ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 10 , October 2019

Overview of Compressor Installations and Issues of Their Energy saving

Olimjon TOIROV, Utkir MIRKHONOV, Zuvur TOIROV, Javokhir OTAYAROV

Head of the Department, Doctor of Technical Sciences, Department of Electrical Machines, Tashkent State Technical University named after Islam Karimov, Tashkent, Uzbekistan

Senior Lecturer, Doctoral Student, Department of Energy Audit, Bukhara Engineering Technological Institute, Bukhara, Uzbekistan

Associate Professor, PhD, Department of Energy, Bukhara Engineering Technological Institute, Bukhara, Uzbekistan

Undergraduate, Department of Electrical Machines, Tashkent State Technical University named after Islam Karimov, Tashkent, Uzbekistan

ABSTRACT: The article describes the principles and purpose of compressor installations. A brief review and analysis of the compressor is done, it is determined that with increasing pressure on the compressor, the temperature decreases. Areas of application for a turbo compressor, reciprocating compressor and rotary compressors in production are given. Compressors are also used as coating equipment for more efficient use. Recommendations are given on improving energy efficiency and saving electric energy at compressor installations.

KEY WORDS: electric drive, compressor, turbocharger, reciprocating compressor, rotary compressors, pressure, performance, energy saving.

I.INTRODUCTION

At present, the continuous development of mechanization in industrial enterprises was link with the use of compressed air energy, simple, easy to use, lightweight and highly reliable pneumatic devices. However, compressed air-powered devices consume much electricity. In many machine tools, the electricity used in compressor drives is about 20 - 30% of the total electricity consumed by the enterprise [1].

Energy conservation in compressed air systems is one of the most pressing tasks facing domestic industrial enterprises today. At many enterprises, the share of energy consumption attributable to compressor equipment, since the backbone of the compressor fleet is still quite often made up of powerful reciprocating and centrifugal compressor units with capacities from several tens to hundreds of m3 / min [2,3].

The use of screw compressors can significantly increase the efficiency of air compression in small enterprises. The introduction of a frequency drive in compressor technology involves a number of advantages, compared with conventional screw compressors; the compressor with a frequency drive during operation maintains the required pressure in the system with an accuracy of 0.1 bar and immediately responds to changes in pressure in the network [2, 4-5].

Air compressors are compressed air (turbo compressor-centrifugal) with compressed air (rotor, screw) and centrifugal compression air due to axial or axial force generated by rotation of the working wheel (rotor) with special construction blades at the expense of reducing operating volume escapes, arrowheads. Compressors commonly used in the manufacturing process are porcelain compressors [6-7].

II. OVERVIEW OF COMPRESSOR INSTALLATIONS

The compression of gas in the piston-driven compressor is due to the periodic fluctuations in the volume of gas as the result of the movement of the piston in the closed cylinder [8,14].

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 10 , October 2019

Fig. 1. Schematic design of a piston-compressor

When piston moves from left to the right, the air is absorbed into the compressor cylinder (Figure 1). When the Piston reaches until end point and begins to move back, the suction valve closes with the SK spring.

When piston is in motion, the air pressure inside the compressor cylinder is lowered and the valve SK is opened as the outside air pressure is greater than the air pressure inside the cylinder and the elasticity of the spring. When the air pressure in front of the suction valve equals the air pressure inside the cylinder, it is closed due to the elasticity of the valve spring.

When piston moves in the opposite direction, the air inside the compressor cylinder compresses and the pressure valve does not open immediately. When the air pressure inside the compressor cylinder is greater than the elasticity of the pressure valve spring, the pressure valve opens and the outside air cylinder with a certain pressure force is released.

During compression of the piston, the compressed air will continue to flow out of the cylinder, then the piston's movement will change from left to right and the entire cycle will be repeat. When the pressure in front of the pressure valve touches the pressure inside the cylinder, the pressure valve is close due to the elastic force of the valve spring [7].

The compressed air generates compressed air over the piston's compressors and needs to be cooled down. Compressed air temperatures can rise to 170 - 220C, which means that compressors can be used safely. For this reason, compressed air temperatures can be carried out in a multistage way so that the compressed air temperature does not exceed the permissible safety values in practice, the use and operation of multistage piston-based compressors.

