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DEVELOPMENT OF A SYSTEM FOR MODELING THE PROCESS OF PETROLEUM PRODUCTS PROCESSING BASED ON FUZZY LOGIC

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Abstract:
Methodological aspects of intellectual system (IS) formation and their usage for forecasting of petro-chemical processes connected with physical-chemical and technology of industrial processes are considered. The principles of IS creation on the base of generalization of industrial units operation experience for special data processing in computer regime for users are expounded. Methods of forming of physical-chemical models of heterogeneous catalytic processes counting catalyst deactivation are generalized.
A computer modeling system refining processes using a systematic approach strategy. At the heart of each system is non-stationary mathematical model of a catalytic process. A production-frame model to determine the causes of accidents in the machines included in the technological installation scheme. The model describes the user personnel actions on elimination emergency situation. Adaptation of industrial facility on a real software product through the development of communication module with a single thematic showcase of plant data.

Keywords: hierarchical models, petroleum refining, neural network algorithm, modeling, dehydrogenation, synthesis, diagnostics, monitoring.

Introduction

The current state of the petroleum refining industry is characterized by the need to continually improve the efficiency of production, which, in turn, places greater demands on the means of automation, control and monitoring of different levels. This applies both to automated control systems of technological processes parameters, and information technologies designed to predict plant performance and quality of the end products. Software foreign producers intended mainly to processes for the preparation and transport of oil and gas are generally not suitable for calculations the catalytic reactor processes of hydrocarbon processing. Existing developments are intended to solve the problem of collecting, archiving and structuring information, local databases and database systems [1,2].
Process modeling systems for oil refining and petrochemical processes, have distinctive properties that enable more efficient to solve the problem of monitoring and optimization of oil refining plants (ORP). Innovative methods is taken into account the reactivity of the multicomponent hydrocarbon feedstock, catalyst capacity and unsteadiness of the reactions on the catalyst surface. This approach allows us to improve the technology, to assess the state of the catalyst, to optimize processes, monitoring and forecasting production. With the introduction of such systems for the production of synthesis there is a problem with their automatic process control system (PCS) plant.

1. Statement of a problem

Existing PCS solved the problems of collecting, archiving, structuring information and providing it to users who include a large number of distributed control systems and communication servers that act as the transfer of technological information between levels of management.

However, the provision of only technological information doesn't create a complete picture of the enterprise. It is necessary to correlate this data with others, so the next step in the development of process control systems in refineries stands analytical data processing.

To analyze the state of technological objects and on the basis of the prediction of production is necessary to have the technological modeling systems that use arrays of information from the process monitoring.

In developing the simulation system is necessary to the synthesis of the mathematical description of chemical-technological system (ChTS). The essence of the principle of hierarchical synthesis of mathematical description is that the mathematical description of each subsequent structural level should be included as an essential part in the mathematical description of the last level.

Creating and improving the simulation algorithms associated with solving a number of difficult problems to determine the goals and objectives of the development and management decision-making. The fundamental issue here is the choice of the mathematical base as automation research structurally complex dynamical systems involves a set of display features simulation, analysis and synthesis of the classes of systems. One possible perspective ways of solving this problem is to create a problem-oriented modeling systems, which are extracted from the model of elementary operations, as defined in equation.

The basis for modeling systems is a hierarchical description of the dynamics of the system under study, are a family of models, each of which describes the behavior of dynamic systems in terms of various levels of abstraction.

In the context of the task proposed to allocate two directions of hierarchical models [4]:

- vertical hierarchy, in which the division of models through the levels is carried out on the structural and functional features of the system;
- horizontal hierarchy, in which the division in levels models is dependent on the methods of investigation.

In the hierarchy of three levels of models are highlighted by vertical:

- level base models containing the simplest models;
- the level of local models, which reflect structural and functional properties of functionally complete devices aimed at solving specific problems;
- the level of global models, which reflect the organization's systems and is a model with a high degree of detail.

Horizontal hierarchy of models includes four levels, depending on the methods of investigation:

- models to get the process of calculating results based on analytical modeling;
- model showing the discrete nature of the processes and presentable logical-differential equation;
- model showing structural coupling mathematical process diagrams based on neural network algorithms;
- models to optimize and predict the state of a system based on artificial intelligence techniques.

In general, the design process involves the development of complex patterns, forming a layered structure and reflecting an iterative, dynamic and hierarchical nature of the processes involved.

For knowledge representation used semantic network, the objects of which are variable, called computational models related to private relations. Semantic memory (SM) is the type of a subject domain (SD). It stores all the information (knowledge), which determines the function of the system. Algorithms and special knowledge

of the properties of admissible classes of algorithms are presented SD in the form of the semantic models can be generated modeling algorithm processing and its implementation.

Mathematical models of simulation objects are stored in the joint venture as a set of relationships that also allow for modification and supplement. As a result, the user can adjust the semantic algorithms to set different eligibility criteria, introduce new algorithms and models to adjust the object model.

