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Modern Technologies for the Treatment and Disposal of Wastewater Generated in the Oil Refining Industry

Abstract

The oil refining industry currently plays a major role in the economy of our state. Unfortunately, the processes of oil production, processing, transportation, and storage are always accompanied by the release of hydrocarbons that pollute the environment. Oil refining and petrochemical plants are among the largest polluters of the environment.

The enterprises of this industry pollute the air, water bodies, and soil, negatively affecting the ecological situation of Baku, Absheron, and Sumgait. In terms of wastewater discharge, these enterprises are the largest source of pollution of water bodies. Therefore, one of the most important problems of the oil-producing and oil-refining sectors is the problem of protecting the production environment and the environment. The oil refining industry is rightfully attributed to the sectors that bear the greatest responsibility for public health. Oil refineries discharge the main part of wastewater into water bodies.

Wastewater of oil refineries mainly contains oil pollution. During the oil refining production and its development at these plants, wastewater is enriched with a number of water-soluble polar compounds: organic acids, alcohols, aldehydes, ketones, and hydroxy acids. The purification of these wastewaters to the parameters provided by the currently applied regulatory requirements and traditional methods is economically expensive. In addition, in some cases, high pollution of water used in technological processes causes significant economic losses, which in most cases are irreversible.

In this regard, issues such as the assessment of wastewater treatment methods at oil refineries, the study of wastewater treatment methods at oil refineries, the introduction of a new type of wastewater treatment, and the calculation of the proposed treatment method are among the urgent problems of environmental protection and ecology. Therefore, the analysis of the impact of oil refining complex enterprises on the environment is important. Thus, the topic of the presented article is relevant.

Keywords: *wastewater, oil refining, technology, methods, cleaning*

Introduction

Wastewaters of oil refining enterprises are formed in all technological facilities, depending on their composition. They are formed after condensation, cooling and washing with water of oil products, from electric desalination plants, alkalization of transparent oil products and liquefied gases, from barometric mixing condensers, mixing plants and from the platform for pouring ethylated gasoline, as well as from cleaning equipment and devices, washing the floors of industrial buildings, cooling equipment and cleaning the circulating water supply system. Precipitation water from the places (sites) where technological facilities are located also join the production wastewater. There are several types of wastewater: neutral wastewater containing oil products - sometimes it is also called neutral oily wastewater; salty wastewater; sulfur-alkaline wastewater; acidic wastewater; wastewater containing hydrogen sulfide. In addition to intermediate and final products of oil refining, wastewater contains oil, naphthenic acids and their salts, emulsifiers, resins, phenols, benzene, toluene, as well as sand, clay particles, acids and their salts, alkalis (Jassi, Braihi, Shabeeb, 2024: 1-3).

Thus, production wastewater at an oil refinery is generated in almost all technological units.

Depending on the sources of generation, production wastewater at an oil refinery is divided into:

1. Neutral wastewater containing oil or oil products. These waters constitute the main part of the water in the first system of industrial wastewater sewage. These include wastewater obtained during condensation, cooling and washing of petroleum products (except for water from barometric condensers of AVB), after cleaning them from their corresponding apparatuses, after cleaning the floors of industrial buildings, water from cooling of pump bushings, drainage water from trays (containers) of technological facilities (except for water from control units in raw material parks), water from the main wells of apparatuses and pumps, as well as wastewater consisting of waste and seepage water from the sites of technological facilities. Oil is mainly present in these waters in the form of an emulsion. Its concentration reaches 5-8 g/l, and the total salt content is 700-1500 mg/l. The relatively low salt content allows the use of wastewater to fill secondary water supply systems after appropriate treatment.

2. Salt-containing wastewater (ELOU wastewater), containing a high content of emulsified oil and a large amount of dissolved salts (mainly sodium chloride). They come from electrodesalination plants and raw material parks. These also include rainwater from the territory of the specified facilities. If accidental waste is not taken into account, the maximum permissible amount of oil products in them should not exceed 10 g/l. Studies of wastewater from ELOU facilities show that the amount of oil in individual samples can reach 30 g/l, which is associated with a violation of the hermeticity of technological equipment, leaks and operational defects. The salt content in the waters of this group depends mainly on the quality of the oil entering the plant.

3. Sulfur-alkaline wastewater is obtained from the alkalization (alkaline treatment) of transparent petroleum products and compressed (liquefied) gases. In the alkaline treatment process, mainly hydrogen sulfide, mercaptans, phenols and naphthenic acids are removed from petroleum products.

In accordance with technological requirements, the composition of sulfur-alkaline wastewater should be as follows: COD (Chemical Oxygen Demand) - up to 85,000 mgO2/l, BOTful (Biochemical Oxygen Demand) - up to 75,000 $mgO_{2/l}$, sulfides (in terms of H2S) up to 26,000 mg/l, total sulfur content up to 35,000 mg/l, volatile phenols up to 5,000 mg/l, petroleum products up to 3,000 mg/l, total alkalinity (in terms of NaOH) - 10,000 mg/l, pH-14.

Chemical oxygen demand (COD) refers to the amount of oxygen required for the oxidation of carbon-containing compounds to carbon dioxide, sulfur-containing compounds to sulfates, and phosphorus-containing compounds to phosphates.

The total biochemical oxygen demand (BOD) is determined by the amount of oxygen consumed by microorganisms for aerobic biochemical oxidation (decomposition) of volatile organic compounds in water, that is, mixtures, over a certain period of time (Gautam, Saini, 2020: 1-4).

However, the composition of wastewater of this category can differ significantly from the established standards or norms. The periodicity of discharge of alkalis, sulfur-alkali wastes used in various plants into the sewer can vary from 2 to 45 days, depending on the type of technological facilities and their capacity, the adopted oil refining regime, the quality of the initial raw materials received, the alkalization (cleaning with alkali) scheme, the hydraulic load in alkaline sedimentation tanks and other factors. The average daily discharge of these waters (excluding washing waters) varies between 0.0009 and 0.0019 m^3 per 1 ton of processed oil.

4. Acidic wastewater from the sulfuric acid regeneration shop is formed as a result of acid losses due to leaks and lack of hermeticity of connections in equipment and apparatus, as well as due to corrosion of equipment, and can contain up to 1 g/l of sulfuric acid.

5. Hydrogen sulfide-containing wastewater mainly comes from barometric mixing condensers. When barometric mixing condensers are replaced with above-ground ones, their volume decreases by 40-50 times.

In addition to barometric waters, hydrogen sulfide is also found in technological condensates of the so-called AVB unit, catalytic cracking, delayed coking, hydrotreating (hydrocleaning) and hydrocracking units, but in addition to hydrogen sulfide, phenols and ammonia are also present in these wastewaters.

When oil refineries and petrochemical plants are combined, wastewaters contaminated with petrochemical synthesis products are formed. Their composition is determined by the type of product obtained. Thus, wastewaters from the production of protein and vitamin concentrates from liquid petroleum paraffins have BOD (Biochemical Oxygen Demand) - up to 1000 mg $O_{2\ /\ l}$, COD (Chemical Oxygen Demand) - 2200 mg $O_{2\ /\ l}$, pH - 4.8-5.6.

Other sources of wastewater include wastewater from ethyl blending facilities and water from piers for pouring leaded gasoline containing up to 10 mg/l of petroleum products and tetraethyl lead, as well as sour wastewater from a synthetic fatty acid plant.

Thus, a large amount of organic substances enter the waste (waste) waters of an oil refinery, of which the final and intermediate products of oil distillation are of greatest importance: oil, naphthenic acids and their salts, demulsifiers, resins, phenols, benzene, toluene. The composition of waste wastewater also includes sand, clay particles, acids and their salts, alkalis.

The data presented show that the composition of individual compounds in wastewater, for example, the content of phenols and oil in sulfur-alkali wastewater, varies within wide limits. The most dangerous for biological treatment plants and water bodies are sulfides and sulfohydrates, which are not allowed in the waters of reservoirs for drinking water, fisheries and cultural and domestic use (Farzana, Haque, Sonali, Saha, 2023: 56-69).

Oil and oil products in industrial and production wastewater are in a dissolved, colloidal and emulsified state. The majority of organic substances dissolved in water are usually determined by biochemical oxygen consumption or chemical (bichromate) oxygen consumption in a water sample.

Research

One of the unique features of oil refining enterprises is that wastewater, as a rule, is a set of flows collected not from isolated production processes or departments, but from the enterprise as a whole. Modern refineries are divided into: fuel and fuel-oil plants, petrochemical plants. The differences in oil refining technology and the profile of production, the depth of oil refining and the types of final products also determine the plant's waste.

