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Prevention of unorganized emissions of ammonia in installations of dewaxing of oils

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Abstract. The problem of lack of automation devices in oil dewaxing units is considered in this work. As a result, fugitive ammonia emissions that exceed the maximum permissible concentration, which adversely affect the health of personnel and the environment, can occur in the atmospheric air. The device and the operating principle of the automatic air separator are shown.

1. Introduction

At present, the interest of modern society to environmental problems, compliance with the requirements of environmental legislation is growing. Industrial organizations of various scales seek to reduce the negative impact on the environment, by achieving favorable characteristics of the equipment. All measures indicate effective control of the environmental impact. The main principle in the work of any industrial company should be the conservation of natural resources and the environment. This cannot be done without proper control over the activities of the enterprise at all stages of production.

Now in industrial enterprises widely used in refrigeration plants operating on ammonia (refrigerant R717), which has good thermodynamic properties. Ammonia – a colorless gas having a pungent suffocating odor belonging to the IV class of hazard. Maximum permissible concentration in the air of working zone is 20 mg/m^2.If the ammonia vapor content in the air is from 20%, an explosion is likely. From the chemical point of view, ammonia is inert to ferrous metals, therefore, in the manufacture of refrigeration equipment, pipelines designed for working with ammonia, various grades of steel and cast iron are used [1]. Ammonia interacts with copper, zinc, dissolves the rubber, so it is possible to use only aluminum-silicon, high-tin bronzes, babbits from alloys of non-ferrous metals.

Due to the fact that ammonia plants that use dangerous refrigerant, are working at high pressure during operation must be complied with safety requirements.

2. Formulation of the problem

The lack of automation equipment of air-purge drum has a number of disadvantages:

– the operation of the air separator is not constant, because ammonia losses occur;

– untimely inclusion of the air separator leads to the accumulation of air in the system, resulting in increased pressure, discharge temperature, deterioration of condensation, there is an increase in electricity costs and as a result, increased wear and tear of equipment;

– untimely shutdown leads to an unorganized release of ammonia into the atmospheric air;

– the quality and timeliness of air removal from the refrigeration system depends on the human factor;

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The main task is to replace existing air separators with automatic ones. As a result of this work using modern means of automation, the air separator was selected, the technical and economic parameters of the refrigeration department were improved, the risk and likelihood of exposure to ammonia and emerging harmful factors of production for personnel were reduced.

3. Main part

At the dewaxing unit of oils type 39 / 8№5, the pour point of the residual and distillate oil fractions is reduced due to the removal of solid paraffins from them. In this case, crystallization is used, based on the cooling of the raw material in a mixture with the solvent. Crystallization of paraffinic hydrocarbons from the solution takes place, followed by separation by filtration from the liquid. The solvent is a mixture of methyl ethyl ketone and toluene. The components of the oils obtained on the unit are subsequently used for the production of lubricating oils. As a result, after dewaxing turns slack wax is used as a raw material, component and petrolatum, required for obtaining no aging material.

The oil dewaxing unit includes the following parts: separation of cooling of the raw material and solvent mixture, separation of filtration, separation of solvent regeneration from solutions and its dehydration, refrigeration unit and commodity park with heating oil heating system. The refrigerating compartment is designed to cool a mixture of raw materials with a solvent and is an ammonia refrigeration unit of two-stage compression based on ammonia compressors (ADK-73/40, AGK-73, condenser condensation unit for ammonia KTV, plate heat exchangers KB-1,2,3, AV3, AVG, crystallizers for cooling of a mix of raw material and solvent and other auxiliary devices). The purpose of cooling is the crystallization of solid paraffinic hydrocarbons from the low-viscosity, medium-viscous and viscous epoxy fraction [2]. For a single filling of all ammonia units of the installation, about 30 tons of ammonia is required, it is intended for cooling the mixture of raw materials with a solvent up to -35 °C.

The cycle follows the pattern: 1) a pair of ammonia from the molds come in liquid separators, where the deposition of mechanically entrained droplets of ammonia; 2) while increasing the level of ammonia up to 60% alarm system compressor, if the level is about 90% automatically locks all compressors; 3) from the liquid separators of the pair are sucked into a two-stage compressor; 4) the precipitated liquid ammonia flows down into the drainage receiver; 5) pairs of ammonia, from the first stage of ammonia compressors, enter the intermediate vessels for cooling; 6) in containers, thanks to direct injection, a constant level of liquid ammonia is maintained; 7) further, saturated vapors are sucked by the second stage of the compressor, compressed and sent through the oil separators for condensation to air-cooling units, water condensers, plate heat exchangers; 8) condensed ammonia flows into the receivers, then enters the coils and enters the evaporator system; 9) fresh ammonia is taken from the reagent farm on a special line to the working receivers, while a vacuum is created in the receiver receiving ammonia, and in the tank from which ammonia is taken, pressure is created by means of ammonia compressors; 10) along the same line, ammonia can be delivered from working receivers to any facility in the workshop or to a reagent farm.

