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MODELING THE TEMPERATURE DEPENDENCE OF DYNAMIC VISCOSITY FOR SAE 10W OIL NO ADDITIVE

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Abstract: *The dynamic viscosity for mineral oil SAE 10W no additive were determined at temperatures from 313 K to 373 K. Some empirical relations that describe the temperature dependence of dynamic viscosity were fitted to the experimental data and the correlation constants for the best fit are presented.*

Keywords: *oil SAE 10W no additive, dynamic viscosity, temperature*

1. INTRODUCTION

There is general agreement that, the characteristic called viscosity is the most important property out of all the physical and chemical properties of lubricating oil. The viscosity of the lubricating oil is considered the best single index of the users for which the oil is to be recommended. There are so many factors that cause change in viscosity like temperature, pressure and rate of shear and age of lubricant. If we are working with oils, it is necessary to know how the viscosity varies with the temperature. The viscosity-temperature relationship is required for many applications because the change in viscosity due to change in temperature, has significant effect on load capacity of bearing elements and flow rate. Correct determination of viscosity at any temperature is essential for designers and users when predicting the performance of lubricants.

The time required for a fresh lubricant to become unfit for use is known as useful life of the lubricant. Viscosity can increase or decrease with the age of lubricant. There are so many reasons (i.e. overheating, chemical reaction, water contamination, formation of heavy decomposition product, contamination from out side, and dilution by fuels) for changing the viscosity with the age of lubricant [1-3].

In this study we determined the viscosity of oil mineral SAE 10W no additive in the temperature range from 313K to 363K. Empirical relations describing the dynamic viscosity variation with temperature were fitted to experimental data and correlation constants for the best fit are presented in this article.

2. MATERIALS AND METHODS

Type of mineral oil SAE 10W no additive used in this paper are produced in Romania. In our investigation we used the following mineral oil SAE 10W no additive.

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Mineral oil SAE 10W no additive have investigated using a Haake VT 550 Viscotester developing shear rates ranging between 3 and 120 s^{-1} and measuring viscosities from 10^4 to 10^6 mPa.s when the HV_1 viscosity sensor is used. The temperature ranged between 40 and 90°C and the measurements were made from 10 to 10°C. The accuracy of the temperature was ± 0.1°C.

3. RESULTS AND DISCUSSION

Fig. 1 show the dynamic viscosity temperature dependence for mineral oil SAE 10W no additive. The behavior of oil sample is that the viscosity decreases with increasing temperature.

Fig. 2 shows the log viscosity depending on the inverse absolute temperature for mineral oil SAE 10W no additive.

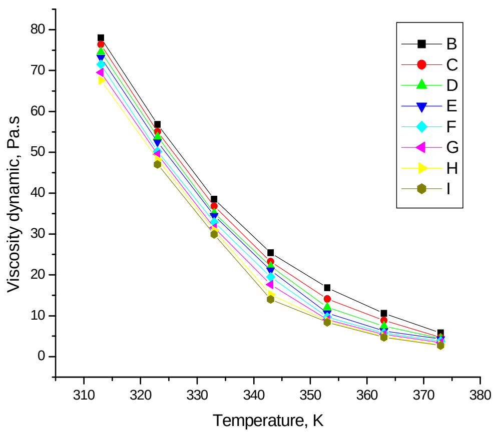

Fig. 1. The viscosities of investigated oil as a function of temperature of mineral oil SAE 10W no additive for different shear rate: B–3.3s^{-1}, C–6s^{-1}, D–10.6s^{-1}, E–17.87s^{-1}, F–30s^{-1}, G–52.85s^{-1}, H–80s^{-1}, I–120s^{-1}.

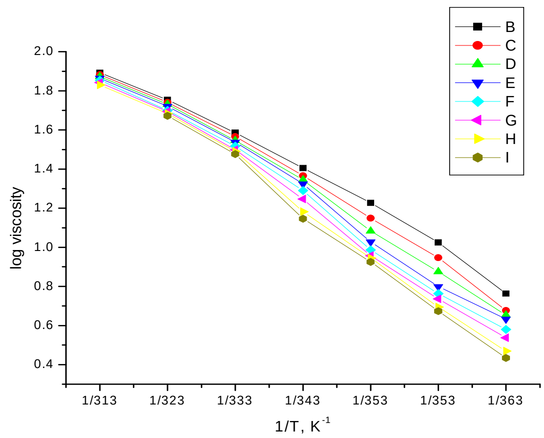

Fig. 2. Dependence log viscosity on the 1/T for mineral oil of different shear rate: B–3.3s^{-1}, C–6s^{-1}, D–10.6s^{-1}, E–17.87s^{-1}, F–30s^{-1}, G–52.85s^{-1}, H–80s^{-1}, I–120s^{-1}.

Mineral oil SAE 10W has been proposed several empirical relationships describing the temperature dependent dynamic viscosity. The more important of these is the Andrade equation (1). Andrade [4, 5] equations are modified versions of equations (2) and (3) [6-11]:

$$\eta = A\cdot 10^{B/T} \quad (1)$$

$$\ln \eta = A + B/T + C/T^2 \quad (2)$$

$$\ln \eta = A + B/T + CT \quad (3)$$

To elucidate the effect of temperature on the absolute viscosity the following equations (4) and (5) have also been used:

$$\log \eta = A/T - B \quad (4)$$

$$\eta = A - B \log T \quad (5)$$

where T is the temperature absolute and A, B and C in the equations (1) to (5) are correlation constants. The results of regression analyses to these relations are presented in Tables 1–4.

