International Journal of Applied Engineering Research ISSN 0973-4562 Volume 11, Number 11 (2016) pp 7278-7283
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Mathematical Modeling for Reforming Unit of Chemical Technological System in Refinery Production Under Uncertainty

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Abstract

This paper proposes a method for developing a structured complex of mathematical models for advanced chemical-technological system (CTS) in refinery production under uncertainty on the basis of information of various characters. According to the proposed method based on the results of studies of each element of CTS, a model of the element system is developed on the basis of collected data and selection criteria, then developed models are combined into a single system for the purpose of the system modeling of the technological system as a whole. Developed method was successfully implemented during the construction of system models of the main assembly of reforming unit of catalytic reforming plant LG-35-11 / 300-95 in Atyrau Petroleum Refinery (PR). A comparison of the known results and the simulation results was performed based on the proposed method and empirical data of Atyrau PR plant. The structure of computer simulation and mode optimization systems of CTS in refinery production was proposed based on mathematical modeling of their work.

Keywords: mathematical modeling, chemical-technological system (CST), reforming unit, theory of fuzzy sets, membership function.

INTRODUCTION

It is well-known that the methods of probability theory and mathematical statistics are often considered for the simulation and optimization of advanced chemical-technological systems in conditions of uncertainty. [1] However, the axioms of probability theory are not always satisfied in the presence of uncertainty, in these cases the use of probabilistic methods is not justified. Moreover, even if describing the processes and systems via probabilistic methods is possible, due to deficiency, complexity and economical irrelevancy of collectting reliable statistical information, it is necessary to describe and develop non-statistical, namely fuzzy models of real CTS and processes. In this regard, one of the most promising approaches is the application of fuzzy set theory (FST) [2 - 5]. For qualitative analysis of advanced CTS, production facilities and systems, certain methods should be approached, for which high precision and rigorous mathematical formalism are not absolutely significant. Hence, the problem of uncertainty because of the vagueness of initial information in the research of complex objects can be effectively resolved by the development of fuzzy mathematical apparatus.

METHOD OF MATHEMATICAL MODELS DEVELOPMENT OF ADVANCED CTS UNDER UNCERTAINTY BASED ON AVAILABLE INFORMATION OF VARIOUS CHARACTER

Applying the research results of constructing mathematical models of complex objects and on the basis of methodology of fuzzy sets theory and expert assessment techniques, the following method of mathematical models development and simulation of work of technological complexes of oil refining based on information of various characters (theoretical, statistical, fuzzy) is proposed [6 -10]. The developed method of constructing models of chemical-technological systems based on information of various characters (CMOCTSBOIOVC) consists of the following primary points:

Method CMOCTSBOIOVC:

1) Research of CTS elements, the links between elements of the system as a whole, the collection of available information and its processing, defining the purpose of the simulation;
2) Determining criteria for evaluation and comparison of models, which can be built for the elements of the system with consideration modeling objective;
3) To conduct an expert assessment of the possible models of each element of CTS and the industrial complex according to the selected criteria and to determine the optimum type of model for each element according to the sum of the criteria values;
    I. If theoretical information for work description of the individual elements are sufficient and deterministic model is effective according to the sum of evaluation criteria, then deterministic models are developed on the basis of the analytical method for this unit;
    II. If statistical data for work description of a single element is sufficient or collection of such sufficient data is viable, also the statistical model is effective according to the sum of criteria of evaluation and comparison, then the statistical models of the element are constructed based on experimental and statistical methods;
    III. If theoretical and statistical data for work description of a single element of CTS and technological complex are insufficient, collection of such data is economically inexpedient, whereas collection of fuzzy information describing the unit operation and its processes is possible, , also the fuzzy model is effective according to the sum of criteria of evaluation and comparison, then fuzzy models are constructed for this unit based on FST methods, go to step 4 for details;
    IV. If theoretical, statistical data and fuzzy expert information to for work description of a single element of the technological system is insufficient, such data collection is unreasonable, hybrid model is built (combined model based on available information of various character) for this unit based on a combination of collected data of various characters (theoretical, statistical, fuzzy). For description of various parameters of the particular unit (CTS element) depending on the character of the information refer to paragraphs 3.1-3.3 or 4;

