MUHAMMAD AL-XORAZMIY
NOMIDAGI TATU FARG'ONA FILIALI

FERGANA BRANCH OF TUIT
NAMED AFTER MUHAMMAD AL-KHORAZMI

"AL-FARG'ONIY AVLODLARI"

ELEKTRON ILMIY JURNALI | ELECTRONIC SCIENTIFIC JOURNAL

TA'LIMDAGI ILMIY, OMMABOP VA ILMIY TADQIQOT ISHLARI

4-SON 1(8)
2024-YIL

TATU, FARG'ONA
O'ZBEKISTON

ISSN 2181-4252

O‘ZBEKISTON RESPUBLIKASI RAQAMLI TEXNOLOGIYALAR VAZIRLIGI

MUHAMMAD AL-XORAZMIY NOMIDAGI TOSHKENT AXBOROT TEXNOLOGIYALARI UNIVERSITETI FARG‘ONA FILIALI

Muassis: Muhammad al-Xorazmiy nomidagi Toshkent axborot texnologiyalari universiteti Farg‘ona filiali.
Chop etish tili: O‘zbek, ingliz, rus.
Jurnal texnika fanlariga ixtisoslashgan bo‘lib, barcha shu sohadagi matematika, fizika, axborot texnologiyalari yo‘nalishida maqolalar chop etib boradi.

Учредитель: Ферганский филиал Ташкентского университета информационных технологий имени Мухаммада ал-Хоразми.
Язык издания: узбекский, английский, русский.
Журнал специализируется на технических науках и публикует статьи в области математики, физики и информационных технологий.

Founder: Fergana branch of the Tashkent University of Information Technologies named after Muhammad al-Khorazmi.
Language of publication: Uzbek, English, Russian.
The magazine specializes in technical sciences and publishes articles in the field of mathematics, physics, and information technology.

2024 yil, Том 1, №4
Vol.1, Iss.4, 2024 y

ELEKTRON ILMIY JURNALI **ELECTRONIC SCIENTIFIC JOURNAL**

«Al-Farg‘oniy avlodlari» («The descendants of al-Fargani», «Potomki al-Fergani») O‘zbekiston Respublikasi Prezidenti administratsiyasi huzuridagi Axborot va ommaviy kommunikatsiyalar agentligida 2022-yil 21 dekabrda 054493-son bilan ro‘yxatdan o‘tgan.

Jurnal OAK Rayosatining 2023-yil 30 sentabrdagi 343-sonli qarori bilan Texnika fanlari yo‘nalishida milliy nashrlar ro‘yxatiga kiritilgan.

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Qo‘lyozmalar taqrizlanmaydi va qaytarilmaydi.

FARG’ONA - 2024 YIL

Jurnal quyidagi bazalarda indekslanadi:

Eslatma! Jurnal materiallari to'plamiga kiritilgan ilmiy maqolalardagi raqamlar, ma'lumotlar haqqoniyligiga va keltirilgan iqtiboslar to'g'riligiga mualliflar shaxsan javobgardirlar.

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PNEUMATIC AND HYDRAULIC TECHNICAL TOOLS OF AUTOMATION

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Abstract: Pneumatic and hydraulic systems manipulate and convert energy into mechanical motion by manipulating gases or liquids under pressure. Each system works under different principles that optimize tasks with specific power and accuracy requirements suitable for various industrial applications

Key words: Automation, Pneumatic systems, Hydraulic systems, Technical tools, Production efficiency, Industrial processes, Energy efficiency, Precision and power, Mechanical control, Environmental safety

Introduction. Automation processes have become an integral part of modern industry, increasing production efficiency, efficient use of energy resources, and reducing the human factor. Pneumatic and hydraulic systems are important among technical tools in these processes.

