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EXCESSIVE ADDITIVE EFFECT ON ENGINE OIL VISCOSITY

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Abstract

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The main goal of this paper is excessive additive (for oil filling) effect on engine oil dynamic viscosity. Research is focused to commercially distribute automotive engine oil with viscosity class 15W–40 designed for vans. There were prepared blends of new and used engine oil without and with oil additive in specific ratio according manufacturer's recommendations. Dynamic viscosity of blends with additive was compared with pure new and pure used engine oil. The temperature dependence dynamic viscosity of samples was evaluated by using rotary viscometer with standard spindle. Concern was that the oil additive can moves engine oil of several viscosity grades up. It is able to lead to failure in the engine. Mathematical models were used for fitting experimental values of dynamic viscosity. Exponential fit function was selected, which was very accurate because the coefficient of determination R^2 achieved high values (0.98–0.99). These models are able to predict viscosity behaviour blends of engine oil and additive.

Keywords: oil additive, dynamic viscosity, engine oil, temperature

INTRODUCTION

The dynamic viscosity is one of critical behaviour of automobile engine oil as state in (Maggi, 2006) and (Kumbár *et al.*, 2013). In this time exist many and many additives which is can influence to flow behaviour of liquids. Ohmo and Matsumoto (2013) write about molybdenum dialkyldithiocarbamate, Thomas *et al.* (2012) prefer transesterification with alcohols, Quinchia *et al.* (2009) and Nassar and Ahmed (2010) use polymeric additives, and Akhmedov *et al.* (2007) write about viscosity additives to oils based on copolymers of alkyl methacrylates and allyl monomers.

Engine oils with higher value of viscosity create a thicker oil layer than oils with lower viscosity. The metal surfaces thus do not contact each other, unless there is a larger irregularity or roughness (Mang and Dresel, 2001). As it is presented in Černý and Mašek (2010), the viscosity is a measure of fluidity of liquids. The oils characterized by lower viscosity are more fluid (tenuous) and have lower internal resistance against flow. The higher viscosity (thicker oil), on the other hand, is connected with higher flow resistance, slower flow and thus higher resistance against movement of lubricated surfaces (Luksa, 1990). There is a general practice that range of ± 20% of viscosity value is accepted for engine oil use. This value was set for large diesel engines (Covitch, 2007). In case of gasoline engines, the higher tolerance (for lower values) is acceptable, also with regard to shearing instability of recently produced oils. Total decrease of viscosity up to 30% is thus acceptable. The viscosity value, which is too low as a result of failure in the injection system and/or water in fuel, can lead to unacceptable thinning of lubricating layer (Zhang *et al.*, 2011).

This article addresses issues connected with the temperature dependence dynamic viscosity of new and used engine oil with oil additive.

MATERIAL AND METHODS

The analyses were performed using the automotive engine oil Mogul (produced in the Czech Republic) designed for vans. This oil is characterised by its producer as all-purpose, multi-grade oil intended for new types of petrol and diesel engines. Its properties are 15W-40 viscosity class, A3/B3 ACEA Standard, SH/CF API Standard, and 501.01/505.00 VW Standard. The used engine oil was taken from Renault Kangoo, 1.4i (55 kW), manufactured in 1999, with oil raid 15,100 km. Oil additive was Oil Treatment (produced in the USA), which is characterized by sentence: “fights friction to help protect against engine wear by providing a thicker cushion between moving engine parts”. The recommended oil-additive ratio is 1:10.

Measuring of temperature dependence of dynamic viscosity of given engine oil and blends was performed using rotational viscometer Anton Paar DV–3P. This experimental device measures the torque of rotating spindle placed into the sample. The viscometer detects the resistance against rotation of cylinder or disc surrounded by measured fluid. The rotating cylinder or disc is connected with electric motor shaft via defined springs. The shaft is rotating by set speed (expressed in rotations per minute). The angle of swing is electronically monitored and offers the precise information on shaft (spindle) position. The measured data are used for calculation of dynamic viscosity expressed in mPa·s. In case of fluids with constant viscosity is the resistance against movement increased with spindle size. The range of measuring and rheological properties determination can be customized according to specific measuring and experimental conditions by selection of spindle and its rotation velocity. Relevant evaluation of the results is conditioned by detailed knowledge of tested material. It is necessary to classify the material in a correct way (Kumbár and Dostál, 2014).

