Study of Dependency of Temperature on Kinematic Viscosity for Blended Oils

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Abstract— **Viscosity and density are the most important parameters for oil since the oil needs to have appropriate values to assure its performance under high pressure and temperature in automobile application. Usually, getting performance from one type of oil is difficult in these days, thus two or more oils are mixed together to achieve desirable properties. To understand the effect of blending on viscosity of oil at various temperatures, three oils- lubricating, gear, and engine oils were taken and they were blended together in various concentrations. The blends were used to calculate viscosity at four different temperatures using a Redwood Viscometer. The graphs plotted between temperature and kinematic viscosity at a particular concentration gave an exponential relation between the two which were in approximation to the equations that were derived from several other previously done experiments. The relation between concentration of oils in an oil blend and kinematic viscosity, at a constant temperature, was also exponential. This led to the formation of a general equation for oil blends, giving relation between kinematic viscosity and temperature, which was found to be compatible with the equations for pure oils.**

Keywords— Oil Blends, Lubricating oil, Engine Oil, Gear Oil, Kinematic Viscosity, Concentration, Temperature

I. Introduction

With the increased production of oils, some physical and chemical properties have become more important than they were in the past. Because of this, (added comma) different properties of different oils were tried to 'blend' to give way for oil with the desired properties, giving the term 'oil blends'.

The most important property of oil is viscosity. Different oils exhibit different viscosities. In addition, viscosity of oil depends on various parameters such as temperature, shear stress and pressure [2]. Now for any purpose the oil must be selected such that it works under the given conditions. But most of the times this is not the case. Therefore oil blends are made to get a near-perfect composition which can work in the given conditions and provide optimum and desired results.

For engineering applications oil viscosity are usually chosen to give optimum performance at required temperature. Knowing the temperature at which oil is expected to operate is critical as oil viscosity is extremely temperature dependent. The viscosities of different oils vary at different rates with temperature [2].

Due to the importance of temperature in determining the viscosity, it's still an active area of research. Several investigations have been conducted previously too, where researches tried to establish a relation between viscosity and temperature and the investigations demonstrated that oil viscosity decreased substantially with an increase in temperature or by the addition of gaseous or liquid diluents, that is concentration in case of oil blends. Therefore both temperature and concentration of the oils are necessary parameters which should be taken care of while preparing an oil blend [3].

In this paper an attempt has been made to investigate the effect of temperature and concentration of the component oils, in an oil blend, using a Redwood Viscometer. Further an attempt is made to establish a relation between the three; viscosity, temperature and concentration.

II. Experimental Setup

A Redwood Viscometer, Fig. (1), was used for performing this experiment. It consists of vertical cylindrical oil cup with an orifice in the center of its base. The orifice can be closed by a ball. A hook pointing upward serves as a guide mark for filling the oil. The cylindrical cup is surrounded by the water bath. The water bath maintains the temperature of the oil to be tested at constant temperature. The oil is heated by heating the water bath by means of an immersed electric heater in the water bath; the provision is made for stirring the water, to maintain the uniform temperature in the water bath and to place the thermometer to record the temperature of oil and water bath. The cylinder is 47.625mm in diameter and 88.90mm deep. The orifice is 1.70mm in diameter and 12mm in length, this viscometer is used to determine the kinematic viscosity of the oil. Through this an attempt is made to derive relations between viscosity, temperature and concentration of the given oils [4].

