Acta of Turin Polytechnic University in Tashkent, 2023, 30, 13-16
Published Online December 2023 in Acta TTPU (http://www.acta.polito.uz/)

MATHEMATICAL MODEL FOR ESTIMATING THE LIFE CYCLE OF MOTOR OILS.

Sharipov A.K.
Turin Polytechnic university in Tashkent
Email: a.sharipov@polito.uz

Abstract– The paper presents an approach to get a mathematical model for describing a life cycle of motor oils an internal combustion engine (ICE). The numerical analysis of this mathematical model considering the variables of the process, is a very hard task. In this case, we propose the determination of this model using a temperatures regime of engine, in order to determine the vary quantity of parameter that effects the resources of the lubricant used an ICE. Our approach based on data uses the I. D. Rodziller theory for the identification of the mathematical model, which follows at varying temperatures of engines to solve the problem. The result data were collected from an used oil well. This paper presents the results of the training phase and of the generated models after several iterations of gasoline and hydrogen blends. Additionally, the paper analyses the differences between the generated theory, according to the number of variables considered, the complexity of the expressions, and the error.

Key words– ICE-internal combustion engine, Kinematic viscosity, mixture density, concentration, velocity intensity, velocity field, interpenetration, interaction, single-phase jet.

I Introduction

The load mode of operation of the engines is set depending on the designed temperature parameters and operating conditions of the vehicles. In this case, the optimal resource consumption of both the machine as a whole and the lubricant in particular is maintained. [1,2] The increased intensity of operation leads to significant loads on the power plant, which in turn leads to an increase in the temperature conditions of its operation, a decrease in the technical and operational life of mechanical systems and lubricants. The temperature regime of engines is the determining parameter that affects the resource of the lubricant used, and is estimated by the temperature of the coolant and oil at the engine outlet. The assessment by the thermal parameter of the oil is not carried out on all vehicles, machines and mechanisms. As a result, the coolant temperature remains the main evaluation parameter [3,4].

The main signs of a malfunction are engine overheating, low pressure in the lubrication system, contamination of the lubricant and its high waste consumption. Violation of the lubrication system performance reduces the resource of the lubricant and is the main cause of emergency equipment failure with further long-term impossibility of its operation. A decrease in oil pressure in the engine lubrication system can be caused by its insufficient quantity, overload or wear of parts of the cylinder-piston group, contamination of oil coolers that disrupt heat dissipation, and malfunction of oil pump pressure reducing valves. During the period of starting the engine in the cold period, oil at low temperatures is poorly pumped in the system, it lingers longer in the gaps of mating parts, which leads to increased wear of parts due to the absence of an oil film on their surfaces. [5,6]

II Formulation of mathematical model

The blending of hydrogen in the composition of gasoline acts in the hydro and property of extracting hydrogen at high temperature. With increasing temperature, the hydro percentage of engine oil increases. The value of the dilution factor for the discharge of hydrogen and 85% mixing of gasoline is determined by the formula of I. D. Rodziller. [7].:

$$v = \frac{1 - e^{-\alpha \sqrt[3]{l}}}{1 + e^{-\alpha \sqrt[3]{l}} \frac{Q}{q_{hydrogen}}} \tag{1}$$

Where: *V=the value of dilution ratio, Q=gasoline capacity, q=hydrogen capacity.*

The dilution ratio of hydrogen in the most polluted gasoline is determined by the formula:

$$n_i = \frac{(q_{hydrogen} + \gamma Q)\partial b}{q_{hydrogen}} \tag{2}$$

Where: *n=nominal quantity of hydrogen, Q=gasoline capacity, q=hydrogen capacity. γ=is the dilution factor.*

The dilution ratio of hydrogen in minimally polluted gasoline is determined by the formula:

$$n_k = \frac{(\beta q_{hydrogen} + Q)}{\beta q_{hydrogen}} \quad (3)$$

Where: *n=minimal quantity of hydrogen, Q=gasoline capacity, q=hydrogen capacity.* β *is the turbulent diffusion coefficient.*

The mixing ratio of hydrogen with gasoline shows what part of the gasoline consumption is mixed with hydrogen [8,9,10].