The main technological processes of oil refining include:

1) oil preparation, its dehydration and desalination;

2) atmospheric and vacuum distillation; destructive processing (cracking, hydrogenation, isomerization); purification of light-colored products;

3) production and purification of oils.

1) With the depth of oil refining, water consumption for industrial purposes and the volume of wastewater increase. The composition of various pollutants in wastewater is determined by the quality of the processed oil, its processing technology and the quality of the final products. The greatest water consumption is observed at the stage of oil preparation, in the process of dehydration and desalination (Lee, Yeo, Cools, Morent, 2018: 3578-3590).

Electrical water desalination and dehydration. Oil coming from oil fields (fields) contains up to 2% water and up to 0.5% salt. It should be noted that oil containing no more than 0.0005% salt and 0.1% water is considered suitable or suitable for processing. Therefore, oil supplied to the oil refinery is first subjected to dehydration and desalination in special electrical desalting units called ELOU. Water is added to crude oil, then the resulting emulsion is divided into two stages: the first is thermal precipitation at 75-80°C; the second is the process of breaking the emulsion and dehydration in electrohydrators. In the process of dehydration and desalination of oil, demulsifiers OP-7, OP-10, diosolvan, OJK, etc. are used to break up a stable emulsion. The water separated in the ELOU units is discharged into a special sewage network. It contains salts, oil, sulfur compounds and other substances in the form of a mixture contained in crude oil.

Oil processing in atmospheric and vacuum conditions. The initial technological process of oil refining is its direct distillation in atmospheric vacuum tubes (AVB) with the production of light distillates and oil fractions. After ELOU, the oil passes through heat exchangers (heat exchangers), then it is heated in the furnace of the atmospheric part of the AVB unit and fed to the atmospheric rectification column, where the separation (fragmentation) of oil occurs with the removal of light products. The light products of the atmospheric column - gasoline, kerosene and diesel fuel - are cooled, condensed in heat exchangers and condensers. The remaining part of the oil products remaining from the atmospheric column passes through the tubular furnace of the vacuum part and enters the vacuum column, where oil distillates and cubic residues are obtained as a result of distillation in vacuum. During the initial distillation of oil, the decomposition of sulfur compounds occurs. Some of them pass into the light distillate and contaminate it, while others are converted into gases and the rest of the oil products. In the mixing barometric condensers of the AVB vacuum columns, the vacuum is created due to the direct contact of water with vapors of oil products and gases. As a result, the water that has undergone the processing process (used) is contaminated with vapors of oil products and hydrogen sulfide. Currently, in a small number of AVB installations, in order to avoid the formation of contaminated wastewater, barometric mixing condensers are replaced with surface (surface) type condensers, in which water does not come into contact with oil products. Two types of products are formed in the direct distillation of oil: distillate (gasoline, kerosene, ligroin (naphtha), diesel fuel, solarium oil) and residue (fuel oil, tar, gas oil). Fuel oil is also partially used as fuel.

Due to the aggressive effect of sulfur compounds on technological equipment made of metal, their presence in commercial oil products is not allowed. Oil products are cleaned of sulfur compounds with aqueous solutions of alkalis (caustic soda). At this time, hydrogen sulfide, mercaptans and other sulfur compounds, as well as phenols, pass from petroleum products to alkaline solutions. After repeated use, alkaline solutions containing large amounts of sulfur compounds, as well as other pollutants, are discharged into a special network - the sulfur-alkali sewage network.

Thus, at the stage of atmospheric-vacuum processing of oil, two types of wastewater are formed: sulfur-alkaline (alkaline-sulfide) during the purification of oil products from sulfur compounds and wastewater after barometric mixing condensers. Both of them contain oil, oil products and sulfur compounds (Zakaria, Shibahara, Bhuiyan, Nakane, 2022: 50-89).

Destructive processing of oil. During deep processing of oil, the residues of direct distillation are subjected to cracking and pyrolysis. Various types of cracking are known:

a. catalytic cracking, which occurs in the presence of catalysts (aluminum chloride, aluminosilicates);

b. hydrogenation cracking (hydrogenation) in a hydrogen atmosphere - here clay is used as a sorbent;

c. dehydrogenation cracking, accompanied by massive hydrogen release; oxidative cracking in an oxygen or air atmosphere.

At modern oil refineries, mainly hydrogenation cracking is more developed.

In catalytic cracking units, the products of distillation (extraction) of oil directly after AVB are subjected to direct decomposition of heavy hydrocarbon molecules to produce high-octane hydrocarbons (gasoline and individual aromatic hydrocarbons). The process is carried out at high temperatures and pressures. Purification of liquid products is also carried out with alkali. Cooling and condensation of finished products are carried out with the help of water in surface (surface) condensers and coolers. At this time, the water is heated to 70-80°C. The possibility of contamination of cooling water with oil products is possible only in case of malfunction and violation of the hermeticity of the apparatus.

During the deep processing of oil using cracking processes, the following are formed:

- gaseous hydrocarbons with a high content of neutral hydrocarbons, which are subsequently sent as raw materials to petrochemical production of oil refineries for the synthesis of alcohol, glycol, glycol derivatives, etc.;
- liquid distillates – cracking - gasoline, aromatic hydrocarbons (for example, benzene, toluene); from liquid products, a number of other compounds are obtained during the pyrolysis of oil at petrochemical enterprises (isoprene, synthetic fiber raw materials, etc.);
- solid decomposition products – the residue (coke) that does not pass through the distillation process of oil. During the condensation of finished products, in addition to the water used to cool them, water is also discharged into the sewer from water separators. The latter, which is mainly called technological condensate, is formed as a result of the condensation of water vapor entering

the apparatus of the installation. Since it is in direct contact and contact with oil products, a significant amount of hydrocarbons can be expected in the technological condensate, and during the processing of sulfur and high-sulfur oil, ammonium sulfides and phenols can also be found (Pervov, Telichenko, 2005: 70 – 74).

Purification of oil products. Acid and alkaline cleaning and washing are used for the purification of oil products. During acid cleaning (periodic and continuous), light fractions of oil are processed in special apparatuses with mixers. Then they are neutralized, washed with water and subjected to alkaline treatment. As a result of cleaning, a large amount of waste is obtained - sour tars, alkaline wastewater, which are difficult to degrease and utilize. However, currently, the solution of this problem is extremely important for protecting the environment from pollution.

Along with general methods for the purification of oil products, special methods are used, for example, desulfurization methods, the most promising of which are catalytic hydrogenation, purification with the help of selective solvents, and others.

Production and purification of oils. The raw material for the production of oils is oil distillates (epaulettes) obtained from AVB units. In order to remove mineral impurities (sulfur, nitrogen, asphalt-resinous substances and other components undesirable for oil) from oil fractions, they are subjected to cleaning using solvents in special installations. This type of installation mainly includes the following devices: deasphalting of oils with propane, dewaxing of oils in acetone - benzene - toluene, hydrotreating of oils and contact cleaning with bleaching clays.

In the deasphalting installation, liquid propane dissolves asphalt-resinous substances contained in the oil epaulets (oil repellents) of the AVB. These substances precipitate and separate in the form of sediment. In this installation, oil products can enter the sewers as a result of leaks in the pump glands (seals) or other malfunctions when washing the floors (Goncharuk, Garkavy, Popenko, Kravets, Boyko, 2004: 479-484).

Pollution of wastewater in the facilities for selective purification and deasphalting of oils from resinous substances and other phenolic compounds is possible only through the sewage discharge of washings from the floors of the pumping station, as well as through leaks in the equipment.

During normal operation of technological equipment, pollution in the dewaxing unit is not significant. However, in case of an accident and in cases of leaks, it is possible for petroleum products with a high freezing point, as well as solvents, etc. to enter the sewage system.

During proper operation of oil hydrotreating units, oil is excluded from being discharged into wastewater. Discharge of oil components into the sewer is possible only in case of an accident and in cases of leaks at the joints of pipelines. A significant amount of pollution enters the wastewater of oil refineries from reservoir parks and during equipment repairs.

An additional source of pollution of the sewage system with oil products and mechanical mixtures is rain and melt water.

Improvement of wastewater treatment systems at oil refining enterprises.

