

## 1 Structure of an automated control system for an oil refinery

**Object:** Technological facility - designed mini oil refinery (refinery)

**Purpose:** Equipping a mini refinery with sensors and actuators, a control cabinet, as well as a workstation for observe the state of the equipment and operate actuators in real time.

*The control cabinet* - is an electrical panel with equipment for switching with external sensors and actuators. A PLC is installed in the control cabinet for receiving signals from external sensors and actuators via laid communication channels, and for issuing signals to actuators via laid communication channels. PLC is a microprocessor device that runs under the control of application software. Variables corresponding to incoming and outgoing communication channels are formed in the PLC memory to transmit data on the physical indicators of the process. The workstation has access to PLC variables.

*Workstation* - a personal computer with pre-installed special and application software for visualization of the "Technological facility". On the workstation monitor screen, it is possible to remotely observe the status of sensors and to operate pumps, valves and other actuators.

### **The main stages of the work performed:**

- Development of design documentation for the installation of sensors (sensors) and actuators (pumps, valves and valves with an electric drive) at the Technological facility.
- Development of technical documentation for the assembly of the Control Cabinet with PLC S7-300 Siemens. Development of electrical circuits for connecting sensors and actuators to the control cabinet and for equipment communications inside the control cabinet.
- Creating of application software (PPO) in the STEP 7 environment for loading into the S7-300 Siemens PLC. Creating of application software (project for visualization and control of the Technological facility) in the WinCC Explorer environment for loading to a personal computer workstation.
- Installation of sensors and actuators at the Technological facility.

- Installation of equipment and PLC S7-300 Siemens inside the control cabinet, connecting it to sensors and actuators. Downloading the developed application software to the S7-300 Siemens PLC.
- Loading the visualization project into the personal computer of the Workstation, connecting the workstation to the PLC S7-300 Siemens (in the cabinet). Starting a visualization project in the WinCC Runtime environment. Commissioning, observing of the state of equipment and operating of actuators in real time.

**Details of work performed:**

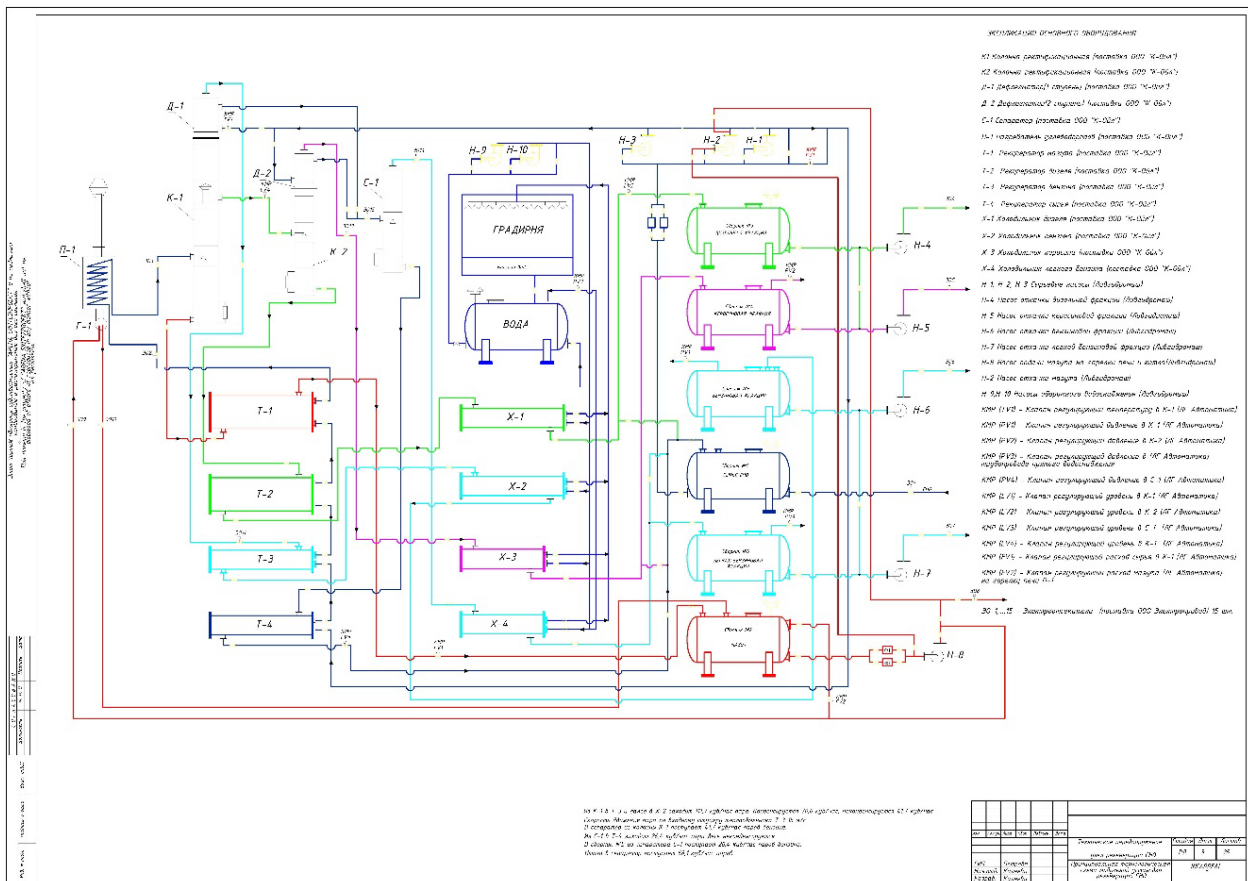
Processing of raw materials (crude oil) and obtaining finished products (gasoline, diesel fuel, kerosene, etc.) is a technological process.

