LUTSK NATIONAL TECHNICAL UNIVERSITY

OPTIMIZATION OF DIESEL FUEL COMPOSITION WITH BIO-COMPONENT AND FUNCTIONAL ADDITIVES

VALENTYNA TKACHUK,
Dean of Customs Affairs, Materials and Technologies Faculty
Doctor of Technical Sciences, Professor
Lutsk National Technical University, Ukraine
v.tkachuk@lntu.edu.ua

CANDIDATE DISSERTATION:

Commodity evaluation of biodiesel based on rapeseed oil and isopropyl alcohol– 2010.

DOCTOR DISSERTATION:

Formation of quality of motor fuels with use of biocomponents – 2021.

RESEARCH INTERESTS:

Quality and range of fuels.

EDUCATIONAL DISCIPLINES:

Commodity Study of Fuel and Lubricants, Safety of Goods.

Professional development, participation in summer schools, trainings

International scientific internship, Portugal, Bragansa, Polytechnic Institute - **2017**
International research internships in Moldova, Chisinau, State agrarian University of Moldova - **2018**

Scientific and methodical work:

- 5 monographs (of them 4 in co-authorship);
- more than 100 scientific publications, of which:
  - 4 patents for invention;
  - 60 articles published in professional editions

(of which 30 are in the journals included in scientific metric databases, 9 of them are Scopus: https://www.scopus.com/authid/detail.uri?authorId=55555980000);

  - 50 theses and materials of scientific conferences;
  - 15 publications abroad.

- more than 20 methodical recommendations for conducting lectures, practical classes, independent work by students;
- a training manual "Commodity. Plastic mass and fuel and lubricants»
- electronic learning resource "Commodity study of packaging materials and containers";
- since 2012 and till now in the composition of the specialized scientific council for the protection of theses for obtaining the scientific degree of the candidate of technical sciences K 32.075.04 in the specialty 05.18.08 - Commodity study of non-food products;

My recent research is on the creation of fuel compositions using biocomponents. The main components of high-octane gasoline compositions for spark ignition engines are refined products and biocomponents: catalytic reforming gasoline; hydrotreated catalytic cracked gasoline; raffinate of benzene production; oil solvent; straight-run gasoline; bioisobutyl alcohol; methyl tert-butyl ether,

and for the manufacture of winter and summer diesel fuels such composition contains: diesel hydrotreated diesel, depressant additive, cetane-boosting additive, and as a biocomponent contains isobutyl ester of rapeseed oil.

VI International Scientific Conference (May 13, 2022)

Quality And Safety of Goods

Environmental friendliness of fuels used in automobile internal combustion engines is a global problem of humanity, which is given considerable attention by both leading scientists and practitioners of the oil refining industry, as well as international environmental organizations. Today, the share of oil that meets the needs of the transport industry is 97-99%, and the share of transport as the final consumer of energy carriers is constantly growing. Therefore, the production of fuels of petroleum origin, which would meet the increased requirements for environmental properties, will grow.

The **object** of research is diesel fuels with different content of biocomponent (IBERO) and additives. The **subject** of the study is the properties of diesel fuels, taking into account changes in the ratio of components of the composition.

To minimize multi-purpose functions, taking into account a certain set of constraints, multi-criteria optimization is designed with the goal achievement task set. The optimum of parameters achieved when such conditions are met is usually called conditional or relative, and the range of process parameters within which output variables are obtained that meet all the specified requirements is called a rational or compromise domain. Mathematical models of the selected type were obtained using the central composite rotatable plan (CCRP) of the experiment, with the specified values of the initial variables in the studied range of values.

Construction of the planning Matrix, calculation of coefficients of regression models, verification of their significance and adequacy, as well as mathematical processing of experimental data were performed using STAT-SENS and STATISTICA 10 software .

Previous studies of the effect of dietary supplements allowed us to establish the scope of the experiment. The initial variables were mixed factors that characterize the ratio of the main components of diesel fuel, namely: x1 and the content of rapeseed oil isobutyl ester, mas.%; x2 – content of cetane-boosting additive, mass.%; x3 – depressant additive content, mas.%.

To obtain mathematical dependencies of the form y = f(xi) for i = 3, the zero level (X0) of the selected factors and their interval of variation (+/-∆) are set. In this case, the centre of the plan is located at a point with coordinates x1, x2, x3, respectively 5, 0.5, 0.1 and intervals of variation – 2, 0.2, 0.05.

