MET 335W

Measurement of Viscosity

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Experiment Title: Measurement of Viscosity

Purpose

1. To learn about the Saybolt method of viscosity testing.
2. Use the Saybolt Viscometer to compare the viscosity of two motor oils, 20w50 and 5w30, at increasing temperatures.
3. Calculate kinematic viscosity for the two oils.
4. Create a graph indicating how the two oils react at different temperatures, with kinematic viscosity as the ordinate and temperature as the abscissa.
5. Describe the effects of temperature on viscosity for oils.

Theoretical Considerations:

1. Viscosity decreases with increasing temperature for liquids while it increases with increasing temperature for gases.
2. The Standard Saybolt Universal Viscosity (SSU) is the unit describing the time in seconds that it takes for 60 mL of sample to pass through a 0.1795-inch diameter orifice.
3. Due to the viscosity of oils decreasing so drastically at temperatures of 200 °F or 93.3 °C, there are specific calculations for kinematic viscosities above 100 seconds and below 100 seconds.

Description of Apparatus:

1. Universal Saybolt Viscometer
   -Consists of a thermostatically controlled oil bath with stirrer motor
   -Two cylinders contained in the bath for the samples to warm
   -Two catch vessels to capture the samples as they drop from the cylinder bottom
   -Control Panel with a power switch, light, thermostat reading of bath, and gauge to dial the desired temperature

Step-by-Step Procedure:

1. The rocker switch that supplies power to the viscosity unit was switched on.
2. The rocker switch that controls the light in the vial section inside the unit was switched on to illuminate the bay.
3. The 2 glass vials were placed under each rear cylinder in the vial section of the unit.
4. The left rear cylinder cap on top of the unit was removed in preparation to add 20W-50 motor oil.
5. The right rear cylinder cap on top of the unit was removed in preparation to add 5W-30 motor oil.
6. The bottle containing 20W-50 motor oil was poured into the left rear cylinder on top of the viscosity unit.
7. The bottle containing 5W-30 motor oil was poured into the right rear cylinder on top of the viscosity unit.

8. One of the thermometers was placed into the left rear cylinder in preparation to measure the temperature of the 20W-50 oil sample.
9. The second thermometer was placed into the right rear cylinder in preparation to measure the temperature of the 5W-30 oil sample.
10. Using the arrow buttons located to the right of the lower digital scale of the thermostat control panel, the oil bath temperature was adjusted to 35°C.
11. A time period of 15 minutes was allowed to give time for the oil bath to reach 35°C.
12. The temperature reading indicated on the left thermometer in the 20W-50 oil sample was observed and recorded on the data sheet.
13. The stopper located on the left side roof of the vial section of the unit was unplugged in order to observe dripping oil.
14. Immediately upon unplugging the stopper, a timer was activated to record the time it took for the hot oil to fill the left vial to the 60 mL level (approximately halfway up the narrow neck of the vial).
15. The time to fill the left vial was then recorded in the data sheet.
16. The temperature reading indicated on the right thermometer in the 5W-30 oil sample was observed and recorded on the data sheet.
17. The stopper located on the right side roof of the vial section of the unit was unplugged in order to observe dripping oil.
18. Immediately upon unplugging the stopper, a timer was activated to record the time it took for the hot oil to fill the right vial to the 60 mL level.
19. The time to fill the right vial was then recorded in the data sheet.
20. In preparation to pour both oil samples in the vials back into the oil baths, both stoppers were reinserted into the proper drain holes in the roof the vial section of the unit.
21. Leaving the thermometer in place, the left vial containing 20W-50 oil was emptied back into the left cylinder on top of the viscosity unit.
22. Leaving the thermometer in place, the right vial containing 5W-30 oil was emptied back into the right cylinder on top of the viscosity unit.
23. Both vials were placed back in their respective positions in the vial section of the unit.
24. Using the arrow buttons located to the right of the lower digital scale of the thermostat control panel, the oil bath temperature was adjusted to 60°C.
25. A time period of 15 minutes was allowed to give time for the oil bath to reach 60°C.
26. The temperature reading indicated on the left thermometer in the 20W-50 oil sample was observed and recorded on the data sheet.
27. The stopper located on the left side roof of the vial section of the unit was unplugged in order to observe dripping oil.
28. Immediately upon unplugging the stopper, a timer was activated to record the time it took for the hot oil to fill the left vial to the 60 mL level (approximately halfway up the narrow neck of the vial).
29. The time to fill the left vial was then recorded in the data sheet.
30. The temperature reading indicated on the right thermometer in the 5W-30 oil sample was observed and recorded on the data sheet.
31. The stopper located on the right side roof of the vial section of the unit was unplugged in order to observe dripping oil.
32. Immediately upon unplugging the stopper, a timer was activated to record the time it took for the hot oil to fill the right vial to the 60 mL level.

