ARPN Journal of Engineering and Applied Sciences

DEVELOPMENT OF TRAINING SIMULATOR FOR OIL REFINERY OPERATORS

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ABSTRACT

In this article, a one of approaches of development of the simulators for oil refinery operator is described. Shows the simulator structure, development of process simulation block, learning scenario, virtualization space, fault diagnostic, analyzing algorithm and results of simulator diagnostics. This simulator can be used for studying of main characteristics of technological processes and control actions, that would ensure the energy saving and safety in oil refinery plant.

Keywords: laboratory equipment, professional retraining, operator training, training simulator.

INTRODUCTION

Modern oil refinery plants are choosing the different ways of development. However, they have the typical goals - the increasing of safety and economic effectivity of production. The technological chain of oil refinery consists of many different units, each of which has a close links with others, so the control of these processes is very difficult. In this case, the oil refinery plants needs to have highly skilled professionals who can solve the different tasks of the technical maintenance and control. Developing of the special training simulators can help to solve this task. A one of approaches of developing of the simulators is described in this article.

DEVELOPMENT OF TRAINING SIMULATOR

Development of training simulator consists of some steps: determination of simulation structure, development of basic technological processes models, learning scenario, virtualization space, analyzing algorithm and determination the fault diagnostics functions.

The simulator structure

The typical structure of simulator contains some modules: the training database, simulation module, learning scenario module, virtualization module and qualification test module. This typical structure has some disadvantages. The main of them - it doesn't connect with the operating process in real time mode. Sometimes, the simulation model has a connection link with real data of process, but it cannot be changed at a real time. Typically, this model is developed based on the information known at the time of the development of the model and do not take into account changes occurring in the industrial exploitation of the equipment. In order to correct these disadvantages, you must create internal models that are able to adapt to changing production processes. In addition, it is necessary to create special training scenarios for operators and their skills level must be analyzed not only at the time of training. It must be monitored at the time of realizing their production activities. This task can be solved with using a new unified structure of simulator. The unified structure is shown on the Figure-1.

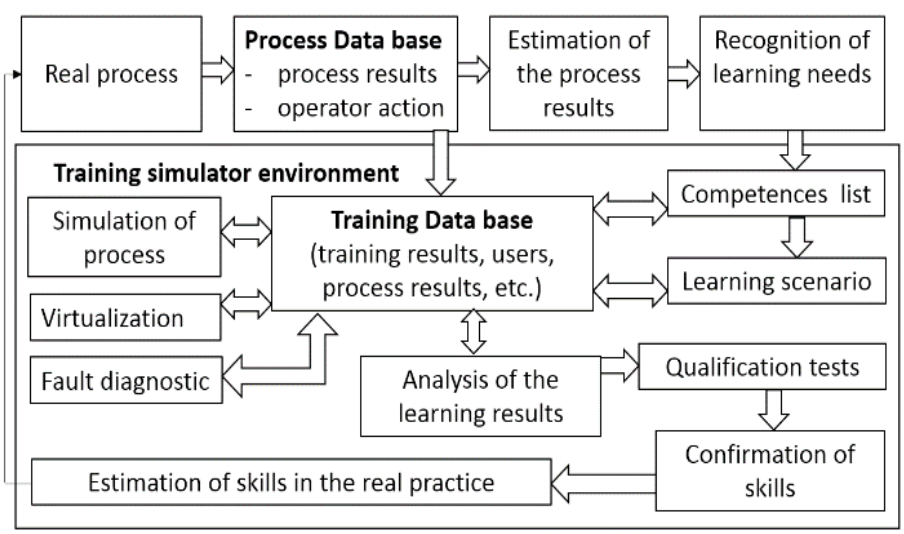

Figure-1. The structure of simulator.

VOL. 11, NO. 17, SEPTEMBER 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

It consists of the typical blocks and the special blocks: the block forming the list of competence, the block of analysis of the learning results, the fault diagnostic block, the skills confirmation block and the block of estimation of skills in the practices. The main properties of all of those blocks are the flexibility, adaptation and scalability.