4) Identification and selection for model construction appropriate fuzzy input $\tilde{x}_i \in A_i, i = \overline{1,n}$ and output $\tilde{y}_j \in \tilde{B}_j, j = \overline{1,m}$ parameters. $\tilde{A}_i \in X$, $\tilde{B}_j \in Y$ – fuzzy subsets, *X, Y* – universal sets. Input parameters can be precise (deterministic), i.e. $x_i \in X_i$, $i=\overline{1,n}$;
5) If $x_i \in X_i$, i.e. input parameters of an object (CTS element) are deterministic (precise), determination of the structure of fuzzy equations of multiple regression (polynomial equations) $\tilde{y}_j = f_j(x_1,...,x_n,\tilde{a}_0,\tilde{a}_1,...,\tilde{a}_n)$, $j=\overline{1,m}$ (solution to the problem of structural identification);
6) 6.On the basis of expert assessments, information collection for description the research object and definition of the term-sets of fuzzy parameters $T(\tilde{X}_i, \tilde{Y}_j)$;
7) Plotting membership function (MF) of fuzzy elements $\mu_{A_i}(\tilde{x}_i)$, $\mu_{B_j}(\tilde{y}_j)$;
8) If input and output parameters of the object are fuzzy, then to formalize fuzzy representations R_{ij}, determining connections between $\tilde{x}_i$ and $\tilde{y}_j$, i.e to construct a linguistic model and refer to step 10;
9) If conditions of paragraph 5 are met, then to evaluate the values of fuzzy coefficients $(\tilde{a}_0,\tilde{a}_1,...,\tilde{a}_n)$, which are identified in paragraph 5 of models $\tilde{y}_j$ (solution to problem of parametric identification), refer to paragraph 11;
10) If the conditions of paragraph 8 are satisfied, then according to the rules of concentrational outputs $B_j = A_i \circ R_{ij}$ to perform definition of fuzzy values of object parameters:

$$\mu^p_{B_j}(\tilde{y}^o_j) = \max_{x_i \in X_i}\{\min[\mu^p_{A_i}(\tilde{x}^*_i), \mu^p_{R_{ij}}((\tilde{x}^*_i, \tilde{y}_j)]\}$$

If $\tilde{x}^*_i -$ values of input parameter of the object estimated (measured) by experts, then the set of current values of the input parameters is defined as a fuzzy set, consisting of the maximum values of the membership function $\mu_{A_i}(\tilde{x}^*_i) = \max(\mu_{A_i}(\tilde{x}_i))$.

Membership function of *p*-th quantum (interval) predicted (fuzzy) values of the output parameters $\mu^p_{B_j}(\tilde{y}^*_j)$ of the modeled object are determined by aforementioned formula.

Numerical values of output parameters of an object $\tilde{y}^{**}_j$ are defined from the set of fuzzy solutions via the following formula:

$$\tilde{y}^{**}_j = \arg\max_{\tilde{y}^*_j} \mu^*_{B_j}(\tilde{y}^*_j)$$

i.e. parameters with member function of maximum value are selected.

11) Test of adequacy condition of a model. If condtion of adequacy is met:

$$S=|y_M - y_E| \leq S_D,$$

where *S* and S_D are criterion and its possible value respectively, y_M and y_E are respectively values of output parameters, obtained by the model and experimentally under similar values of input parameters, then the developed models are recommended for research and determination of optimum modes of object operation – CTS elements and the system as a whole. Otherwise, to define the cause of inadequacy and to go back to corresponding paragraphs for solution to the question of providing adequacy of the model.

RESULTS AND DISCUSSION

Results of the theoretical research are specified and implemented in practice during development of mathematical models of the main assembly of reforming unit CTS - catalytic reforming plant of Atyrau Petroleum Refinery. Mathematical models of reactor R-2, P-3, P-4,4a reforming unit plant are constructed based on the above method, i.e. based on the statistical data and expert information processed by FST methods, also using equations of the material and heat balances of plant assemblies.