Mechanical treatment of wastewater. Mechanical treatment units are designed for the primary treatment of wastewater from oil products and mechanical mixtures consisting of solids. Mechanical treatment is carried out in sand traps (traps), settling tanks, hydrocyclones, centrifuges, and filters (Temerdashev, Temirkhanov, Musorina, 2006: 111-113).

Figure 1. Description of the mechanical treatment of wastewater

Sand traps (traps) are used to retain large mineral impurities and coarsely dispersed oil products. Sand traps (traps) for oil refineries with a low content of solid organic matter in wastewater are designed based on the storage conditions of most oil products. According to VUTP-97 - i.e., the Guidelines for the technical design of industrial water supply, sewage and wastewater treatment of oil refining enterprises ("Departmental instructions for the technical design of industrial water supply, sewage and wastewater treatment of oil refining enterprises - VUGP-97"), the volume of sand traps is taken from the calculation of the five-minute residence time of wastewater. Sand traps are equipped with devices for collecting floating oil products, such as oil, and removing sediment. The efficiency of oil products retention is up to 75%, suspended solids up to 20%. In the treatment plants of oil refineries, sewage plants, horizontal (horizontal-rectangular) and round (circular) sand traps with circular movement of the working flow are used.

Oil traps (traps) are designed to remove the main part of oil products and small mineral particles. The residual concentration of pollutants in the purified water after oil traps is 100 mg/l for oil products (purification effect 90 - 95%) and 90 mg/l for solids (purification effect 55 - 70%) for the first sewage system, and -150 mg/l (purification effect 90 - 95%) and 85 mg/l (purification effect 45 - 65%) for the second sewage system, respectively.

The efficiency of wastewater treatment due to oil products depends on the initial amount of oil products in the wastewater, their dispersion and should be carried out according to sedimentation curves determined by plant laboratories or industrial research institutes. For new plants, the volume of oil catchers (traps) is assumed to be equal to the two-hour flow of wastewater.

In recent years, for the treatment of oil-containing wastewater, shelf (thin-layer) oil traps (traps) have been increasingly used, the working volume of which is divided into separate sedimentation zones by inclined plates, which ensures thin-layer sedimentation and clarification. In such sedimentation tanks, the influence of density and convection currents on the sedimentation and clarification process is practically excluded, and the uniform distribution of the working flow provided at the beginning of construction is maintained along the entire length of the latter, therefore the volume utilization factor can be 80 - 85%. The sedimentation height in these structures is equal to the (vertical) distance between the plates and is many times less than the height of the sediment layer in conventional sedimentation tanks, and therefore the duration of the process of proper wastewater treatment is much shorter (35-40 minutes).

Figure 2. Thin-layer oil trap block

Thin-layer multi-layer (level) oil traps (traps) have a significantly smaller volume (4-6 times) and occupy a smaller area. Their use allows you to do without additional sedimentation and settling tanks, since the concentration of oil products in the purified water supplied for physicochemical treatment is 40-50 mg / l. However, the results of inspections at oil refineries show that the concentration of oil products can be 150 g / l and more. When using shelf (hollow) oil traps, which have a volume 5-6 times smaller, the process of accumulating oil products occurs very quickly. Therefore, their constant continuous discharge is required. Otherwise, oil products can be removed with purified water. All this requires precise operation of treatment facilities. In addition, heavy oil products falling into the oil trap adhere to the surface of the plates in the layers and eventually destroy them. Therefore, during the operation of multi-layer oil traps (traps), it is necessary to determine the oiling period of the layer space in order to determine the period between washing the blocks (Ilyin, Kolesnikov, Denisova, 2006: 3-4).

Attention should be paid to the selection of materials for plates with low adhesion to heavy oil products in the block and to taking measures to prevent clogging of the block space (clogging area). In this regard, the VUTP-97 guidelines, i.e., the Technical Design of Industrial Water Supply, Sewage and Wastewater Treatment of Oil Refineries, recommend the use of oil traps (traps) with parallel plates in wastewater streams containing transparent oil products and not containing high-viscosity oil products (tar, bitumen, etc.).

Currently, it is recommended to combine sand traps (traps) with oil traps (traps). The nature of the pollutants deposited in sand traps and oil traps is the same, and they differ only in size. Combining these two structures allows you to save on the production areas occupied by these structures. In order to separate the sand from the fine clay fraction formed during longer settling, it is necessary to arrange two rows of holes in the oil or oil traps along the movement of water. In this case, larger particles (sand) will be collected in the first hole, which can be removed from the oil and oil trap (trap) regardless of the removal of fine sediments collected in the second hole (Magid, Kuptsov, 2006: 13-14).

Hydrocyclones, which play the role of sand traps (traps) and oil and oil traps (traps), are increasingly used to purify wastewater containing oil or oil products from oil products and solid particles from oil refining enterprises.

Pressure hydrocyclones have a relatively small diameter of the cylindrical part, D = 15-1000 mm. The impurities in them are separated and released as a result of centrifugal forces that exceed the force of gravity by hundreds and thousands of times. Therefore, the duration of the process is correspondingly reduced, and the volume required for treatment is also reduced compared to the volume of sedimentation tanks.

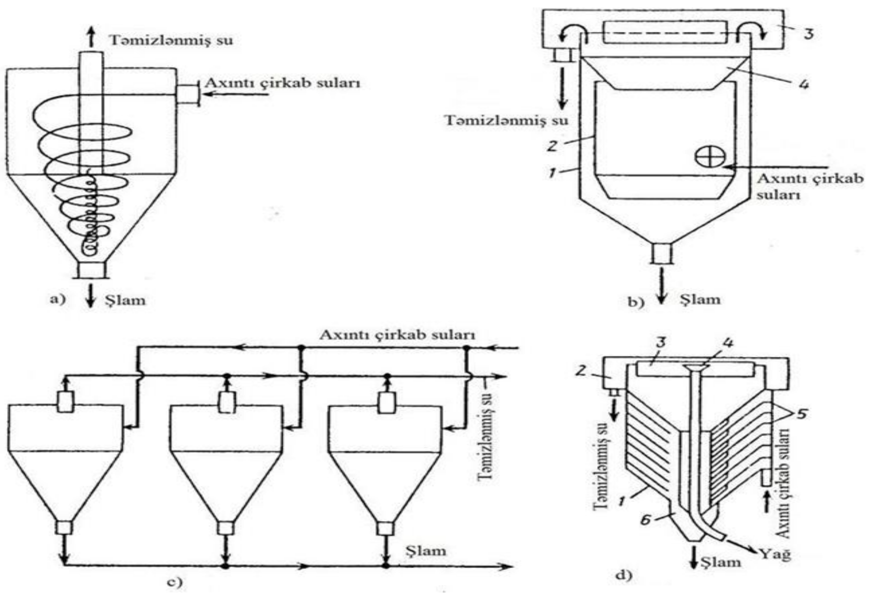

Figure 3. Hydrocyclone operating scheme.

a – pressure, b – with an internal cylinder and a conical diaphragm: 1- housing; 2-internal cylinder; 3 – annular trough; 4 – diaphragm. c – block of pressure hydrocyclones; d- Multi-tier hydrocyclone with inclined pipes for removing purified water:1- conical diaphragms; 2 – trough-container; 3 - top; 4 - oil collecting container (funnel); 5 - distribution containers; 6 – slit for discharging sludge.

Non-pressure hydrocyclones have a diameter of D = 2 -12 m, the centrifugal forces in them are very small. However, during the rotational movement of the flow, conditions are created that facilitate the agglomeration of suspensions and, therefore, their more intensive separation and removal. In addition, when the flow moves in a spiral, the volume of the apparatus is used more fully. The above-mentioned advantages allow for the wider application of small-volume open hydrocyclones compared to settling tanks; they operate at high specific hydraulic loads, which reduces the area required for the placement of treatment facilities.

Physicochemical treatment of oil-containing wastewater. Physicochemical methods are used to treat oil-containing wastewater from colloidal and dissolved contaminants. A large number of physicochemical methods are known for treating wastewater from this type of contaminants: coagulation, flocculation, flotation, electrocoagulation, electroflotation, sorption, ozonation, electromagnetic separation (separation), liquid phase oxidation, coalescence, ultrafiltration, and others. Currently, coagulation, flocculation, flotation, and sorption treatment are most often used at oil refining enterprises.

