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New Mathematical Relationship of Dependance of Dynamic Viscosity of Absolute Temperature for Sunflower Oil

KEYWORDS: dynamic viscosity, relations, temperature, sunflower oil

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ABSTRACT *Rheology of vegetable oils is concerned with how oil responds to applied forces and deformations. The basic parameters of the stress (force per area) and strain (bending length), are essential for all rheological assessments for sunflower oil. The fundamental parameter in study rheological behavior of a vegetable oil is viscosity. This article proposes three relationships of dependence of the natural logarithm of dynamic viscosity with temperature for sunflower oil. The purpose of this study was to find a linear, polynomial or exponential dependence between temperature and natural logarithm dynamic viscosity of sunflower oil, using the Andrade equation changes. Equation constants A, B and C were determined by fitting linear, polynomial or exponential.*

INTRODUCTION

Rheology of vegetable oils is concerned with how oil responds to applied forces and deformations. The basic parameters of the stress (force per area) and strain (bending length), are essential for all rheological assessments for sunflower oil. The fundamental parameter in study rheological behavior of a vegetable oil is viscosity [1- 4].

Vegetable oils are a reliable substitute for petroleum-based lubricants. Compared to mineral oils, vegetable oils have the following advantages: a higher viscosity index, lower losses and improved lubrication, leading to improved energy efficiency. Vegetable oils have performance limitations, particularly thermal, oxidative and hydrolytic stability. Vegetable oils contain fatty acids in a proportion of about 80-95 %, which is one of the main improvers in lubricants. Vegetable oils are suitable lubricant at high pressure [5, 6].

The more important of these is the Andrade equation (1). The Andrade equations are modified versions of equations (2) and (3) [7-12]:

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

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

and

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

T is the temperature absolute and A, B and C in the equations (1) to (3) are correlation constants. This article proposes three new relationships of dependence of the natural logarithm of dynamic viscosity with temperature for sunflower oil. The dynamic viscosity of oils was determined at temperatures and shear rates, the 100°C and the 40°C, respectively, 3.3 to 120 s^{-1}. The purpose of this study was to find a linear, polynomial or exponential dependence between temperature and natural logarithm of dynamic viscosity of sunflower oil using Andrade equation changes. Equation constants A, B and C were determined by fitting linear, polynomial or exponential.

MATERIALS AND METHOD

The sunflower oil used in this paper is provided by a company from Bucharest, Romania. The sunflower oil were 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 ranging was from 40 to 100°C and the measurements were made from 10 to 10 degrees. The accuracy of the temperatures was ± 0.1°C.

RESULTS AND DISCUSSION

This article proposes three equations (4) to (6) temperature dependence of natural logarithm dynamic viscosity checked only for sunflower oil. The software Origin 6.0 was used to determine constants equation for sunflower oil. In addition, the parameters A, B and C change with shear rate. Therefore, by imposing constant shear rate, the parameters can be determined.

$$\ln\eta = A + BT \quad (4)$$

$$\ln\eta = A + BT + CT^2 \quad (5)$$

$$\ln\eta = A + B\cdot 10^{-T/C} \quad (6)$$

The dependence of natural logarithm dynamic viscosity on the temperature for sunflower oil at shear rate 3.3 s^{-1} (the black curve from Fig. 1) was fitting linear as shown in figure 1. The linear dependence of natural logarithm dynamic viscosity on the temperature for sunflower oil at 3.3 s^{-1} is described for equation (4):

$$\ln\eta = 8.55163 + (-0.01614)T$$

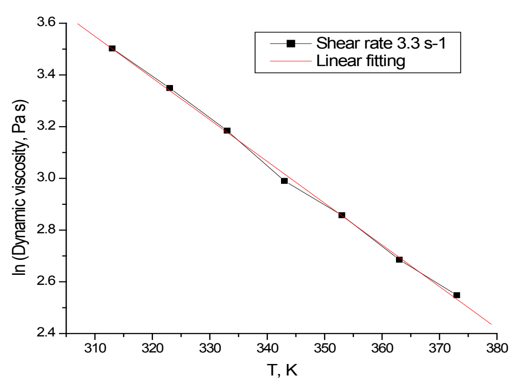

Figure 1: The dependence ln viscosity on the temperature at 3.3 s^{-1} for right to B and 1B represents the linear fitting to B

Table 1 shows the value of parameters of the described

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by equation (4) sunflower oil and correlation coefficient, R^2. As shown in table 1 the software found it linear equation applied shear rate right of sunflower oil. The root mean square error means that experimental data is spread equation. Remains the same temperature range, where the equation was fitted other experimental data.

