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# Developing the Dispatch Control and Automation Stage for the Demineralization of Water in the Nitric Acid Production Process

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**Abstract.** Water demineralization is a crucial stage in the technological processes of nitric acid production, as water quality directly affects equipment efficiency and overall plant productivity. Demineralization is used to remove undesirable impurities from water, which helps prevent corrosion, deposits on working surfaces, and product contamination. In modern conditions, automated dispatch systems are widely used to optimize this process, enabling real-time monitoring and management of operations. This article examines the key aspects of the dispatching process for water demineralization in nitric acid production, as well as the benefits of automation. In this article, the possibility of increasing the productivity of the process and the quality of the product by analyzing the possibility of transferring the automatic control system to the dispatch center during the demineralization of water during the production of nitric acid at the Navoiazot enterprise is considered.

## INTRODUCTION

Nitric acid is a colorless, transparent liquid with a pungent, suffocating odor. Chemical formula: $HNO_3$. Non-flammable, fire-hazardous liquid, is an oxidizer, increases the flammability of flammable materials. Nitric acid is infinitely soluble in water, reacts with water to produce heat.

Nitric acid ($HNO_3$) is produced industrially through a process called the Ostwald process. This process involves several stages using ammonia ($NH_3$) as a feedstock. Here are the main steps for producing nitric acid:

- Oxidation of ammonia to nitrogen oxides (NO and $NO_3$)
- Oxidation of NO to $NO_3$
- $NO_3$ absorption in water
- Removal of nitrous acid
- Nitric acid concentration

The nitric acid produced by the process typically has a concentration of about 50-60%. To obtain a more concentrated acid (approximately 98%), a distillation process is carried out.

Thus, in industry, the process of producing nitric acid is multi-stage, starting with the oxidation of ammonia and ending with the purification and concentration of the resulting nitric acid.

There are 3 types of main equipment (equipment sets):

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The turbo unit ensures the supply of all process gases through the process equipment and maintains the required pressure.

Waste heat boiler with catalytic combustion reactor.

The absorption column with cooling coils ( fed with cooling water and chilled water) on plates is the highest equipment of the plant.

Additional equipment:

- ammonia evaporators;
- a set of heat exchangers for cooling nitrous gases – low pressure section;
- a set of heat exchangers for cooling nitrous gases – high pressure section;
- bleaching tower.

One of the above- mentioned main processes was the interaction of air with ammonia in the reactor of the waste heat boiler; we will analyze the automation system and modern methods of controlling this process in the article.

## MATERIALS AND METHODS

Regulation of the air-ammonia ration. For process control, installation ammonia superheater E-106 is a horizontal shell-and-tube heat exchanger with a distribution chamber and a tube bundle with U-shaped tubes, the length of effective heat exchange is 2965 mm [1,2]. Tubes in the amount of 201 pieces with a diameter of 19.05x2.11 mm are flared and welded in a tube sheet. Along the entire length of the tube bundle for support, there are partitions in the amount of 8 pieces to compensate for thermal expansion and prevent oscillation [3,4].

The E-106 ammonia superheater is equipped with process nozzles for level measurement and nozzles for installing a thermocouple. Medium-pressure steam is used as a heat carrier. Gaseous ammonia is fed into the intertube space through nozzle A1, passes between the tubes and is heated to a temperature of 180 °C and exits through nozzle B1. Medium-pressure steam of 28 bar (2.8 MPa) with a temperature of 230 °C enters the distribution chamber through nozzle U1, the resulting steam condensate is drained through nozzle U2. Below is shown in Fig. 1 the control of the superheater in the production of nitric acid [5,6].