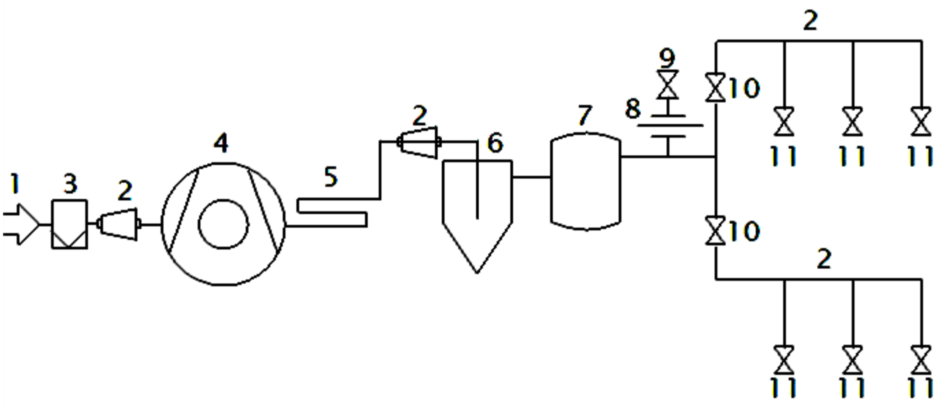

Fig. 2. Compressor devises and air network of industrial factor:
1 - atmospheric air intake, 2 - tubular conductor, 3 - air filter, 4 - compressor, 5 - refrigerator, 6 - water separator, 7 - air intake, 9 - diaphragm, 9 - diaphragm lock, 10 - air locking ports, 11 - consumer ventilation

Figure 2 is a compressed air supply scheme for an industrial enterprise. The compressed air distribution system consists mainly of distribution pipes, lock fittings and compressors. The compressor device (station) consists of compressors, motors and auxiliary devices, regardless of the length or shortness of the compressed air system. In each of the constituent elements of the system, an effort is made to minimize the cost of wasted electricity. Because the compressor has a Efficiency of only 35 - 45%.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 10 , October 2019

The rotation speed of the high-powered compressor compressors usually does not exceed 500 rpm and is only 1000-1500 rpm for minors [9-10].

Compressors are called superchargers that serve to deliver compressed air or gas at pressures of 0.2-0.3 MPa. The increase in the compression ratio in the compressors changes the thermodynamic state of air or gases.

The range of piston and centrifugal compressors is varied and corresponds to the specifications of these machines. Thus, Porsche-operated piston compressors at a given closed air volume in the cylinder during discharge may create a significant compression ratio of P_2 / P_1 with relatively limited supply of air or gas. Porcelain compressors are highly efficient and their use is best suited at pressures above 1 MPa and at low currents (no more than 100-150 m^3 / min) [11-12].

Centrifugal compressors (turbo compressors) are structurally and print-like in a multistage centrifugal pump. The difference is that the working fluid is compressed gas and thus thermal processes occur. The use of centrifugal compressors is best suited for the delivery of large quantities of air (at least 50 m^3 / min) at relatively low pressures (0.7-0.8 MPa).

A) Compressor classification

Each type of compressor machine has its advantages and disadvantages, which should be considered in the selection of installation in each case.

Centrifugal machines have a number of important advantages compared to piston machines. Centrifugal machines have no wearable parts - pistons, valves, etc. They do not require internal lubrication and therefore do not pollute compressed air or gas, which is very important in food production. Due to the high rotation speed of centrifugal compressors, they can be connected directly to electric motors or steam turbines.

Installation of tubular compressors is more compact - they weigh less, occupy a small production area. Since air or gas is flowing smoothly through the compressor in one direction, there is no need to install the receivers in separate steps. Inertial forces do not appear during the operation of turbochargers, and therefore their foundations are lighter than the foundations of cross-compressors.

The main disadvantages of turbochargers are their low efficiency and the inability to obtain high pressure at relatively low flows.

B) Piston compressors

The print head of the compressor is the same as the pump. The only difference is that the pump compresses Pisto fluid during the entire charging process, and the compressor releases air or gas only when the pressure in the compressor cylinder exceeds the pressure in the discharge line [13-14].