The technological process is implemented at a mini refinery facility. See the general view of the Technological facility in Fig. 1.1, fig 1.2



Technological facility -mini refinery has the following composition: - technological equipment (column, tanks, heat exchangers, pumps, valves, pipelines) which are interconnected with each other, in accordance with the technological scheme.

The technological scheme is shown in fig. 2. It is part of the documentation that was developed for mini refineries.



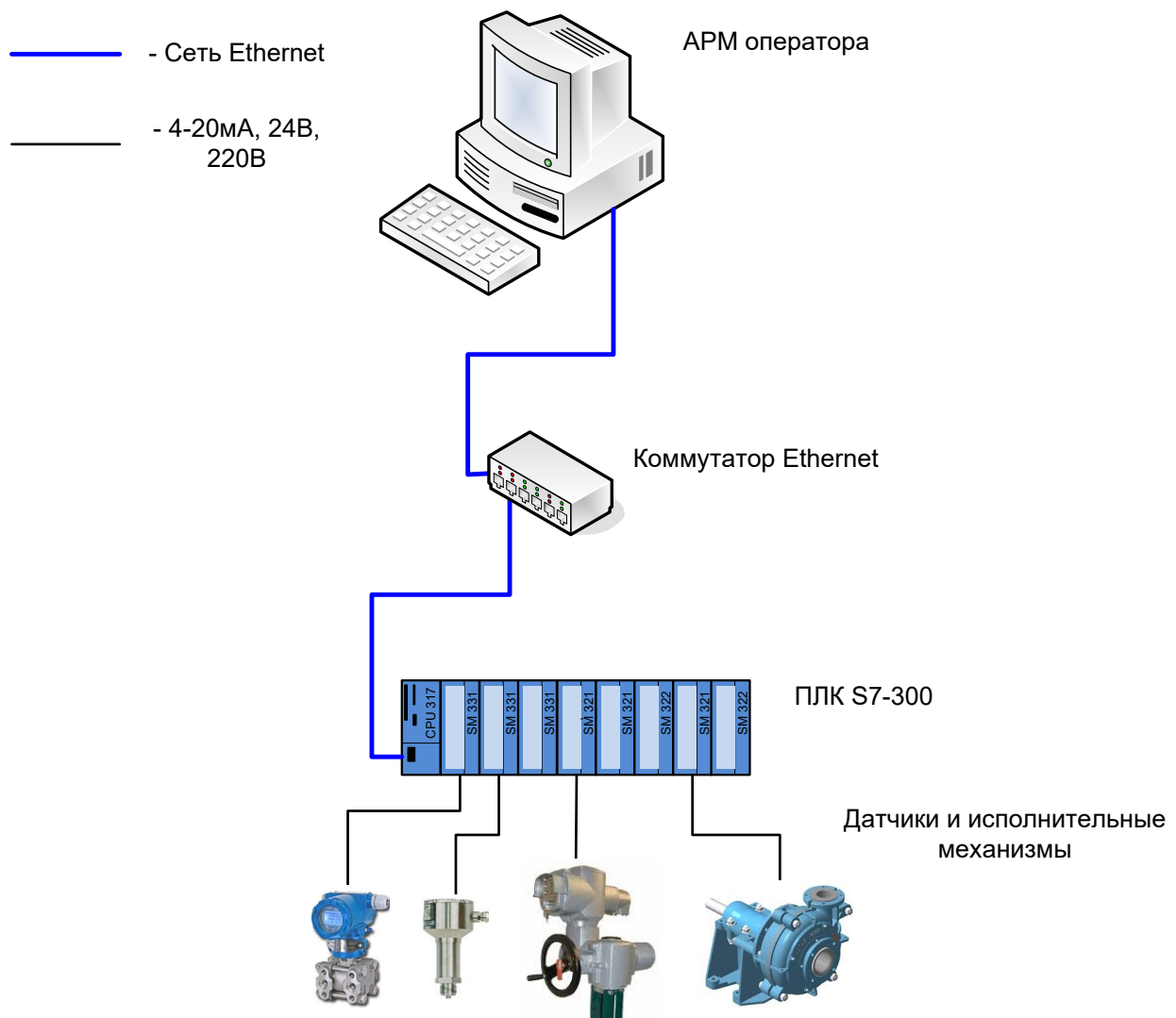
Raw materials or semi-finished products (products) are contained and transported inside the process equipment. Products are contained and transported at specified values of physical parameters (temperature, pressure, flow, level) inside the equipment. The values of the physical indicators of the product are read and transmitted by sensors that are installed on the equipment and pipelines. The products are transported by pumps through pipelines, the flow rate of the liquid during transportation is controlled by electrically actuated valves.

An automated process control system (APCS) has been created at the mini refinery to observe the physical indicators of the technological process and operate technological operations.