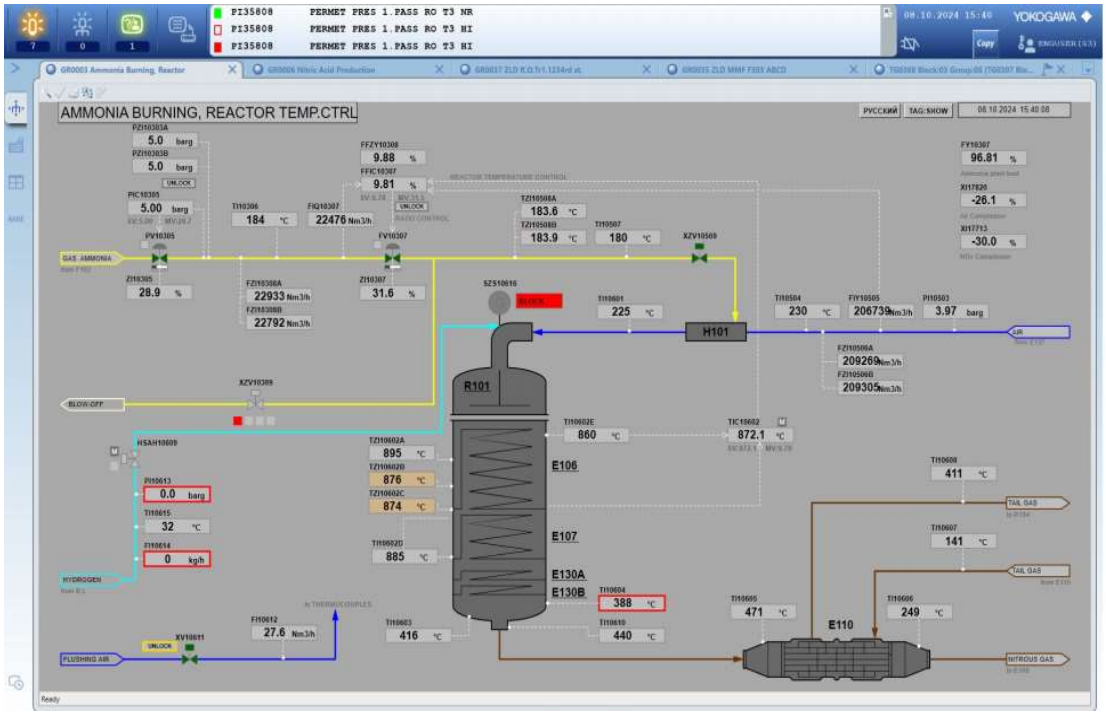



**FIGURE 1.** Automated control of the reactor.

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The upper level of the automated process control system for the production of nitric acid in Navoiazot planning and management are modern chemical process control.

Planning (MES) ACSTP – MES (Manufacturing Execution System) is this work release in the field work release operations manage and control to do help giver software solution He is a business level system (for example, ERP) and work release process between bridge to be and work release efficiency, quality and compatibility optimization for real at the time data and concepts present is enough.

Management (ERP) ACSTP - ERP (Enterprise Resource Planning) is organizations main business processes manage and integration for which uses software supply type ERP systems information centers and Finance, people resources, supply chain, trade and work release such as different departments across information flow makes it easier. This integrated approach to businesses operations in order efficiency increase and based on decisions acceptance to do help gives.

## RESULTS AND DISCUSSION

Dispatching demineralization water production nitric acid. Technology of demineralization of water in production of nitric acid are moistening role dispatching and control of process. Technology of this process is carried out in Fig. 2.

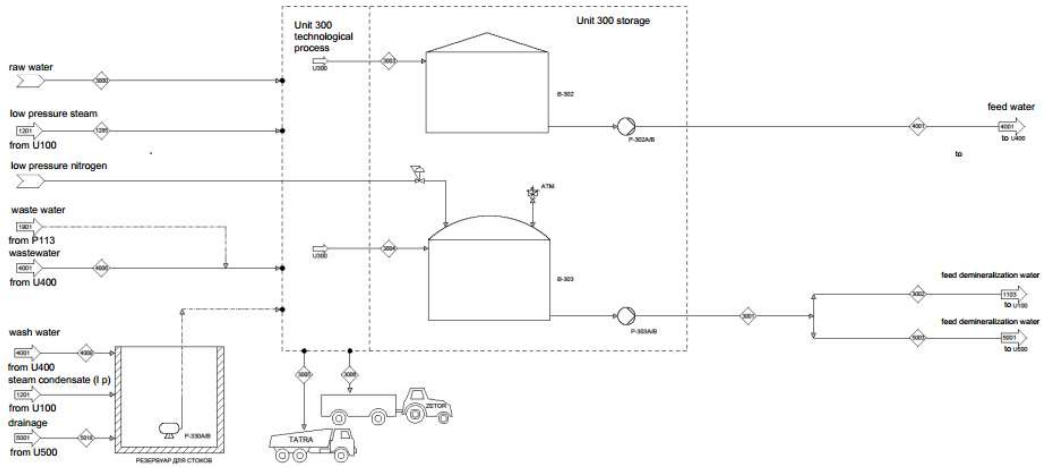



**FIGURE 2.** Technology demineralization water.

In the production of nitric acid, make-up demineralized water is produced in a water treatment plant that produces demineralized water and make-up water for cooling towers. The major part of the demineralized water produced is used as boiler make-up water, a smaller amount as process water (PWT) in the nitric acid process and make-up water in the chilled water circuit [7,8].