Coagulation is used in wastewater treatment to accelerate the settling of finely dispersed mixtures (dirt) and emulsified substances. During coagulation, the interaction of dispersed particles with coagulants and their aggregation into aggregates leads to the enlargement of dispersed particles. Coagulants are more effective for removing colloidal particles from water, i.e. particles with a size of 1 - 100 microns. Coagulants in water form flakes, which quickly settle under the influence of gravity. The most commonly used coagulants are aluminum sulfate $Al_2\ (SO_4)_3\ 18\ H_2O$, aluminum oxychloride $Al_2\ (OH)\ 5\ Cl$, etc.

Reagent treatment of wastewater with mineral coagulants has the following disadvantages:

- relatively large doses of coagulants (for example, the dose of aluminum sulfate for the first sewage system is 50 mg/l, for the second system - 100 mg/l);

- high content of SO-2 and Cl-1 ions in the treated water, which leads to corrosion of the water supply circulation systems during water reuse;

- The formation of significant volumes of high-moisture sediments makes it difficult to dewater these sediments (Seyfullayeva, Ələkbərova, Məmmədova, 2006: 43-89).

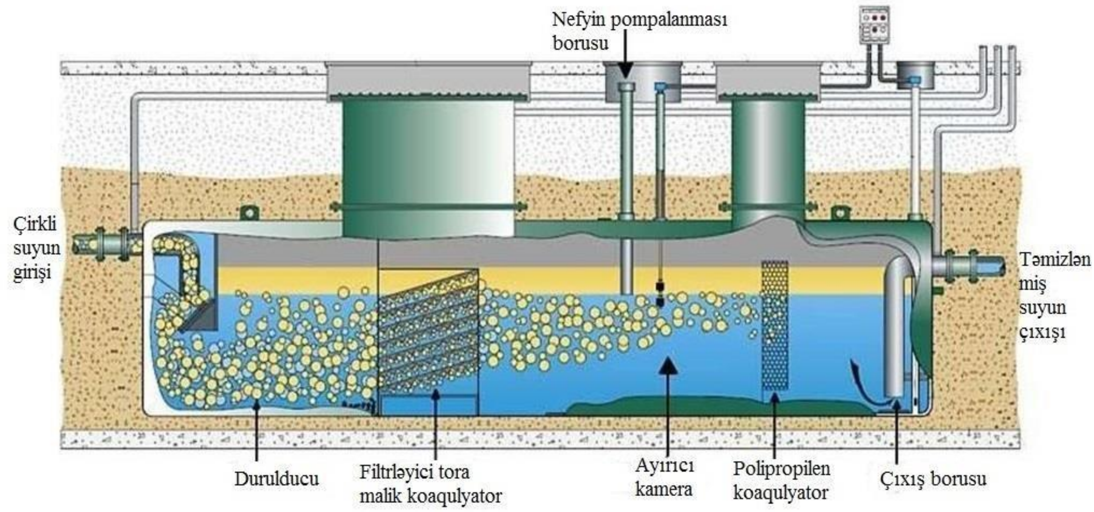

Figure 4. Schematic representation of the coagulation process

During flocculation, unlike coagulation, aggregation (combination) of solid particles occurs not only during direct contact of the particles, but also as a result of the interaction of molecules adsorbed on the flocculant particles. Flocculation is carried out to intensify the process of formation of flakes of aluminum and iron hydroxides, in order to increase the rate of their sedimentation. The use of flocculants allows you to reduce the dose of coagulants, reduces the duration of the coagulation process and increases the rate of sedimentation of the resulting flakes.

The flotation method consists in the formation of "particle-bubble" complexes, their floating or surfacing, and the removal of the foam layer formed from the surface of the water being treated. Adhesion of particles to the surface of gas bubbles in a liquid can occur if there is no wetting of the particles by the liquid or if weak wetting is observed. Flotation treatment can be effective in removing impurities that have natural hydrophobicity (oil, petroleum products, oils, synthetic detergents, etc.). Coagulation and flocculation significantly intensify the flotation process of impurities, since in this case the hydrophobicity of particles increases, the size of aeroflocs increases, and accordingly the forces that raise impurities to the surface of the water in the flotation chamber increase (Ponomarev, Boyev, Chuchalin, Porkhachev, Khananov, 2003: 38-42).

Electrochemical purification methods (electrocoagulation, electroflotation) have a number of significant advantages over reagent methods: they do not increase the mineralization and salinity of wastewater, which plays an important role in the organization of water supply circulation systems; less sediment is formed; they simplify the technological scheme of purification; there is no need to organize a reagent economy; the possibility of full automation of production facilities is provided; Small production areas are required to accommodate electrochemical purification units.

The sorption method is used for deep purification of water from oil products in finely emulsified and dissolved states. Currently, a large number of organic and inorganic materials are used for the production of oil sorbents: coal, peat, expanded clay, perlite, silica gel, zeolites, sawdust, sapropel, shale, polypropylene, polyurethane, teflon and others.

There are three main methods for the regeneration (restoration) of activated carbon: chemical, low-temperature and thermal. All these methods are expensive and energy-intensive, require special equipment. In addition, due to the porous structure, sorbents have low mechanical strength, and the loss of sorbents as a result of wear during washing is 0.1 - 2% per cycle, during hydraulic overloading - 0.3 - 4%, the loss of mass of the sorbent during regeneration reaches 10%.

In recent years, due to the development of membrane technologies, the scope of application of membrane filters has expanded significantly. Membrane filtration is a type of filtration, when the filter has a thin partition of less than 0.1 mm and a high degree of porosity, it is called a membrane filter. The range of particles removed by filtration through a semipermeable membrane is quite wide and is usually 0.0001 - 10 microns. The role of the membrane is to serve as a selective barrier, allowing some components in the liquid to pass through and retaining others. Membrane filtration is divided into microfiltration, ultrafiltration, nanofiltration, reverse osmosis, dialysis and electrodialysis filtration (Galleev, Saifullin, 1996: 36-39).

Conclusion

1. Pollution of the environment, i.e. air and water basin, soil occurs during all technological processes of oil refining: in atmospheric-vacuum and vacuum units, in catalytic and thermal cracking units, in the process of contact cleaning and coking of oils, in the process of hydroforming and dewaxing, in the production of bitumen. Sources of pollution include tube furnaces, flares (torches) and general plant facilities; oil and oil product storage tanks (reservoirs), open drains of columns and units, chutes, sewage wells and open surfaces of treatment facilities - sand traps, oil traps (traps), additional sedimentation ponds, quartz filters, aerotanks of I and II stages, second and third sedimentation tanks after aerotanks, storage pools. The main pollutants of the air basin are hydrogen sulfide, sulfur dioxide, nitrogen oxides, carbon monoxide, saturated and unsaturated hydrocarbons. Additional air pollution occurs when the equipment is not hermetically sealed

2. An analysis of the environmental impact of the oil refining and petrochemical industries has shown that they are currently the largest source of water pollution in terms of wastewater discharge. When wastewater is discharged into water bodies, the degree of compliance of wastewater with established standard indicators is not achieved. The reason for the discharge of insufficiently treated wastewater into water bodies is mainly due to the inefficient operation of existing wastewater treatment systems at enterprises.

3. A comparative analysis of wastewater treatment methods was conducted. All the described methods for treating wastewater from oil products have certain disadvantages, which make them unsuitable for use in their pure form for treating wastewater from oil refineries. First of all, this is unacceptable from the point of view of high operating costs, the complexity of the technology, ecology and environmental protection. In addition, wastewater from oil refineries is characterized by high pH and concentration of petrochemical compounds, which makes it impossible to use membrane bioreactors directly for wastewater treatment.

4. It has been established that membrane technologies are one of the priority directions of the scientific and technological process. The reverse osmosis method, as one of the types of membrane technology for water desalination and desalination, allows creating resource-saving and waste-free technological processes, thereby solving the environmental problems of water resource protection.

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A comparative study of the quaternary ammonium salts of enanth and undecanoic acids treated with triethanolamine

Abstract

At present, the wide application of surfactants in various fields such as detergents, foam and emulsion stabilizers, fluorogens, hydrophobizers, and corrosion inhibitors makes their synthesis one of the urgent issues. In the article, the results of the study of oil-collecting and oil-dispersing properties of the quaternary ammonium salt formed by triethanolamine (TEA) of enanthic acid, which is a monobasic carbonic acid, in distilled, drinking, and seawater contaminated with Balakhani oil are given. The surface activity property of the products of different concentrations of this complex was calculated using a tensiometer, and the element content was calculated using the calculation method. The complex formed by enanthic acid with TEA shows high surface activity by reducing the surface tension from 71.98 mN/m to 26.3 mN/m at that boundary.

