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Creation of the virtual exercise machine of the technological production with the use of OMEGALAND dynamic modelling environment

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Abstract. The paper considers creation of the virtual model of receiving normal butane from isobutene-butene fraction with use of an integrated environment of OMEGALAND dynamic model operation to study the characteristics of the set technological mode. In the research process function chart was chosen and the parameters defining the key quality indicators of technological process of receiving normal butane were determined. The inventory which will participate in the simulation model is picked up. "Visual Modeler" dynamic model operation software with the graphic module and the module of the database are chosen as a medium for technological process modelling. The virtual model of a column used in simulators for tutoring and training prompt actions of technicians is created. Calculations of the established condition of process are performed, the analysis of sources to check the model for compliance with a real object is carried out.

1. Introduction

Recently, training of personnel has been drawing more and more attention of the management of the organizations. The success of any firm depends on quality of personnel training. Technologies and the systems of tutoring of personnel, as for assessment of the current level of training of operation personnel, and for its increase are developed and take root. Different types of tutoring are put into practice: instructing, master classes, trainings, tutoring with application of computer simulators and stands.

Computer simulators are simulators, computer or mechanical ones which imitate production control, the device or the vehicle. Therefore, the computer exercise machine is a means of effective tutoring by means of which it is possible to increase its quality of training technicians [1-3].

The relevance of development of computer simulators consists of two trends of the last years. First, it is the need for the effective system of training of operator personnel which is caused by constant complication of technological processes and emergence of new information management systems. Second, we have information technologies which are constantly moving forward which creates an excellent opportunity for creation of new systems for training on the virtual model surpassing the majority of the known traditional forms of education in efficiency, including not always available and potentially dangerous trainings on real objects [1, 2].

The computer simulator for the operator of technological process includes:

- Existence of high-precision mathematical models of a wide range of the processes having pronounced technological and administrative specifics;
- Realization of the specified models in the imitation mode (or dynamic model operation) with use of special methods of the numerical solution of high-dimensional systems algebra - differential equations;
- Reconstruction of a workplace of the trained operator of process, similar (psychologically and, partly, physically) to its workplace in real process, including the organization of the operator interface and an operating control;
- Creation of the corresponding workplace of the instructor of the tutoring exercising control and control of a training;
- Existence of the methodical and didactic base of computer tutoring considering specifics of decision-making processes and transfer of skills by operators of technological processes;
- Development of methods of the analysis and assessment of results of a training, methods of tariffing and certification of operators by results of training at exercise machines [3-5].

One of indisputable advantages of exercise machines is significant reduction in cost of process of training of specialists, its obviousness, a possibility of bringing to automatism of realization of operations by operators of technological processes, and, therefore, to enable the realization of professional competences of process of training of future expert.

2. Description of the technological process

A basic element of a system of receiving normal butane and isobutene from isobutene - butane fraction is the rectification column with the corresponding binding. The central gas-fractionation installation is intended for rectifying division of a long distillate of hydrocarbons into separate fractions: isobutene, butane, etc. hydrocarbons. The design capacity is 1000000 tons/year [6, 7].

The rectification column is bound to other inventory to one technological line.

In a column under pressure up to 7 kgf/cm2 (0.7 MPas) the sum of butanes is fractionated isobutene and normal butane. Couples of isobutene fraction at the top of K-1 column with a temperature up to 600 come to a dephlegmator where they are condensed due to supply of return water in pipe space. Condensate flows down in capacity, from where, moves on column top as a phlegm, and the rest on level in capacity is taken away on a finished goods warehouse. For an exception of uprating of pressure in a column on the line of return water after the condenser the pressure governor is established.

Heating of the bottom of the column is carried out via the portable boiler the warmed-up ferry with pressure of 6 kgf/cm 2 (0.6 MPas). From the boiler steam condensate is taken away in the general collector of steam condensate of low pressure.

The distillation residue of a column, normal butane, comes to the refrigerator where there is a cooling with return water then it is taken away on level cubed of a column on a finished goods warehouse.

3. Description of raw, grocery and power streams

Raw stream is the long distillate of light hydrocarbons. Grocery streams are fractions of normal butane with butane content not less than 97.5%, and isobutene, with isobutene content not less than 97% [8, 9].

Power streams are the trade effluent for cooling of finished goods, the water cooled for condensation of vapours from column top, steam for heating of a cube of columns.

During creation of the virtual model, the norms of the technological mode are used, the norms are taken from reference books [10-12].

