EXPERIMENT NO. 5

Determination of Viscosity Indices of Lubricating oils

Aim of the experiment

To determine the viscosity indices of lubricating oils

Objectives

- To determine the kinematic viscosities of two different lubricating oils at 40°C and 100°C
- To calculate the viscosity indices of the two lubricating oils using standard test procedure (ASTM D2270)

Apparatus required

- Cannon-Fenske viscometers (size nos.: 150, 200 and 300)
- Oil bath for viscometers
- 2 types of Lubricating oils

Theory

The viscosities of liquids decrease with rise in temperature. Lubricants are used in a wide range of temperatures to reduce friction between moving machine parts from the point of its start (at cooler temperatures) up to higher temperatures attained as the machine runs. It is desired that the viscosities of the lubricants should not change to an appreciable extent during this range of temperature. Viscosity index (VI) characterizes the variation of kinematic viscosities of petroleum products like lubricants with changes in temperature between 40°C and 100°C. Higher the VI, lesser is the change in kinematic viscosity with temperature.

The Cannon-Fenske viscometer used in this experiment is a variant of the Ostwald viscometer which is a glass U-tube with two bulbs (reservoirs) separated by a capillary. The time taken by a liquid to pass between two marks above and below the upper reservoir is measured and used to calculate the kinematic viscosity of the test liquid, given by

$$\nu = C \times t$$

where,

ν=kinematic viscosity of the liquid in mm^2/s (cSt),

C= viscometer constant in mm^2/s^2 (approximate values are: 0.035 for size no. 100, 0.1 for size no. 200 and 0.25 for size no. 300) and

t=time required by the liquid to pass between the two marks of the viscometer in seconds.

Procedure

Follow the steps given below to run the experiment for finding VI.

1. Set the temperature of the oil bath to 40°C.
2. Charge the two viscometers with the two types of lubricating oils.
3. After the temperature of the bath reaches the set value, mount the viscometers in the oil bath such that both the marks shown on the viscometer are well below the upper level of oil in the bath.
4. Allow sufficient time for the oils in the viscometers to reach the temperature of the bath.
5. Take a rubber bulb and create suction to draw the upper level of oil above the upper mark shown in the viscometer.
6. Take a stopwatch to determine the time taken by the liquid level in the viscometer to drop from the upper mark to the lower mark.
7. Calculate the kinematic viscosities at 40°C.
8. Increase the temperature of the bath to 100°C and repeat steps 2 to 6.
9. Calculate the kinematic viscosities at 100°C.
10. After calculating the kinematic viscosities, calculate the VI of each of the oils according to the formulae given in the 'Calculations' section.

Experimental data

Table 1: Kinematic viscosities of the given lubricants at 40°C and 100°C obtained by Cannon-Fenske viscometer

Lubricant	Time taken for the liquid to pass between the two marks at 40°C, secs	Kinematic viscosity at 40°C, cSt	Size no. of viscometer used at 40°C	Time taken for the liquid to pass between the two marks at 100°C, secs	Kinematic viscosity at 100°C, cSt	Size no. of viscometer used at 40°C

Calculations

A. For oils with VI less than, or equal to 100

$$VI = \frac{L - U}{L - H} \times 100$$

where, L= kinematic viscosity at 40°C of an oil of 0 viscosity index having the same kinematic viscosity at 100°C as the oil whose viscosity index is to be calculated (cSt),
H=kinematic viscosity at 40°C of an oil of 100 viscosity index having the same kinematic viscosity at 100°C as the oil whose viscosity index is to be calculated (cSt),
Y=kinematic viscosity at 100°C of the oil whose viscosity index is to be calculated (cSt)
and U= kinematic viscosity at 40°C of the oil whose viscosity index is to be calculated (cSt).

If the kinematic viscosity of the oil at 100°C is less than or equal to 70 cSt, obtainthe corresponding values for *L* and *H* from Table 3. The measured values of kinematic viscosities which are not listed in the table can be obtained by linear interpolation.

If the kinematic viscosity of the oil at 100°C is greater than 70 cSt, the following relations need to be used to calculate L and H:

$$L = 0.8353Y^2 + 14.67\,Y - 216$$

$$H = 0.1684Y^2 + 11.85\,Y - 97$$

B. For oils with VI greater than, or equal to 100

$$VI = \left[\frac{(\text{antilog}\,N) - 1}{0.00715}\right] + 100$$

where,

$$N = \frac{\log H - \log U}{\log Y}$$

H, U and Y have the same meanings as mentioned above.

If the kinematic viscosity of the oil at 100°C lies between 2-70 cSt, obtainthe corresponding values for *L* and *H* from Table 3. The measured values of kinematic viscosities which are not listed in the table can be obtained by linear interpolation.

If the kinematic viscosity of the oil at 100°C is greater than 70 cSt, the following relations need to be used to calculate H as follows:

$$H = 0.1684Y^2 + 11.85\,Y - 97$$

Results

The following must be reported:

- complete identification of the lubricant tested
- viscosity indices (VI) rounded off to the nearest whole number(When the number is exactly halfway between two numbers, report the nearest even number.)
- calculation procedure followed (A or B)

Inferences

Give some comments on the results you have obtained.