Figures, tables, and equations must be inserted in the text and may not be grouped at the end of the paper. Important: A miscount of figures, tables, or equations may result in revisions. Please double check the numbering of these elements before you submit your paper to your proceeding's editor [9,10].

Demineralized water supplied to the plant is heated in to a temperature of 52°C with a simultaneous decrease in the temperature of NC (nitric acid condensate). Warm demineralized water is used as make-up water for the boiler feedwater and is mixed with condensate from the steam turbine, entering at a temperature of 42°C from the P-105A/B pump. The mixture of demineralized water and condensate is then heated to a temperature of 89°C in heat exchangers by heat exchange with secondary air and then with LP steam in a heat exchanger. Then the water enters the deaerator inlet. The boiler feedwater at the deaerator outlet with a temperature of 108°C is prepared by injecting a solution of deoxidizer and alkalizing agent into the suction of the P-101A/B pump and is fed to the F-104 steam drum through the steam drum level regulating valve and the economizer. Sodium tripolyphosphate solution is dosed to the economizer inlet to protect (passivate) it and the surface of the steam drum. Part of the boiler feedwater from the

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deaerator, pumped by the P-112A/B pump, is also used as water to reduce the superheat temperature for generating medium and low pressure steam.

**TABLE 1.** The material balance demineralized water and water purification:

| Stream Description | LPS1 | RAW1 | DMW1 | DMW1 | CWS1 |
|---|---|---|---|---|---|
| phase | Gas | Liquid | Liquid | Liquid | Liquid |
| Steam fraction | 1 | 0 | 0 | 0 | 0 |
| Pressure, bar g. | 3.5 | 3 | 6.7 | 6.8 | 1.3 |
| Temperature, ºWITH | 147.2 | 26 | 32 | 32 | 22 |
| Mass flow rate, kg/h | 6420.2 | 228560.3 | 99959.8 | 49000.2 | 136802 |
| Flow rate - volumetric · $m^3/h$ | 2700 | 225 | 103 | 52 | 140 |
| Density, $kg/m^3$ | 3 | 1001 | 990 | 990 | 920 |
| Viscosity, MPa | 0.002 | 0.8 | 0.7 | 0.7 | 0.8 |
| | | Molar composition, % mass | | | |
| H2O | 102 | 98 | 101 | 101 | 101 |
| Air | 0 | 0 | 0 | 0 | 0 |
| Salts | 0 | 0.3 | 0 | 0 | 0 |
| Solid parts | 0 | 0.004 | 0 | 0 | 0 |

Dispatching of water demineralization process in nitric acid production is an important part of the overall control system, as demineralized water is used at various stages of the technological process, including dilution of nitric acid and cooling of equipment. The main aspects of dispatching of water demineralization in nitric acid production consist of the following stages:

- Analysis of the technological process of water demineralization - Definition of the stages of water demineralization, including filtration, removal of salts and impurities. Evaluation of water parameters at the input and output of the system (hardness, conductivity, salt content). Determination of the production need for demineralized water by volume and quality.
- Dispatching objectives - Maintaining stable water quality. Optimizing equipment operation to minimize energy costs and chemical reagent consumption. Ensuring uninterrupted supply of demineralized water for production processes. Ensuring system reliability and preventing emergency situations.
- Integration with the ACSTP - Connection of the demineralization system with the main APCS for nitric acid production to synchronize processes. Implementation of a monitoring and control system through a single interface, which will allow operators to see the status of all process units in production in real time.
- Control parameters of the demineralization system - Water conductivity is one of the main indicators of the quality of demineralization. Water temperature - affects the efficiency of the demineralization process. Pressure in the system - maintaining optimal pressure values for the correct operation of the equipment. Water level in tanks - monitoring and control of the level to prevent interruptions in the water supply.
- Monitoring and signaling - Installation of sensors for key process parameters (conductivity, pressure, temperature). Setting up a warning and signaling system when parameters go beyond acceptable limits. Automatic transmission of emergency signals to the central control panel for quick response.
- Operation mode control - Automation of the change of the plant operation modes depending on the current state of the system (for example, switching to backup equipment when the main one fails). Automatic adjustment of the reagent supply depending on the state of the water.
- Preventive Maintenance Planning - Implement a system of maintenance alerts based on sensor data (e.g. filter contamination, depleted ion exchange resins). Create a maintenance schedule based on system operation and equipment manufacturer recommendations.