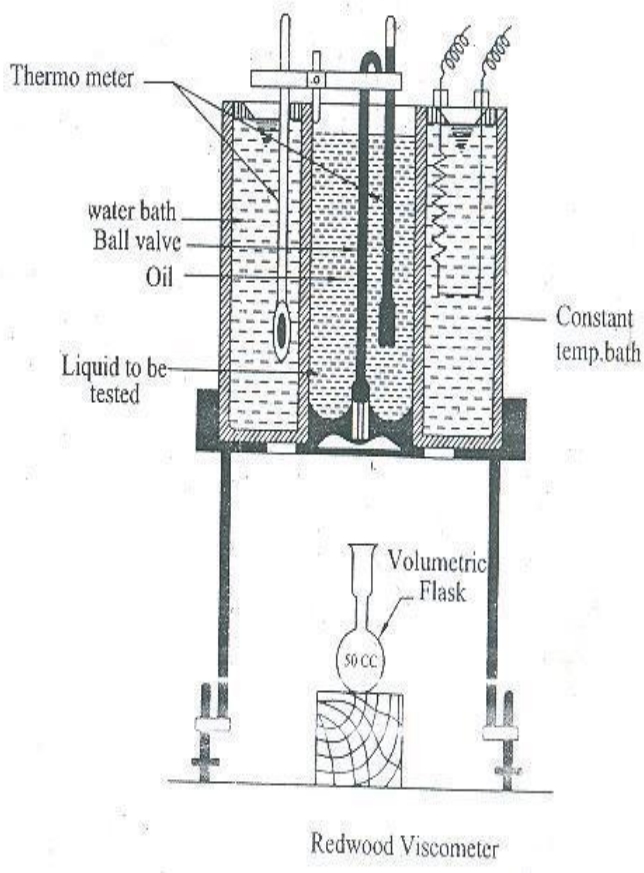

Fig.1. Redwood Viscometer

A. Oils used

For this experiment three oils were taken namely- Lubricating oil, Gear oil, Engine oil. The experiment was conducted for three combinations at five different concentrations and at four different temperatures- 55°C, 65°C, 75°C and 85°C.

Engine oil was a SAE 20W40 oil.

Gear oil was SAE 80W90.

Lubricating oil was 20W-20.

B. Formula used

Kinematic Viscosity = At-B/t (in centistokes) (1)

Where,

A = 0.26

B = 172

t = Saybolt second

III. Results and Discussion

The three combinations of oil blends that were made for the experiment were- Lubricating and gear, gear and engine oils and engine and lubricating oils.

A. Lubricating oil and gear oil

Table 1 shows the blending concentration of lubricating oil and gear oil. For example, 75; 50 represents 75 ml of lubricating oil was mixed with 50 ml of gear oil to get the blend. After the blend, the temperature represents the temperature at which the blend was heated and the Saybolt seconds were found out from the apparatus. Kinematic viscosity was found using (1).

Table 1. Data for mixture of Lubricating and gear oils:-

Concentration (ml)	Temperature (C)	Time (s)	Kinematic Viscosity (cst)
125; 0	55	254	65.3648
	65	183	46.64284
	75	113	27.8623
	85	88	20.93114
100;25	55	324	83.71068
	65	210	53.78333
	75	142	35.71225
	85	103	25.11495
75; 50	55	448	116.0972
	65	250	64.314
	75	164	41.59427
	85	115	28.4087
50; 75	55	494	128.0928
	65	278	71.66309
	75	188	47.96777
	85	129	32.21054
25; 100	55	484	125.4857
	65	299	77.16642
	75	199	50.87819
	85	141	35.44369
0; 125	55	614	159.3607
	65	428	110.8793
	75	265	68.25283
	85	165	41.86061

Fig. 2 to Fig 7 represents the corresponding correlation between the temperature and the kinematic viscosity. Temperature is in degree Celsius and viscosity in centistokes.

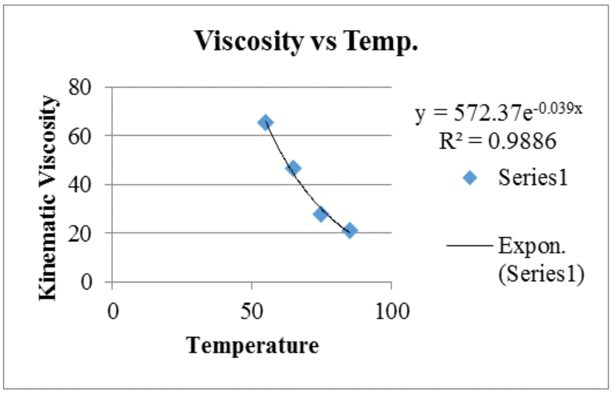

Fig.2. Graph between Kinematic viscosity and temperature for pure lubricating oil at various temperatures.