TABLE-1 THE SHEAR RATE, VALUE OF PARAMETERS OF DESCRIBED BY EQUATION (4) AND CORRELATION COEFFICIENT FOR SUNFLOWER OIL

Shear rate, s^{-1}	Value of parameters of the described by equation (4)		Correlation coefficient, R^2
	A	B	
3.3	8.5516	-0.0161	0.9992
6	7.6188	-0.0140	0.9903
10.6	7.3249	-0.0135	0.9839
17.87	7.4352	-0.0141	0.9888
30	7.5632	-0.0145	0.9958
52.95	7.7538	-0.0151	0.9992
80	7.6972	-0.0151	0.9977
120	4.3355	-0.0062	0.9987

The dependence of natural logarithm dynamic viscosity on the temperature for sunflower oil at shear rate 6 s^{-1} (the black curves from Fig. 2) was fitting polynomial as shown in figures 2. The polynomial dependence of natural logarithm dynamic viscosity on the temperature for sunflower oil at 6 s^{-1} is described for equation (5):

$\ln\eta = 19.97521 + (-0.08631)T + (1.05386E\text{-}4)T^2$

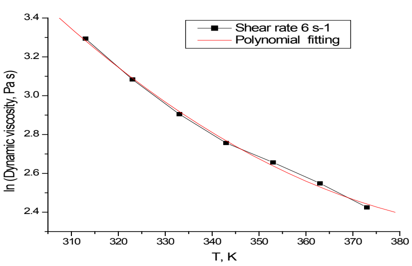

Figure 2: The dependence ln viscosity on the temperature at 6 s^{-1} for curve to C and 1C represents the fitting polynomial to C

Table 2 shows the value of parameters of the described by equation (5) sunflower oil and correlation coefficient, R^2. As shown in table 2 the software found it polynomial equation applied shear rate right of sunflower oil. The dependence of natural logarithm dynamic viscosity on the temperature for sunflower oil at shear rate 6 s^{-1} (the black curves from Fig. 3) was first order exponential decay as shown in figures 3. The exponential dependence of natural logarithm dynamic viscosity on the temperature for sunflower oil at 6 s^{-1} is described for equation (6):

$\ln\eta = 2.36526 + 30403.99337\exp(-T/30.23727)$

TABLE-2 THE SHEAR RATE, VALUE OF PARAMETERS OF DESCRIBED BY EQUATION (5) AND CORRELATION COEFFICIENT FOR SUNFLOWER OIL

Value of parameters of the described by equation (5)			Correlation coefficient, R^2
A	B	C	
10.9061	-0.0299	2.0081E-5	0.9988
19.9752	-0.0863	1.0539E-4	0.9973
23.8393	-0.1101	1.4085E-4	0.9995
21.7043	-0.0976	1.2170E-4	0.9995
15.4084	-0.0603	6.6911E-5	0.9980
9.6793	-0.0264	1.6423E-5	0.9987
14.4240	-0.0544	5.7373E-5	0.9997
6.3981	-0.0180	1.7073E-5	0.9991

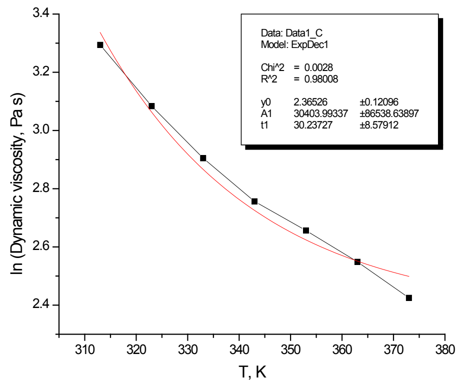

Figure 3: The dependence ln viscosity on the temperature at 6 s^{-1} for curve to C and 1C represents exponential curve fitting C

Table 3 shows the value of parameters of the described by equation (6) sunflower oil and correlation coefficient, R^2. As shown in table 3 the software found it exponential equation applied shear rate right of sunflower oil.

TABLE-3 THE SHEAR RATE, VALUE OF PARAMETERS OF DESCRIBED BY EQUATION (6) AND CORRELATION COEFFICIENT FOR SUNFLOWER OIL

Value of parameters of the described by equation (6)			Correlation coefficient, R^2
A	B	C	
2.4184	6009.5005	36.6423	0.9554
2.3652	30403.9933	30.2372	0.9800
2.3128	157506.0876	25.9284	0.9804
2.1939	107920.0338	26.8674	0.9738
2.1469	36430.2013	29.7441	0.9570
2.0128	6501.2333	36.0014	0.9518
1.9965	13315.7030	33.1789	0.9658
2.0401	154104.2508	24.8050	0.9417

CONCLUSIONS

The dynamic viscosity of sunflower oil was determined for temperature range between 313 – 373 K and shear rates ranging from 3.3 – 120 s^{-1}. This article proposes three new relationships natural logarithm dynamic viscosity dependence of the absolute temperature for sunflower oil. Equation constants were determined by linear, exponential or polynomial beast curves obtained at different shear rates using the program Origin 6.0. The correlation coefficients thus obtained were 0.94175 and 0.99919 values between.

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