Depending on the mode of action, the mutual compressors work simple and double-sided, the location of the cylinders is divided into horizontal, vertical and slope cylinders; Depending on the number of compression steps, they are one, two, and multi-phase, with cooling air and water.

Air compressors, oxygen compressors, ammonia compressors and carbon dioxide compressors are distinguished by their purpose, using stationary and portable compressors in the food industry.

C) Basic Elements of Compressor Equipment

The traditional compressor device used for industrial purposes must have some support equipment required for the normal operation of the compressor.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 10 , October 2019

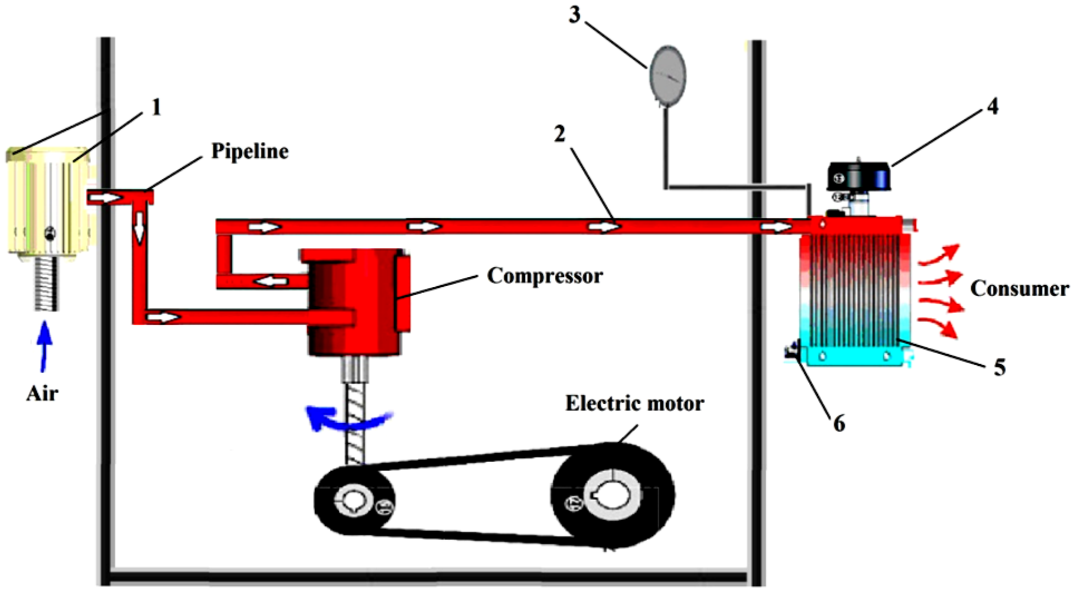

Fig. 3. Installation Scheme of Air Piston Compressor

The gas collector is usually installed directly behind the air compressor. Its purpose is to equate sinusoidal air supply with compressor piston. The gas collector must be equipped with oil retention and condensation moisture separators [17].

The gas collector is equipped with a closed reservoir 5, often cylindrical, safety valve 4 and drain valve 6, as well as a manometer. An explosive mix is formed which is especially dangerous if the compressor is not cooled sufficiently.

A control valve 2 is installed between the compressor and the gas collector to prevent the gas from returning if the pipes are broken in the compressor. A filter / (usually a type of oil) must be installed in front of the air compressor to clean the air from the outside. If dust, contaminated air enters the compressor, the cylinder burns out and worn out.

Cross-compressor installation is characterize by a variety of design and layout schemes. It depends on:
a) Delivery, from 1-2 l / min to 500 m^3 / min;
b) Pressure from 100 MPa to 150 MPa;
c) Power and pressure-dependent power consumption of ten to 7,000 kW or more.

D) Piston vacuum pumps

Pumps that absorb gas or air below atmospheric pressure and push them into the atmosphere are call vacuum pumps. In the food industry, vacuum pumps are used mainly for evaporation of condensate vapors and gases at evaporation stations, factories and baking plants and in vacuum filter units. Low vacuum pumps are often use, producing vacuum up to 93.3-96 kPa in the suction pipe, i.e. up to 92-95% of atmospheric pressure (absolute vacuum 101.3 kPa).