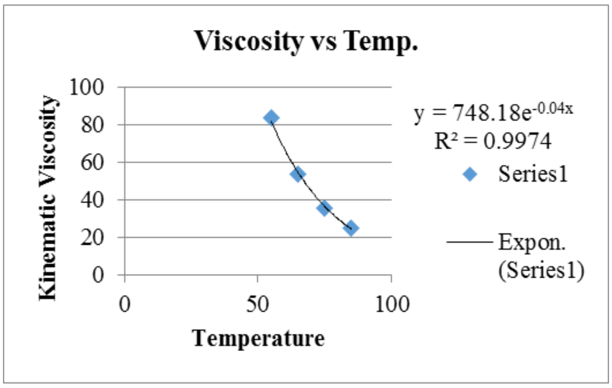

Fig.3. Graph between Kinematic viscosity and temperature for blend of lubricating oil and gear oil (4:1) at various temperatures.

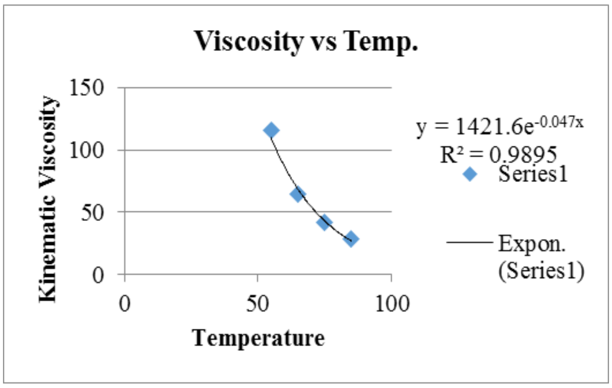

Fig.4. Graph between Kinematic viscosity and temperature for blend of lubricating oil and gear oil (3:2) at various temperatures.

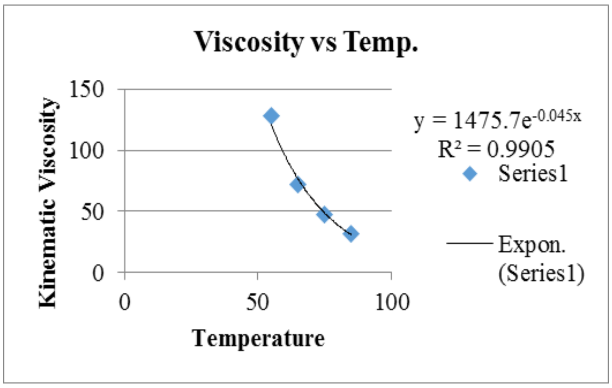

Fig.5. Graph between Kinematic viscosity and temperature for blend of lubricating oil and gear oil (2:3) at various temperatures.

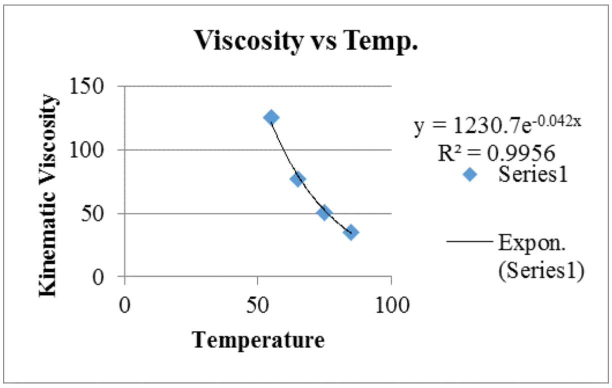

Fig.6. Graph between Kinematic viscosity and temperature for blend of lubricating oil and gear oil (1:4) at various temperatures.