2. The concept of the problem decision

Formally modeling algorithms based on these models can be represented as follows:

$$M= < I, P, \Phi, X, Y, \Omega >,$$

where I – identifier of model; P= P (x_1,x_2,…,x_n) - Single predicate defined on the X-set. The meaning of this predicate is the formal definition of the possibility of using this model; $\Phi : X \rightarrow Y$ (XUY=Z) - mapping a certain set of properties describing the modeling algorithm; $X=\{x_1, x_2,..., x_n\}$ - input variables computational model; $Y=\{y_1, y_2,..., y_n\}$- output variables computational model; $Z=\{z_1, z_2,..., z_n\}$- the totality of variables; Ω- the scope of the model, which is defined by a pair of the domain of the X and Y values, i.e. $\Omega=\{X,Y\}$

In the process of working with models input variables of two types can occur: definite and indefinite. In accordance with this set X will be divided into X^D and X^I two disjoint subsets, i.e,

$$X^I \cup X^D = X \ (X^I \cap X^D = \varnothing)$$

Elements of X^I-set can be determined with the introduction of a relationship between certain variables X^D. Such t relation leads to the formation of more complex tiered computing model or another model M having as an output a Y-vector and undefined X^I vector of variables can be represented as a set of $N_m=N_x \cup N_y$ model-maps with scalar vectors $Y_k \in Y$, k= 1,2,…, N_m.

Used sub-models, which are blocks of different dimensions, can also be represented in the form:

$$m_i = < I, P_i , f_i , x_i , y_i , \Omega >$$

Then the components of the original model described by the elementary components of the following models:

$$M=\{m_i\}, \Phi=\{f_i\}, \ i \in [1, N_m]$$

$$(\forall x)P(X) \leftrightarrow [P_1(X_1) \wedge P_2(X_2) \wedge ... \wedge P_{Nm}(X_{Nm})]$$

$$X=\bigcup_{i=1}^{N_m} X_i; \qquad Y=\left(\bigcup_{i=1}^{N_m} Y_i\right)/X$$

$$Z=\bigcup_{i=1}^{N_m} Z_i; \qquad \Omega_i = P_z Z_i(\Omega): i=1,2,...,N_m$$

P_zZ_i (Ω)- the Ω- set of projection onto the hyperplane, the coordinates of which are components of the Z_i-vector.

Such forms of representation computational models allow to generalize the procedures associated with the formation of modeling algorithms, and present them as formal problems to be solved on the basis of these models.

Consider creating a process simulation system on the example of the dehydrogenation process of n-paraffin's. The mathematical model of the process of dehydrogenation of higher n-paraffin's is a system of differential equations [3]:

$$G\frac{\partial C_i}{\partial z}+G\frac{\partial C_i}{\partial V}=(1-\varepsilon)\sum_{j=1}^{N} r_j \qquad \text{i=1…M, j=1…N}$$

where G - raw material consumption, m^3/h; C_i- i-th hydrocarbon concentration, mol/m^3; V- catalyst volume, m^3; ε - sponginess of the catalyst layer, ε=0…1; r_j- j-th response speed, $mol/m^3 \cdot h$; z - given time or the total volume of recycled raw materials after the catalyst regeneration, m^3, $z=G_t$; t- time, h; M- nomber of components; N- number of reactions.

The equation of the heat balance in differential form is written as [3]:

$$G\frac{\partial T}{\partial z}+G\frac{\partial T}{\partial V}=\frac{(1-\varepsilon)\left(\sum_{j=1}^{N}\left(\Delta H_{jr_j}\right)\right)}{c_p}$$

where T- process temperature, K; ΔH_j - thermal effect of reaction, J/mol; c_p- the heat capacity of the mixture, J/kg·K.

The initial and boundary conditions:

$$z=0;\ C_j=0;\ T=T_{i,pr.v}$$

$$V=0;\ C_j=C_{i,st};\ T=T_{i,st}$$

Thus, the dimensionality of the system of equations of the mathematical model coincides with the number of substances whose concentration is determined by calculations, plus one equation for determining the temperature profile across the reactor. It is a table containing, outlet flows for a specific date calculation.

Based on the simulation experiment conducted in the dehydrogenation reactor using process modeling system experienced a smooth rise in input temperature 469 °C to 477 °C (fig.1). At the same time there have been small changes in temperature due to changes in raw material load. The coke concentration was 1.3 wt.%.

If we consider that on the catalyst of this brand in the operation was deposited not more than 3% by wt. the coke, we can assume that the current operation of the catalyst cycle is nearing its end. This also indicates a high content of diolefins in the dehydrogenation reactor products - about 0.8 wt.%