Pneumatic systems are mainly used in processes that require speed and low cost, while hydraulic systems are used in tasks that require great power and precision. Both technologies have their advantages and limitations in choosing and using them. In automation, pneumatic and hydraulic systems are widely used to control and move various mechanisms. Below are the details of these technical tools:

Pneumatic technical tools. Pneumatic systems work using compressed air. They are simple, inexpensive, and easily adjustable, often used in tasks requiring high speed and repeatability.

These technical tools are selected depending on their tasks in automation processes. Pneumatic systems are used where speed and simple control are required, and hydraulic systems are used where high power and precise movement are required.

Methods: A simple steam-driven centrifugal compressor is modeled together with its basic unit. Gaseous propane is used as the working gas. This model allows a deeper understanding of the principles of gas compression and control of the compression unit. The working gas pressure passes through the adjusting-suction tank, after which it falls on the suction side of the compressor ("intake"). The gas is compressed and passes to the output pipe ("compressor outlet"), where the pressure is adjusted before leaving the system. The compressor has a minimum flow bypass which is used to prevent pumping when the correct gas flow is less than the minimum required for the compressor. The speed of the steam turbine is adjusted according to the pressure of the gas leaving the compressor.

Control principles The cold working gas is transferred to the suction drum E-l and then to the intake pipe of the compressor suction. The pressure in the outlet pipe from E-l is provided by the regulator PIRC-200, the valve of which is located in the gas transmission line at PV-200 E-l. The TIR-310 sensor monitors the temperature in E-l, and the FIR-100 sensor monitors the consumption of working gas in the E-l tank. The LIR-400 sensor controls the condensate level in E-l. As the level accumulates, the condensate is removed from the E-l by means of a pusher (lock) with a lever NS-001. For emergency pressure reduction, the E-l tank is equipped with an NS-003 adjustable barrier safety valve on the side of the spring-loaded safety valve (PPK). The gas enters the suction side of the TK-1 compressor and is compressed to a higher pressure, which the PIRC-210 regulator maintains. During compression, the temperature of the working gas rises, which is indicated by the TIR-320 sensor. The PIRC-210 adjuster controls the speed of the steam turbine operation using the PV-210 valve located in the steam-to-turbine transfer line. The XIR-700 sensor shows the speed of the compressor.

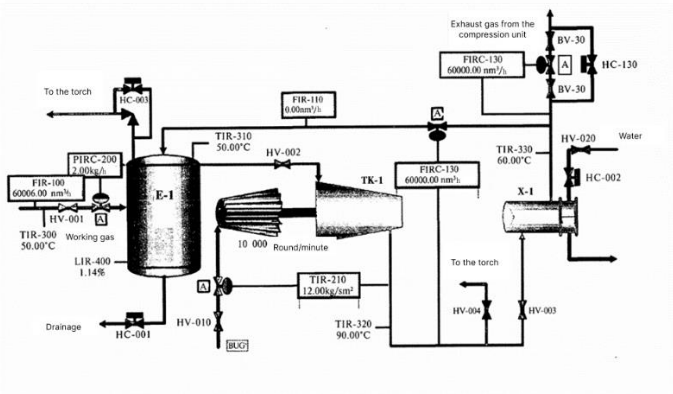

Figure 1. Scheme of a centrifugal compressor compression unit.

Then the gas goes to the output pipe (pipeline) of the compressor, and after cooling in the X-l water cooler, it is transferred to the tank with a constant pressure of 10 kg/cm2. Gas is released through the FV-130 valve of the FIRC-130 flow adjuster. The TIR-330 sensor shows the temperature of the gas after the X-l cooler. If the direct gas flow from TK-1 is below the compressor pumping level, the FIRC-120 adjuster opens the FV-120 valve on the compressor bypass to prevent pumping. After cooling, the gas returns to the E-l tank on the suction side of the compressor. The FIR-110 sensor controls gas consumption by bypass. When the working range of the main parameters of the compression unit is exceeded, a warning or alarm signal appears. When the gas consumption from the compressor decreases, a warning message "pumping may occur" appears. When the compressor's speed increases from 18,000 revolutions per minute or reaches 60% level in the E-l tank, the automatic barrier is activated: to stop the turbocompressor, the separator HV-010 is closed in the steam line going to the turbine.