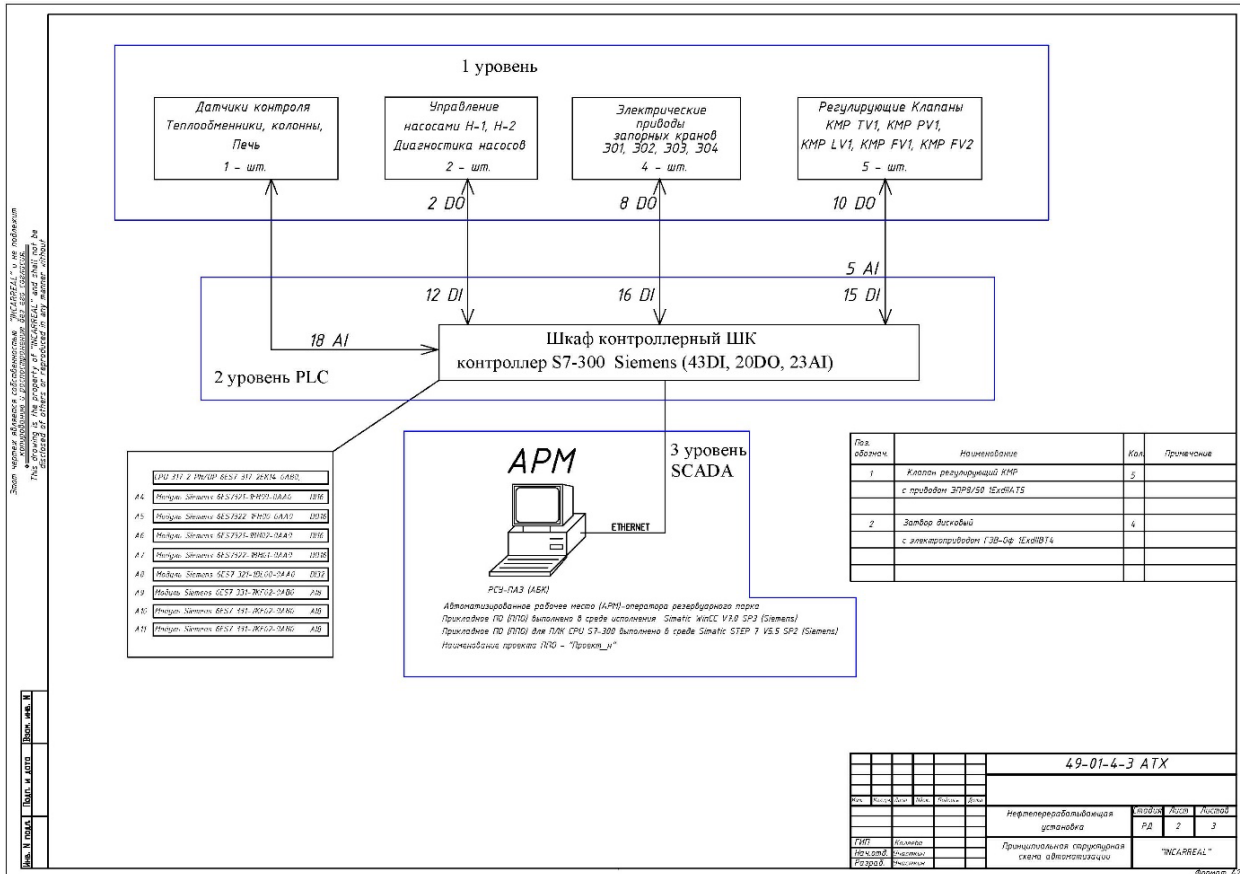
The automated process control system (APCS) performs:

- control (visualization) of the values of physical indicators of raw materials (semi-finished products) inside the equipment;
- control of pumps and valves in order to keep the values of physical indicators in the required interval;
- control of pumps and valves in an emergency;
- control of pumps and valves by the operator, who monitors the values of physical indicators.