The complex of enanthic acid and TEA exhibits the ability to accumulate oil in seawater, both in the pure and 5% forms of the reagent.

The complex formed by undecanoic acid with TEA shows high surface activity by reducing the surface tension from 71.98 mN/m to 23 mN/m at that boundary.

Keywords: *oil accumulation, oil dispersion, surface tension, surfactant, carbonic acid*

Introduction

Oil pollution is a significant hazard for the marine environment. Sources of such pollution include oil exploration and production operations, natural seeps, atmospheric input, tanker accidents, industrial discharge, and urban run-off. Increasing demand for petrochemicals has led to increased levels of petroleum hydrocarbons in marine, coastal and estuarine environments. Oil in the sea can occur as dispersed oil droplets, as an emulsion (water in oil or oil in water), bound to solid particles, or solubilized in water. Chemical dispersants and collectors are used as cleaning agents to alter the normal behavior of petroleum hydrocarbons by increasing their functional water solubility, resulting in increased bioavailability and altered interactions between dispersant, oil, and biological membranes.

The use of chemical dispersants is still restricted by many governmental regulations and controlled by guidelines in field application. This situation is mainly due to the bad reputation of the first generation of dispersants developed in the early 1970s, which were, in some cases, so toxic to the marine environment that adverse effects of the dispersed oil were much greater than the effects of untreated oil.

Oil spill dispersants and collectors reduce the interfacial tension in the oil–water interface to very low values. It therefore takes only a small amount of mixing energy to increase the surface area and break the oil slick into droplets stabilized by oil spill surfactant. The behavior of a surfactant is affected by its hydrophilic-lipophilic balance (HLB).

Currently, like other water basins of the world, the pollution of the reservoir of the Caspian Sea and the related deterioration of the ecological situation here are considered urgent issues. Examples of sources of pollution of this sea include tankers carrying oil, accidents during oil extraction and transportation.

Oil spills degrade water quality and disrupt the balanced relationship of the upper water layers with the atmosphere, leading to a disruption of oxygen to living organisms.

Oil-based films that reflect the sun's rays prevent the energy from being absorbed by the water. Thremoval of such spots is especially necessary for the life of marine inhabitants, because more than a hundred species of fish, 95% of the world's sturgeon population live in the Caspian Sea.

Surfactants (SAMs) used to remove thin layers of oil from the water surface are divided into oil dispersants and oil collectors (Asadov, Ahmadova, Rahimov, Mammadova, 2011: 1012-1017; Asadov, Nasibova, Poladova, Rahimov, Asadova, 2012: 175-178; Asadov, Tantawy, Zarbaliyeva, Rahimov, 2012: 2; Asadov, Akhmedova, Aga-Zadeh, Nasibova, Zarbalieva, Bagirova, Ragimov, 2012:1916-1927; Asadov, Salamova, Eyyubova, Yolchuyeva, 2020: 388-398; Asadov, Rahimov, Salamova, 2012: 505-511; Asadov, Tantawy, Zarbaliyeva, Rahimov, 2012: 199-200; Asadov, Tantawy, Zarbaliyeva, Rahimov, Ahmadova, 2012: 136-145; Asadov, Tantawy, Zarbaliyeva, Rahimov, 2012: 621-630; Asadov, Tantawy, Zarbaliyeva, Rahimov, 2013: 261-267; Penfold, Thomas, 2024: 8084-8102; Jiang, Liu, Tan &Lin, 2019: 11-23; Jiang, Fu, Xie &Lin, 2014: 1799-1805; Asadov, Tantawy, Azizov, Zarbaliyeva, Rahimov, 2013: 13-23; Asadov, Zarbaliyeva, Rahimov, Salamova, Eyyubova, Ahmadova, Asadova, 2014: 205-214).

The presented article is dedicated to the study of the oil-collecting and oil-dispersing properties of the complex formed by enanthic acid with TEA.

Research

Enanthic acid is insoluble in water, relative molecular mass 130.2 g/mol, an oily, colorless liquid with a general formula of $C_6H_{13}COOH$, boiling point 223°C, sparingly soluble in water but well soluble in ethanol, has an unpleasant oily odor. is a saturated monobasic carbonic acid. Undecanoic acid is a monobasic saturated carbonic acid with the formula $C_{10}H_{21}COOH$, well soluble in methanol, ethanol, acetone, chloroform, molar mass 186.3 g/mol, melting point 28-30.5°C, boiling point 284°C in the form of a white powder at room temperature.

Triethanolamine (TEA) is a colorless, transparent, ammonia-smelling liquid with a molar mass of 149.19 /mol-1, a density of 1.124 g/ml-1, a solidification point of 22°C, a boiling point of 335°C, and a refractive index of 1.4850 (20°C).

IR-spectra of salts of undecanoic and tetradecanoic acids formed with TEA were recorded on FT-IR, Spectrum BX and ALPHA (Bruker) spectrometers using a KBr disk. The surface activity of substances was determined at the air-water interface using a KSV Sigma 702 (Finland) tensiometer using a Du Nui ring.

The reaction between enanthic acid and TEA was carried out under laboratory conditions in a 1:1 molar ratio at room temperature with vigorous stirring.

The scheme of the reaction is as follows:

$C_6H_{13}COOH + N(C_2H_4OH)_3 \rightarrow$

$[C_6H_{13}COO^- N^+ H(C_2H_4OH)_3]$

The quaternary ammonium salt obtained on the basis of enanthic acid and TEA has a relative molecular mass of 279.4 g/mol, dissolves in 0.75%, 0.1% solutions in water by forming a colloidal solution, and is well soluble in ethyl and isopropyl alcohols.

According to the results of the element composition research by calculation method, the mass share of carbon in the quaternary ammonium salt of enanthic acid with TEA is 55.9%, the mass share of hydrogen is 10.5%, the mass share of oxygen is 28.6%, and the mass share of nitrogen is 5%.

The reaction between undecanoic acid and TEA was carried out in laboratory conditions in a 1:1 mol ratio at 34 °C for 3-4 hours with intensive stirring. The general scheme of reactions can be shown as follows:

$C_{10}H_{21}COOH + N(C_2H_4OH)_3 \rightarrow [C_{10}H_{21}COO^- N^+ H(C_2H_4OH)_3]$

Relative molecular mass of the salt formed by undecanoic acid with TEA

335.5 g/mol, ethyl and isopropyl alcohol are well soluble. Based on the calculation, the element composition of this salt was calculated and it was determined that the mass share of carbon is 60.9%, the mass share of hydrogen is 11.2%, the mass share of oxygen is 23.4%, and the mass share of nitrogen is 4.5%, respectively.

The surface activity property of the complex formed by enanthic and undecanic acids with TEA were determined using a tensiometer at the water-air interface at a temperature of 21°C (Table 1).

The surface activity property of the complex formed by undecanoic and enanthic acids with TEA was determined using a tensiometer at the water-air interface at a temperature of 21°C (Table 1).

item name	Density of SAM (% by mass)											
	0.00025	0.0005	0.00075	0.001	0.0025	0.005	0.0075	0.01	0.025	0.05	0.075	0.1
	Values of surface tension at the air-water boundary, $mN \cdot m^{-1}$											
Undecanoic acid+TEA	48.4	39.5	35.8	33.1	28.6	26.8	25.8	25.2	23.6	23.1	23.2	23.0
Enanthic acid +TEA	71.6	58.7	61.9	56.8	51.9	50.6	45.5	45.4	33.3	28.1	27.5	26.7

The complex formed by enanthic acid with TEA shows high surface activity by reducing the surface tension from 71.98 mN/m to 26.3 mN/m at that boundary.

Complexes formed by enanthic acid with TEA were studied as an oil collector and oil dispersant in cleaning the water surface clouded with an oil layer with a thickness of 0.17 nm. The effectiveness of this reagent was studied in the laboratory on waters with different degrees of mineralization using the Balakhani light oil sample. The reagent was used both in its pure form and in the form of a 5% aqueous solution. The reduction of the area of the initial oil layer due to the penetration of the reagent into oil-contaminated waters determines its effectiveness. The oil accumulation coefficient is a quantity that characterizes this effect. K is calculated as the ratio of the initial area of the oil layer to the area of the oil spot formed by the effect of the reagent.