4. Choice of the environment of model operation

The integrated environment for dynamic model operation of OmegaLand from Omega Simulation allows to create the virtual models of installations which can be used not only for tutoring of operators, but also for studying and check of chemical processes and also development of new processes. Thanks to the ability to precisely model work of installations on the basis of real data on processes, the OmegaLand environment could win the international recognition and became the world leader of sales since 2000 when it was for the first time presented at the market.

OmegaLand is the general term for an integrated environment of dynamic model operation. OmegaLand allows to create the systems supporting various purposes necessary in various industries by combination of the functional modules, such as databases and graphics. For these purposes the software package of dynamic model operation "Visual Modeller" developed by means of the most advanced technologies allowing to receive excellent performance characteristics in real time and to create large-scale virtual process units is used. OmegaLand has various modules:

The module of model of the process unit (Visual Modeller) creates dynamic model of the process unit and carries out model operation process. The so-called virtual process unit can be created.

Module of management of execution (EXEC) operates execution of OmegaLand and operates the modules which are a part of OmegaLand together with the data used by these modules as model.

Module of the database (DB) provides the function of the database available in real time. This module can collect these backgrounds, define new variables to which VIEW refers and to calculate values of tags, using calculation formulas.

Graphic module (GRAPHIC) provides a graphical user interface (GUI) which is immediately used by users [13].

5. Discussion

The first stage in creation of dynamic model of process in Visual Modeller is the choice of the substances participating in this process. The necessary substances which are available in base can be looked for by the name (name), a formula (Chem. Formula) or by the room in library (Lib. No.) which can be internal (Inner Library) or external (External File). To add substance, it is necessary to find it in library and to choose one of the found options.

In the way described above it is necessary to add all substances used in model (water, oxygen, nitrogen) in the project. And then we create the systems used in process.

To add an entrance stream to the function chart it is necessary to drag necessary model of a stream to the area of the function chart. The program gives the chance to fill initial parameters of model where for example it is possible to change a name of the created stream

Not tuned models are displayed on the working field in yellow colour. Tuned models are displayed in white colour. By double-clicking on an element it is possible to cause additional settings of model and to fill all necessary parameters. For example, for model of a stream it is necessary to set the following parameters: component structure (Feed Composition); temperature (Temperature) – 25 °C; pressure (Pressure) – 700kPa; number of a system of components (System No.) – 1.

For a task of component structure of the entered object it is necessary to register its percentage ratio at each component of a system (for example: water-0.5, oxygen-0.25, nitrogen-0.25).

In this point the creation of a stream comes to an end.

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Addition and setup of the equipment, sensors are made the same way.

In the developed process model, the main substances, are: isobutene; normal butane; ammonia; hydrogen sulphide, water (it is used as impurity, and also in the process for cooling or heating). Then systems which can be used further were created.

On the basis of the functional technological scheme in the working area, the process model shown in figure 1 was assembled.

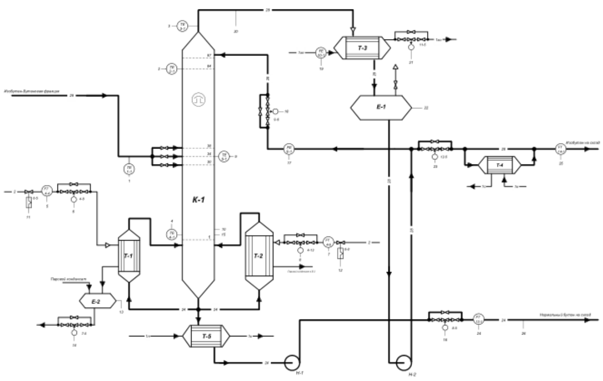

Figure 1. The function chart of receiving normal butane and isobutane from isobutane - butane fraction.

In the process of collecting the technological scheme, the task of adjusting the existing model of the column was identified, due to the discrepancy in the number of incoming and outgoing flows. As a result of the work, taking into account adjustments and amendments, a virtual model of the technological process was obtained.

On the basis of the obtained process model, the steady state conditions were studied [14, 15, 16].

The equation of model of the established condition of processing equipment can be received if to establish zero instead of a term of a derivative on time in the equation of dynamic model. To come into the established process model fortune, it is necessary to solve in unison these equations of model for all units of processing equipment of this process. Generally, the equations of model are non-linear, and the quantity of the collateral equations or variables becomes very larger as variables of all models of processing equipment and streams are used. In particular, for the program of model operation of the process unit, such as Visual Modeller which considers all inventory existing on the real process unit for model operation the number of variables sometimes becomes equal about hundreds of thousands or millions.