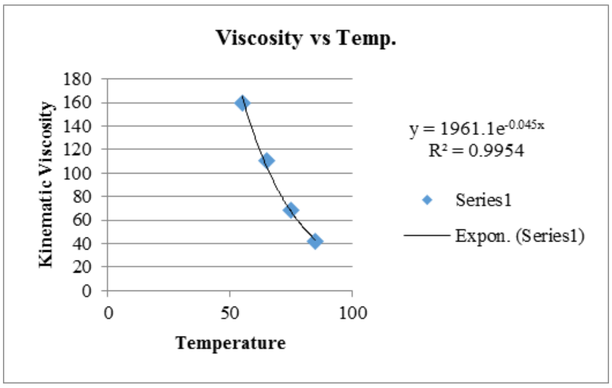

Fig.7. Graph between Kinematic viscosity and temperature for pure gear oil at various temperatures.

B. Lubricating oil and Engine oil

Table 2 shows the blending concentration of lubricating oil and engine oil. For example, 75; 50 represents 75 ml of lubricating oil was mixed with 50 ml of engine oil to get the blend. After the blend, the temperature represents the temperature at which the blend was heated and the Saybolt seconds were found out from the apparatus. Kinematic viscosity was found using (1).

Table 2. Data for mixture of Lubricating and Engine Oils

Concentration	Temperature (C)	Time (s)	Kinematic Viscosity (cst)
125; 0	55	254	65.3648
	65	183	46.64284
	75	113	27.8623
	85	88	20.93114
100;25	55	260	66.94038
	65	197	50.34944
	75	105	25.66667
	85	88	20.93114
75; 50	55	282	72.71184
	65	242	62.21132
	75	138	34.63725
	85	97	23.45196
50; 75	55	265	68.25283
	65	172	43.72291
	75	108	26.49204
	85	90	21.49444
25; 100	55	256	65.89008
	65	185	47.17297
	75	124	30.85694
	85	94	22.61553
0; 125	55	235	60.37021
	65	159	40.26138
	75	117	28.95419
	85	85	20.08235

Fig. 2 to Fig 7 represents the corresponding correlation between the temperature and the kinematic viscosity. Temperature is in degree Celsius and viscosity in centistokes.

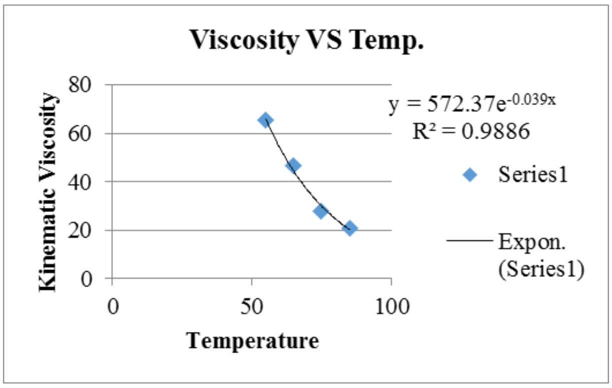

Fig.8. Graph between Kinematic viscosity and temperature for pure lubricating oil at various temperatures.

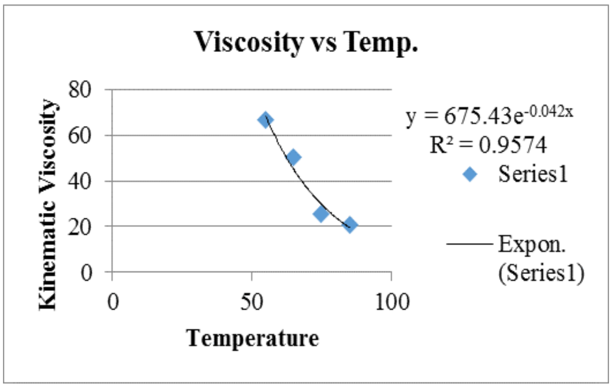

Fig.9. Graph between Kinematic viscosity and temperature for blend of lubricating oil and engine oil (4:1) at various temperatures.

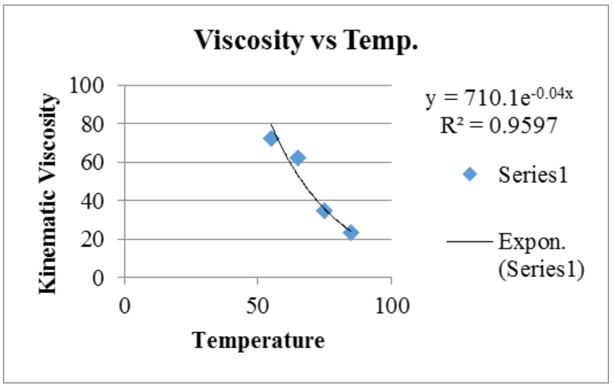

Fig.10. Graph between Kinematic viscosity and temperature for blend of lubricating oil and engine oil (3:2) at various temperatures.

