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# Methods for Testing the Viscosity Index with the Aid of Multiple Correlation

*The authors approach in the present paper the problem of testing the viscosity index of an oil using the mathematical-statistic methods for its use in writting the viscosity constraint in the blending model.*

An important place in the problem of modelling the oil blends with the aid of modern methods of mathematics and electronic computers with a view to getting some blending optimum formula, from the view point of cost price (minimum) or of the user (maximum), is held by the constraints referring to viscosity index.

As is known, Dean Davis index is a number computed on the base of conventional prerequisites showing the quality of an oil from the view point of viscosity variation with the temperature. A low viscosity index shows a high viscosity variation with the temperature and conversely.

Analysing the oils which separate paraffin at low temperature, the viscosity index does not characterize anymore the viscosity variation with the temperature in the field of those temperatures. According to STAS 55-58 [2] the viscosity index is mainly tested as follows:

We compare the oil to be researched, to which the kinematic viscosity was tested at 98.9°C and 37.8°C, with two reference oils which have the same viscosity as the oil to be researched at 98.9°C. The reference oils belong to two suppositional oil serries chosen as standard.

The reference oils in the first serries ($L$) are oils of (Pensilvania type) whose viscosity variation with temperature is low; to these ones there were conventionally attributed the viscosity index 100. The reference oils in the second series ($H$) are oils of (Gulf Coast type) whose viscosity variation with the temperature is high; to these ones there were conventionally attributed the viscosity index 0.

The kinematic viscosities at a 37.8°C temperature of the reference oils which have at 98.9°C the same kinematic viscosity ($\lambda$) as the oil to be researched, tested also at 98.9°C, is computed as follows:

$$L = 1.655\,\lambda + 1.2625\,\lambda^2, \tag{1}$$

$$H = 1.4825\,\lambda + 0.91375\,\lambda^2. \tag{2}$$

The viscosity index ($Iv$) is computed by the formulae:

$$Iv = \frac{L - U}{L - H} \times 100 \tag{3}$$

where $U$ is the kinematic viscosity of the oils to be researched at 37.8°C in centistokes.

To this purpose, the viscosity of the oil to be researched at 98.9°C and at a 37.8°C temperature is tested according to STAS 117-56.

We have to find out in the table from STAS the values $L$ and $L - H$ corresponding to the kinematic viscosity at 98.9°C of the oil to be researched and to introduce them in relation (3). The got results from the computation are rounded off through truncation. As regards the test precision we take as a base the viscosities resulted at three consecutive tests which do not differ from their average by more than 0.3% from the average value.

In the case of viscosity tests made by different operators with different equipment, the difference between the viscosity indexes must not exceed by more than 50% the above values.

**Table 1**

*Table regarding the precision for testing the viscosity index ($Iv$)*

| Kinematic viscosity at 98.9°C (centistokes) | Two tests difference of viscosity index ($Iv$) | |
|---|---|---|
| | Oil with $Iv = 0$ | Oil with $Iv = 100$ |
| 4 | 6 | 4 |
| 6 | 4 | 3 |
| 8 | 4 | 2 |
| 12 | 3 | 1 |
| 20 | 2 | 1 |

In the present paper the authors have worked out with the aid of multiple correlation, a relation under the form:

$Iv = f(V_1, V_2, V_3)$ where:

$V_1$ — is the viscosity in centistokes at 50°C

$V_2$ — is the viscosity in centistokes at 37.8°C

$V_3$ — is the viscosity in centistokes at 98.9°C.

The viscosities were transformed from Engler degrees into centistokes (cst) ones with the aid of chart 5 in [3]. Then, the viscosity is transformed from centistokes in blending indexes ($IA$) with the aid of table III. 8 in [1]. The

viscosities expressed in *IA* units behave linearly into the blending. Thus, the primary data in table 2 have been linearized according to table 3.

