Increasing reliability of production work personnel when using graphic models of technological processes

S Sh Abyzgildina and Z R Mazina
Ufa state petroleum technological university, 1, Kosmonavtov street, Ufa, 450062, Russia
E-mail: sakina39@rambler.ru

Abstract. One of the main causes of accidents at oil refining and petrochemical plants is the human factor. Major accidents at petrochemical plants lead not only to loss of life, but also to environmental contamination. Currently, a complex system of tests and exams is used for staff training. One of the most effective training methods is the use of computer simulators. Unfortunately, the cost of these training systems is estimated in the dozens and hundreds of thousands of dollars. Plants themselves cannot develop such complex information systems on their own due to the lack of relevant software products on the market. A possible solution to the problem of meeting the needs of petrochemical plants is to develop a software platform for creating technological simulators that would meet the explosion safety rules. In this regard, to develop mathematical models of complex chemical and technological systems, a method and program for modeling chemical and technological processes is necessary. To increase the efficiency of calculation algorithms it is proposed to use the method of graphic models.

Production personnel is a key point in nowadays systems of technology control. Safety and reliability of any technological process is mainly dependent on reliable work of the production personnel [1,2].

Getting a higher education diploma is just the initial step in making a qualified professional of any profile. True competence comes only after years of production experience. According to specialists, engineering and production staff find themselves at a loss, when facing a technological malfunction or emergency, - their actions become unpredictable (slowdown and erroneous operating double the malfunctions and their after-effects).

Decisions are often taken under vague and risky conditions, that lays responsibility on the operator. An operator’s error is any production operation going on beyond working conditions of the unit. The higher is the operator’s strain the better his or her individual traits are to be in character with the production tasks. That makes it possible to minimize the rate of malfunction (overload), and to ensure the task to be accurately done.

To make the production personnel’s work more reliable, one should mainly use scientific approach to training the personnel, which means one should work out new technologies to lower the harm that can be done to the personnel by the technologic process [3].

It is achieved by finding methods of optimum solution and using simulators for keeping up the personnel’s high efficiency [4,5].
In order to work out a common structure of the training system for the personnel, it is necessary to analyze the unit to be operated, to compile trends that would be the basis for the common structure of the training system [6]. This ensures solving of the whole set of problems in controlling and keeping up physical parameters, in reliable and safe functioning of the whole technological unit and measuring instruments on every stage of the technological process [7].

Most breakdowns are caused not only by wrong operating but also by an imperfect quality of information on the technological scheme [8].

The safety principle of any petroleum and petrochemical production is accurately worked out and practically tested in the technological process.

The traditional technological scheme is graphical representation of the operations that make a complete chemical technologic process. The main flows are figured in straight lines with the flow direction arrows (figure 1).

![Figure 1](image1.png)

**Figure 1.** The main flows of the technologic scheme of an Atmospheric pipe store unit.

In the technological scheme, onward appearances of units are figured and more rarely the inwards (for non-standard units) (figure 2).

![Figure 2](image2.png)

**Figure 2.** The main apparatus of the technological scheme of an atmospheric pipe stove.
The present representation of technologic schemes makes it difficult to analyze and master them, for their being tangled and for multiple line closings. The graphic representation of the scheme in use is complicated to have a full view at a glance, as it is large, and couplings among units are tangled, which makes it hard to make the total traits of different units or a peculiar feature of a certain unit at first sight.

Information systems development made it possible to represent technologic schemes using computer graphics.

The system of information processing meets new requirements the information in technological schemes either. The graphic pattern of a technological scheme is better adapted for representing the systems of operating the technologic processes by means of computers and to represent the personnel training system, as it is visual and requires little space.

Graphic patterns make it possible to simplify representation of technological schemes and shorten the information stored in them. Representation in computer graphics makes it possible to put patterns on technologic schemes, when necessary. When viewing a scheme or checking a particular unit on the computer display, it is possible to enlarge any figure. That provides a quicker access to the information needed.

The representation of a technologic scheme can be simplified by adding the pattern of the technologic flow, the patterns of main flows, pattern schemes of checking and measuring apparatus and automated control systems.

The graphic patterns are to be made in such a way that the personnel would operate the technologic process effectively, safely and without overstrain.

Working up and use of graphic patterns will ensure efficiency and safety of technological units in petroleum and petrochemical industry and make it possible to solve a number of problems on processing and analyzing a great deal of information as well as to work out directions on how to choose the right solution, make the correct diagnosis and so on.

As an example, you can see the technological scheme (figure 3) of an atmospheric pipe stove unit and its graphic pattern (figure 4).

![Figure 3. A technological scheme of an atmospheric pipe stove unit.](image-url)
Figure 4. A graphic pattern of an Atmospheric pipe stove unit.

The pattern is simple thanks to a new approach to the representation of apparatus which makes it possible to easily learn the technologic scheme. To achieve it, several simple principles are presented:

- Working up schemes and flows. Apparatus are on the flow schemes.
- Flows are separated in a tree-like shape (the main flow goes from the left to the right and from below upwards).
- Circulation is figured as a circle. The main flow goes counter clockwise.
- Apparatuses for splitting raw material are figured as circles. Apparatuses for transferring the stuff are figured as triangles.

Availability of simple patterns of technologic schemes will make it possible to visually control the work of technological units on the monitor screen.

That enables an operator to control the unit totally, to picture all the processes going on there, and to determine how to operate efficiently and what to do in case of emergency if the conditions change.

The graphic patterns that have been worked out enable one to simplify representation of schemes with the information stored, to raise the information capacity of the technological schemes and simplify shift of information into electronic forms.

After mastering the graphic patterns, the personnel raise qualification, efficiency of experience in emergencies, comprehension of cause and effect ties in the units, self-reliance and ability to do tasks of operation on their own and quickly respond to technological malfunction, thereby lowering the psychological stress.

Wide use of graphic representation of technological schemes will make it possible to raise accident-free and safe work rate that is to make the personnel’s training easier and adaptation in potentially dangerous chemical production quicker. The use of standard graphic patterns will make training of the personnel easier and will quicken adaptation to a different technological process.

A graphic pattern is an up-to-date method of launching, operating and making safe a technologic process. It is easy for system analysis and has a framework for subsequent information system.

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