Table 3. Research results of the oil collection and oil dispersing ability of the TEA complex of enanthic acid (Balakhani oil; thickness 0.17 mm)

The case of giving the reagent to the surface of the oil	Distilled water		drinkable water		Sea water	
	τ, saat	$K(K_D,\%)$	τ, saat	$K(K_D,\%)$	τ, saat	$K(K_D,\%)$
Undiluted product	0-24 48-72 72-96	Dispersed	0-24 48-72 72-96	Dispersed	0-24 48-72 72-96	Dispersed
5% aqueous dispersion	0-24 48-72 72-96	4 Dispersed	0-24 48-72 72-96	5 Dispersed	0-24 48-72 72-96	Dispersed

As can be seen from Table 2, the complex of Enanthic acid and TEA exhibits the ability to accumulate oil in seawater for both application forms of the reagent.

Table 3. Research results of the oil collection and oil dispersing ability of the TEA complex of undecanoic acid (Balakhani oil; thickness 0.17 mm)

The case of giving the reagent to the surface of the oil	Distilled water		drinkable water		Sea water	
	τ, hour	$K(K_D,\%)$	τ, hour	$K(K_D,\%)$	τ,hour	$K(K_D,\%)$
Undiluted product	0-24 48-72 72-96	15.1 8.7 12.2	0-24 48-72 72-96	10.3 8.7 7.6	0-24 48-72 72-96	Dispersed
5% aqueous dispersion	0-24 48-72 72-96	15.2 2.6 2.5	0-24 48-72 72-96	12.2 3.5 Dispersed	0-24 48-72 72-96	17.3 15.2 11.1

As can be seen from Table 3, the complex of Undecanoic acid and TEA exhibits the ability to accumulate oil in seawater for the 5% application forms of the reagent.

Conclusion

Based on the results of the study, quaternary ammonium salts formed by undecanoic and enanthic acids with TEA show high surface-activity properties, similar to quaternary ammonium salts formed by TEA of other higher carboxylic acids (Shahverdiyeva, 2024: 21-25; Shahverdiyeva, Salamova, 2024: 34-38).

Solutions of new complexes of undecanoic and tetradecanoic acids synthesized on the basis of TEA in different concentrations have oil-dispersing and oil-collecting properties.

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Solar Panels - Reality or Fantasy?

Abstract

Solar panels are used to convert solar energy into electricity. Solar panels are gaining popularity as reliable and almost completely independent sources of electricity. Their operating principle is quite simple, but the equipment complex for generating electricity from sunlight is highly resilient. The continuous pollution of the environment by waste from thermal power plants leads to an increase in atmospheric carbon dioxide concentration, resulting in an intensifying greenhouse effect. This has negative impacts on nature, contaminating drinking water sources, eroding the top layer of soil, and adversely affecting human health. Consequently, it leads to the emergence of diseases in the living nature. To prevent the negative effects of environmental pollution on ecosystems in the modern era, it is both economical and appropriate to utilize alternative energy sources.

The article discusses the main types of solar panels, their advantages and application areas, how and where they should be correctly installed, what components they consist of, whether they can be used in the private sector, and the economic benefits of utilizing modern technologies.

Keywords: *Environmentally friendly, solar panels, electricity supply, solar energy, climate conditions, monocrystalline*

Introduction

Years ago, obtaining free electricity seemed like a fantasy. However, as technology advances, the alternative energy sector is gaining more popularity. Solar panels can indeed be an effective energy source under certain conditions. Therefore, let's take a look at how effective solar panels can be in our climate zone.

The natural climatic conditions in Azerbaijan create opportunities to increase electricity production using solar energy. Our country has between 2400 - 3200 hours of sunshine annually. Therefore, the largest solar power plant in the Caucasus has been established in the Garadag region of our country. The plant has a capacity of 230 MW and utilizes 570,000 solar panels. By 2030, with the construction of solar power plants in Bilasuvar, Neftchala, and Jabrayil, the total capacity generated from solar power plants in our country is expected to exceed 1 GW, surpassing 25% of the total energy production.

Main part: Solar panels can be used to provide electricity for houses, cottages, and vacation homes outside the city. They can also be used for mobile homes and buildings located far from main power transmission lines. In short, they can be utilized anywhere there is space for installation and a need for an additional energy source (1).

Research

Solar panels are a system composed of multiple interconnected photovoltaic cells. The photoelectric effect is the phenomenon where materials emit electrons as a result of light exposure. These cells convert solar energy into electric current. Solar panels can achieve efficiencies of up to 40%, but this requires suitable conditions. Generally, it makes sense to install such systems in areas with many sunny days throughout the year. Additionally, the geographic latitude of your home should be taken into account, as solar radiation diminishes as one approaches the poles. However, if there are many sunny days in your region during the winter season, solar panels can significantly reduce electricity consumption from the city grid.

Solar panels are divided into three main types:

1) Monocrystalline solar panels are made up of many individual cells filled with silicon. This type of solar panel is effectively used in marine transportation due to its water resistance. Monocrystalline panels are characterized by their relatively light weight, compact size, flexibility, reliability, and durability. They are easy to install and are directly dependent on sunlight.

Even light cloud cover can cause a halt in energy production. Monocrystalline solar panels are shown in figure 1.

Figure: 1. Monocrystalline solar panels

2) Thin-film solar panels are a type of solar cells used to convert solar energy. Their main characteristic is that they are made from less material compared to traditional silicon-based solar panels (2). Thin-film solar panels are shown in Figure 2.

Figure: 2. Thin-film solar panels

The thin-film solar panels have several advantages and disadvantages:

Advantages:

Lightweight: Thin-film panels are easier to install on difficult and non-standard surfaces (such as building roofs) because they are lighter and more flexible.

Lower manufacturing costs: The production of these panels requires less energy, which reduces their costs.

Energy production: Thin-film solar panels can perform better in certain weather conditions (such as cloudy or shaded environments).

Flexible materials: These panels can be produced in various shapes and sizes, making them more suitable for custom projects.

Negative aspects:

Lower Efficiency: Thin-film solar panels typically have lower energy conversion efficiency compared to silicon-based solar panels.

Shorter Lifespan: Generally, thin-film panels may have a shorter lifespan, which can be a disadvantage for consumers planning long-term use.

Space Requirement: More extensive solar panels may be needed to produce the same amount of energy (4).

Usage areas:

Thin-film solar panels are typically used on building rooftops, solar power plants, and portable energy systems.

Overall, thin-film solar panels have advantages in specific applications and environments, playing an important role as a modern solution in solar energy production.

3) Half-crystalline solar panels – these panels contain crystals oriented in different directions within the cells. This allows them to capture diffused light and be less dependent on direct sunlight. This type of solar panel is primarily produced in the form of the blue panels we are visually familiar with. They are slightly cheaper than monocrystalline models and are successfully used for lighting homes, administrative buildings, and even streets (5).

Why solar panels specifically?

1. The sun is almost everywhere. As long as there is access to sunlight, electricity can be generated through these devices.
2. Autonomy. There is no need to connect to a central power supply. As a result, it is possible to reduce the overall costs of the home. You are not dependent on the pricing policies of the energy companies in your area.
3. When it comes to running electrical cables to remote villages and farms, sometimes it is cheaper to install solar panels.
4. Environmental cleanliness. This is the main advantage of this technology. There is no need to use non-renewable natural resources, which is well known.

Solar panels can be used in the residential sector. Solar panels can be successfully utilized not only on an industrial scale but also in the field of individual construction. With the start of production of products by local manufacturers, their prices have significantly dropped below those of Western analogs. Over time, the cost of installations decreases, making them more accessible to a wider audience. Manufacturers usually offer their products with a working period of 25 years (3).

Now calculate the number of sunny days in your region. Divide the cost of the equipment by 25 years and then divide that result by the annual sunny days. This will help you determine if these systems are beneficial for you. Additionally, consider the area needed to produce 1 kW of electricity. You can find this information from vendors or consultants who offer solar panels. Also, take into account the active solar radiation period, which is usually during the summer months. Now think about what your electricity needs are during this period. Solar panels can provide excellent lighting solutions. What is often not mentioned in advertising brochures is that the batteries will need to be replaced regularly (6).

Even the most efficient photovoltaic devices first store electrical energy in batteries and then send it to the home's electrical supply system. By being informed about the lifespan, cost, and capacity of regular car batteries, one can determine how much the maintenance of solar batteries will cost. More effective specialized energy storage units will be significantly more expensive and ultimately may not be cheap at all. Additionally, it is important to consider the efficiency of the available models. Even the best ones may not work effectively everywhere, especially in areas with low sunlight. It is known that a battery covered in dust will operate less efficiently. Therefore, it is crucial to think about the timely and regular cleaning of the panel's surface. Furthermore, in hot weather, the electronics may refuse to operate. Currently, these technologies are not accessible to all members of society. However, modern trends indicate that the existing shortcomings will be addressed in the near future, and that scientists will find new methods for producing cheaper models, making them accessible to everyone.