Comparison of the compositions of experimental compositions of diesel fuels was carried out according to the following properties y1 and cetane number; y2 – lubricity, diameter of the wear spot at a temperature of 60 ° C, microns; y3 – maximum filterability temperature, ° C. In accordance with the central Composite rotatable plan of the experiment, 15 model compositions were developed, illustrated with examples of the ratio of components in Table.

Table. Compositions of experimental compositions of diesel fuel using a biocomponent

Composition №	Content of components, mas. %				Total
	Diesel fuel of petroleum origin grade L	Rapeseed oil isobutyl ester (IBERO)	Cetane boosting additive	Depressant additive	
1	96.65	3.00	0.30	0.050	100,00
2	92.65	7.00	0.30	0.050	100,00
3	96.25	3.00	0.70	0.050	100,00
4	92.25	7.00	0.70	0.050	100,00
5	96.55	3.00	0.30	0.150	100,00
6	92.55	7.00	0.30	0.150	100,00
7	96.15	3.00	0.70	0.150	100,00
8	92.15	7.00	0.70	0.150	100,00
9	91.04	8.36	0.50	0.100	100,00
10	97.76	1.64	0.50	0.100	100,00
11	94.07	5.00	0.83	0.100	100,00
12	94.74	5.00	0.16	0.100	100,00
13	94.32	5.00	0.50	0.180	100,00
14	94.48	5.00	0.50	0.016	100,00
15	94.4	5.00	0.50	0.100	100,00

To quantify the number of given factors, modelling of the compositions of experimental compositions was carried out taking into account that the total content of components was adjusted to 100% using fuel of petroleum origin of the L brand, which is produced at PJSC "Ukrtatnafta". Results of the experiment set according to the plan taking into account the centre of the plan and the intervals of variation are shown in Table.

Table. Results of studies of indicators of diesel fuel properties using dietary supplements

№ of component	Plan			Component content, mas.%			Property indicators		
	x_1	x_2	x_3	Rapeseed oil isobutyl ester	Cetane boosting additive	Depressant additive	Cetane number	Lubricity: wear spot diameter at 60 ° C, microns	Maximum filterability temperature, ° C
1	-1	-1	-1	3.00	0.30	0.050	50	448	-7
2	1	-1	-1	7.00	0.30	0.050	51	436	-5
3	-1	1	-1	3.00	0.70	0.050	53	449	-6
4	1	1	-1	7.00	0.70	0.050	54	440	-5
5	-1	-1	1	3.00	0.30	0.150	50	451	-10
6	1	-1	1	7.00	0.30	0.150	51	436	-8
7	-1	1	1	3.00	0.70	0.150	53	445	-11
8	1	1	1	7.00	0.70	0.150	54	432	-9
9	1.6818	0	0	8.36	0.50	0.100	52	429	-5
10	-1.6818	0	0	1.64	0.50	0.100	52	451	-10
11	0	1.6818	0	5.00	0.83	0.100	56	443	-9
12	0	-1.6818	0	5.00	0.16	0.100	49	445	-8
13	0	0	1.6818	5.00	0.50	0.180	52	439	-12
14	0	0	-1.6818	5.00	0.50	0.016	52	443	-4
15	0	0	0	5.00	0.50	0.100	52	442	-8

Since some of the coefficients in the obtained equations are insignificant, it is necessary to perform further statistical processing of the model. Such processing was carried out and provided for the gradual exclusion of model components if they were insignificant, followed by recalculation of the remaining coefficient values and checking the adequacy of the model. After excluding the weightless coefficients the final models were obtained $\hat{y}1$-$\hat{y}3$:

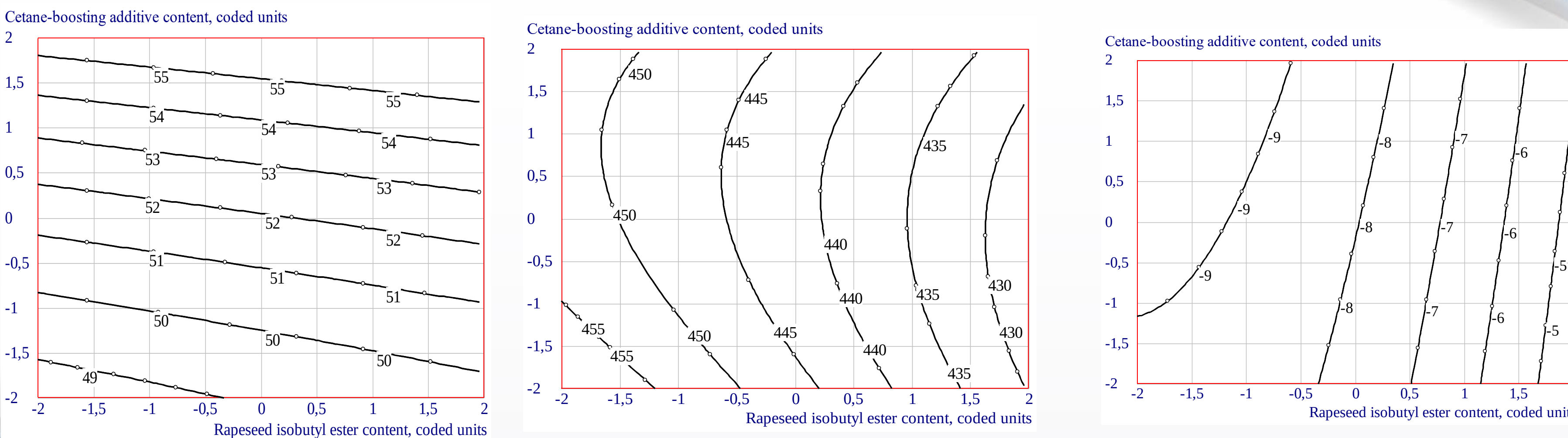
$$\hat{y}\ 1 = 51{,}916 + 0{,}29289x1 + 1{,}7407x2 + 0{,}16583x22$$

$$\hat{y}\ 2 = 441{,}45 - 6{,}2972x1 - 0{,}61241x2 - 1{,}1516x3 + 0{,}625x1x2 - 0{,}875x1x3 - 1{,}875x2x3 - 0{,}43923x12 + 0{,}97497x22$$

$$\hat{y}\ 3 = - 8{,}0438 + 1{,}1283x1 - 0{,}19637x2 - 2{,}0835x3 - 0{,}375x2x3 + 0{,}26777x12$$

where $\hat{y}$ i – predicted values of the output variable according to the j-th Model. Verification of the adequacy of the obtained mathematical models was carried out according to the Fischer criterion.

A comparison of the parameters (quality indicators) of diesel fuels obtained experimentally and the predicted results using the above mathematical models (ŷ1-ŷ3) is shown. Figure 1 presents graphical reviews of the studied parameters for factors x1 (content of rapeseed oil isobutyl ester) and x2 (content of cetane-enhancing additive) in the range of ±2 encoded units at a fixed value of x3 at the level of 0.



a) b) c)

Fig. 1. Feedback diagrams for factors X1 and X2 at X3 = 0 by parameters:
a) cetane number; b) lubricity, microns.; c) maximum filterability temperature,° C