The sample oil was measured in temperature range –5 °C to +95 °C using standard spindle of R3 type, which is the most suitable spindle for this kind of test specification. The spindle speed (revolutions per minute) was selected to 30 rpm.

RESULTS AND DISCUSSION

Temperature dependence dynamic viscosity of new engine oil, used engine oil, new engine oil with additive, used engine oil with additive, and pure additive was evaluated in temperature range –5 °C to +95 °C. The comparison of dynamic viscosity values of all samples engine oil and pure additive is shown in the Tab. I.

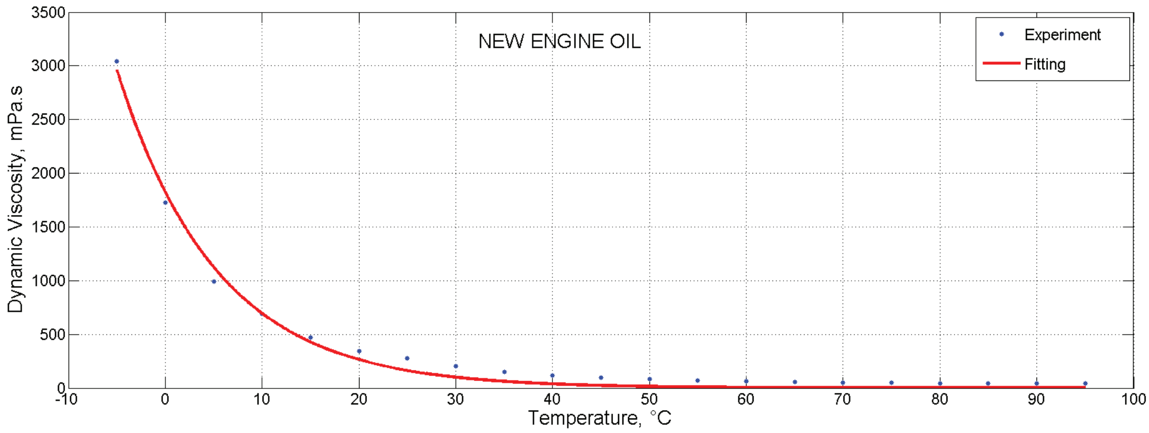
The temperature dependence dynamic viscosity of samples without additive was measured and fitted, as it can be seen in Fig. 1 and Fig. 2.

The temperature dependence dynamic viscosity of samples with additive was measured, as it can be seen in Fig. 3 and Fig. 4. The temperature dependence dynamic viscosity of pure additive is shown in the Fig. 5.

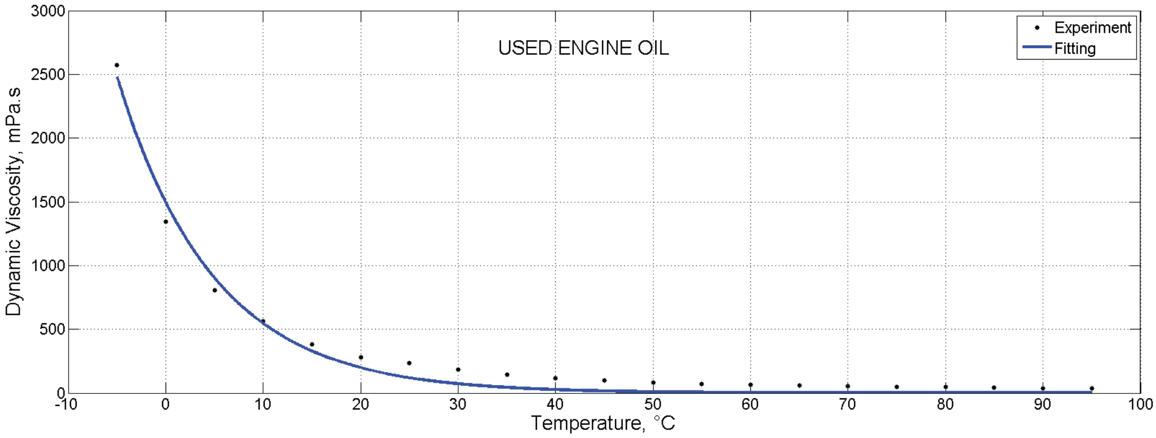
It can be seen that additive has excessive effect on the engine oil viscosity. We can say that