Air from the system is removed by means of air separators, representing a small vertical heat exchanger of a rigid type (Figure1). Its work consists in condensing ammonia from the air-ammonia mixture under pressure, due to the evaporation of the liquid refrigerant. Ammonia compressors create a vacuum in the ammonia evaporation system. Air entering the system is possible only through insufficiently tight connections, for example, through gland seals or at the opening of individual elements of the installation at the time of repair work, as well as when filling with a refrigeration reagent. Air, creating additional pressure in the system, prevents normal condensation of ammonia vapors.

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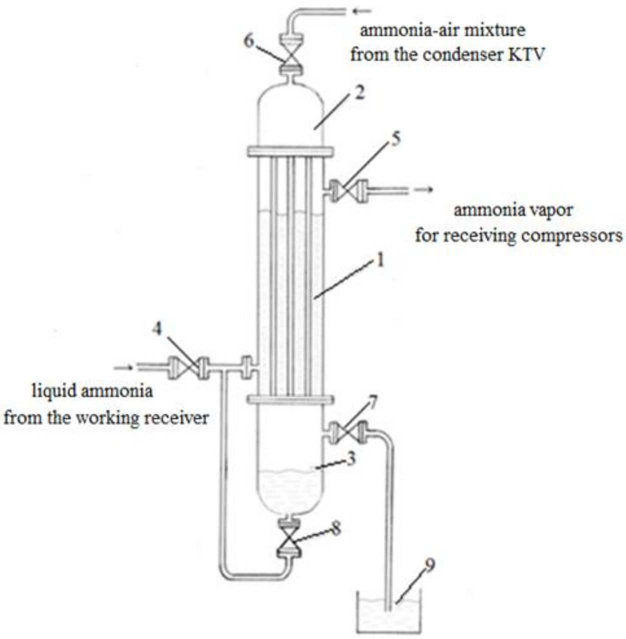

Figure 1. Ammonia air separator:
1– annular space; 2 – tube space; 3 – the bottom cap; 4 – valve supplying liquid ammonia from the working receiver; 5 – the valve for the extraction of ammonia vapors from the shell space; 6 – valve supplying the air-ammonia mixture into the pipe space; 7 – air venting valve; 8 – valve for supplying condensed ammonia to the shell side of the air separator body; 9 – a tank of water.

The refrigeration unit includes ammonia compressors ADK-73/40 and AGK-73, the technical characteristics of which are given in table 1.

Table 1. Technical specifications of compressors.

Compressor brand	AGK-73		ADK-73/40	
	Low grade	High degree	Low grade	High degree
Diameter of the cylinder, mm	730	450	730	400
Cylinder piston stroke, mm	550	550	550	550
Stem diameter, mm	100	100	100	100
Number of revolutions per minute	167	167	167	167
Theoretical volume of the compressor, m^3 / h	4570	1710	4570	1340
Cooling capacity, kcal / h	about 900000		about 400000	
Indicator power consumption Ni, hp	669	669	669	669
Power consumption on shaft Ne, hp	786	786	786	786
Diameter of pipelines, mm	325/8	325/8	325/8	-
Diameter of stop valves, mm	300	300	300	-
Motor type	SDK 760-167		SDK 760-167	
Motor power, kW	623		623	
Voltage, V	6000/3000		6000/3000	
Number of revolutions per minute	167		167	
Weight of compressor without motor, kg	22600		23700	
Weight of motor, kg	12700		12700	

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In case of emergencies, the following measures should be taken:

1. When the pressure of the second stage of the compressors is increased because of the large accumulation of air in the ammonia system, it is necessary to turn on the air separator and eliminate the leaks through which air is sucked.

2. If the air separator is not working properly:

2.1. If an insufficient amount of liquid ammonia is supplied, then open between the tube space;

2.2. If ammonia is high, then stop the flow by opening the suction valve to freeze the air separator;

2.3. At low pressure, fully open the valve at the inlet of the ammonia-air mixture into the air separator.

3. When the air-to-air discharge tube from the air separator freezes because of the mercury tank with liquid ammonia, it is necessary to restart the excess ammonia into the annular space of the air separator.

Ammonia horizontal compressor brand AGK-73 is a twin-stage compressor of double-stage compression with direct drive from a synchronous motor. Cooling capacity of the compressor is about 900,000 kcal / h at evaporation temperature totк= +35 °C, condensation temperature tк = +35 °C and subcooling temperature before the control valve ti= +30 °C.

Ammonia horizontal compressor brand ADK-73/40 is also a twin compressor of two-stage compression of a double action with direct drive from a synchronous motor. The cooling capacity of the compressor is about 400,000 kcal / h at evaporation temperature to= -43°C, condensation temperature tк= +38°C and subcooling temperature before the control valve ti= +35 °C.