Table 2: Basic Values for *L* and *H* for Kinematic Viscosity in 40 to 100°C system(ASTM, 2004)

Kinematic Viscosity at 100°C, mm²/s (cSt)	L	H	Kinematic Viscosity at 100°C, mm²/s (cSt)	L	H	Kinematic Viscosity at 100°C, mm²/s (cSt)	L	H	Kinematic Viscosity at 100°C, mm²/s (cSt)	L	H	Kinematic Viscosity at 100°C, mm²/s (cSt)	L	H	Kinematic Viscosity at 100°C, mm²/s (cSt)	L	H
2.00	7.994	6.394	7.00	78.00	48.57	12.0	201.9	108.0	17.0	369.4	180.2	24.0	683.9	301.8	42.5	1935	714.9
2.10	8.640	6.894	7.10	80.25	49.61	12.1	204.8	109.4	17.1	373.3	181.7	24.2	694.5	305.6	43.0	1978	728.2
2.20	9.309	7.410	7.20	82.39	50.69	12.2	207.8	110.7	17.2	377.1	183.3	24.4	704.2	309.4	43.5	2021	741.3
2.30	10.00	7.944	7.30	84.53	51.78	12.3	210.7	112.0	17.3	381.0	184.9	24.6	714.9	313.0	44.0	2064	754.4
2.40	10.71	8.496	7.40	86.66	52.88	12.4	213.6	113.3	17.4	384.9	186.5	24.8	725.7	317.0	44.5	2108	767.6
2.50	11.45	9.063	7.50	88.85	53.98	12.5	216.6	114.7	17.5	388.9	188.1	25.0	736.5	320.9	45.0	2152	780.9
2.60	12.21	9.647	7.60	91.04	55.09	12.6	219.6	116.0	17.6	392.7	189.7	25.2	747.2	324.9	45.5	2197	794.5
2.70	13.00	10.25	7.70	93.20	56.20	12.7	222.6	117.4	17.7	396.7	191.3	25.4	758.2	328.8	46.0	2243	808.2
2.80	13.80	10.87	7.80	95.43	57.31	12.8	225.7	118.7	17.8	400.7	192.9	25.6	769.3	332.7	46.5	2288	821.9
2.90	14.63	11.50	7.90	97.72	58.45	12.9	228.8	120.1	17.9	404.6	194.6	25.8	779.7	336.7	47.0	2333	835.5
3.00	15.49	12.15	8.00	100.0	59.60	13.0	231.9	121.5	18.0	408.6	196.2	26.0	790.4	340.5	47.5	2380	849.2
3.10	16.36	12.82	8.10	102.3	60.74	13.1	235.0	122.9	18.1	412.6	197.8	26.2	801.6	344.4	48.0	2426	863.0
3.20	17.26	13.51	8.20	104.6	61.89	13.2	238.1	124.2	18.2	416.7	199.4	26.4	812.8	348.4	48.5	2473	876.9
3.30	18.18	14.21	8.30	106.9	63.05	13.3	241.2	125.6	18.3	420.7	201.0	26.6	824.1	352.3	49.0	2521	890.9
3.40	19.12	14.93	8.40	109.2	64.18	13.4	244.3	127.0	18.4	424.9	202.6	26.8	835.5	356.4	49.5	2570	905.3
3.50	20.09	15.66	8.50	111.5	65.32	13.5	247.4	128.4	18.5	429.0	204.3	27.0	847.0	360.5	50.0	2618	919.6
3.60	21.08	16.42	8.60	113.9	66.48	13.6	250.6	129.8	18.6	433.2	205.9	27.2	857.5	364.6	50.5	2667	933.6
3.70	22.09	17.19	8.70	116.2	67.64	13.7	253.8	131.2	18.7	437.3	207.6	27.4	869.0	368.3	51.0	2717	948.2
3.80	23.13	17.97	8.80	118.5	68.79	13.8	257.0	132.6	18.8	441.5	209.3	27.6	880.6	372.3	51.5	2767	962.9
3.90	24.19	18.77	8.90	120.9	69.94	13.9	260.1	134.0	18.9	445.7	211.0	27.8	892.3	376.4	52.0	2817	977.5
4.00	25.32	19.56	9.00	123.3	71.10	14.0	263.3	135.4	19.0	449.9	212.7	28.0	904.1	380.6	52.5	2867	992.1
4.10	26.50	20.37	9.10	125.7	72.27	14.1	266.6	136.8	19.1	454.2	214.4	28.2	915.8	384.6	53.0	2918	1007
4.20	27.75	21.21	9.20	128.0	73.42	14.2	269.8	138.2	19.2	458.4	216.1	28.4	927.6	388.8	53.5	2969	1021
4.30	29.07	22.05	9.30	130.4	74.57	14.3	273.0	139.6	19.3	462.7	217.7	28.6	938.6	393.0	54.0	3020	1036
4.40	30.48	22.92	9.40	132.8	75.73	14.4	276.3	141.0	19.4	467.0	219.4	28.8	951.2	396.6	54.5	3073	1051