To calculate the pressure: P=A/F

P — pressure (Pa), F — power (N), A — surface area (m²).

The ideal gas law. To determine the basic state of compressed gas in pneumatic systems:

PV=nRT

P — pressure (Pa), V — capacity (m³), n — the amount of matter of a gas (mol),

R — total gas constant (8.314 J/(mol\cdotpK)), T — absolute temperature (K).

Airflow speed. To calculate air flow:

Q=v·A

Q — air flow (m³/s), v — speed (m/s), A — cross-sectional surface area (m²).

Bernoulli’s equation

Calculation of the energy balance of the fluid flow:

$$P_1+\frac{\rho v_1^2}{2}+\rho g h_1=P_2+\frac{\rho v_2^2}{2}+\rho g h_1$$

P — pressure (Pa), ρ — liquid density (kg/m³), v— flow rate (m/s), g — free fall acceleration (9.81 m/s²), h — height (m).

The system is modeled from two hermetic containers: suction (E-l) and working (E-2) containers, between which the working fluid is transferred using a pump (see Fig. 22.2). Fluid consumption is supported by the regulator, the valve of which is installed at the point of flow. Water is used as the working fluid, the vessels are hermetically sealed with a protective layer of nitrogen. Control principles Water is transferred to the suction tank E-l of the pumps. The LIR-401 sensor monitors the liquid level in E-l. A two-channel PIRC-210 regulator controls the pressure from the E-l tank. The "A" valve of the regulator releases nitrogen into the atmosphere when the pressure exceeds the regulator mark, and through the "B" valve, if the pressure is lower than the mark, nitrogen is introduced into the tank. Water is pumped from E-l to the working tank E-2 with the main pump H-1A (or the spare pump N-1V); BIRC-110 adjuster of its consumption from pumps

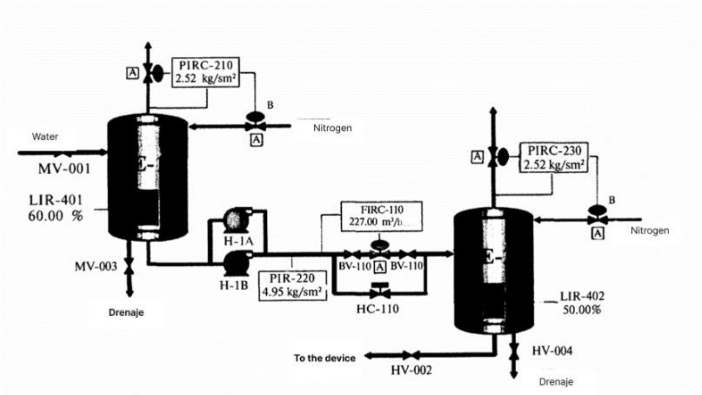

Figure 2. Scheme of the pump and valve technological unit.

It is supplied with the help of the FV-110 valve located in the pipe going to the E-2 tank. The pressure in the E-2 tank is also boosted with nitrogen and regulated by a two-channel PIRC-230 regulator similar to the PIRC-210. Sensor LIR-401 monitors the liquid level in E-2.

Results: Cold start. General considerations. A "cold start" exercise allows you to learn the sequence of actions required to safely and correctly start a fluid handling unit. The necessary equipment up to and after the vessel system (that is, upstream and downstream) is ready for operation. Before transferring the working fluid to the technological unit, all systems in common use must be started, checked and ready for work. It is also assumed that the following systems are ready to run:

1. Device for transferring working fluid.
2. Container for receiving working fluid.
3. General purpose factory systems:

• Air cleaning system inside the plant and around the tool.

• Power supply system.

• Drainage system.