4. Results

In total, the cooling capacity of the working compressors is 1980 kW. For this value, an automatic air separator of the brand AV-2 (Figure 2), developed by VNIHI (All-Russian Scientific Research Institute of the Refrigeration Industry), is suitable. They are exploited for many years at various enterprises.

The cooler, appliances, fittings and pipelines are compactly mounted on a common frame. Thus, the automatic air separator brand AV-2 is a unit ready for inclusion in the system of an ammonia refrigeration unit [3, 4].

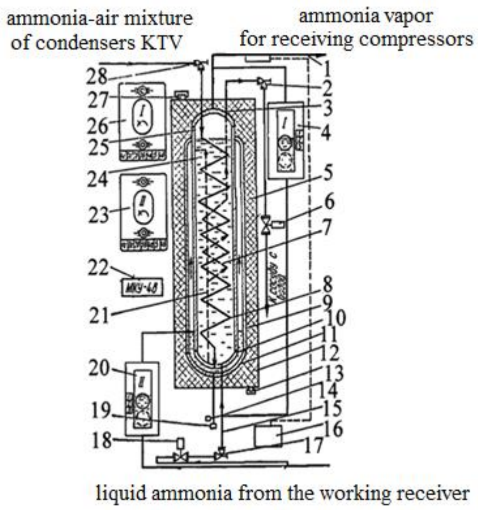

Figure 2. Automatic air separator brand AV-2:
1 – the suction pipe; 2, 17,28 – shut-off valves; 3, 10, 11 – bottoms; 4,20 – level sensors; 5 – insulation; 6, 18 – solenoid valves; 7, 8 – coils; 9 – an external pipe; 12 – a casing; 13.27– plugs; 14.15 – branch pipes; 16 – temperature relay; 19 – stopper; 21 – secondary cooling coil tube; 22 – intermediate MKU – 48; 23, 26 – amplifiers; 24 – inner tube; 25 – housing.

The principle of operation is based on cooling the air-ammonia mixture under the condensing pressure, by boiling ammonia in the inner tube. The supply of ammonia to it is automatically controlled by the level 4 float switch of the PRU-2 mark in combination with the solenoid valve 18. Liquid ammonia produced by the air separator is permanently removed from the annular space through the float level sensor chamber into the linear receiver [5-7].

5. Conclusion

Replacing an existing air separator with an automatic one will result in a reduction in ammonia emissions to the atmosphere, thus minimizing the likelihood of negative impact of ammonia on workers, and in the case of large emissions on the population living near the territory of the enterprise.

On the given technological block the following types of damaging factors are possible: shock wave, thermal radiation and toxic damage.

The most dangerous scenario for the development of an accident at a dewaxing plant is the complete depressurization of one of the crystallizers with the expiration of a dangerous substance - ammonia, the damaging factor is toxic damage. The probability of occurrence of the most dangerous scenario of an emergency at the deep dewaxing unit of oils is 4.6×10^{-05} 1 / year. In creating the damaging factors, up to 2180 kg of ammonia can participate. In addition to ammonia, the main harmful substances released into the atmosphere from sources are hydrocarbons and toluene.

Reduction to or below a regulated level (maximum permissible concentration) or complete elimination of air pollution by emissions along with other technological indicators is one of the main criteria for the quality of the plant's operation. To reduce emissions of harmful substances into the environment, the following measures are envisaged:

– draining of oil products from heat exchangers and steaming of heat exchangers for repair is carried out in a drainage tank with subsequent processing;

– the inert gas thrown into the atmosphere is first cleaned in the absorber by an oil component, which is then pumped out for regeneration;

– air discharged to the atmosphere from the ammonia system is preliminarily cooled by ammonia in an air separator with condensation of ammonia and its return to the system.

Continuous operation of the automatic air separator will ensure a constant removal of air from the system, which will lead to an improvement in the following indicators:

1. Practically complete absence of unorganized ammonia emissions into the atmosphere, respectively, reduction of environmental pollution, and a reduction in the likelihood of exceeding the MPC standards in the work area of personnel;

2. Timely removal of air from the system, respectively, reducing the load on ammonia compressors, which in turn will lead to a reduction in energy consumption, a reduction in the amount of water consumed in water-cooled condensers and less equipment wear [6].

Thus, it becomes clear that there is an interest in minimizing the presence of air in the system, which will certainly lead to an increase in the technical and economic performance of the installation. The feasibility of introducing an automatic air separator is confirmed not only by technical advantages, but also by economic efficiency.

The obtained results can be used as a rationalization proposal for the introduction of an automatic air separator brand AV-2 on the dewaxing unit of oil type 39/8№5, the production of oils, additives and lubricants.

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