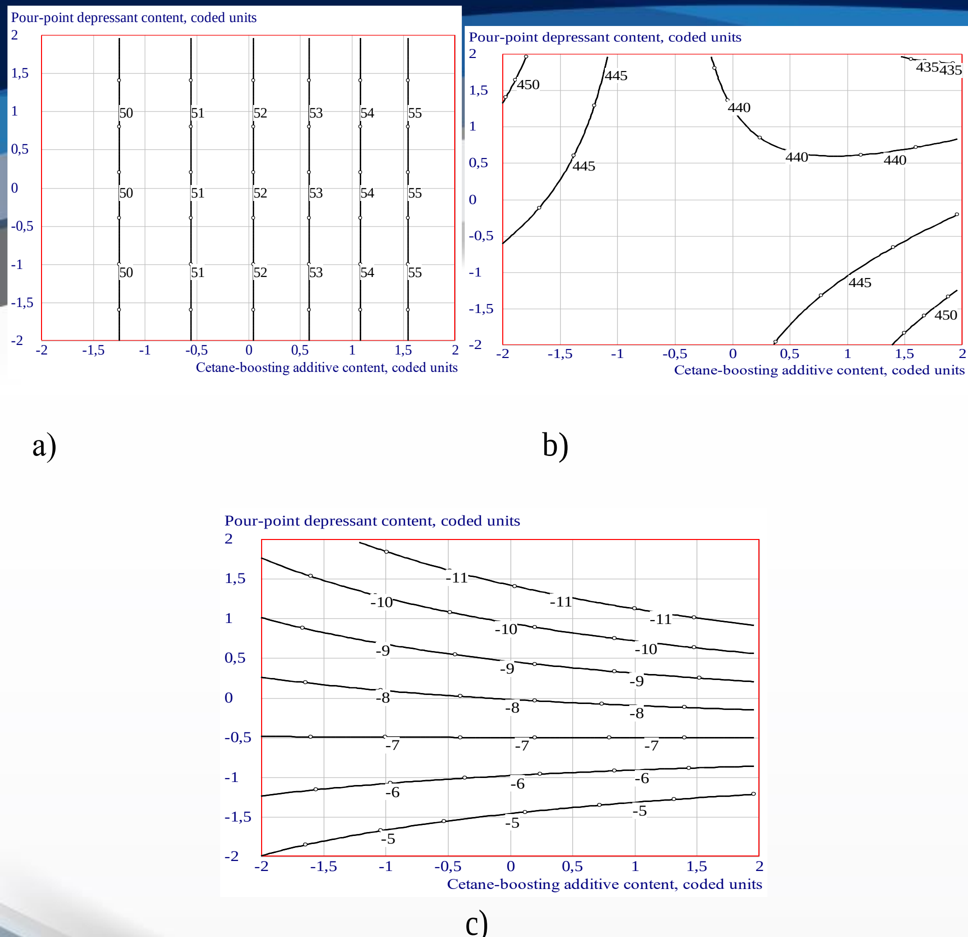


Fig. 2. Feedback diagrams for factors X2 and X3 at x1 = 0 by parameters: a) cetane number; B) lubricity, microns.; C) maximum filterability temperature, ° C