The structure of reforming model (structural identification of models) in form of systems of multiple regression equations (1)-(4) and systems of fuzzy multiple regression equations(5) is determined as a result of collection and processing of experimental-statistical and expert data, also using the idea of sequential inclusion of regressors [11] on the basis of antecedent information and the proposed method CMOCTSBOIOVC:

$$y_{R2} = a_o + \sum_{i=1}^{5} a_1 x_i + \sum_{i=1}^{5}\sum_{k=i}^{5} a_{ik} x_i x_k, \qquad (1)$$

$$y_{R3} = a_o + \sum_{i=1}^{5} a_1 x_i + \sum_{i=1}^{5}\sum_{k=i}^{5} a_{ik} x_i x_k, \qquad (2)$$

$$y_{R4} = a_o + \sum_{i=1}^{5} a_1 x_i + \sum_{i=1}^{5}\sum_{k=i}^{5} a_{ik} x_i x_k,$$

$$y_{R4a} = a_o + \sum_{i=1}^{5} a_1 x_i + \sum_{i=1}^{5}\sum_{k=i}^{5} a_{ik} x_i x_k, \qquad (3)$$

$$y_j = a_{0j} + \sum_{i=1}^{5} a_{ij} x_{ij} + \sum_{i=1}^{5}\sum_{k=i}^{5} a_{ikj} x_{ij} x_{kj},\ j = 1,2 \qquad (4)$$

$$\tilde{y}_j = \tilde{a}_{0j} + \sum_{i=1}^{5} \tilde{a}_{ij} x_{ij} + \sum_{i=1}^{5}\sum_{k=i}^{5} \tilde{a}_{ikj} x_{ij} x_{kj},\ j = \overline{3,7} \qquad (5)$$

where $y_{R2}, y_{R3}, y_{R4}, y_{R4a}$ – catalyzate volume with reactor outputs P-2, P-3 and P-4 and R4a; $y_j,\ j = 1,2$ – volumes of dry gas (DG) and hydrogen-containing gas (HCG) respectively; $\tilde{y}_j,\ j = \overline{3,7}$ - qualitative indicators of catalyzate: octane number ($\tilde{y}_3$ – at least 86 according to motor method); fractional concentration ($\tilde{y}_4$ – 10% ddistillation – not less than 70ºC, $\tilde{y}_5$ – 50% distillation – no more than 115ºC); pressure of saturated gases ($\tilde{y}_6$ – no more than 500 mm Hg.); resin concentration in 100 ml of petroleum ($\tilde{y}_7$ – no more than 5,0 mg.); x_1 – crude, hydrogenate from output of hydrotreating block, m^3/hour; x_2 – bulk speed in reactors, hour^{-1}; x_3 – pressure in reactors P-2, P-3, P-4 and P-4a in ºC, x_4 – pressure in reactors P-2, P-3, P-4 and P-4a in kg/cm^2; x_5 – ratio H$_2$/crude, nm^3; a_{0j}, a_{ij}, a_{ikj} and $\tilde{a}_{0j}, \tilde{a}_{ij}, \tilde{a}_{ikj},\ i,k = \overline{1,5}$ – identified regression coefficients (~ – sign of fuzziness), respectively constant term; coefficients of linear (x_{ij}), quadratic and mutual influence (x_{ij},x_{kj}) respectively.

Hence, models, describing volume of production from the reforming unit output, are constructed via experimental and statistical methods in the form of multiple regression models, whereas models, that illustrate qualitative indicators of production, are designed based on fuzzy information from specialists and experts in form of fuzzy multiple regression equations [12]. Coefficients of models (1) - (5) are determined by known methods of parametric identification on the basis of the least squares method (using Regress and based on MatLab system[13]).