I: *Comparison of dynamic viscosity values ($p > 0.05$)*

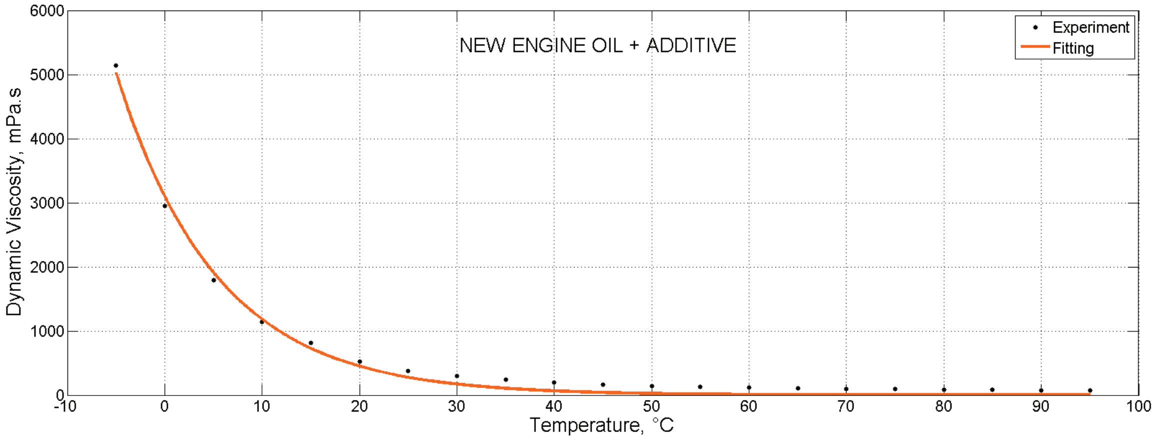
	Dynamic viscosity, mPa.s				
Temperature, °C	**New engine oil**	**Used engine oil**	**New engine oil + additive**	**Used engine oil + additive**	**Additive**
–5	3,043 ± 152	2,575 ± 129	5,135 ± 257	4,824 ± 241	75,827 ± 3,791
0	1,729 ± 86	1347 ± 67	2,950 ± 148	3,139 ± 157	48,973 ± 2,449
5	990 ± 50	804 ± 40	1,791 ± 90	1,898 ± 95	33,866 ± 1,693
10	690 ± 34	561 ± 28	1,142 ± 57	1,122 ± 56	26,347 ± 1,317
15	471 ± 24	380 ± 19	820 ± 41	799 ± 40	18,543 ± 927
20	347 ± 17	278 ± 14	518 ± 26	617 ± 31	13,737 ± 687
25	276 ± 14	237 ± 12	373 ± 19	482 ± 24	11,064 ± 553
30	207 ± 10	182 ± 9	296 ± 15	370 ± 19	8,139 ± 407
35	152 ± 8	142 ± 7	243 ± 12	289 ± 14	5,755 ± 288
40	116 ± 6	114 ± 6	202 ± 10	227 ± 11	4,326 ± 216
45	98 ± 5	97 ± 5	164 ± 8	186 ± 9	3,560 ± 178
50	81 ± 4	82 ± 4	141 ± 7	163 ± 8	3,069 ± 153
55	69 ± 3	72 ± 4	126 ± 6	143 ± 7	2,536 ± 127
60	61 ± 3	65 ± 3	114 ± 6	124 ± 6	2,046 ± 102
65	55 ± 3	59 ± 3	104 ± 5	107 ± 5	1,824 ± 91
70	51 ± 3	53 ± 3	98 ± 5	102 ± 5	1,645 ± 82
75	48 ± 2	49 ± 2	93 ± 5	96 ± 5	1,449 ± 72
80	46 ± 2	46 ± 2	87 ± 4	89 ± 4	1,297 ± 65
85	45 ± 2	41 ± 2	85 ± 4	87 ± 4	1,232 ± 62
90	44 ± 2	39 ± 2	78 ± 4	84 ± 4	1,160 ± 58
95	43 ± 2	39 ± 2	76 ± 4	81 ± 4	1,095 ± 55