According to the operating principle, vacuum pumps are compressors that absorb, compress, and then pump gas at reduced pressure. Although the applied pressure is not much higher than that of the atmosphere, the compression rate of P_2 / P_1 in vacuum pumps is much higher than that of conventional compressors.

E) Circulating compressors

The rotary compressors work with the machines that is to say on the principle of substitution. Most of the energy supplied to the gas is delivered directly through compression [15-16].

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 10 , October 2019

The essence of the rotary compressor action (Figure 4), regardless of the design features, is absorbed into the gas or air compressor cavity, which increases as the rotor rotates. The melted gas enters the closed chamber, reducing its volume as the rotor rotates. Compression by lowering the volume will increase the pressure and release the gas into the exhaust pipe.

Circulating compressors that produce excessive pressure of 0.28-0.3 MPa (under atmospheric pressure) are called explosives, and high-pressure compressors. Rotary compressors and blowers have a number of advantages over pistons: balancing due to lack of movement; possibility of direct connection with electric motor; single gas supply; low structural weight, lack of valves, etc. At the same time, rotary compressors have lower mechanical efficiency and lower pressure than piston-powered compressors.

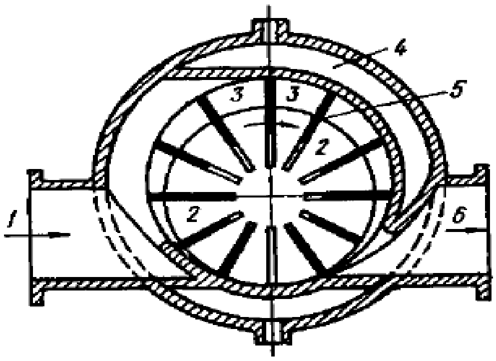

Fig. 4. Rotary plate compressor

Turbo compressors are centrifugal compressor machines that operate in the same way as centrifugal pumps. They are mainly used when relatively large amounts of gas or air are fed at low pressure (0.15-1.0 MPa) [16].

Due to the lower air density, the compression level at one stage of the turbocharger does not exceed 1.2-1.3 in the commonly used peripheral speed.

To obtain a high compression ratio of 1.6-1.8, the peripheral speed must be increased to 400 m/s due to the use of high-quality steel for propellers. Often, multi-level machines are used to increase air compression while maintaining a normal compression rate [17-18].

III. RESULTS

The main electrical components of the compressors are its electric motors and startups. Asynchronous motors with short rotor rotors in compressors up to 100 kW, asynchronous motors with phase rotors on high capacity compressors and synchronous motors with very high compressors.

To operate compressor engines with rated voltage up to 1 kV, magnetic drives and contactors are used, as well as special control devices to control the operation of the compressor, as well as light alarms to alert service personnel to various accidents. Compression motors with a nominal voltage of more than 1 kV are used in the installation of complete separation devices.

Asynchronous motor drive of compressors is widely used in the management of pump devices. For example, an asynchronous-ventilated cascade scheme is widely used in the management of medium-power compressors. The use of synchronous motors with high power compressors can be very effective [19, 23].

When controlling the compressors asynchronous motors, non-electric control of their speed is applied. When large-phase compressors operate in modes with phase rotor asynchronous motors that are less than the nominal value of load, control schemes can be used to ensure that the motor performance is close to the nominal.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 10 , October 2019