**Table 2**

*Primary data for the viscosity of various oils*

| *I* | Viscosity at 50°E, E | Viscosity at 37.8°C, cst. | Viscosity at 98.9°C | Density |
|---|---|---|---|---|
| 96 | 3.82 | 47 | 6.5 | 0.8830 |
| 90.1 | 7.70 | 107 | 10.7 | 0.8950 |
| 83 | 20.20 | 323 | 20.9 | 0.8980 |
| 90.1 | 7.00 | 98 | 10.1 | 0.8940 |
| 90.8 | 6.62 | 89 | 9.5 | 0.8920 |
| 91.2 | 6.11 | 83 | 9.1 | 0.8910 |
| 91.2 | 5.72 | 76 | 8.6 | 0.8900 |
| 92.4 | 5.21 | 70 | 8.2 | 0.8890 |
| 92.5 | 4.93 | 65.6 | 7.8 | 0.8870 |
| 93.6 | 4.70 | 59 | 7.7 | 0.8860 |
| 94.3 | 4.30 | 55 | 7.1 | 0.8840 |
| 94.9 | 4.00 | 51 | 6.8 | 0.8960 |
| 84.3 | 15.00 | 231.4 | 17.1 | 0.8940 |
| 86.1 | 12.40 | 187.4 | 15.1 | 0.8920 |
| 86.7 | 10.50 | 153.4 | 13.3 | 0.8900 |
| 88.4 | 8.70 | 124.2 | 11.7 | 0.8890 |
| 96.6 | 7.40 | 103.6 | 10.5 | 0.8880 |
| 92 | 6.3 | 86 | 9.35 | 0.8880 |
| 93.8 | 5.46 | 72 | 8.40 | 0.8870 |
| 94.2 | 4.63 | 60 | 7.50 | 0.8850 |
| 85.6 | 13.80 | 204 | 16.00 | 0.8960 |
| 86 | 12.20 | 182.6 | 14.80 | 0.8956 |
| 86.6 | 11.20 | 164.2 | 14.10 | 0.8953 |
| 87 | 11.20 | 167.0 | 14.10 | 0.8950 |
| 89.2 | 8.25 | 120 | 11.40 | 0.8944 |
| 89.3 | 7.66 | 108 | 10.60 | 0.8941 |

We compute the regression coefficients *) on which base the following relation has been got which to allow the testing of oils viscosity index, depending on the kinematic viscosities at 37.8°C, 50°C, 98.9°C and of density at 15/4 (4),

$$Iv = 128.902328 - 0.416294\ V_1 - 0.597827\ V_2 - 1.117013\ V_3 + \quad (4)$$

$$+ 23.121414\ d$$

where:

$Iv$ — is the Dean Davis viscosity index
$V_1$ — is the kinematic viscosity at 50°C (linearized)
$V_2$ — is the kinematic viscosity at 37.8°C (linearized)
$V_3$ — is the kinematic viscosity at 98.9°C (linearized)
$d$ — is the oil density at 15/4.

It was used the REMUS program (Selective Multiple Regression) worked out within the Laboratories of Economic Cybernetics Department, Academy of Economic Studies [5].

Table 3

*Data regarding the linearized viscosities*

| $I$ | $V_1$ | $V_2$ | $V_3$ | $d$ |
|---|---|---|---|---|
| 96 | 28.88 | 30.61 | 20.94 | 0.8830 |
| 90.1 | 31.72 | 33.40 | 23.93 | 0.8850 |
| 83 | 34.60 | 36.48 | 27.27 | 0.8980 |
| 90.1 | 31.32 | 33.13 | 23.63 | 0.8940 |
| 90.8 | 31.19 | 32.83 | 23.28 | 0.8920 |
| 91.2 | 30.99 | 32.60 | 23.03 | 0.8910 |
| 91.2 | 30.61 | 32.30 | 22.69 | 0.8900 |
| 92.4 | 30.20 | 32.04 | 22.41 | 0.8890 |
| 92.5 | 29.92 | 31.75 | 22.10 | 0.8870 |
| 93.6 | 29.69 | 31.45 | 21.77 | 0.8860 |
| 94.3 | 29.23 | 31.19 | 21.52 | 0.8840 |
| 94.9 | 29.05 | 30.93 | 21.24 | 0.8960 |
| 84.3 | 33.90 | 35.57 | 26.37 | 0.8940 |
| 86.1 | 33.20 | 35.04 | 25.75 | 0.8920 |
| 86.7 | 32.75 | 34.47 | 25.10 | 0.8900 |
| 88.4 | 32.13 | 33.86 | 24.83 | 0.8890 |
| 90.6 | 31.51 | 33.30 | 23.83 | 0.8880 |
| 92.0 | 31.06 | 32.71 | 23.18 | 0.8880 |
| 93.8 | 30.45 | 32.13 | 22.55 | 0.8870 |
| 94.2 | 29.46 | 31.51 | 21.86 | 0.8850 |
| 85.6 | 33.65 | 35.27 | 26.05 | 0.8960 |
| 86.0 | 33.13 | 34.97 | 25.92 | 0.8956 |
| 86.6 | 32.94 | 34.67 | 25.41 | 0.8953 |
| 87.0 | 32.94 | 34.06 | 25.38 | 0.8950 |
| 89.2 | 31.81 | 33.76 | 24.28 | 0.8944 |
| 89.3 | 31.64 | 33.43 | 23.88 | 0.8941 |