1: *Temperature dependence dynamic viscosity of new engine oil*



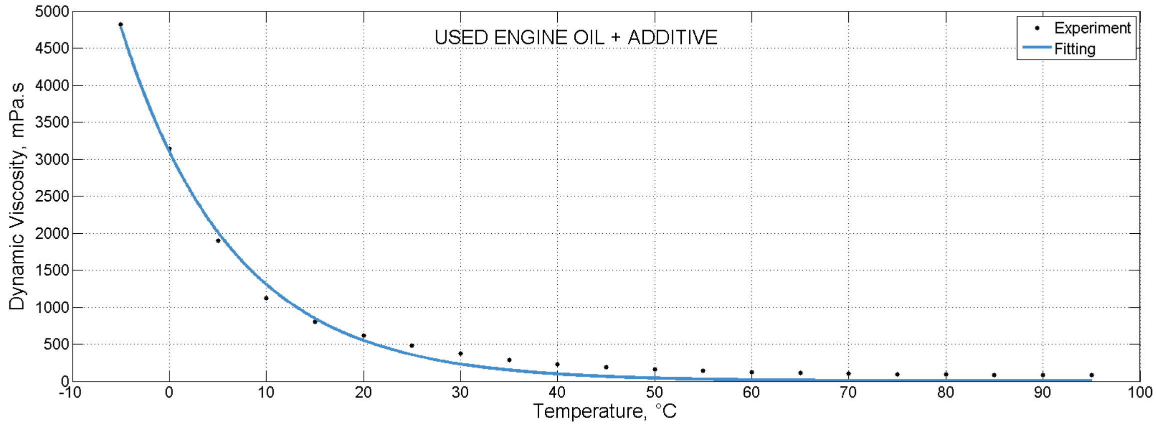
2: *Temperature dependence dynamic viscosity of used engine oil*



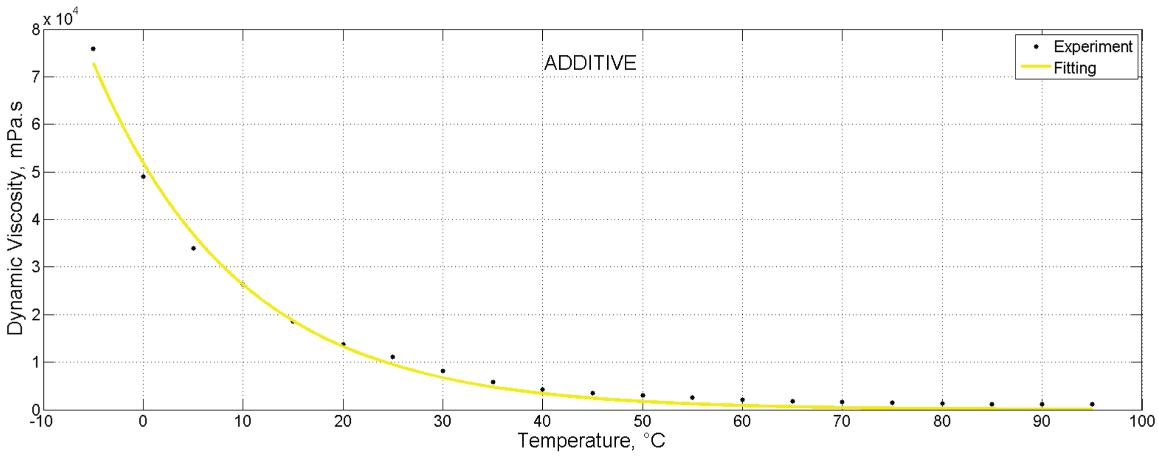
3: *Temperature dependence dynamic viscosity of new engine oil with additive*

the additive moves blends of several viscosity grades up. The decrease dynamic viscosity is around 60–70 times for all samples in temperature range –5 °C to +95 °C. It is expect but if we pour oil additive to engine oil filling in recommended ratio 1:10 the viscosity increased too much.

If we pour additive to new engine oil the dynamic viscosity at 0 °C increase from 1,729 to 3,000 mPa·s. At 40 °C it is from 116 to over 200 mPa·s and at 95 °C it is from 43 to about 80 mPa·s. If we pour additive to used engine oil the dynamic viscosity at 0 °C increase from 1,347 to about 3,000 mPa·s. At 40 °C it is from 116 to over 200 mPa·s and at 95 °C it is from 43 to about 80 mPa·s.