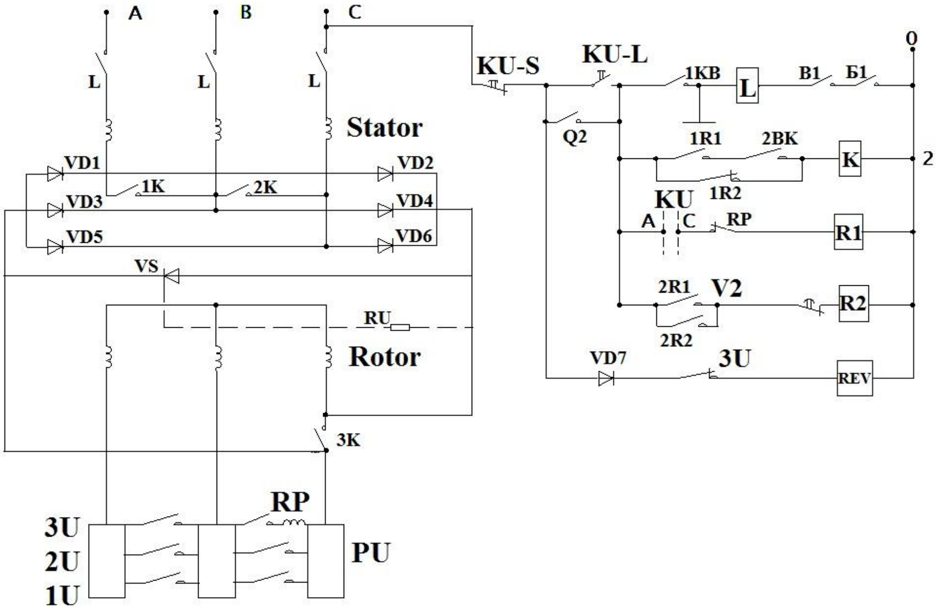

Fig. 5. Synchronization principle electrical scheme of phase rotor asynchronous motor

Figure 5 illustrates the phase rotor asynchronous motor synchronization scheme. The circuit consists of a three-phase bridge circuit breaker VD1 - VD6, thyristor VS and sync contacts 1K, 2K, 3K. In addition to starting and adjusting devices, the control circuit includes two intermediate relays R1 and R2, contact switch K, control switch with electromagnetic time relay REV and "Stop" (KU-S) and "Start" (KU-P) buttons. The line contactor L has a control circuit of 1KB and B1 in the control circuit. Block - Contact 1KB will prevent the line contactor L from being switched off (this will prevent the engine from running in synchronous mode) while Block B1 will control the adjustment of the time relay coil circuit.

When starting the engine (when the Start button is pressed) the contactor K connects to the control voltage through 1R2 and connects the voltage 1K and 2K, the contactor 3K on the rotor circuit, and 1KB on the circuit contact circuit. After the motor has received acceleration and the third-speed acceleration contacts the 3U and the rotor current goes through the reel of the polarized RP. Relay RP connects and disconnects the circuit breaker R1 in its relay circuit, adjusting to the rotor current frequency. Relay R1 returns the RP output one by one. The contact is connected to the 3K and directs the rotor current to the positive output of the circuit breaker, and the contact is opened when the rotor current reaches zero. When the third-phase acceleration is activated, block-contacts in the relay REV circuit are opened 3U, the relay is disconnected from the REV circuit and closes its contact on the R2 circuit for a period of time. This time is necessary for the motor to reach the synchronous speed threshold as the last step resistance is disconnected from the circuit. If 1R1 contact in the coil chain is connected during this time, it will be connected to the voltage source and the release contact will block itself by relay R2 using 2R2. Then the breaker in the contactor K chain breaks off the 1R2 chain. When the rotor is zero, the contact RP is opened, followed by the contact 1R1, which disconnects the contactor K from the mains and contacts 1K - 3K. The current is switched on and the motor goes into synchronous operation [24-25].

Table 1 below shows the specifications of some compressors used in compressed air systems of industrial enterprise [22]

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 10 , October 2019

Table 1

Type of compressor	Efficiency of work, m^3/ min	Compression pressure, MPa	Power consumption, kW	Comparison consumption of electrical energy, kW*h/1000 m^3
ВУвз 3/8	3.0	0.78	19.5	125.0
КСЭ 5М	5.0	0.78	33.0	124.0
ВП – 10/9	11.0	0.78	68.0	116.0
ВП3 – 20/9	22.0	0.78	132.0	112.0
2ВП 10 – 50/8	50.0	0.78	270.0	98.0
4ВП 10 – 100/8	100.0	0.75	540.0	97.0

IV. CONCLUSION

Energy efficient use of compressor devices: 1. Depending on the load level of the compressor asynchronous motors, the voltage applied to the stator wind can be reduced by up to 30% by optimizing the operating mode of the motors by using adaptive automatic tuning devices.
2. Optimal control of the excitation current of the compressor motors can be achieved by minimizing the loss of electric power in the engine and increasing the dynamic stability of the engine.
3. The oscillations of the electric solvent can be suppressed by the synchronous motors of the compressor motors depending on the speed of the motor.
4. The use of thyristor frequency modifiers to control the frequency of the asynchronous motors of the compressors by controlling the voltage of the stator voltage is of great value.