The multiple correlation coefficient is 0.987, therefore very closed to 1. The standard error is equal to 0.559 and the variation coefficient is 0.622.

Bearing in mind the above stated problems, we suggest as the relation ascertained by the authors to be used in the technical speciality literature, namely:

$$Iv = 128.9020 - 0.4163\ V_1 - 0.5978\ V_2 - 1.1170\ V_3 + \\ + 23.1214\ d \qquad (5)$$

The results got with the aid of REMUS program are presented in table 4.

Table 4

EQUATION OF VARIABLE 11

| VARIABLE NAME | VAR NO | REGRESSION COEFF. |
|---|---|---|
| CONSTANT | | 128.902328 |
| *V1* | 2 | −.416294 |
| *V2* | 3 | −.597827 |
| *V3* | 4 | −.117013 |
| *D* | 5 | 23.121414 |
| MULTIPLE CORRELATION COEFF. | | .987 |
| MULTIPLE DETERMINATION | | 97.383 |
| STANDARD ERROR | | .559 |
| VARIATION COEFFICIENT | | .622 |

## EXAMPLE OF APPLYING THE RELATION

We suppose that an oil has the following quality:

density at 15/4 = 0.8956
$V_1$ = viscosity 50°C = 12.2°E
$V_2$ = viscosity 37.8°C = 182.6 cst
$V_3$ = viscosity 98.9°C = 14.8 cst.

The viscosity is converted with the aid of chart 5 in [3] from °E into centistokes, following: 12.2°E = 99 cst.

Then, the linearized values are read with the aid of table III. 8, following:

$V_1$ = 12.2°C = 99 cst = 33.13;
$V_2$ = 182.6 cst = 34.97;
$V_3$ = 14.8 cst = 25.92.

Replacing these values in (5), it follows:

$$Iv = 128.9020 - 0.4163 \times 33.13 - 0.5978 \times 34.97 - 1.1170 \times$$

$$\times 25.92 + 23.1214 \times 0.8956 = 85.96.$$

The practical testing of the viscosity index in laboratory according to STAS 55-58, has lead to the value of 86. It results a difference of 0.04 units of viscosity index $Iv$,— difference that is virtually negligible.

The main quality of the suggested method excepting the rapidity in computing the viscosity index, is the precision, namely:

Repeatibility error
(the same equipment and operator) = $\pm$ 0.5 units $Iv$

Reproduction error
(various equipment and operators) = $\pm$ 1 units $Iv$.

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## METHODES POUR DETERMINER L'INDICE DE VISCOSITE A L'AIDE DE LA CORRELATION MULTIPLE

Les auteurs abordent, à l'aide des méthodes statistiques mathématiques, le problème de la détermination de l'indice de viscosité d'une huile, en utilisant cet indice lors de la mise en formule de la contrainte de viscosité du modèle de mélange.

## МЕТОДЫ ОПРЕДЕЛЕНИЯ ПОКАЗАТЕЛЕЙ ВЯЗКОСТИ ПРИ ПОМОЩИ МНОЖЕСТВЕННОЙ КОРРЕЛЯЦИИ

В настоящей работе авторы заирагивают вопрос определения показателей вязкости некоторых масел при помощи статистико-математических методов с целью описания ограничения вязкости в модели смееи.

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