4: *Temperature dependence dynamic viscosity of used engine oil with additive*



5: *Temperature dependence dynamic viscosity of additive*

The temperature dependence dynamic viscosity of all samples was modeled using exponential fit function. The general formula was used:

$$\eta = A \times e^{k \times t}, \quad (1)$$

where
η ....dynamic viscosity [mPa·s],
t ....temperature [°C],
A ......coefficient [mPa·s],
k ....coefficient [°C⁻¹].

The values of coefficients and determination coefficient R^2 are shown in the Tab. II.

CONCLUSIONS

The role of engine oil in the engine operation is of multipurpose character. None of the oil characteristics or physical properties can be preferred and/or increased to the exclusion of other. The dynamic viscosity is one of critical physical behaviour of automobile engine oil. The temperature dependence dynamic viscosity of new engine oil, used engine oil, new engine oil with additive, used engine oil with additive, and additive was evaluated using the rotary viscometer. It was found significant temperature dependence viscosity of all samples. This dependence was modelling using exponential fit function, which was very accurate because

II: *Values of coefficients A, k and determination coefficient R^2*

	A, mPa·s	***k*, °C⁻¹**	**R²**
New engine oil	1,825	−0.0967	0.9894
Used engine oil	1,495	−0.1011	0.9823
New engine oil + additive	3,100	−0.0966	0.9925
Used engine oil + additive	3,100	−0.0866	0.9918
Additive	51,860	−0.0681	0.9936

the coefficient of determination R^2 achieved high values (0.98–0.99). The decrease dynamic viscosity is around 60–70 times for all samples in temperature range −5 °C to +95 °C. It is expect but if we pour oil additive to engine oil filling in recommended ratio 1:10 the viscosity increased too much. If we pour additive to new engine oil the dynamic viscosity at 0 °C increase from 1,729 to 3,000 mPa·s. At 40 °C it is from 116 to over 200 mPa·s and at 95 °C it is from 43 to about 80 mPa·s. If we pour additive to used engine oil the dynamic viscosity at 0 °C increase from 1,347 to about 3,000 mPa·s. At 40 °C it is from 116 to over 200 mPa·s and at 95 °C it is from 43 to about 80 mPa·s. The main conclusion of this article is not matter if we pour the additive to new or used engine oil, but important is that the additive is able to moves engine oil of several viscosity grades up. It may not be in accordance with manufacturer's recommendations and it can lead to failure in the engine.

SUMMARY

This paper deals with excessive additive (for oil filling) effect on engine oil dynamic viscosity. The role of engine oil in the engine operation is of multipurpose character. None of the oil characteristics or physical properties can be preferred and/or increased to the exclusion of other. The dynamic viscosity is one of critical physical behaviour of automobile engine oil. Research is focused to commercially distribute automotive engine oil with viscosity class 15W–40 designed for vans. There were prepared blends of new and used engine oil without and with oil additive in specific ratio according manufacturer's recommendations. Dynamic viscosity of blends with additive was compared with pure new and pure used engine oil. The temperature dependence dynamic viscosity of samples was evaluated by using rotary viscometer with standard spindle. It was found significant temperature dependence viscosity of all samples. This dependence was modelling using exponential fit function, which was very accurate because the coefficient of determination R^2 achieved high values (0.98–0.99). The decrease dynamic viscosity is around 60–70 times for all samples in temperature range −5 °C to +95 °C. It is expect but if we pour oil additive to engine oil filling in recommended ratio 1:10 the viscosity increased too much. If we pour additive to new engine oil the dynamic viscosity at 0 °C increase from 1,729 to 3,000 mPa·s. At 40 °C it is from 116 to over 200 mPa·s and at 95 °C it is from 43 to about 80 mPa·s. If we pour additive to used engine oil the dynamic viscosity at 0 °C increase from 1,347 to about 3,000 mPa·s. At 40 °C it is from 116 to over 200 mPa·s and at 95 °C it is from 43 to about 80 mPa·s. The main conclusion of this article is not matter if we pour the additive to new or used engine oil, but important is that the additive is able to moves engine oil of several viscosity grades up. It may not be in accordance with manufacturer's recommendations and it can lead to failure in the engine.

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