33. The time to fill the right vial was then recorded in the data sheet.
34. In preparation to pour both oil samples in the vials back into the oil baths, both stoppers were reinserted into the proper drain holes in the roof the vial section of the unit.
35. Leaving the thermometer in place, the left vial containing 20W-50 oil was emptied back into the left cylinder on top of the viscosity unit.
36. Leaving the thermometer in place, the right vial containing 5W-30 oil was emptied back into the right cylinder on top of the viscosity unit.
37. Both vials were placed back in their respective positions in the vial section of the unit.
38. The entire process was repeated for both oil samples using separate temperature settings of 80°C, 110°C, and 130°C.

Recorded Data Tables (Raw Data)

Oil number 1 description: 20W-50 motor oil		
Temperature Setting	Temperature (°C)	Time (seconds)
1	35	621
2	60	280
3	80	125
4	110	68
5	130	52

Oil number 2 description: 5W-30 motor oil		
Temperature Setting	Temperature (°C)	Time (seconds)
1	35	368
2	60	252
3	80	80
4	110	55
5	130	45

Sample Calculations:

1. Kinematic Viscosity, for times greater than 100 seconds:

Viscosity (v) = (2.33 x10^-6) (SSU)

Unit is ft^2/s

At 35°C, 20w50 Kinematic Viscosity = (2.33 x10 ^-6) (621) = 14.5 x 10^-4 ft^2/s

2. Kinematic Viscosity, for times less than 100 seconds:

Viscosity (v) = [(0.226 x SSU) -195/ SSU] (10.76 x 10^-6)