Is it possible to use solar panels for a private home? One of the advantages of a private home is its ability to be modified. This is also possible with alternative energy sources. Solar panels for a private home are, to this day, the best way to provide environmentally friendly electricity for oneself.

Which area to strengthen. Installing solar panels on the roof is clearly an option for private homes, but it is not always the best solution. A south-facing roof naturally provides the best results for fixed solar panel installations, but this is not the only option. In such an installation, it is important for the roof to be oriented southward. Do not position solar panels on the east or west walls. This way, during the most intense hours of sunlight, only vertical light will fall on your panels, significantly reducing the system's efficiency. Solar energy is not produced continuously. It may be abundant during peak hours, but as evening approaches, production completely ceases. The installation of solar panels on the roof is shown in Figure 2 (7).

Figure 3. Installation of solar panels on the roof

Are solar panels cost-effective for individual homes? In Western countries, interest in solar energy largely stems from ecological concerns, with the pursuit of economic benefit being secondary. However, the situation is somewhat different in our local context. If current electricity prices are maintained, a solar battery system installed for a single home and a family of four can pay for itself completely within 4-5 years. During this time, the lifespan of photovoltaic panels is around 20-25 years, but batteries will need to be replaced every 5-7 years, depending on their quality. Currently, electricity prices are not falling worldwide, so over the lifespan of the panels, the system is likely to pay for itself at least 4-5 times.

The composition of a solar energy battery:

1. Solar panels;
2. Controller that manages the charging of the batteries;
3. Batteries. Selecting the right battery is the most challenging task and is the most expensive component of the system;
4. Inverter. Used to convert direct current (DC) into alternating current (AC) at 220V (8).

The elements mentioned above form the basis for building an autonomous energy system based on solar energy batteries. If desired and within your means, you can calculate and enhance the capabilities of the autonomous energy system in your home. This article will help you get started on obtaining alternative energy and building the system by yourself, as well as support further research on the topic.

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Research Methods of the Fundamental Mathematical Characteristics of Quality Indicators in Modern Computer Networks

Abstract

The study of the fundamental mathematical characteristics of quality indicators in modern computer networks is crucial for understanding, analyzing, and optimizing network performance. This study encompasses various mathematical concepts and analysis techniques applied to evaluate network parameters such as latency, throughput, packet loss, jitter, and error rates.

Key mathematical characteristics explored in the study include mean, variance, percentiles, correlation coefficients, probability density functions, confidence intervals, and queueing theory. These mathematical tools provide network professionals with valuable insights into the behavior and dynamics of network systems.

Through statistical analysis, network engineers can assess the central tendency, variability, and distribution of network performance metrics. Mathematical modeling allows for the prediction of network behavior under different conditions and facilitates optimization efforts to improve network efficiency and reliability.

Practical examples demonstrate the application of mathematical analysis in real-world network scenarios, including traffic management, quality of service provisioning, wireless network optimization, and network security. By leveraging mathematical models and statistical tools, network professionals can identify performance bottlenecks, optimize resource allocation, and enhance overall network performance to meet business objectives and user requirements.

Keywords*: Modern computer networks, mathematical characteristics, quality indicators, correlation coefficient, quality of service*

Introduction

In the realm of modern computer networks, ensuring optimal performance, reliability, and efficiency is paramount for meeting the demands of users and supporting a wide array of applications and services. Achieving this goal requires a thorough understanding of the underlying mathematical characteristics of quality indicators within these networks. This study delves into the fundamental mathematical aspects that underpin the evaluation and enhancement of quality indicators in contemporary computer networks.

The quality of a computer network encompasses various metrics, including but not limited to latency, throughput, packet loss, and jitter. These metrics collectively define the network's ability to deliver data reliably and efficiently from source to destination. However, assessing and improving network quality necessitates more than just measuring these parameters; it requires a nuanced understanding of their statistical properties and distribution patterns.

The mathematical characteristics explored in this study provide essential tools for analyzing network performance, identifying potential bottlenecks, and devising strategies for optimization. By leveraging statistical methods and mathematical models, network engineers can gain insights into the behavior of network traffic, anticipate performance issues, and implement targeted improvements to enhance overall network quality.

Through this investigation, we aim to shed light on the pivotal role that mathematical analysis plays in modern network management and optimization. By elucidating the principles underlying quality indicators and their mathematical underpinnings, we strive to empower network practitioners with the knowledge and tools needed to build robust, efficient, and resilient computer networks that meet the evolving demands of today's digital landscape.

Research

Conducting an extensive review of existing research, academic papers, and technical documentation related to quality indicators in modern computer networks. This involves synthesizing information from peer-reviewed journals, conference proceedings, and industry reports to establish a foundational understanding of the topic and identify gaps in knowledge.

Gathering relevant data from operational computer networks or network simulations. This may include collecting network performance metrics such as latency, throughput, packet loss, and jitter from network monitoring tools or conducting controlled experiments to generate empirical data. Analyzing the collected data using statistical methods to uncover patterns, trends, and relationships among quality indicators.

Developing mathematical models to describe the behavior of quality indicators in computer networks. This could involve using queuing theory, probability theory, and other mathematical frameworks to model network processes and analyze network performance. Validating the mathematical models through simulations or empirical data analysis to ensure their accuracy and applicability to real-world scenarios.

Conducting controlled experiments or simulations to investigate the effects of different network configurations, protocols, or traffic patterns on quality indicators. This may involve varying network parameters, introducing simulated network events, or implementing optimization strategies to observe their impact on network performance (Ibrahimov, 2023: 387-397).

Employing statistical techniques to analyze the variability and distribution of quality indicators within network data. This includes calculating descriptive statistics such as mean, median, variance, and percentiles to characterize the central tendency and dispersion of data. Additionally, performing inferential statistics to make inferences and draw conclusions about the population based on sample data.

Collaborating with experts from diverse disciplines such as mathematics, computer science, telecommunications, and network engineering to leverage their expertise and perspectives. This interdisciplinary approach enables the integration of mathematical principles with practical knowledge of network technologies, leading to more comprehensive research outcomes (De Vera D., 131-142).

Investigating real-world case studies or practical applications of mathematical characteristics in improving network quality. This involves analyzing specific network scenarios, identifying performance bottlenecks, and proposing solutions based on mathematical models and analysis techniques.

By employing these research methods, the study aims to advance our understanding of the fundamental mathematical characteristics of quality indicators in modern computer networks and contribute to the development of more efficient, reliable, and resilient network infrastructures.

Fundamental mathematical characteristics. Studying the fundamental mathematical characteristics of quality indicators in modern computer networks is an essential area for evaluating and enhancing the performance, reliability, and efficiency of network systems. Here are several key mathematical characteristics commonly used in analyzing network quality:

This is the primary measure of central tendency, indicating the average value of a quality indicator. For instance, the mean delay time (the time taken for data transmission from sender to receiver) or the average bandwidth (the amount of data that can be transmitted per unit of time) (Deep Singh, 2012).

The mean is one of the fundamental mathematical characteristics used to analyze quality indicators in modern computer networks. In the context of networks, the mean typically refers to the average value of a specific parameter, such as delay time, bandwidth, or packet loss, measured over a certain period of time or at a specific point in the network.

The mean is calculated as the sum of all parameter values divided by the number of these values. The formula for calculating the mean $\bar{x}$ is presented below:

$$\bar{x} = \frac{{}_{i=1}^{n} x_i}{n}$$

where:

x_i - parameter values,

n - number of measurements.

An example of using the mean in the context of computer networks could be calculating the average packet delay time between network nodes over a certain period of time. This allows network engineers to assess the overall performance of the network and identify potential issues such as network congestion or equipment problems.

The mean is an important tool for analyzing network quality, but it is also important to consider other mathematical characteristics such as standard deviation to obtain a more comprehensive understanding of data distribution and possible anomalies in the network.

Variance and Standard Deviation. These measures assess the degree of variability in quality indicator values within the network. For example, the variance of delay time can indicate the variability in data transmission.

Variance and standard deviation are two important mathematical characteristics used to analyze the spread of data around their mean in modern computer networks. They allow for assessing the degree of variation or dispersion of data, which is crucial when studying network quality indicators such as latency, bandwidth, and others.