Development of process simulation block

The process simulation block has the three types of models: two models with slow pace solutions and one model with fast pace solutions. The structure of simulation block is shown on the Figure-2.

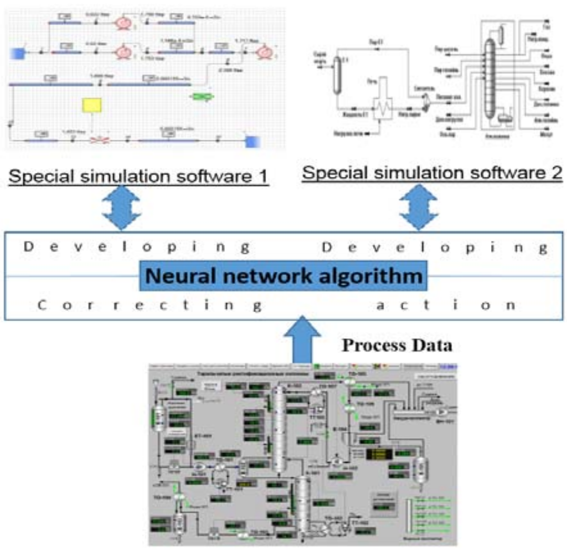

Figure-2. The structure of simulation block.

The simulation block must be used in the real time, so it must be give results very quickly. Therefore, the models with slow pace solutions cannot be used in the simulator.

The best method of solving with fast pace solutions are the neural network modeling method. The neural network model uses the big number of values of technological data. These values can be gave from different sources. The most easily used source is the real process, but unfortunately, you cannot get a big massive data of parameters at the first moment of developing model. These parameters can be gotten in the real practices only after continuous using of model. Therefore, at the first time we need to get many parameters of technological process. Those parameters can be gotten from the special model. This model is developed in the special software. In spite of it's solutions with the slow pace it can be very useful. It get many parameters in the different areas. Usually the factory doesn't have historical data of alarm mode parameters. The model can help to solve this problem of information insufficiency.

The simulator has a different models, one of them is the model of preflash column. The first step of model creating is determination the input and output variables. Input variables preflash columns: crude oil flow (Fro), crude oil temperature (Tro), the qualitative characteristics of the crude oil (Qro), flow of reflux to the column (Ff), rate of heat flow into the column (Fh), flow of low-boiling fractions (Flbf). Output variables:column top temperature (Tc), column bottom temperature (Tcb), level in the column (Lc), a dephlegmator level (Ld), the pressure in the column (Pc),% content of low-boiling components in the stream of low-boiling fraction stream (Plb), temperature after the air cooler (Tac), residual stream temperature (Trs).The schema of creating model is shown in the Figure-3.

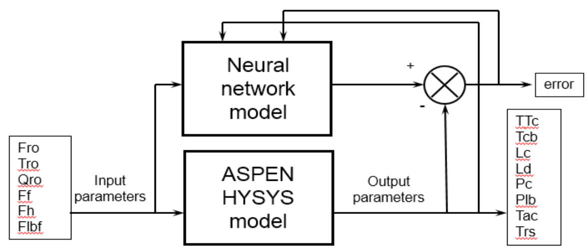

Figure-3. The schema of creating preflash column model.

A neural network with two hidden layers was chosen to solve this problem: twelve neurons in the first hidden layer, a six-second and two in the third. (Chosen of this topology based on the theory of Kolmogorov) As a function of the activation in the inner layers used the hyperbolic tangent, the input and output layers of the network to use linear activation function. algorithm backpropagation was selected for training the neural network. Figure-4 shows graphs of the results of network training.

Assessing the adequacy of the network was carried out by examining the correlation functions. These correlation coefficients allow to state that the network training went pretty well (correlation coefficient in the training sample - 0.95, on a test - 0.77). This is also confirmed by the neural network response graphs in the training and test samples presented in Figure-4.