REFERENCES

[1] Khashimov A.A, Saidahmedov S.S. Basics of electric drive, Tashkent, Science and Technology, 199 p, 2011.
[2] Zubarev A.M., Kuzin I.A., Khabibova N.Z. Comparative analysis of the effectiveness of screw compressors. Proceedings in Chemistry and Chemical Technology, vol. 30, No. 2 (171), P. 94-95, 2016.
[3] Sinyukov A.V., Sinyukova T.V. Energy saving in compressor control systems. Materials of the IV International Scientific and Technical Conference "Energy Saving and Efficiency in Technical Systems". Tambov State Technical University, P. 339-340, 2017.
[4] Mikhailov A.K., Voroshilov V.P. Compressor machines. Moscow: Energoatomizdat, 288 p, 1989.
[5] Kuznetsov MA, Filinkov L.I. Energy saving at the compressor station through the use of a programmable logic controller in the southern regions of Russia. Collection of articles based on the results of the International scientific-practical conference "Problems of the efficiency and safety of functioning of complex technical and information systems", P. 61-64, 2017.
[6] Khashimov A.A. Energy saving devices for automated electrodes, Tashkent, Tashkent State Technical University, 1994.
[7] Khashimov A.A., Imomnazarov A.T. Energy savings in electromechanical systems, Tashkent, 2005.
[8] Khashimov AA, Mirisaev A.U., Kan L.T. Energy Saving Asynchronous Electric Drives, Tashkent, Science and Technology, 2011.
[9] Braslavsky I.Ya. Energy-saving asynchronous electric drive, Moscow, Academy, 2004.
[10] Moskalenko V.V. Automated control systems for electric drives. Textbook, Moscow, Infra-M, 2004.
[11] Barkov V.A. Power Electronics in an Automated Electric Drive, St. Petersburg: "Nestor", 252 p, 2000.
[12] Goldberg O.D., Helemskaya S.P. Electro mechanics, Textbook for high schools, Moscow, Academia Publishing House, 512 p, 2007.
[13] Ivanov - Smolensky A.V. Electric machines, Vol. Textbook for high schools, Moscow, MPEI Publishing House, Vol. 1, 652 p, 2004.
[14] Katsman M.M. Collection of tasks on electric machines. Textbook manual for universities, Moscow, Publishing Center "Academy", 154 p, 2012.
[15] Kopylova I.P. Electric machines, Textbook for high schools, Moscow, Yurait, 675 p., 2012.
[16] Nagrath I.J., Kothari D.P. Electric Machines. Twelfth Reprint, Tata McGraw, Hill, New Delhi, 684 p, 1995.
[17] Rentzsch H. Elektromotoren. Electric Motors, Asea Brown Boveri, 861 p, 1992.
[18] Epifanov A.G. Electromechanical energy converters, Textbook for high schools, St. Petersburg: Publishing House "Lan", 208 p, 2004.
[19] Ibrahimov U, Electric machines, Tutorial, Tashkent: Instructor, 2001.
[20] Majidov S. Electric machines and drive, Tutorial, Tashkent: Instructor, "Ziyo-Nashir" Ltd., 408 p, 2002.
[21] Bose B. Power Electronics and Motor Drives, Elsevier, ISBN 978-0-12-088405-6, San Diego, USA, 2006.
[22] Krause P.; Wasynczuk O., Sudhoff, S. Analysis of Electric Machinery and Drive Systems (sec. Ed.), IEEE Press, ISBN 0-471-14326-X, Piscataway, USA, 2002.
[23] Kotelents N.F., Akimova N.A., Antonov M.V. Exploitation and repair of electric machines, Moscow, Academy, 2003.
[24] Smirnov A.A., Gurlov I.V., Melnikov V.I. The device, operation and repair of electrical machines, SPb: PGUPS, 98 p, 2005.
[25] Bystritsky G.F., B.I. Kudrin. The selection and operation of power transformers, Textbook, Moscow, Publishing Center "Academy", 176 p, 2003.