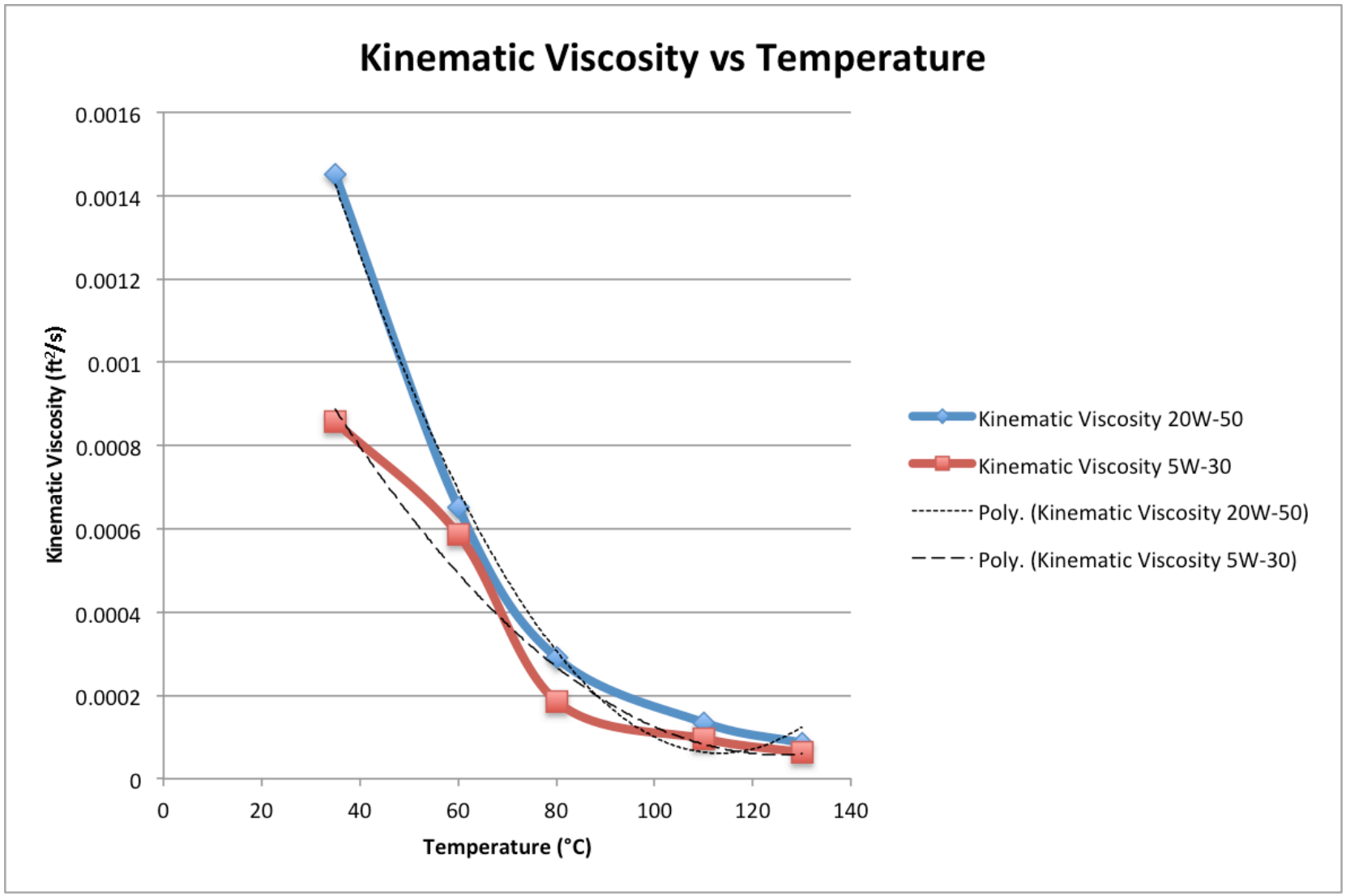
Unit is ft^2/s

At 110°C, 20w50 Kinematic Viscosity = ((0.226 x 68) -195/ 68] (10.76 x 10^-6)
= (15.4- 2.87) (10.76 x 10^-6)
= (13.5) (1.08 x 10^-5)
=1.35 x 10^-4 ft^2/s

Calculated Data Table:

Calculation of Kinematic Viscosity of Two Motor Oils				
Thermostat Temperature (°C)	20w50 Time (s)	20w50 Viscosity (ft^2/s)	5w30 Time (s)	5w30 Viscosity (ft^2/s)
35	621	14.5×10^{-4}	368	8.57×10^{-4}
60	280	6.52×10^{-4}	252	5.87×10^{-4}
80	125	2.91×10^{-4}	80	1.86×10^{-4}
110	68	1.35×10^{-4}	55	0.96×10^{-4}
130	52	0.86×10^{-4}	45	0.63×10^{-4}

Graph


Kinematic Viscosity vs Temperature
Kinematic Viscosity (ft²/s)
0.0016
0.0014
0.0012
0.001
0.0008
0.0006
0.0004
0.0002
0
0
20
40
60
80
100
120
140
Temperature (°C)
Kinematic Viscosity 20W-50
Kinematic Viscosity 5W-30
Poly. (Kinematic Viscosity 20W-50)
Poly. (Kinematic Viscosity 5W-30)

Discussion of Results and Conclusions:

Kinematic viscosity can be described as a fluid's resistance to flow, if only gravity is acting on it. Density of the fluid and gravity provide the motivational force to move the liquid through the viscometer. Two different motor oils were compared at various temperatures. Since there was no change in mass, there was an expansion of volume, with heat. Larger volume at constant mass gives less density and less molecular compression. This allows for better flow.

Increasing the heat for 20w50 and 5w30 motor oils showed that the viscosity decreased per the Saybolt Viscometer. The principal of the Saybolt Viscometer is not really based on any definition of viscosity; it is simply measuring how quickly a fluid passes through a small measured orifice to fill a 60 mL vial. Thus, its results are relative. However, for a simple piece of equipment, it does serve the purpose of comparing the viscosities of the two different motor oils.

American Society for Testing and Materials (ASTM) Standard 2161 provides for a conversion between the viscosity measured in SUS and kinematic viscosity.

Sources of error for this lab: 1) Slight discrepancy between the thermostat oil bath temperature and the temperature of the thermometer in the specimen cylinders; 2) Variation in orifice size;3) variation in sensor readings of 60 mL of specimen; and 4) calibration of timers, tubes, and thermometers may not have been maintained. Of note, thermostat readings were digital and more precise and accurate than hand held thermometer in the cylinders.