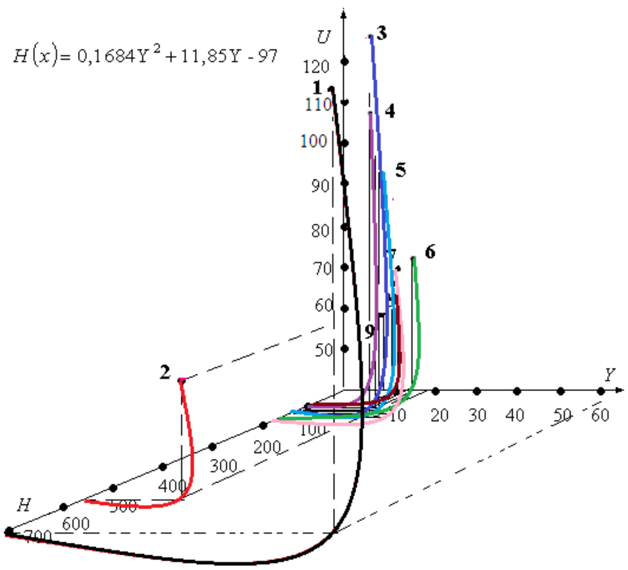

Fig. 1: Entry of hydrogen into gasoline mixtures, increase in hydro and determination of elimination limits.

This coefficient is determined by the formula:

$$\beta = \frac{1 - e^{-\alpha(\sqrt[3]{l} - \sqrt[3]{l_0})}}{1 + e^{-\alpha(\sqrt[3]{l} - \sqrt[3]{l_0})} \frac{Q}{q_{cm}}} \quad (4)$$

Where: β*=coefficient of hydrogen, Q=gasoline capacity, q=hydrogen capacity, l=refers to the distance.*

Under L - means the distance at which hydrogen is supplied. To determine the dilution ratio of gasoline with hydrogen [11,12,13], the following formula is proposed:

$$n_p = \frac{S\varphi H}{Ax(B-L)lgRe_\delta} \quad (5)$$

Where:

$$Re_\delta = \frac{\vartheta H}{D} [here \quad D = \frac{\vartheta g H}{2mC}, \quad 2m = 0,7C + 6] \quad (6)$$

Where: *D=diffusion Reynolds number. V=velocity of diffuse of hydrogen,* R_e*=Reynolds number,* n_p*=normal quantity of hydrogen, g=gravitational acceleration.*

$$A = \frac{S_{eks}}{S_{lab}} \quad (7)$$

[here S_{lab} is determined by the formula at A=1]
coefficient of proportionality, changing from 0.9-2;

$$\varphi = \frac{l_{eks}}{l_{lab}} \quad (8)$$

Where: φ*=tortuosity coefficient (from outlet line to design line), x=-distance from the end of the release, B= is the width of the dissolved part of gasoline; L= the length of the scattering outlet, H=average depth of flow over outlet, V=average flow velocity over outlet. [14,15,16,17].*

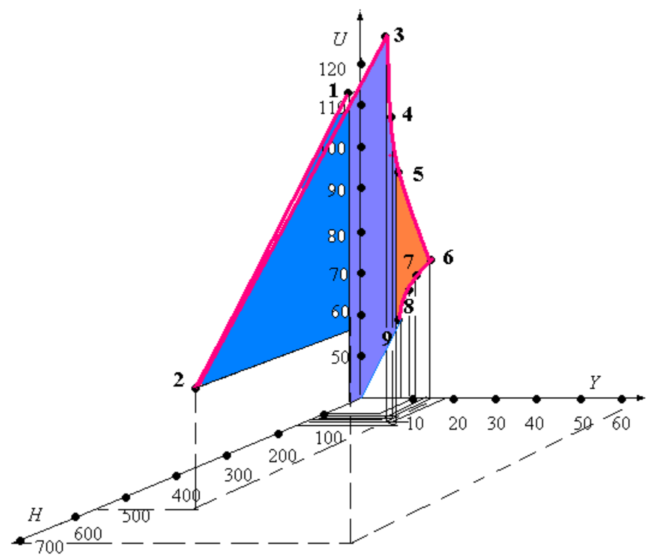

Fig. 2: Engine oil life cycle graph and find out of life cycle limits.