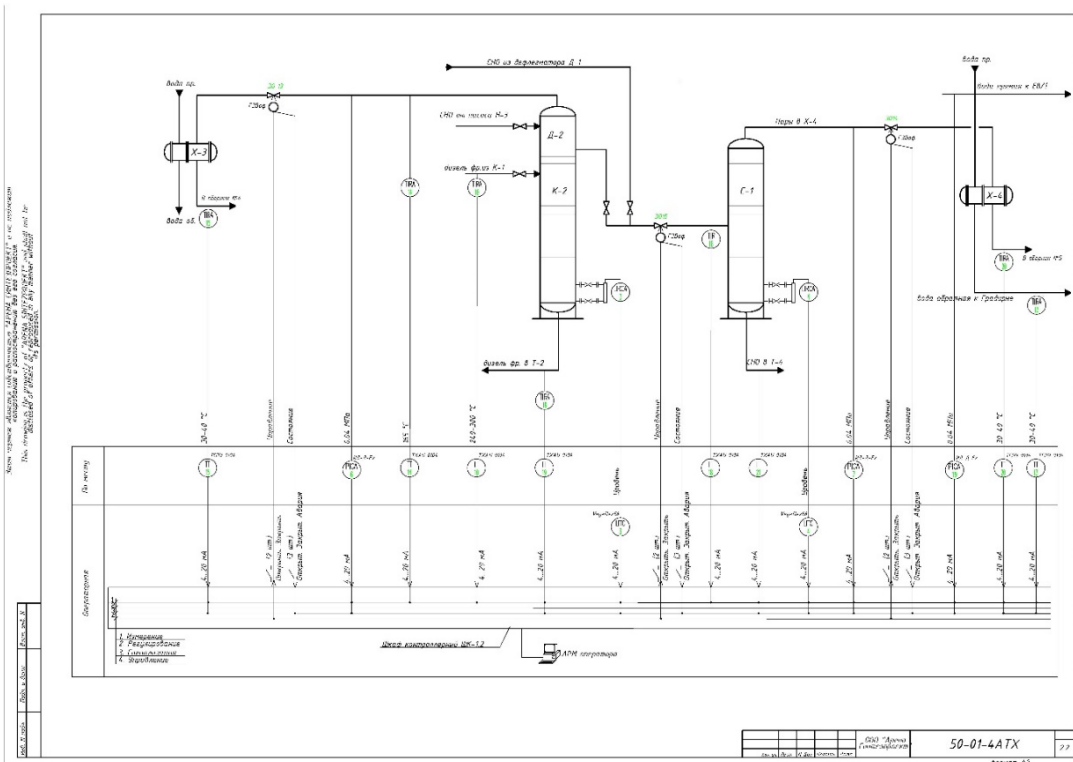
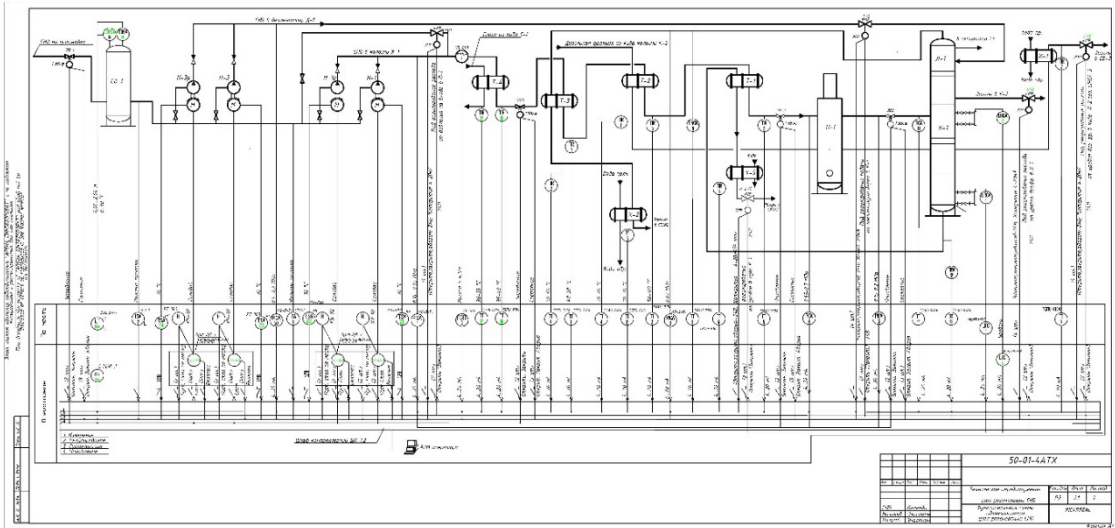
The block diagram of the Automated Process Control System (APCS) is shown in the figure below.