Results of parametric identification of models, defining catalyzate volumes from reactors ($y_{R2}, y_{R3}, y_{R4}, y_{R4a}$) and HCG ($y_2$) are provided in the following form (6)-(9):

Thus, as a result of a parametric identification of models working formulae for determination of catalyzate volume for reactor outputs ($y_{R2}, y_{R3}, y_{R4}, y_{R4a}$), volume of DG and HCG (y_1, y_2) are obtained, moreover fuzzy values, characterizing qualitative indicators of catalyzate ($\tilde{y}_3, \tilde{y}_4, \tilde{y}_5, \tilde{y}_6$ and $\tilde{y}_7$) are derived. For this purpose after processing experimental statistical data (about reactor operation) and expert information (about quality of catalyzate), parameters (regression coefficients) a_{0j}, a_{ij}, a_{ikj} and $\tilde{a}_{0j}, \tilde{a}_{ij}, \tilde{a}_{ikj}$ are identified using Matlab system on the basis of the method of least squares.

For instance, in our case, for determination of catalyzate volume from reactor outputs y_{R4}, y_{R4a} after parametric identification the following working formula is obtained:

$$\begin{aligned} y_{R4},\ y_{R4a} = {} & 0.39898x_1 + 12.07692x_2 - 0.03158x_3 - 1.02391x_4 + \\ & + 0.0196x_5 + 0.0051x_1^2 + 9.28995x_2^2 - 0.00006x_3^2 - 0.0445x_4^2 + \\ & + 0.0445x_4^2 + 0.00005x_5^2 + 0.2302x_1x_2 + 0.0001x_1x_3 + 0.0022x_1x_4 + \\ & + 0.00049x_1x_5 + 0.03645x_2x_3 - 0.52508x_2x_4 - 0.00068x_3x_4 \end{aligned} \qquad (6)$$

Figure 1 represents the graph of dependence of catalyzate volume from reactor outputs P-4, R4a on temperature.

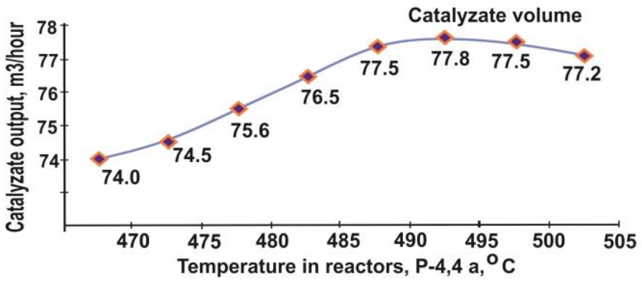

Figure 1: Dependence graphs $y_1 = f_1(x_3)$, x_1,x_2, x_4, x_5 – fixed

x_1 =80 m^3/hour ,volume of crude;
x_2 =1,3 hour^{-1}, bulk speed;
x_4 =24 kg/cm^2, P-4,4a pressure in reactors;
x_5 =400 nm^3, ratio H$_2$/crude;

Identification of fuzzy coefficients $\tilde{a}_{ij}, i=\overline{0,6}$ and $\tilde{a}_{ikj}, i,k=\overline{0,6},\ j=\overline{3,7}$ of systems of equations (5) are carried out on the basis of application of FST and α-sets.

After parametric identification of model (5) (for α levels: 1 and left and right 0.5; 0.75) mathematical models, describing the dependence of qualitative indices of catalyzate from input-mode parameters(for example, octane number of catalyzate $\tilde{y}_3$) are identified in the following form:

$$
\begin{aligned}
&\tilde{y}_3 = f_3(x_{13},x_{23},\dots,x_{53}) = (0.5/0.43 + 0.75/0.433 + 1/0.435+0.75/\\
&/0.437+ 0.5/0.44)x_{13}+(0.5/20.0769+0.75/20.07691+1/20.07692+\\
&+ 0.75/20.07693 + 0.5/20.07694)x_{23} + (0.5/0.05281+\\
&0.75/0.05282 + 1/0.05283+0.75/0.05284+ 0.5/0.05285)x_{33}-\\
&-(0.5/0.72487 + 0.75/0.72495 + 1/0.72500 + 0.75/0.72505+\\
&+ 0.5/0.72513)x_{43} + (0.5/0.04221 + 0.75/0.04233+1/0.04243 +\\
&0.75/0.04253+ 0.5/0.0427)x_{53}+0.75/0.04253+ 0.5/0.0427)x_{53}+\\
&+(0.5/0.0052+0.75/0.0053+1/0.0054+0.75/0.0055+0.5/0.0052+\\
&+0.5/0.0056)x_{13}^2 - (0.5/15.4434 +0.75/15.4436 +1/15.4437 +\\
&0.75/15.4439+0.5/15.4441)x_{23}^2+(0.5/0.000007+ 0.75/0.00005+\\
&+1/0.00011 +0.75/0.00015 + 0.5/0.00020)x_{33}^2 - (0.5//0.0300+\\
&+0.75/0.0301 + 1/0.0302 + 0.75/0.0303 + 0.5/0.0304)x_{43}^2+\\
&(0.5/0.000004+0.75/0.00005+1/0.00010+0.75/0.00015 +0.5/\\
&/0.00022)x_{53}^2 + (0.5/0.00010 + 0.75/0.00017 + 1/0.00022+1/\\
&/0.00022+0.75/0.00027+0.5/0.00034)x_{13}x_{33}+(0.5/0.00012+0.75/\\
&/0.0002+1/0.00027+0.75/0.00033+0.5/0.0004)x_{13}x_{53}-0.5/0.5572+\\
&+0.75/0.5574+1/0.5576+0.75/0.5578+0.5/0.55814)x_{23}x_{43} +(0.5/\\
&/0.00005 + 0.75/0.00006 + 1/0.00008 + 0.75/0.00012 +0.5/\\
&/0.00016) x_{33}x_{53}
\end{aligned}
$$

Analogically defined $\tilde{y}_4$ – 10% distillation, $\tilde{y}_5$ – 50% distillation, $\tilde{y}_6$ – pressure of saturated steam and $\tilde{y}_7$ – resin concentration in 100ml. of petroleum.

For determination of optimum temperature of reforming process based on the proposed method of modeling technological complexes on the basis of information of different characters (paragraphs 3.3, 4, 6-8,10-11) linguistic models are designed, that determine the effect of reforming reactor temperature on output of catalyzate and stability of catalyst. These models describe the linguistic connection "If T_R is moderate, then y_1 is moderate, y_2 is normal, if is high, then y_1 is above moderate, y_2 is above normal, if T_R is extremely high, y_1 is below moderate, y_2 is below normal", where T_R - temperature of reactor, y_1 - the output from the reactor catalyzate, y_2 - stability of the catalyst.

On the basis of expert assessment results and applying proposed in work [6] analytical dependence, the membership functions of fuzzy parameters are developed:

- $\mu_A(T)=exp(|(T-485)\cdot 0.5|)$ – reactor temperature is low;
- $\mu_A(T)=exp(|T- 495)\cdot 0.5|)$ – reactor temperature is moderate;
- $\mu_A(T)=exp(|T-520)\cdot 0.6|)$ – reactor temperature is high;
- $\mu_A(T)= exp(|T-545)\cdot 0.7|)$ – reactor temperature is extremely high;
- $\mu_B(y_1) = exp(|y_1-65)\cdot 0.4|)$ – catalyzate output is low;
- $\mu_B(y_1) = exp(|y_1-70)\cdot 0.6|)$ – catalyzate output is moderate;
- $\mu_B(y_1) = exp(|y_1-75)\cdot 0.7|)$ – catalyzate output is higher than moderate;
- $\mu_B(y_1) = exp(|y_1-67)\cdot 0.5|)$ – catalyzate output is lower than moderate;
- $\mu_B(y_2) = exp(|y_2-70)\cdot 0.3|)$ – catalyst stability is under normal;
- $\mu_B(y_2) = exp(|y_2-90)\cdot 0.5|)$ – catalyst stability is normal;
- $\mu_B(y_2) = exp(|y_2-95)\cdot 0.7|)$ – catalyst stability is above normal.