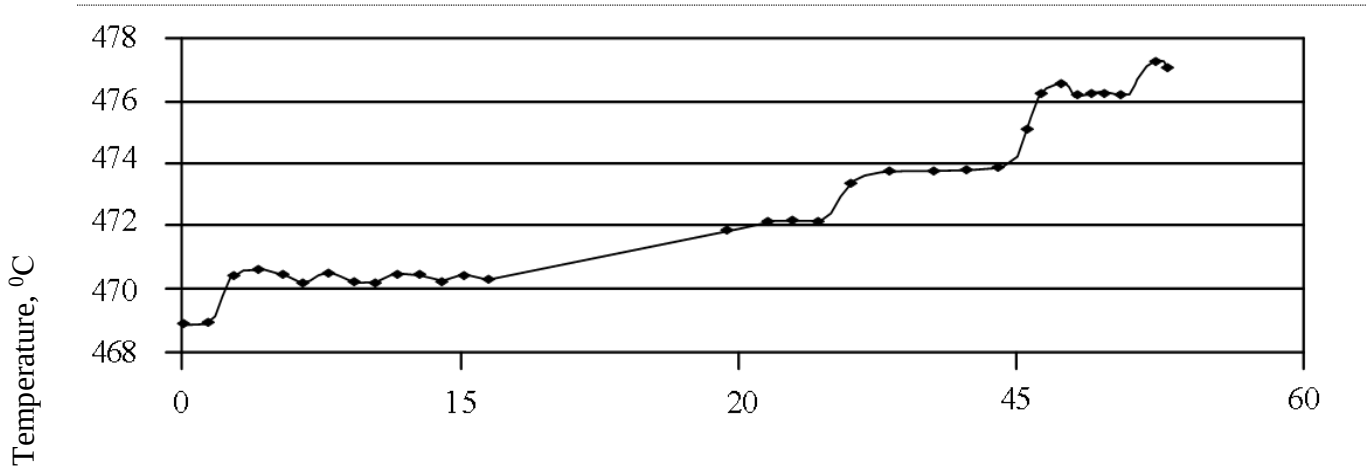

Fig.1. Rate of temperature rise in the dehydrogenation reactor

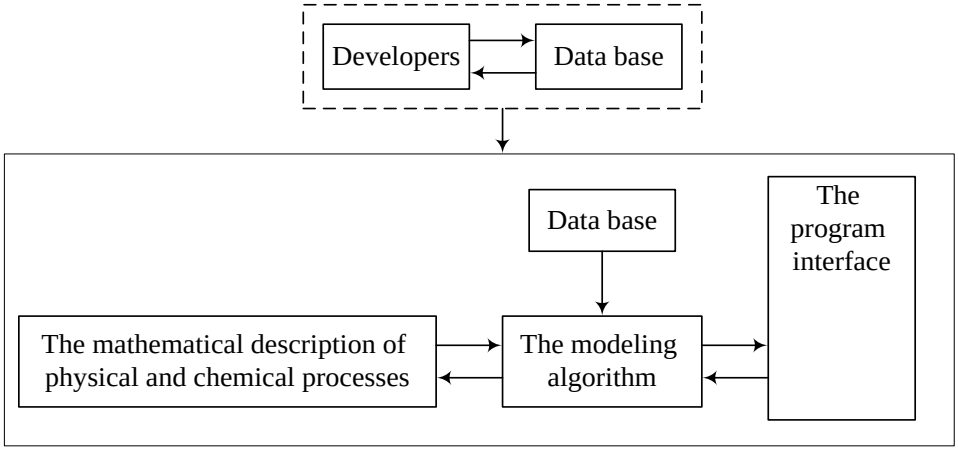

Fig. 2. Scheme of the interaction module with the computer modeling system

3. Realization of the concept

Studies have shown that a systematic approach in general and in particular the principle of decomposition is very useful when creating computer modeling systems (CMS) in the development environments of computer applications, such as family "Borland Delphi". In this case, each device modeling algorithm is localized within a single module, the included Delphi-project of your application, and the CMS is a collection of modules, supplemented by a description of the interface, numerical databases and repositories of various elements programming language syntax (methods and classes). Scheme of interaction of individual modules of the program «PDA» modeling of processes of synthesis of linear alkyl benzenes is shown in Fig. 2.

The modeling system for linear alkyl benzenes synthesis of realized production-frame model to determine the causes of accidents in the machines included in the technological plant scheme. Also, the model demonstrates personnel actions on elimination this emergency situation. The user selects the device, where there was an emergency, and then selects an emergency. After selecting the situation, a list of possible reasons for its occurrence and order of personnel action for its elimination.

Conclusion

One of the most important issues related to further support adaptation programs was modeling systems. For this purpose, formed the so-called application initialization file. This module is designed to transmit data to a program describing processes. The module is designed in such a way that its internal procedures with little change file initialization sensors are capable of sampling data from any production plants.

The main advantage of CMS, is to carry out optimization calculations. Thus, diolefin hydrogenation process simulation showed that the optimal flow rate selective poison dimethyl disulfide allows to increase the yield, linear alkyl benzene can be increased by 2.0 ... 14.0%, which is equivalent to approx. 45-315 million sum/year of additional income with virtually no increase in the cost of other stages of the production.

Thus, the developed modeling systems for oil refining processes and oil chemistry are software products, which are of great practical importance and provide timely monitoring, accurate forecasting and optimization calculations, including on economic criteria.

Designed of alkyl benzene modeling of processes of synthesis system includes a diagnosis of the causes of the deviation module of the industrial plant and can be used for the organization of personnel actions in case of emergencies in the devices included in the technological plant scheme.

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