For the initial dilution in an arbitrary section of an axisymmetric hydrogen jet,[68] we have the formula:

$$n_H = \frac{0,258}{1-m} \left(\frac{d}{d_0}\right)^2 \left[\sqrt{m^2 + 8,1(1-m)\left(\frac{d_0}{d}\right)^2} - m\right] \quad (9)$$

Where: n_H*=the quantity of hydrogen,* $m = \frac{\vartheta p}{\vartheta 0}$ *is the ratio of the calculated flow rate to the outflow rate of the gasoline jet, d=- jet diameter at an arbitrary distance from the outlet,* d_o*=the diameter of a single falling jet of gasoline.*

The limiting value of the initial dilution is observed in the section where the maximum jet diameter reaches a value equal to the depth of the gasoline flow. For this case, formula (5) takes the form:[18,19,20]

$$n_H = \frac{0,258}{1-m}\left(\frac{H}{d_0}\right)^2\left[\sqrt{m^2+8,1(1-m)\left(\frac{d_0}{H}\right)^2}-m\right] \quad (10)$$

To calculate the dilution of gasoline with hydrogen [6], there is a formula:

$$n_{tot} = \frac{(q_{cm}+Q)}{q_{cm}+Qe^{-\beta(\frac{1}{R})^{\frac{1}{4}}}+Q_H} \quad (11)$$

for lowest total dilution

$$n_{tot} = \frac{(q_{cm}+Q)}{(Q-Q_H+q_{cm})e^{-\beta(\frac{1}{R})^{\frac{1}{4}}}+Q_H} \quad (12)$$

Where: Q_H=*is the consumption of a mixture of gasoline and hydrogen in the initial dilution section:*

$$Q_H = n_H q \quad (13)$$

Based on the analysis given in table, we will compile a function of changes.

	U	***Y***	***H***
1	116,6	66,8	705,83
2	111,52	15,97	5656
3	109,75	14,39	139,9
4	108,94	14,2	138,2
5	96,29	14,58	143
6	79,93	13,7	131,2
7	76,82	11,6	102,8
8	76,81	12,88	118,7
9	75,9	11,43	3457

TABLE 1

Based on these parameters and using a 1-table, we write Newton's interpolation formula in the form [21]:

U and Y = kinematic viscosity at 40^oC and 100^oC; H = the value determined on the basis of a special table, if it is higher than 70 mm^2/s at 100^oC, it is determined by the following formula:

$$H = 0.1684Y^2 + 11.85Y - 97 \quad (14)$$

$$L(x) = y_0\frac{(x-x_1)(x-x_2)}{(x_0-x_1)(x_0-x_2)} + y_1\frac{(x-x_0)(x-x_2)}{(x_1-x_0)(x_1-x_2)} \quad (15)$$

$$L(x) = 0,1684x^2 + 11,85x - 97$$
$$H(x) = 0,1684Y^2 + 11,85Y - 97$$

III MATERIALS AND METHODS

Green hydrogen is defined as hydrogen produced without releasing any hazardous emissions. Using an electrolysis process that uses a car battery as electricity, green hydrogen is created from water.

For the research development, a spark-ignition engine was used, with a compression ratio of 9.5:1, displacement of 2.0 L and natural aspiration. Additionally, air-hydrogen mixer was used in engine intake manifold system.

Engine oils from the three different manufacturers were used in research. All oils were of the different viscosity grade and were applied to 3 vehicles (one each oil). Which were operated in similar conditions. The tested cars were operated mostly on gasoline blend with hydrogen gas. The FTIR methods are used to analysis changes of viscosity index, total acid number (TAN), total base number (TBN), and flash points of engine oils.

Obtained practical analysis result were used to determine functional dependencies, describing the kinetics of the formation of specific characteristics of oil. Newton interpolation formula was used as a measure of error. In the analysis, the model is based on the 2nd order polynomial regression. When all the test indicated have yielded non-significant result, the procedure was completed.