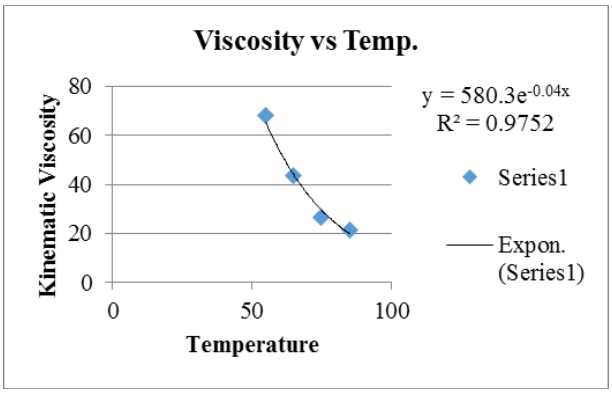

Fig.11. Graph between Kinematic viscosity and temperature for blend of lubricating oil and engine oil (2:3) at various temperatures

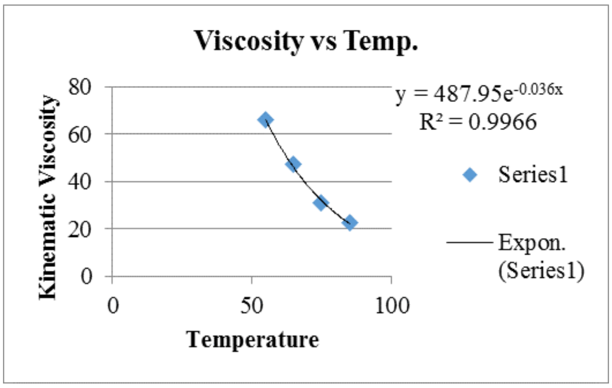

Fig.12. Graph between Kinematic viscosity and temperature for blend of lubricating oil and engine oil (1:4) at various temperatures

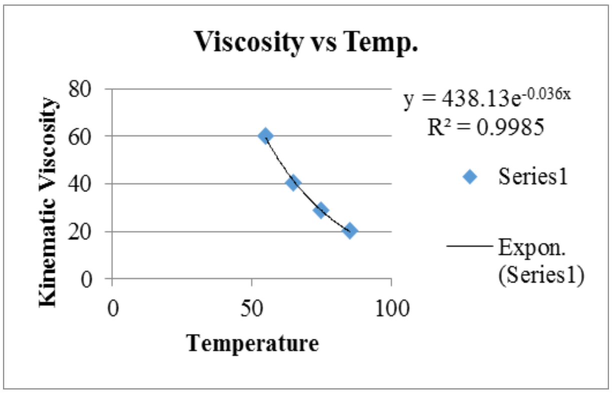

Fig.13. Graph between Kinematic viscosity and temperature for pure engine oil at various temperatures

C. Lubricating oil and Engine oil

Table 2 shows the blending concentration of gear oil and engine oil. For example, 75; 50 represents 75 ml of gear oil was mixed with 50 ml of engine oil to get the blend. After the blend, the temperature represents the temperature at which the blend was heated and the Saybolt seconds were found out from the apparatus. Kinematic viscosity was found using (1).

Table 3. Data for mixture of Gear and Engine Oils

Concentration	Temperature (C)	Time (s)	Kinematic Viscosity (cst)
125; 0	55	614	159.3607
	65	428	110.8793
	75	265	68.25283
	85	165	41.86061
100;25	55	412	106.7037
	65	371	95.99774
	75	201	51.40677
	85	138	34.63725
75; 50	55	384	99.39339
	65	326	84.23393
	75	185	47.17297
	85	128	31.94016
50; 75	55	335	86.58806
	65	249	64.05124
	75	154	38.92636
	85	112	27.58875
25; 100	55	287	74.02244
	65	204	52.19931
	75	133	33.29053
	85	97	23.45196
0; 125	55	235	60.37021
	65	159	40.26138
	75	117	28.95419
	85	85	20.08235

Fig. 2 to Fig 7 represents the corresponding correlation between the temperature and the kinematic viscosity. Temperature is in degree Celsius and viscosity in centistokes.

