NUMERICAL METHODS INVOLVED IN LUBRICANT LIFE CYCLE DETERMINATION

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1. Introduction

The paper proposes a method for the lubricants wear degrees diagnosis, based on determination of the rheological properties, specially about the reducing of the viscosity values during the time. The experimental stand used for measuring the rheological parameters of the lubricants is a cone and plate viscometer, which offers absolute viscosity determination with precise shear rate and shear stress information.

In order to estimate the wear degree of the used oils, a theoretical relation is proposed [1], which establish the variation of the viscosity versus the equivalent distance covered by the motor vehicle:

$$\eta = \eta_0 e^{-Kd} \tag{1}$$

The two parameter characteristics are the initial viscosity η_0 for the fresh oil and the wear intensity coefficient *K*. These values are determined using the regression analysis method.

2. Experimental procedure

Experimental investigations were undertaken with the aim to check the assumed theoretical method. They were carried out at the ambient temperature of 20 ^{0}C, for three types of oils, which lubricate motor vehicles with different wear degrees:

- ELF EXCELLIUM LDX 5W-40 from a Diesel motor vehicle with 130000 km way;
- ELF PERFORMANCE EXPERTY 10W-40 from an essence motor vehicle with 38000 km way;
- ELF COMPETITION ST 10W-40 from an essence motor vehicle with 80000 km way.

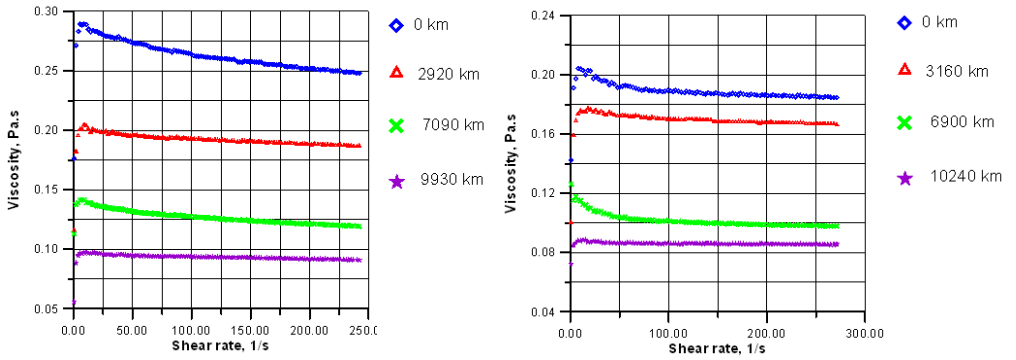
For each type of oil, the mean life time recommended by the producers is 10000 km, [2]. During this period, a few samples of lubricants have been collected, corresponding at different wear degrees: for fresh oil (at 0 km) and for used oil (approx. at 3000 km, 7000 km and 10000 km).

3. Results

Two typical rheograms, obtained with the Brookfield cone and plate viscometer, for two tested oils, are presented in Figure 1, a and b. In these figures, four curves are presented, corresponding for different wear degrees of the tested oils. It can observe that the viscosity decreases with equivalent distance of the motor vehicle, and clearly depends of the oil type.

The experimental data have been numerical analyzed using the regression analysis method, in order to obtain the mean values of the viscosity, for fresh and used oils (see Table 1). The same table presents the values of the correlation coefficient, which is an indicator of the correlation level between the theoretical Newtonian model and the experimental data.

In order to obtain the main values of the initial viscosity η_0 for the fresh oil and the wear intensity coefficient *K* (see Eq. 2), the data from Table 1 are numerically treated and the results are presented in Table 2.



a. ELF EXCELLIUM LDX 5W-40 oil b. ELF PERFORMANCE EXPERTY 10W-40 oil

Figure 1. Experimental rheogram for tested oils

Type of oil	Wear degree	Equivalent distance, km	Viscosity, Pa.s	Correlation coefficient
ELF EXCELLIUM LDX 5W-40	Fresh oil	0	0.186	0.963
	Used oil	2920	0.167	0.982
		7090	0.086	0.991
		9930	0.099	0.994
ELF PERFORMANCE EXPERTY 10W-40	Fresh oil	0	0.253	0.957
	Used oil	3160	0.189	0.978
		6900	0.122	0.989
		10240	0.092	0.995
ELF COMPETITION ST 10W-40	Fresh oil	0	0.229	0.968
	Used oil	2850	0.164	0.975
		7100	0.118	0.988
		9870	0.068	0.990

Table 1. Regression parameters for tested oils

Type of oil	Initial viscosity, Pa.s	Wear intensity coefficient, km^{-1}	Correlation coefficient
ELF EXCELLIUM LDX 5W-40	0.188	$7.793 \cdot 10^{-5}$	0.811
ELF PERFORMANCE EXPERTY 10W-40	0.254	$10.092 \cdot 10^{-5}$	0.996
ELF COMPETITION ST 10W-40	0.234	$11.582 \cdot 10^{-5}$	0.964

Table 2. Main values of the initial viscosity and wear intensity coefficient

4. Conclusions

Analyzing the experimental results obtained with this rheological method, it can be observed an important tendency of viscosity decreasing during the working time. Using the determination of the two characteristic parameters, the initial viscosity η_0 for the fresh oil and the wear intensity coefficient K, a new criteria for the wear degree of the oils is obtained.

5. References (selected)

[1] Czarny, R. "A study of thixotropy phenomen in lubricating greases", EUROTRIB' 89, Vol. IV, Helsinki, sept.1989, pp. 198-203
[2] *** ELF Lubricants, www.lubricants.elf.com/lub/lubroot.nsf/