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- Energy Optimization - Monitor energy consumption at each stage of the demineralization process. Automatically optimize pumps and other energy-consuming components to reduce costs. Assess system performance based on collected data.
- Integration with water treatment and consumption system - Coordination with the inlet water treatment system (e.g. prefiltration and coagulation). Regulation of the supply of demineralized water depending on the needs of the different sections of the nitric acid production.
- Reporting and data analysis - Maintaining an archive of system operation data (water consumption, energy consumption, water quality). Data analysis to identify deviations and develop measures to improve system operation. Generating reports for management and technical specialists.
- Increasing the reliability of the system - Implementation of backup demineralization lines to eliminate shutdowns in the event of equipment failure. Programming emergency shutdown or replacement of equipment in the event of failures.

Dispatching the water demineralization process will ensure stability and high quality of demineralized water, which, in turn, will increase the efficiency of nitric acid production and reduce the costs of equipment repair and maintenance.

Development of the upper level of the ACSTP for nitric acid production.

The creation of an automated process control system (ACSTP) for nitric acid production requires a structured approach. High-level planning for the development and implementation of the ACSTP by the following structures:

Analysis of the current state of production (Conducting an audit of existing technological processes and equipment. Determination of key parameters and stages of nitric acid production (for example, the stages of ammonia oxidation, absorption, cooling and recovery). Assessment of the current level of automation and identification of bottlenecks.)

- Definition of the goals and objectives of the automated process control system (Optimization of equipment operation to increase productivity. Reduction of energy and raw material consumption. Ensuring process safety and reducing emergency situations. Improving product quality. Minimization of emissions of harmful substances into the environment.)
- Development of technical specifications (Definition of requirements for the functionality of the system. Description of the main parameters that must be monitored (temperature, pressure, gas composition, flow rate, etc.). Development of an automation scheme and system architecture. Accounting for integration with other systems in production (for example, ERP systems for resource accounting and logistics).
- Selection of equipment and software (Selection of controllers, sensors and actuators that will be used for monitoring and controlling processes. Definition of software for control and visualization (SCADA systems, PLC). Conducting a tender among suppliers of equipment and software.)
- System design (Development of functional process control diagrams. Determination of installation points for sensors and actuators. Preparation of electrical and pneumatic equipment connection diagrams)
- Programming and configuration (Development of software for PLC controllers. Configuration of SCADA system for real-time monitoring. Implementation of control algorithms for process optimization)
- Testing and debugging the system (Conducting factory tests of equipment (FAT – Factory Acceptance Conducting comprehensive testing on-site (SAT – Site Acceptance Testing). Checking all scenarios of the system operation and adjustments if necessary.)
- Personnel training (Training of operators and technical personnel to work with the automated process control system. Preparation of instructions for the operation and maintenance of the system.)
- Launch and implementation (Gradual inclusion of the system into operation (staged launch). Monitoring the operation of the system in real conditions and making adjustments. Carrying out commissioning work and final commissioning of the system.
- Monitoring and Maintenance (Ensuring 24-hour monitoring of production parameters. Regular maintenance of the system to prevent failures. Updating software as needed.)
- Optimization and improvements (Collection of data for analysis of system efficiency. Continuous modernization of the system based on operating experience.)

This plan will create a reliable and efficient management system for nitric acid production, ensuring safe and cost-effective processes.

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## CONCLUSION

Dispatching of the water demineralization process in the production of nitric acid plays an important role in maintaining stable operation of the equipment and improving the quality of the final product. Automation of this stage allows not only to minimize the risks of emergency situations, but also to significantly reduce the costs of system maintenance. The introduction of modern water treatment management technologies helps to increase production efficiency and reduce the negative impact on the environment, which makes automation and dispatching key elements in the development of the chemical industry. It is recommended to create an automated control system for the process of separating water from minerals in the nitrogen production process and to control this system taking into account the nature of the process.

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