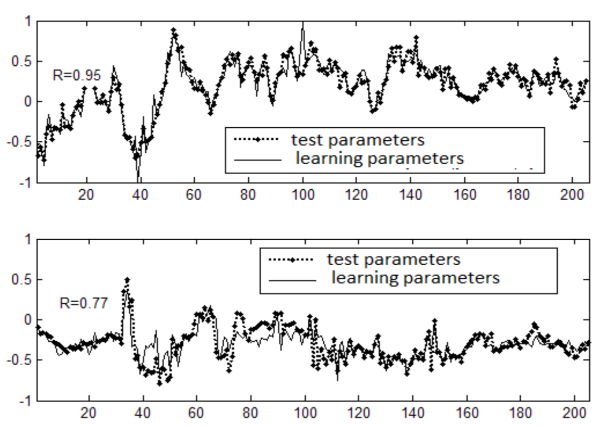

Figure-4. Output response to neural network learning (above) and the test (bottom) of the input signal sample.

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The Figure shows clearly that the simulation results almost exactly repeated behavior of the object. All this allows us to conclude that the successful solution of the problem. This model can be used in the simulator.

Development learning scenario

The new scenario can be developed immediately when the needs has been appeared. It helps to increase wide range of capabilities of this simulator.

The examples of learning scenario are:

- Running/Stopping technological processes
- Stabilization in run mode
- Change of unit capacity
- Troubleshooting
- Solution emergency

Each scenario contains the ways of task solving and the level of difficulty. In the realizing a scenario a operator choses the some direction of solving of main task. Complex of her or his solution can be characterized by the 4 types of results: normal, optimal, emergency, alarm. Every results has a color: blue, green, yellow, red. Operator can see the color of results of her ore his solution in learning mode and can not see it in the test mode. So, the task can be solved when a operator will see the green and blue color at the screen.

Development of virtualization space

The main task of developing of training simulator is the integration of SCADA-system and 3D space. The 3D space must show all of operator actions and all action that can be happened after these actions.

The schema of integration of SCADA and 3D space is shown on the Figure-5.