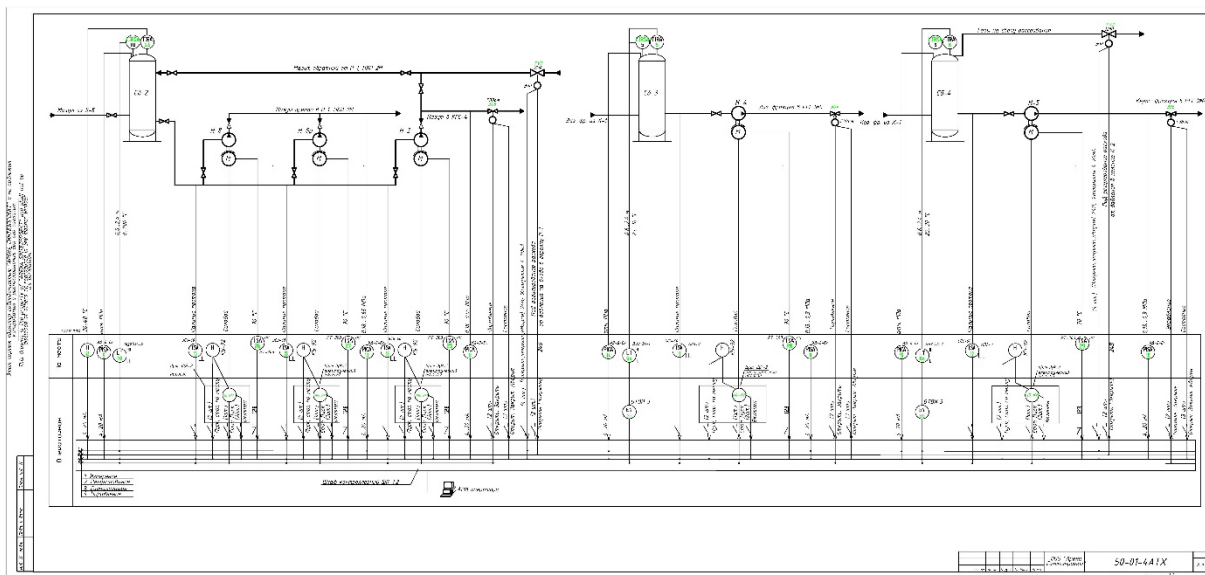


The automated process control system is divided into three levels. For a mini refinery, a block diagram of automation has been developed, see Fig. 3