Table 1. The shear rate, value of parameters of the theoretical model described by equation (4), coefficient correlation and range temperatures for mineral oil.

Shear rate [s^{-1}]	Value of parameters of the theoretical model described by eq. (4)		R^2	Temp. Range [^0C]
	A	B		
3.30	0.1858	2.1223	0.9959	40-90
6.00	0.2008	2.1360	0.9963	40-90
10.60	0.2083	2.1341	0.9971	40-90
17.87	0.2159	2.1361	0.9957	40-90
30.00	0.2225	2.1318	0.9962	40-90
52.95	0.2275	2.1264	0.9968	40-90
80.00	0.2359	2.1286	0.9968	40-90
120.0	0.2519	2.1885	0.9985	40-90

Table 2. The shear rate, value of parameters of the theoretical model described by equation (5), coefficient correlation and range temperatures for mineral oil.

Shear rate [s^{-1}]	Value of parameters of the theoretical model described by eq.(5)		R^2	Temp. Range [^0C]
	A	B		
3.3	2406.6548	936.4609	0.9726	40-90
6.0	2400.9456	934.9312	0.9693	40-90
10.6	2371.3208	923.7730	0.9664	40-90
17.87	2349.1828	915.4438	0.9648	40-90
30.0	2292.9727	893.7809	0.9616	40-90
52.95	2246.9135	876.0181	0.9588	40-90
80.0	.2202.5145	858.9199	0.9564	40-90
120.0	1790.3300	697.5534	0.9408	40-90

Table 3. The shear rate, value of parameters of the theoretical model described by equation (2), coefficient correlation and range temperatures for mineral oil.

Shear rate [s^{-1}]	Value of parameters of the theoretical model described by eq. (2)			R^2	Temp. Range [^0C]
	A	B	C		
3.30	4.6294	-0.2563	-0.0214	0.9993	40-90
6.00	4.6509	-0.2841	-0.0223	0.9996	40-90
10.60	4.7047	-0.3402	-0.0174	0.9982	40-90
17.87	4.7525	-0.3863	-0.0139	0.9938	40-90
30.00	4.7435	-0.4022	-0.0138	0.9945	40-90
52.95	4.7472	-0.4246	-0.0124	0.9953	40-90
80.00	4.7255	-0.4259	-0.0147	0.9958	40-90
120.0	5.1091	-0.6164	0.0040	0.9971	40-90

Table 4. The shear rate, value of parameters of the theoretical model described by equation (3), coefficient correlation and range temperatures for mineral oil.

Shear rate [s^{-1}]	Value of parameters of the theoretical model described by eq. (3)			R^2	Temp. Range [^0C]
	A	B	C		
3.3	2.1038	-0.1859	7.7532	0.9959	40-90
6.0	2.1159	-0.2008	8.2209	0.9963	40-90
10.6	2.1133	-0.0208	8.4466	0.9971	40-90
17.87	2.1146	-0.0216	8.6783	0.9957	40-90
30.0	2.1096	-0.0222	8.8734	0.9962	40-90
52.95	2.1037	-0.0228	9.0216	0.9968	40-90
80.0	2.1050	-0.0236	9.2763	0.9968	40-90
120.0	2.1633	-0.0252	9.8220	0.9985	40-90

Table 5. The shear rate, value of parameters of the theoretical model described by equation (1), coefficient correlation and range temperatures for mineral oil.

Shear rate [s^{-1}]	Value of parameters of the theoretical model described by eq. (1)		R^2	Temp. Range [^0C]
	A	B		
3.3	2.1223	0.6519	0.9959	40-90
6.0	2.1360	0.6297	0.9963	40-90
10.6	2.1341	0.6189	0.9971	40-90
17.87	2.1362	0.6083	0.9957	40-90
30.0	2.1318	0.5991	0.9962	40-90
52.95	2.1265	0.5921	0.9968	40-90
80.0	2.1286	0.5809	0.9968	40-90
120.0	2.1885	0.5598	0.9985	40-90

In Tables 1-5 we see that the empirical relations which give the best results in this study the temperature dependence of oil viscosity is described by equations (1), (2), (3) and (4), where the correlation coefficient values are close by 1.00. Equation (5) is not suitable to describe the temperature dependence of oil viscosity, because the values of correlation coefficients are less than 1. Relationships (1), (2), (3) and (4) are less suitable to describe the temperature dependence of viscosity of mineral oil SAE 10W no additive.

CONCLUSIONS

The equations that best describe the temperature dependent dynamic viscosity of mineral oil SAE 10W no additive studied are (1), (2), (3) and (4) for which correlation coefficients have values close to one. Mineral oil SAE 10W no additive viscosity decreases with increasing temperature at constant shear rate. Plotting the log of the inverse dynamic viscosity depending on temperature shows a linear decline.

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