Using the content of aforementioned linguistic dependence and rules of logical conditional derivation for the current case according to proposed methods the following linguistic models are obtained:

$$
\begin{aligned}
&if\ \tilde{x} \in \tilde{A}\,(low),\ then\ \tilde{y}_1 \in \tilde{B}_1\,(low),\ \tilde{y}_2 \in \tilde{B}_2\,(bnorm),\\
&if\ \tilde{x} \in \tilde{A}\,(mod),\ then\ \tilde{y}_1 \in \tilde{B}_1\,(mod),\ \tilde{y}_2 \in \tilde{B}_2\,(norm),\\
&if\ \tilde{x} \in \tilde{A}\,(high),\ then\ \tilde{y}_1 \in \tilde{B}_1\,(amod),\ \tilde{y}_2 \in \tilde{B}_2\,(anorm),\\
&if\ \tilde{x} \in \tilde{A}\,(ehigh),\ then\ \tilde{y}_1 \in \tilde{B}_1\,(bmod),\ \tilde{y}_2 \in \tilde{B}_2\,(bnorm)
\end{aligned}
$$

where *low, bnorm, mod, norm, high, amod, anorm, ehigh, bmod* – fuzzy parameters describing concepts «low», «below normal», «moderate», «normal», «high», «above moderate», «above normal», «exteremely high», «below moderate» respectively; $\tilde{x}$, $\tilde{y}_1$, $\tilde{y}_2$ – input and output linguistic variables, describing the reactor temperature, output of catalyzate and stability of catalyzate, respectively; $\tilde{A}$, $\tilde{B}_j$, j=1,2 – fuzzy sets, describing input and output parameters.

Mathematical models of reforming furnace F-1. Multichamber furnace of reforming *F-1* is designed to provide temperature in reaction zone 490-530ºC. Primary adjustable parameters of the furnace: volume of flow (60-80 m^3/hour); temperature (input 433-443, output – 500-530ºC); pressure (24-28 kg/cm^2).
According to the research results, the models of the furnace are designed based on experimental-statistical methods. As a result of data processing of mode sheets, and other experimental-statistical data via methods of regression analysis and application of the MatLab system, furnace models (for the last third cameras) are identified in the next form:

$$
\begin{aligned}
y_1 = {} & 0.49555x_1 + 0.01773x_2 - 0.86667x_3 + 0.00629\,x_1^2 +\\
&+0.00004\,x_2^2 -0.03209\,x_3^2 +0.00067x_1x_2+0.00068x_1x_2+\\
&+0.00734x_1x_3 -0.000657x_2x_3
\end{aligned}
$$

$$
\begin{aligned}
y_2 = {} & 0.66242x_1 + 0.597701x_2 -5.77777\,x_3 +0.008438\,x_1^2 +\\
&+0.008438\,x_1^2 + 0.001374\,x_2^2 - 0.21399\,x_3^2 + 0.00457x_1x_2+\\
&+ 0.00067x_1x_2+0.04907x_1x_3 -0.00443x_2x_3
\end{aligned}
$$

where y_1, y_2 – volume of flow and output temperature of furnace respectively; x_1, x_2, x_3 – input factors, namely, volume of input flow, temperature and pressure of furnace.

Optimum operating conditions of the object can be determined, optimization problems can be solved and recommendations for effective management of the reforming process can be accomplished with the current system of models, modeling work of CTS – reforming unit of catalytic reforming Atyrau Refinery plant in interactive mode. Results of simulation of the object operation, comparison of them with other known results and experimental production data are demonstrated in a table (refer to Table 1).

Based on the results of comparison (refer to Table 1) it is apparent that offered models provide better results rather than known ones: output of target production increased (1,4 wt% , 0,6 m^3/hour), qualitative indicators, which cannot be determined by deterministic methods, of target production are obtained.

In solving optimization problems of CTS, which are multicriterial objects as technological complexes of oil refining system of computer simulation and optimization (CSO) by mathematical modeling of work modes is considerably useful. These systems combine the possibilities of modeling methods, optimization and modern computer technology, that speeds up and improves the optimization procedure. The following structure of the CSO system of technological objects by modeling modes of their operation is proposed (see figure 2).