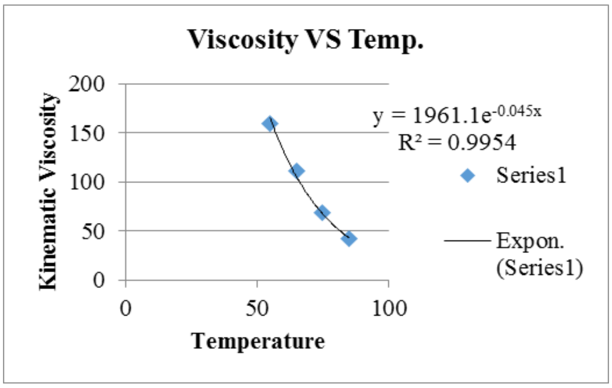

Fig.14. Graph between Kinematic viscosity and temperature for pure gear oil at various temperatures.

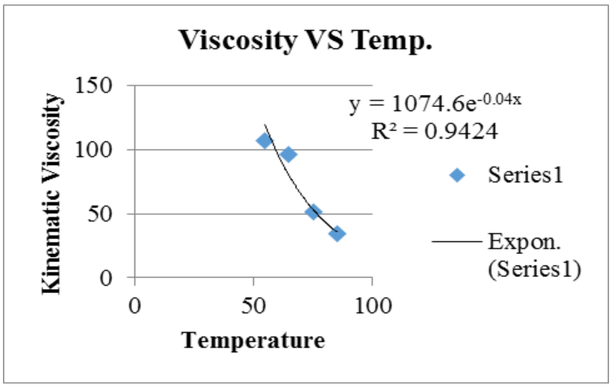

Fig.15. Graph between Kinematic viscosity and temperature for blend of gear oil and engine oil (4:1) at various temperatures

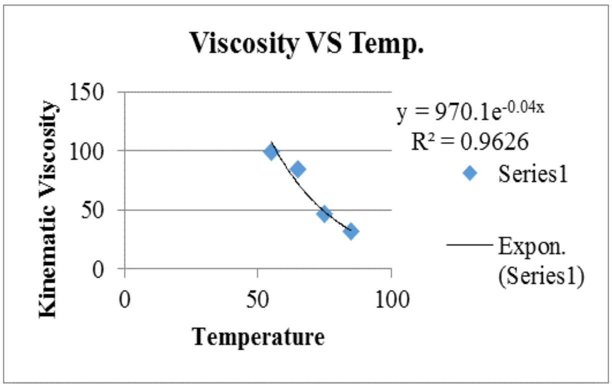

Fig.16. Graph between Kinematic viscosity and temperature for blend of gear oil and engine oil (3:2) at various temperatures

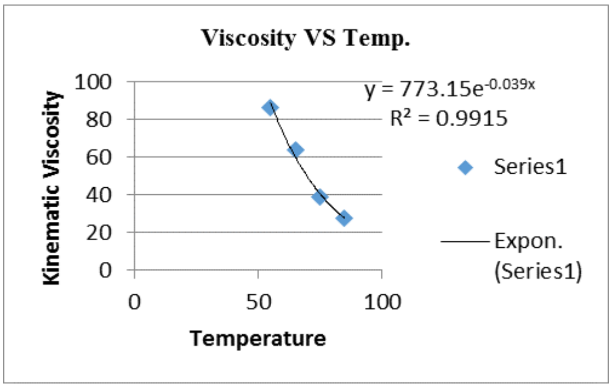

Fig.17. Graph between Kinematic viscosity and temperature for blend of gear oil and engine oil (2:3) at various temperatures.