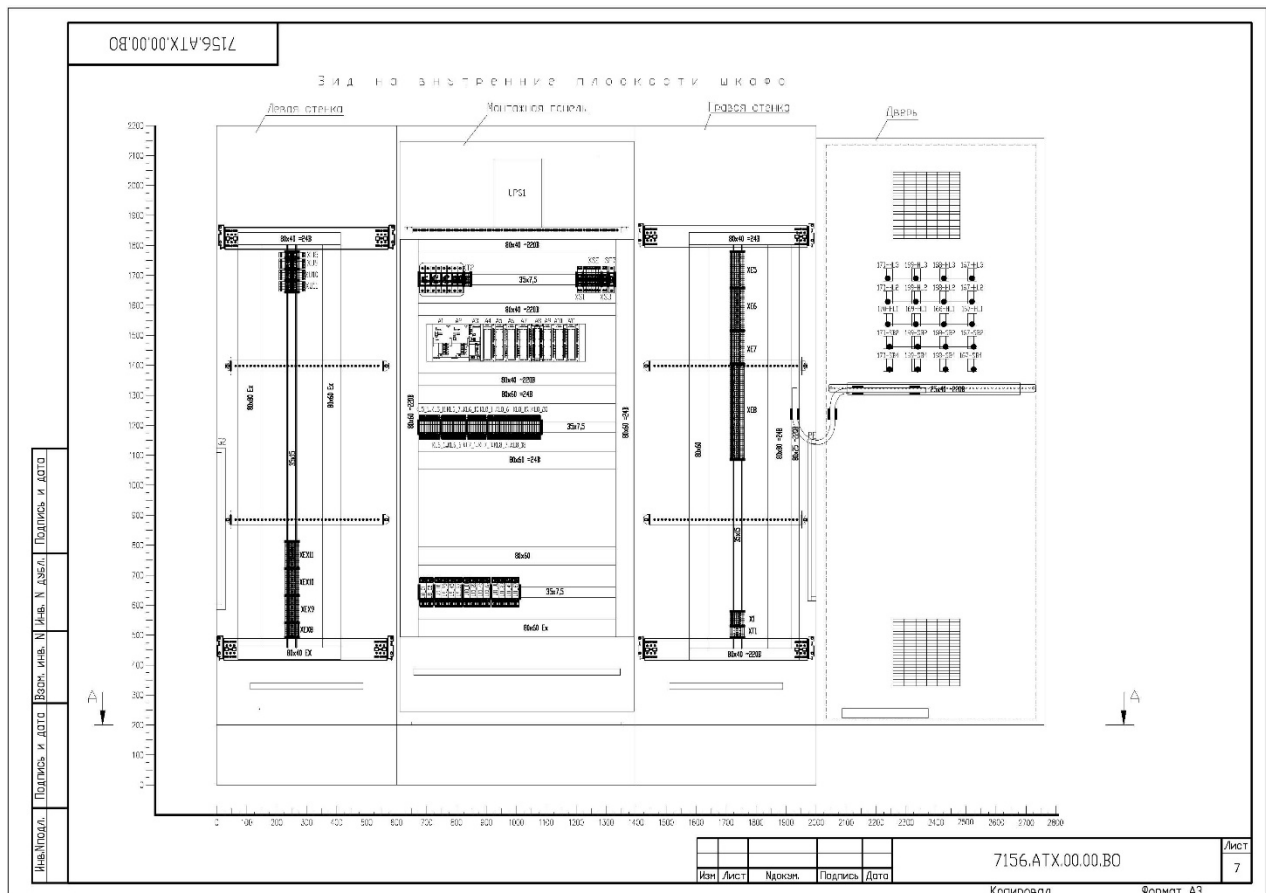
Level 1 - the lower level of automation - the level of instrumentation and actuators (sensors, pumps, valves). Functional automation schemes have been developed for mini refineries. In functional diagrams, sensors are shown for each piece of equipment and the communication channels of sensors with the PLC with their characteristics (discrete, analog, interface). Subsequently, in accordance with the functional diagram, the sensors were installed on the equipment and pipelines of the Technological facility. After installation, the sensors were connected to the cable control cabinet. Functional diagrams for the process unit - mini refinery can be seen in fig. 4.1, fig. 4.2, fig. 4.3





Level 2 - basic level of automation (controller level - SIMATIC S7-300). The composition of the second level 2 is a control cabinet with PLC S7-300 Siemens. The technical documentation for the control cabinet assembly, including wiring diagrams for connecting the equipment inside the cabinet, was developed for a mini refinery. Subsequently, the control cabinet was completed and installed on the Technological facility. The PLC control cabinet was connected to sensors, pumps and valves via previously designed communication channels. For process control, application software (APS) has been developed in the Simatic STEP 7 environment for downloading to the PLC. The composition of the control cabinet and its appearance is shown in fig. 5.1, fig. 5.2





Level 3 – the upper level of automation (workstation – operator workstation). The composition of the 3rd level includes an automated workplace of the operator - a PC workstation (personal computer) (Human Machine Interface WinCC).