Table 1: Comparison of known results [14, 15], simulation results on the basis of the proposed method and experimental data of Aturay Petroleum Refinery LG plant

Parameters, defined as a result of simulation	**Known models: based on Runge–Kutta methods**	**roposed models**	**Experimental production data**
1	2		4
Output of target production of hydrotreating unit (hydrogenate), wt%	94,1	95.3	95.0
Aromatic carbon concentration y_A, wt%	68,9	-	-
Concentration of unsaturated hydrocarbons in hydrogenate, wt%	-	0.7005	$(0.8500)^L$
Concentration of sulfur in hydrogenate, wt%	-	0.000046	$(0.000047)^L$
Concentration of water-soluble acids and alkalis in hydrigenate, wt%	-	0.000003	$(0.000003)^L$
Hydrogenate output from column C-1, m^3/hour	76.00	79.5031	76.5575
Output HCG from C-2, m^3/hour.	1700	1700	1705
Output HCG from column C-3, m^3/hour.	1672	1670	1680
Volume of raw gas mixture output from furnace F-101, m^3/hour.	-	75.00	74.90
Temperature of output flow of furnace F-101, °C	-	340	340
Catalyste volume, m^3/hour.	77,2	77,8	77.5
Octane number of production (based on MM)		87	$(86)^L$
Fractional concentration of catalyzate, °C: 10% distillation 50% distillation	- -	67 110	$(68)^L$ $(114)^L$
Resin concentration in 100 ml of petroleum, mg.	-	4.85	$(5)^L$
Flow from reforming furnace output F-1, m^3/hour	-	77.85	77.60
Temperature of output furnace flow F-1 (3-camera), °C	-	530	530

Note: input and mode process parameters are taken approximately similar, $()^L$ denotes that they are obtained empirically.

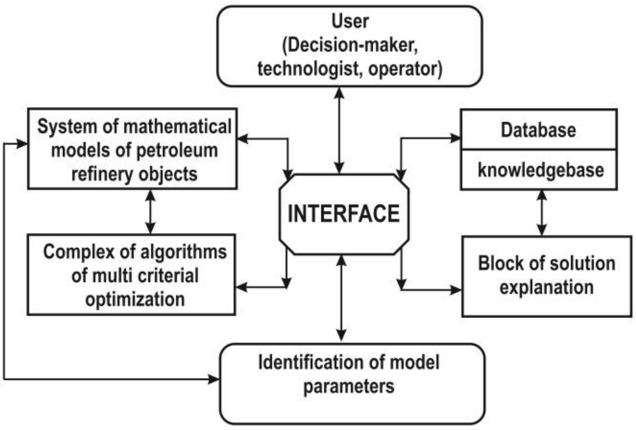

Figure 2: CSO system structure of technological objects of oil refinery by mathematical modeling of their operation.

Established structure of the CSO system in the long term enables extension of mathematical software, including new functions and capabilities. Moreover, the proposed CSO system in case of presence of the technical hardware (a connection device with an object) and relevant software allows to close control loop, i.e. enables to control directly and optimally the object.

CONCLUSION

Originality of research results lies in the fact that there has been proposed a method of mathematical modeling of CTS such as complex technological assemblies in the face of uncertainty, allowing on the basis of information of different character to build adequate models of advanced CTS, a complex of mathematical models of the reforming unit in catalytic reforming plant has been developed; a structure has been created and there has been presented the main functional blocks of computer modeling and optimization of technological petroleum refining objects on the basis of modeling. Superiority of proposed computer system is determined by the fact that its structure includes a set of algorithms and models, as well as user-friendly intelligent interface, which enable to solve the problems of modeling and multicriterial optimization of interrelated CTS, technological assemblies in oil refinery production.

Hence, based on theory of systems and fuzzy sets, probability methods, methods of expert assessments for the first time a generalized method of constructing mathematical models of CTS is developed, through case study on technological complex of oil refinery production (reforming unit of catalytic reforming plant) using information of various character. The proposed method has been successfully implemented in the construction of mathematical models and simulation of operation modes of reforming unit of catalytic reforming Atyrau Petroleum Refinery plant. The suggested approach can be successfully implemented during development of adequate mathematical models and effective modeling of complex electronic systems taking into account knowledge, experience and intuition of expert-specialists in a subject area (scientists, specialists and researcher of electronic schemes)

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