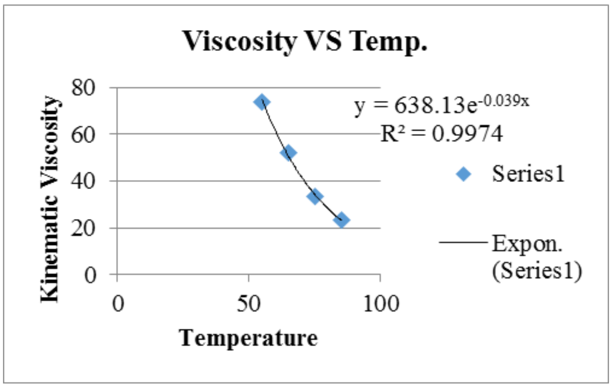

Fig.18. Graph between Kinematic viscosity and temperature for blend of gear oil and engine oil (1:4) at various temperatures.

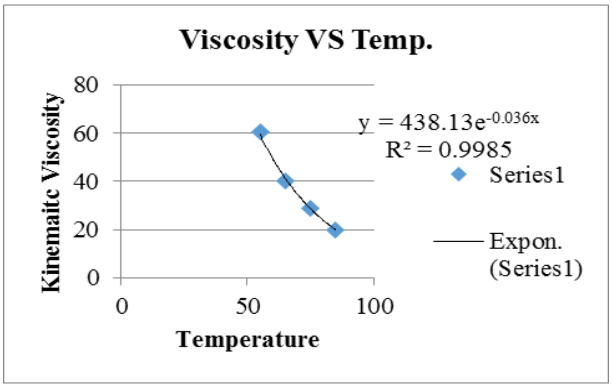

Fig.19. Graph between Kinematic viscosity and temperature for pure engine oil at various temperatures.

With these results, it is shown that the kinematic viscosity of an oil blend varies exponentially with temperature. It can also be seen from the graphs that as the concentration of the high viscosity oil increases in the oil blends, the slope of the viscosity-temperature curve also increases.

IV. CONCLUSION

From the above performed experiment, we came to the following conclusions:-

(1) The dependency of the Temperature and Kinematic viscosity is as per the formula

$$\vartheta = ae^{-bT}$$

Where 'a' and 'b' are constants and ϑ is the kinematic viscosity and T is the variable temperature.

(2) Here the value of 'a' depends on the volume fraction of the components in the oil blend and 'b' is a constant value whose approximate value is 0.04.

(3) As per the observation, the value of viscosity falls exponentially as the temperature is raised.

(4) For a particular temperature, as the volume fraction of higher viscous oil increases, the value of viscosity of the oil blend increases exponentially.

(5) As the volume fraction of the higher viscous oil increases in the blend, the value of 'a' increases.

REFERENCES

[1] Guillermo Centeno, Gabriela Sánchez-Reyna, Jorge Ancheyta, José A.D. Muñoz, Nayeli Cardona "*Testing various mixing rules for calculation of viscosity of petroleum blends"*, Instituto Mexicano del Petroleo, Eje Central Lazaro Cardenas 152, D.F. 07330, Mexico. Fuel 90 (2011) 3561–3570. Elsevier.

[2] Gwidon W. Stachowiak, Andrew W. Batchelor, "Engineering Tribology", Elsevier. 225, Wyman street, Waltham, MA, USA. First edition. pp 11-12.

[3] Jasem M. AI-Besharah, Omar A. Salman, and Saed A. Akashah," *Viscosity of Crude Oil Blends"* Kuwait Institute **for** Scientific Research, Petrochemicals Materials Division, 13109 Safat, Kuwait. Ind. Eng. Chem. Res. 1987,26, 2445-2449, 1987 American Chemical Society.

[4] M A Boda, P N Bhasagi, A S Sawade, R A Andodgi, "*Analysis of Kinematic Viscosity for Liquids by varying temperature*", PG Students, Department of Mechanical Engineering, N K Orchid College of Engineering & Technology, Solapur, India. International Journal of Innovative Research in Science, Engineering and Technology. Vol. 4, Issue 4, April 2015.