The solution of such bigger nonlinear equation would be impractical not only from the point of view of spent time, but also and in terms of stability of calculation. To improve this situation, Visual Modeller provides the excellent approach called by "Hybrid Modular Method". To add function of calculation of the established state to model of processing equipment, it is very important that the user was well familiar with this hybrid modular method.

There are two main standard methods for calculation of the equation of model of all process: modular method and method of the equations.

By means of a modular method, each unit of processing equipment has the procedure (module) for calculation of the equations of model, and calculation of all process is carried out by a serial call of each module. Unit of processing equipment (module) consists of the equations which in turn are caused, and all equations of model of all process are calculated. For the simplest serial modular method, the module is prepared for each unit of processing equipment to calculate conditions of streams of a product from conditions of streams of a delivery that is carried out in the direction from top to down in compliance by a stream of materials. If there is a circulation flow assuming stream conditions (temperature and structure), calculation begins with the processing equipment which is down the assumed stream. After realization of a cycle of calculations, estimated conditions are updated by the results calculated by the processing equipment located up a stream. Repeating this process until the estimated value and the calculated value don't coincide, it is possible to solve the equations of model of all process.

One of advantages of this modular method is that modules are independent programs and each module has the calculation method unique for the processing equipment that allows to carry out stable and fast calculations of processing equipment.

Other advantage is that as variables in processing equipment don't appear outside, the number of the processed variables can be small. However, the modular method has several serious shortcomings. For example, the specifications and restrictions concerning several units of processing equipment can't be processed; the balance of pressure can't be processed precisely; or the convergence of the circulating streams sometimes can be very sluggish.

On the other hand, the method of the equations represents a way for the collateral solution of all equations of all process without creation of modules. By means of this method of the specification and restriction it is possible to set freely, and the balance of pressure can be processed precisely. But there are particular shortcomings, namely: the scale of model has to be limited as the number of the processed variables can become very larger and the nonlinear collateral equations are solved at once, calculations become unstable if only rather exact initial values aren't provided for all variables.

The hybrid modular method of the Visual Modeller program represents a combination of a modular method and a method of the equations, using the best AND functions of a possibility of these methods. Roughly speaking, calculation of each unit of processing equipment is carried out by means of the module, but calculation of all process is carried out by means of a method of the equations. For calculation of all process unit, not all variables which are in models of processing equipment are used but only key parameters of processing equipment which have the considerable impact on balance of all process unit. In other words, the equation for calculation of balance of all process unit is the equation which is simplified to represent interrelation between variables of a stream and key parameters of the process unit. For Visual Modeller this type of the equation is called "Structural Equation", and its variables are called "Structural Variables".

Process of calculation of the established state by means of a hybrid modular method represents iterative calculations. In the beginning estimates of all variables of a stream have to be received to begin calculation. These first estimates are called "initial values". Then, with these values of variables of a stream, the module of each unit of processing equipment calculates the established condition of each unit of processing equipment. At the same time the module of unit of processing equipment creates the structural equations of unit of processing equipment, using computed results. The Visual Modeller system will solve the structural equations of all process unit consisting of all structural equations created at the same time by each unit of processing equipment. As a result, it is possible to receive new variables of a stream and key parameters of processing equipment (structural variables). If to repeat the above-stated calculation for the updated data until results of estimates and calculations coincide, then we will receive rigorous decisions for all process unit.

As it clearly follows from the above explanation, the process equipment model plays the following three roles in the hybrid modular method:

- It calculates initial values of variables of a stream;
- It defines the structural equations;
- It calculates the established condition of processing equipment under the given conditions of a stream and carries out the structural equations [17, 18].

Where the definition of a structural equation means the definition of the form of a structural form and the variable included in the structural equation, to perform a structural equation means to calculate the values of the coefficients and constant terms of the equation contained in the structural equation [19,20].

6. Conclusion

In this work the virtual model of process of receiving normal butane from isobutene - butane fraction, with use of OMEGALAND integrated environment of dynamic model operation was developed for the research of characteristics of the set technological mode.

In the work, the function chart of process was chosen and the parameters defining the key quality indicators of process are determined. The inventory which will participate in a simulation model is picked up. The environment for model operation of technical process is chosen. The virtual model of a column for use in the virtual model of technological process is finished. Calculations of the established condition of process are performed, the analysis of sources to check the model for the compliance to a real object is carried out.

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