and the second oil being 5W-30. On the graph above, the 20W-50 oil is the blue curve with circular points and the 5W-30 oil is the orange curve with the triangular points.*

The 20W-50 oil has a much more "cleaner" curve, almost the opposite of exponential like, than the 5W-30 oil. What this portrays in my opinion, is that the 20W-50 oil has a much higher viscosity than the 5W-30 oil at lower temperatures. I say that because when the temperature gets higher (above 90 degrees Celsius), the difference in values for both oils is within 0.0004 ($\frac{ft^2}{s}$).

The other thing that I see when looking at the curves is that the temperature was only the same in each oil once out of the five settings (20%). The temperatures themselves were also not equivalent to the setting that was chosen. An example of this would be that we chose 130°C for the last setting but the oils only reached 126°C and 125°C respectively. So those few degree differences could portray into some variance into the final calculation for the kinematic viscosity.

There were a few sources of error that could affect the values that were calculated above. First, are we dealing with fresh oil or are we dealing with used oil. The warming up and cooling down of the oils could affect the viscosity over time. Secondly, as mentioned briefly above, the temperatures of the oils never reached the actual setting on the machine. This brins up an opportunity where the machine may not be calibrated and isn't reading the setting properly. A slight variance in temperature correlates to variance in the kinematic viscosity. Lastly, a source of error could be the timing as this alone is used in the kinematic viscosity equation. While it may be easy to hit the start/stop button on a stopwatch, it's extremely hard to stop it exactly when the vial hit 60mL. An apparatus could be built to automatically time it when a switch hit 60mL, but hopefully you understand what I'm trying to get at. In the same line as the time source of error, it would be hard for a user to say stop when the vial hit 60mL exactly. So, it could be a little lower than 60mL or a little higher than 60mL and then that messes with the equation to find the kinematic viscosity as well. Overall, the lab is in good hands because the graphing curves show a similar path (minus one point for 5W-30). This was a fun one!