IV RESULT

The propagation speed of the mixture of diffusion of gasoline and hydrogen along the O_x axis also decreases across the cross section, which means an increase in the vortex mixture. A decrease in oil pressure in the engine lubrication system can be caused by an increase in vortex zones and insufficient oil. It is proposed to increase the speed of the jets of a mixture of gasoline and hydrogen under strict conditions.

V REFERENCES

[1] Bronstein I. N., Semendyaev K. A. A reference book on mathematics for engineers and students of technical colleges Moscow. "Science" 1981. 720p.

[2] Jovliev U. T., Khudaykulov S. I. Algorithm for accounting for vortex zones when entering the pumps. Bulletin of the Turin Polytechnic University in the city of Tashkent, issue 1/2018, pp. 58-60.

[3] Mirzakhmadov B.N., Khudaykulov S.I. "Development of combined heat supply systems under conditions of gas interaction with a solid wall" (pp. 95-97) scientific-methodical journal of "scientific progress" issn: 2181-1www. tashkent, uzbekistan. 2021, july 15.

[4] Mirzakhmadov, BN, Saidkhuzhaeva, NS, Khudaykulov

SI "Calculation of heat losses at combined heat supply". the journal of academic research in educational sciences issn 2181-1385.volume 2, special issue 4. june 2021 98-100).

[5] Sharipov A., Inoyatkhodzhaev J. "The main characteristics of engine oil and their influence over time" ASTA TTPU-2 / (2019) 122-125.

[6] Khudaykulov S.I., Usmonova N.A. O'.Sh. R. Simulation of the Lift of Two Sequential Gate Valves of the Karkidon Reservoir. MIDDLE EUROPEAN SCIENTIFIC BULLETIN ISSN 2694-9970 148-156. Middle European Scientific Bulletin, VOLUME 18 Nov 2021.

[7] Valueva E.P., Sviridov V.G. Introduction to Fluid Mechanics, Study Guide. - M .: Publishing house MEI, 2001 .- 212 p..

[8] Gosmen A.D., Pan V.M., Ranchel A.K., Spalding D.B., Wolfshtein M. Numerical Methods for Studying Viscous Fluid Flows, Moscow, 2002.

[9] Zaguzov I.S., Polyakov K.A., Mathematical modeling of viscous fluid flows near solid surfaces, textbook for students, Samara, 2001.

[10] Zaguzov I.S., Polyakov K.A. Mathematical models in aerohydromechanics. part 1, Samara, 2002.

[11] Zaguzov I.S., Polyakov K.A. Mathematical models in aerohydromechanics. part 2, Samara, 2002.

[12] Elizarova T.G. Lectures, mathematical models and numerical methods in the dynamics of gas and liquid, Moscow, Moscow State University, 2005.

[13] Pushkina I.G., Tishkin V.F. Adaptive computational grids from Dirichlet cells for solving problems of mathematical physics: construction techniques, examples. Mat. modeling. T.12, no.3, 97p., 2000

[14] Shkadov V.Ya., Zapryanov Z.D., The flow of a viscous fluid, M-1984, 200p.

[15] Abrashkin A.A., Yakubovich E.I., Vortex dynamics in the Lagrangian description.-M: Fizmatlit, 2006-176p. ISBN 5-9221-0725-9.

[16] Zenkovich D.A.Matrix Lagrangian description of vortex structures in an ideal fluid. // Abstract of the dissertation for the degree of candidate of physical and mathematical sciences. Nizhny Novgorod, 2002.22p.

[17] IN AND. Sologaev, Hydraulics (mechanics of liquid and gas) Textbook, Omsk, Publishing house SibADI, 2010

[18] V.G. Babsky, N.D. Kopachevsky, A.D. Myshkis, L.A. Slobozhanin, A.D. Tyuptsov, Zero gravity hydromechanics. "Science", M.t 2006, 504 p.

[19] Tsaplin S.V., Romanov A.E., Bolychev S.A., Davydenko S.V., Tyutmin D.V. Hydrodynamics and Gas Dynamics. Laboratory workshop, Samara, 2005, 102s.

[20] Popov D.N., Panaiotti S.S., Ryabinin M.V. Hydromechanics, 2002.-385 p.

[21] Popov D.N., Panaiotti S.S., Ryabinin M.B., Fluid mechanics, Moscow, 2002.