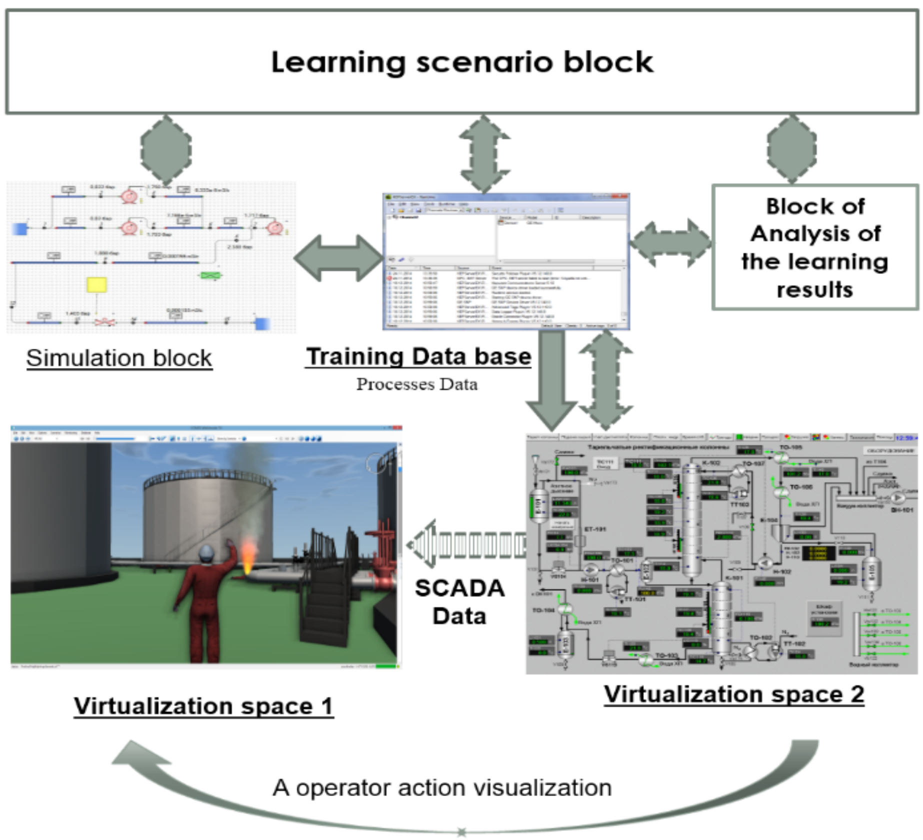

Figure-5. SCADA and 3D space integration.

The main function of virtualization block are:

- Visualization of operator actions inside the SCADA system;
- Visualization of technological equipment in 3D space with scaling details;
- Visualization of valves, buttons and pumps and other closed member elements in 3D space;
- Simulation and visualization of technological processes changes according to the learning scenarios

Fault diagnostic

The fault diagnostic block consists of 4 main subsystems:

a) Subsystem of operator actions and solutions analyzing

b) Subsystem of instructor actions and solutions analyzing.

c) Subsystem of analyzing of equipment and simulation software conditions (including the self-diagnose).

d) Subsystem of learning scenario analyzing

Development of analyzing algorithm

The analyzing algorithm helps to determinate special functions:

- The number and quality of professional skills of each operators,
- The number and level of qualifications of instructor
- It must compare the number of errors of operators in the learning processes and real practices
- It must determinate the information redundancy and inaccuracy
- It must determinate the needs to change the competences list

Results of diagnostics simulator

Simulation work has been diagnosed in several learning scenarios. One of them was a Running/Stopping technological processes. Start-up of high-tech equipment is the difficult process, consisting of a set of actions. These actions are carried out by the operator in certain sequence which is described in technological documentation. The end result of these actions is the conclusion of equipment to an operating mode. Even small deviations from technical documentation can create conditions under which installation won't be able to enter an operating mode. Manual start of technological units has low effectively and very strongly depends from the operator. Therefore development algorithm for automation of start-up of the equipment of complex technological processes is the actual task for the industrial enterprises allowing increasing safety and efficiency of conducting complex technological processes.

To conduct the study in this paper as the object was chosen as an experimental laboratory setup for the separation of water-alcohol mixtures at the distillation columns.

Ramp-up during operation of the laboratory setup is the moment of receipt of a water-alcohol mixture, with an alcohol content of at least 94%. The unit has 45 input variables and 22 output variables. With the help of expert composed sequence of actions for start-stop of object. Three starts of installation by the given sequence of technological operations and operations without application of special algorithms were carried out before creation of system of automatic start-up of the equipment. Time to output equipment to the mode very variously changes from 123 minutes to 54 minutes and directly depends from actions and experience of the operator.

Also in the course of execution of operation the algorithm of execution of strict sequence of actions was made. Algorithm was realized in Proficy Workflow environment, then it was integrated in top level of DCS. Communication between DCS and developed system was set by means of OPC technology. Process of start-up of installation with connection of the developed algorithm showed that installation output time for the mode was reduced till 50 minutes.

Proceeding from results of research, the conclusion that it is expedient to apply the developed algorithm to start-up of the equipment of difficult technological processes, it reduces probability of a mistake of the operator, loss of raw materials, energy carriers, reduces an unproductive operational load on the operator, increases safety of guiding of complex technological processes.

CONCLUSIONS

Thus, a comprehensive simulation training device is an effective means to improve the quality of educational services in the preparation of specialists for the oil refining industry. When using it, the students and operators learn much faster the necessary material, as well as significantly faster find practical applications received in the framework of the discipline of theoretical knowledge. The transition to the establishment of an integrated simulator allowed to expand a number of problems of training specialists for the oil refining industry and improve the quality of the process of providing educational services.

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