• Nitrogen transfer system. Make sure that all the pre-launch steps listed below have been completed and that the device is ready to launch. Pre-launch steps:

1. Washing and cleaning of equipment and pipes, removing clogs.

2. Checking the permeability of pipes along the entire technological chain, while necessarily controlling the presence of pressure.

3. Acceptance of electricity, NOA air and process air, nitrogen to the device.

4. Check the operation of the device, prepare for work and try using the pumps. 5. Check and start the NOA (all adjusters should be in lever mode with the adjuster valve closed).

6. Notify all service personnel related to the operation of the node about the start of commissioning. The following describes the start-up process, that is, the sequence of your actions when starting the technological unit.

Procedure 1. Pour water into the E-l container. To do this, open the separator HV-001 in the line of water going to E-l. Check the level in the container according to the indications of the LIR-401 sensor. In the actual installation, if the vessel is not provided with a level gauge, the filling control should be carried out by means of a measuring bottle.

2. Insert nitrogen into E-l. To do this, open the "V" valve of the PIRC-210 adjuster.

3. When the pressure in E-l approaches 2.52 kg/cm2, set the PIRC-210 adjuster to automatic mode with a value of 2.52 kg/cm2.

4. In the same way, using the "V" valve of the PIRC-230 adjuster, hermetically close the container E-2. Set the adjuster to automatic with a value of 2.52 kg/cm2.

5. When the level in tank E-l rises to about 40%, start pump N-1A.

6. On the valve assembly of the FIRC-110 instrument, open the spacers of the adjustment valve BV-110.

7. Open the FV-110 valve of the FIRC-110 flow regulator by 10-20%.

8. Observe the increase in the level in the tank E-2 according to the indications of the sensor UR-402.

9. When the level in E-l rises to 50%, FV-1 to maintain the level in tank E-l near 50%.

10. Open the valve and gradually increase the water flow through the pumps. When the water consumption approaches 227.0 m3/h, set the FIRC-110 freezer to 227.0 m3/h and switch to automatic mode. 10. Observe the increase in the level in tank E-2 according to the readings of the LIR-402 sensor. When the level rises to 45-50%, open the separator HV-002. After a certain period of time, the fluid drive unit will return to normal operation mode. Normal stop. General considerations. The purpose of the Normal Shutdown exercise is to learn the sequence of actions required to shut down the device properly and safely. A complete shutdown of a fluid handling unit is usually performed to perform scheduled maintenance of the main unit or as required by production as directed by management. All relevant employees must be notified of the impending termination.

Conclusion: Pneumatic and hydraulic technical tools are an integral part of automation processes and are effectively used in various industries. With these technologies, high accuracy, power and efficiency are achieved. Pneumatic systems are important in processes where lightness and speed are required, while hydraulic systems are important in areas where high power and strength are required.

In this study, the main components, advantages and disadvantages, control principles and comparative analysis of pneumatic and hydraulic systems were presented. The following important conclusions can be drawn from this:

Pneumatic systems: It is a low-cost and convenient technology that offers advantages where low power, high speed and security are required.

However, high-pressure compressed air has limitations due to reduced efficiency and insufficient power in areas where high power is required.

Hydraulic systems: It provides high power and torque and allows handling large loads. Also, the accuracy and smoothness of the system make it ideal for areas where high precision is required.

However, oil leaks and the need for complex technical maintenance increase its environmental safety and cost.

Comparative analysis of systems: Pneumatic systems are fast and safe, while hydraulic systems are efficient in terms of power and precision. Both should be used appropriately depending on specific needs and requirements during the selection process.

The part of the study on management principles and modeling of technological processes is important for increasing efficiency and ensuring safety in the use of pneumatic and hydraulic systems. In the future, it is necessary to further improve these systems to increase energy efficiency and ensure environmental safety.

These conclusions serve as an important guideline for the rational use of pneumatic and hydraulic systems in automation.

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