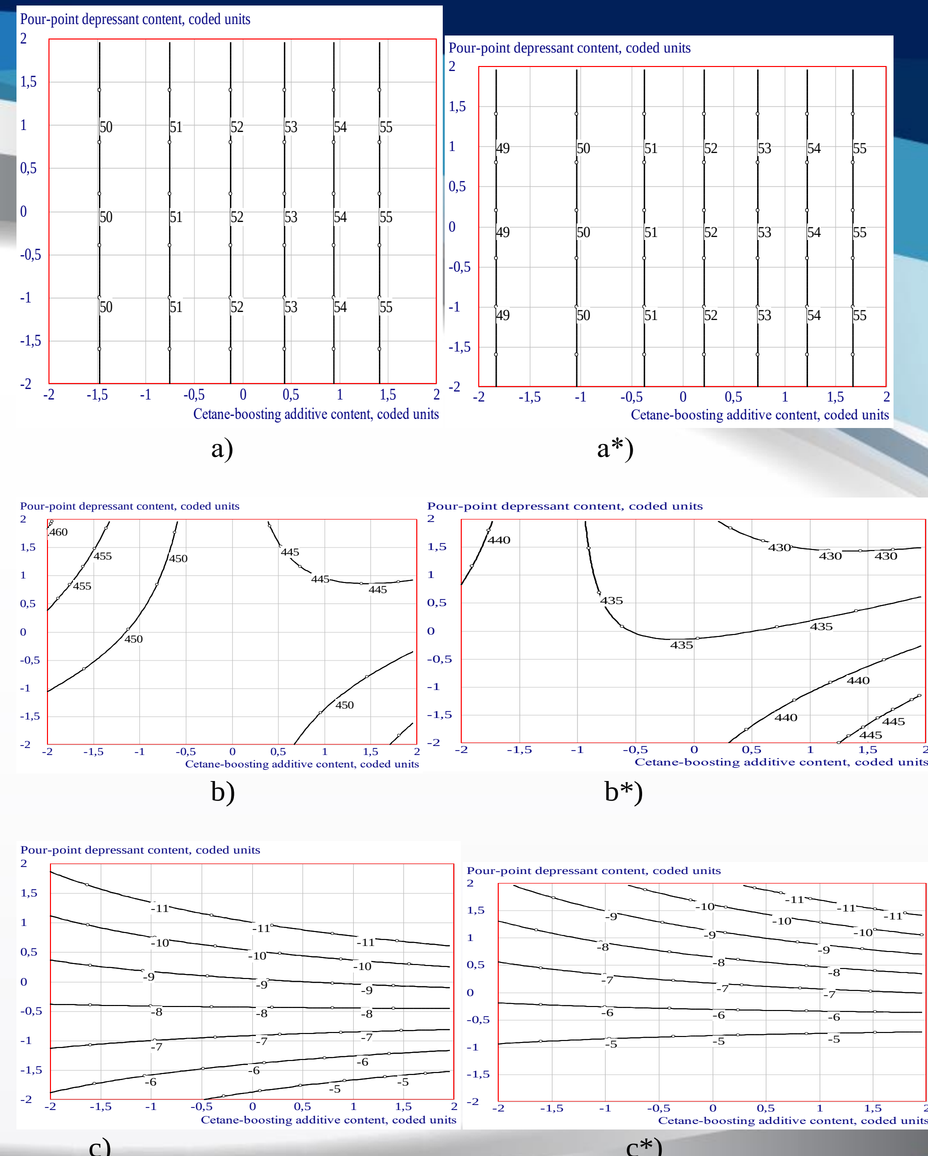


Fig. 3. Response diagrams for factors x2 and x3 by parameters cetane number (a, a*), lubricity (b, b*), filterability limit temperature (c, c*), at fixed values of factor x1 at the levels of -1 (a, b, c) and +1 (a*, b*, c*)

So, if the content of isobutyl ester of rapeseed oil in the composition of diesel fuel is stabilized at a certain optimal level (0.95 code. units; 6.9 mas.%), then a compromise section is obtained (fig. 4) provides for the consumption of cetane-boosting and depressant additives in the optimal mode.

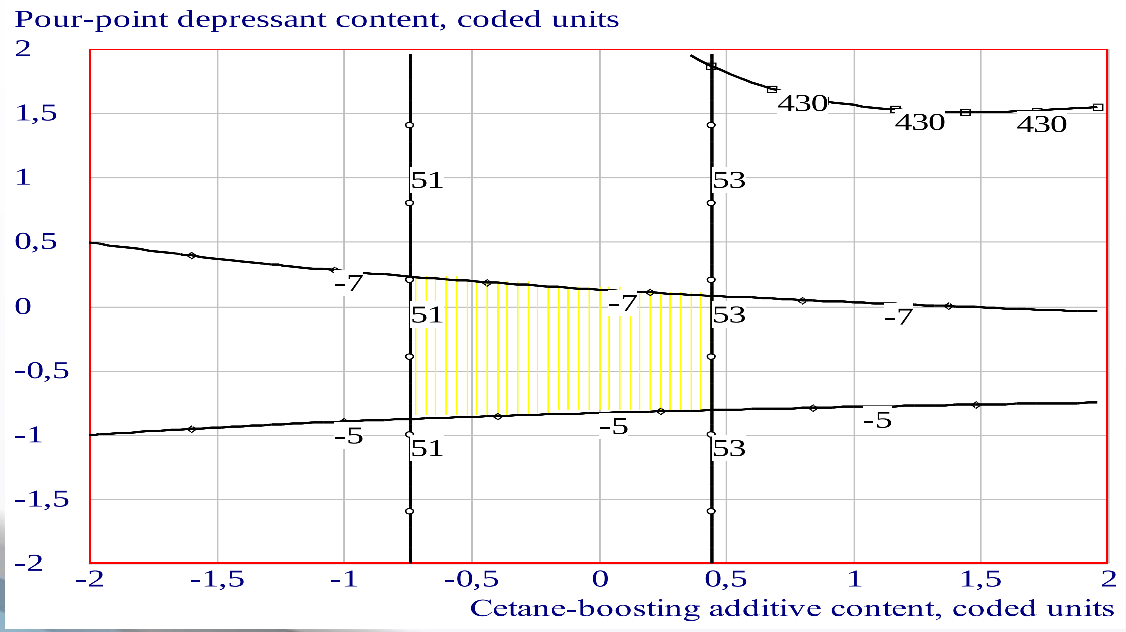


Fig. 4. Compromise area of optimal diesel fuel composition using a bio-component

As a result of the conducted studies, optimal compositions of diesel fuel of the ”S" brand were obtained using isobutyl ester of rapeseed oil and functional additives. The consumption of components in a mixture of commercial diesel fuel to achieve optimal set properties is: IBERO – 6.9 mas.%; cetane-boosting additive - 0.48 mas.%, depressant additive - 0.1 mas.%. In addition, an optimal compromise area was established for the production of diesel fuels with the specified parameters with the ability to adjust the content of additives in their compositions.

THANK YOU FOR YOUR ATTENTION!

Welcome to Ukraine

UA