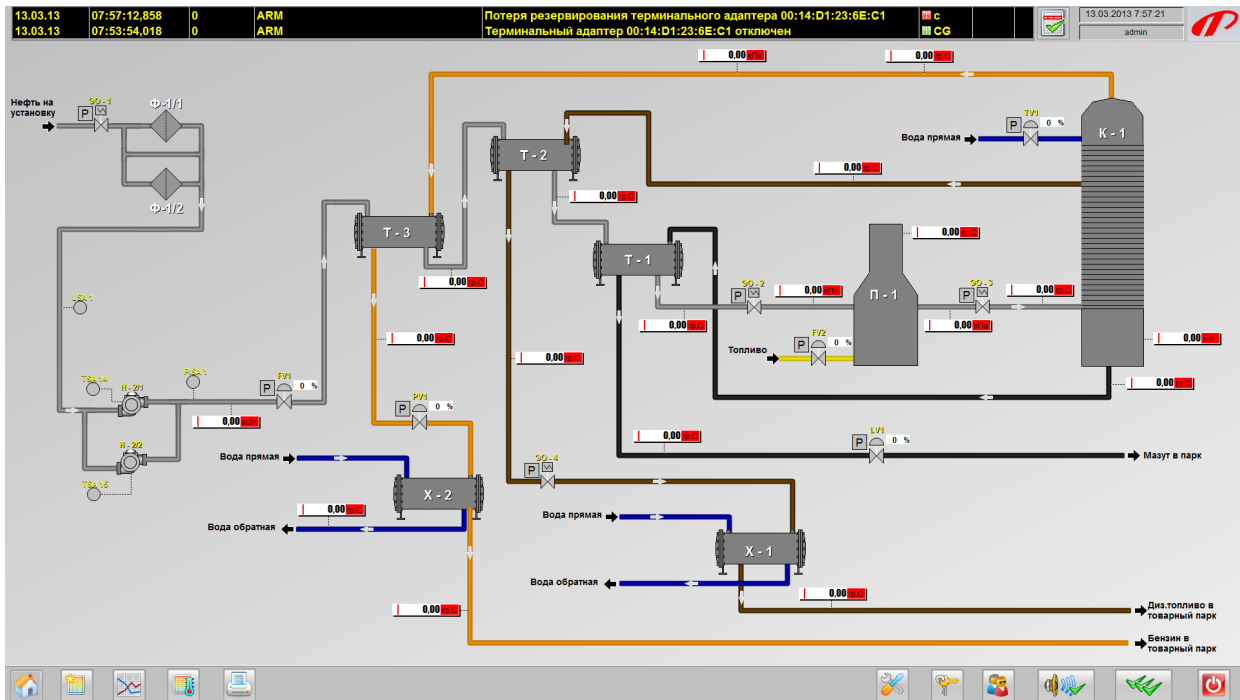
Special software - WinCC Siemens was downloaded to the personal computer of the workstation. It has two modules, the WinCC Explorer development environment and the WinCC Runtime runtime environment.

Application software (project for visualization and control of the Technological facility) was developed in the WinCC Explorer environment for mini refineries. The project contains a mnemonic diagram of a mini-refinery, which is similar to the technological scheme of a mini-refinery. Windows with physical indicators of the process (tags) are linked to the equipment and pipelines of the mnemonic diagram.

After development, the visualization project is run on the workstation in the WinCC Runtime environment. Communication is established between the personal



computer of the workstation and the PLC (inside the control cabinet). Application program - visualization and control project accesses the PLC memory and identifies variables of physical quantities. Values of variable physical quantities of the PLC are assigned to the generated tags of the visualization project in real time. The mnemonic diagram of a workstation for a mini refinery is shown in fig. 6



**At the 1st level of automation, the following tasks are solved:**

- obtaining information about the technological process and the operation of the equipment, which is the input for the 2nd level;
- control of actuators according to specified algorithms by control signals received from outputs of the 2nd level.

**At the 2nd level of automation, the following tasks are solved:**

- collection and processing of information coming from control and measuring devices of the 1st level;
- regulation of the technological process by supplying control signals to the actuators of the 1st level;
- inclusion of blocking of actuating mechanisms in case of technological parameters going beyond the permissible limits;
- alarm message generation;
- data exchange with 3rd level of automation.

**At the 3rd level, the following tasks are solved:**

- data collection and archiving;
- display on the monitor screen in a form convenient for the operator of operational data;
- display on the monitor screen in a form convenient for the operator of archived data;
- setting the settings and operating modes of the process control system for individual nodes of process equipment.