4.50	31.96	23.81	9.50	135.3	76.91	14.5	279.6	142.4	19.5	471.3	221.1	29.0	963.4	401.1	55.0	3126	1066
4.60	33.52	24.71	9.60	137.7	78.08	14.6	283.0	143.9	19.6	475.7	222.8	29.2	975.4	405.3	55.5	3180	1082
4.70	35.13	25.63	9.70	140.1	79.27	14.7	286.4	145.3	19.7	479.7	224.5	29.4	987.1	409.5	56.0	3233	1097
4.80	36.79	26.57	9.80	142.7	80.46	14.8	289.7	146.8	19.8	483.9	226.2	29.6	998.9	413.5	56.5	3286	1112
4.90	38.50	27.53	9.90	145.2	81.67	14.9	293.0	148.2	19.9	488.6	227.7	29.8	1011	417.6	57.0	3340	1127
5.00	40.23	28.49	10.0	147.7	82.87	15.0	296.5	149.7	20.0	493.2	229.5	30.0	1023	421.7	57.5	3396	1143
5.10	41.99	29.46	10.1	150.3	84.08	15.1	300.0	151.2	20.2	501.5	233.0	30.5	1055	432.4	58.0	3452	1159
5.20	43.76	30.43	10.2	152.9	85.30	15.2	303.4	152.6	20.4	510.8	236.4	31.0	1086	443.2	58.5	3507	1175
5.30	45.53	31.40	10.3	155.4	86.51	15.3	306.9	154.1	20.6	519.9	240.1	31.5	1119	454.0	59.0	3563	1190
5.40	47.31	32.37	10.4	158.0	87.72	15.4	310.3	155.6	20.8	528.8	243.5	32.0	1151	464.9	59.5	3619	1206
5.50	49.09	33.34	10.5	160.6	88.95	15.5	313.9	157.0	21.0	538.4	247.1	32.5	1184	475.9	60.0	3676	1222
5.60	50.87	34.32	10.6	163.2	90.19	15.6	317.5	158.6	21.2	547.5	250.7	33.0	1217	487.0	60.5	3734	1238
5.70	52.64	35.29	10.7	165.8	91.40	15.7	321.1	160.1	21.4	556.7	254.2	33.5	1251	498.1	61.0	3792	1254
5.80	54.42	36.26	10.8	168.5	92.65	15.8	324.6	161.6	21.6	566.4	257.8	34.0	1286	509.6	61.5	3850	1270
5.90	56.20	37.23	10.9	171.2	93.92	15.9	328.3	163.1	21.8	575.6	261.5	34.5	1321	521.1	62.0	3908	1286
6.00	57.97	38.19	11.0	173.9	95.19	16.0	331.9	164.6	22.0	585.2	264.9	35.0	1356	532.5	62.5	3966	1303
6.10	59.74	39.17	11.1	176.6	96.45	16.1	335.5	166.1	22.2	595.0	268.6	35.5	1391	544.0	63.0	4026	1319
6.20	61.52	40.15	11.2	179.4	97.71	16.2	339.2	167.7	22.4	604.3	272.3	36.0	1427	555.6	63.5	4087	1336
6.30	63.32	41.13	11.3	182.1	98.97	16.3	342.9	169.2	22.6	614.2	275.8	36.5	1464	567.1	64.0	4147	1352
6.40	65.18	42.14	11.4	184.9	100.2	16.4	346.6	170.7	22.8	624.1	279.6	37.0	1501	579.3	64.5	4207	1369
6.50	67.12	43.18	11.5	187.6	101.5	16.5	350.3	172.3	23.0	633.6	283.3	37.5	1538	591.3	65.0	4268	1386
6.60	69.16	44.24	11.6	190.4	102.8	16.6	354.1	173.8	23.2	643.4	286.8	38.0	1575	603.1	65.5	4329	1402
6.70	71.29	45.33	11.7	193.3	104.1	16.7	358.0	175.4	23.4	653.8	290.5	38.5	1613	615.0	66.0	4392	1419
6.80	73.48	46.44	11.8	196.2	105.4	16.8	361.7	177.0	23.6	663.3	294.4	39.0	1651	627.1	66.5	4455	1436
6.90	75.72	47.51	11.9	199.0	106.7	16.9	365.6	178.6	23.8	673.7	297.9	39.5	1691	639.2	67.0	4517	1454
												40.0	1730	651.8	67.5	4580	1471
												40.5	1770	664.2	68.0	4645	1488
												41.0	1810	676.6	68.5	4709	1506
												41.5	1851	689.1	69.0	4773	1523
												42.0	1892	701.9	69.5	4839	1541
															70.0	4905	1558

Reference: ASTM, 2004. Standard Practice for calculating Viscosity Index from Kinematic Viscosity at 40and 100°C.