Variance represents the mean of the squared deviations of each value from the mean value. The formula for calculating the variance σ^2 is as follows:

$$\sigma^2 = \frac{{}_{i=1}^{n} (x_i - \bar{x})^2}{n}$$

where:

x_i- values of the parameter,

$\bar{x}$- the mean,

n - the number of measurements.

Standard deviation is the square root of the variance and is used to measure the average deviation of values from the mean. The formula for calculating the standard deviation σ is as follows:

$$\sigma = \sqrt{\sigma^2}$$

A high standard deviation indicates a large spread of data around the mean, while a low standard deviation indicates that most values are close to the mean.

In the context of computer networks, variance and standard deviation can be used to assess the degree of variation in network parameters such as latency or bandwidth. This helps network engineers and administrators understand how stable the network operates and identify potential issues or anomalies that require attention (İbragimov, 2021: 419-424).

Percentiles. Percentiles allow for evaluating the proportion of quality indicator values that fall below a certain threshold. For instance, the 95th percentile of delay time indicates that 95% of measured delays were below this value.

Percentiles are a statistical measure used to assess the distribution of values within a dataset, including in the context of modern computer networks. They help evaluate the proportion of values that fall below a certain threshold, providing insight into the spread and distribution of data.

In computer networks, percentiles are often used to analyze various quality indicators such as latency, packet loss, or bandwidth. For example, the 95th percentile of latency represents the value below which 95% of latency measurements fall. This indicates the latency level experienced by the vast majority of network traffic, making it a useful metric for understanding user experience and network performance (Beshley, 2016).

Calculating percentiles involves sorting the dataset in ascending order and then determining the value corresponding to a specific percentile rank. The formula for calculating a percentile depends on the interpolation method used, with common methods including linear interpolation or nearest rank interpolation.

By analyzing percentiles in network performance data, network engineers can identify trends, outliers, and potential areas for improvement. For instance, consistently high percentiles may indicate latency issues affecting a significant portion of network traffic, prompting further investigation and optimization efforts. Therefore, percentiles play a crucial role in assessing and improving the quality of service in modern computer networks.

Median. The median is the value that divides an ordered list of values into two equal parts. It helps assess the central tendency of data without considering outliers.

The median is a statistical measure of central tendency that divides a dataset into two equal halves. In the context of quality indicators in modern computer networks, the median is a valuable metric for understanding the typical value of a parameter without being influenced by extreme values or outliers.

To compute the median, the dataset is first sorted in ascending order, and then the middle value is selected as the median. If the dataset has an odd number of values, the median is the middle value. If the dataset has an even number of values, the median is the average of the two middle values (Ibrahimov, 2021: 1-4).

In computer networks, the median can be applied to various quality indicators such as latency, throughput, or packet loss. For example, calculating the median latency provides insight into the typical delay experienced by network traffic, disregarding any extreme delay values that may skew the results.

By utilizing the median, network engineers and administrators can better understand the central tendency of network performance metrics, allowing them to make informed decisions regarding network optimization and troubleshooting. Additionally, the median complements other statistical measures such as the mean and standard deviation, providing a more comprehensive understanding of network behavior and performance.

Correlation Coefficient. This parameter assesses the degree of linear dependence between two quality indicators. For example, the correlation between delay time and bandwidth can indicate how one parameter affects the other.

The correlation coefficient is a statistical measure used to determine the strength and direction of the relationship between two variables. It indicates how much one variable changes in relation to another variable. In the context of modern computer networks, the correlation coefficient is a valuable tool for understanding the association between different network performance metrics (Kornilov, 2017: 35-42).

The correlation coefficient typically ranges from -1 to 1. A correlation coefficient of 1 indicates a perfect positive correlation, meaning that as one variable increases, the other variable also increases in a linear fashion. A correlation coefficient of -1 indicates a perfect negative correlation, where one variable decreases as the other increases. A correlation coefficient of 0 suggests no linear correlation between the variables.

In computer networks, the correlation coefficient can be calculated between various quality indicators such as latency, throughput, packet loss, and network congestion. For instance, a positive correlation between latency and packet loss might suggest that higher latency is associated with higher packet loss, indicating potential network congestion issues.

To compute the correlation coefficient, mathematical formulas such as Pearson's correlation coefficient are commonly used. Pearson's correlation coefficient measures the linear relationship between two variables by dividing the covariance of the variables by the product of their standard deviations (Stepanov, 2010: 221).

By analyzing the correlation coefficient, network engineers and administrators can gain insights into the relationships between different network performance metrics. This enables them to diagnose network issues more effectively, prioritize optimization efforts, and make informed decisions to improve overall network performance and reliability.

Probability Density Function (PDF). The PDF describes the probability of a random variable taking on a particular value. It provides a comprehensive understanding of the distribution of quality indicators in the network.

A Probability Density Function (PDF) is a mathematical function that describes the probability distribution of a continuous random variable. In the context of modern computer networks, PDFs are utilized to model and analyze various quality indicators such as latency, throughput, and packet loss.

The PDF provides information about the likelihood of different values occurring within a given range for a continuous variable. Unlike discrete probability distributions, where each value has an associated probability, PDFs describe probabilities over intervals for continuous variables. The area under the PDF curve within a specific interval represents the probability of the variable falling within that interval.

PDFs are often characterized by their shape, such as Gaussian (normal) distribution, exponential distribution, or uniform distribution, depending on the characteristics of the data being modeled. For example, latency in computer networks often follows a Gaussian distribution, with most values clustered around the mean latency and fewer values occurring at higher or lower latencies.

Mathematically, the PDF is represented by a function $f(x)$, where x is the variable of interest. The PDF function satisfies the following properties:

1.The area under the PDF curve over the entire range of possible values equals 1.

2.The PDF is non-negative for all values of the variable x

PDFs play a crucial role in analyzing network performance, as they provide insights into the probability distribution of quality indicators. By understanding the PDF of network parameters, such as latency or throughput, network engineers can anticipate potential performance issues, optimize network configurations, and improve overall network reliability and efficiency.

Confidence Intervals. Confidence intervals are used to estimate the range of values within which the true value of a quality indicator lies with a certain probability.

Confidence intervals are a statistical concept used to estimate the range of values within which a population parameter, such as a mean or proportion, is likely to lie. In the context of modern computer networks, confidence intervals are employed to assess the precision of estimated network performance metrics based on sampled data.

A confidence interval consists of a lower bound and an upper bound, providing a range of values that is believed to contain the true value of the population parameter with a certain level of confidence. This level of confidence, often denoted by $1-\alpha$, represents the probability that the true parameter falls within the interval. Common choices for the confidence level include 95%, 99%, or other predetermined values.

The calculation of a confidence interval typically involves the sample mean (for estimating the population mean) or sample proportion (for estimating the population proportion), along with the standard error of the estimate. The standard error quantifies the variability of the estimate due to random sampling (Başarin, 2009: 342).

For example, in estimating the mean latency of a computer network based on a sample of latency measurements, a 95% confidence interval might indicate that we are 95% confident that the true population mean latency falls within the calculated interval.

Mathematically, a confidence interval is expressed as:

$$\text{Confidence Interval} = \text{Point Estimate} \pm \text{Margin of Error}$$

where:

- Point Estimate is the sample statistic (e.g., sample mean or proportion),
- Margin of Error is a measure of the variability of the estimate, usually computed based on the standard error and the critical value from the appropriate probability distribution.

Confidence intervals provide valuable information about the precision and reliability of estimated network performance metrics, allowing network engineers to make informed decisions and draw meaningful conclusions about network behavior and quality.

Queueing Theory

This mathematical theory is employed to analyze and model network queues and service levels, predicting network performance based on various factors such as load and bandwidth.

Queueing theory is a branch of applied mathematics that studies the behavior of waiting lines, or queues, in systems where entities, such as customers, requests, or packets, arrive at a service facility and wait for service. In the context of modern computer networks, queueing theory is widely used to analyze and model the performance of network systems, including routers, switches, and servers.

Key concepts in queueing theory include:

1. Arrival Process. Describes how entities arrive at the system. This may follow a Poisson process, where arrivals occur independently at a constant rate, or other arrival patterns such as deterministic or non-homogeneous arrivals.

2. Service Process. Defines the service provided to entities in the system. This may involve processing requests, transmitting data packets, or servicing customers. The service time can be constant or follow a probability distribution.

3. Queue Discipline. Specifies the rules for determining which entity is served next when multiple entities are waiting in the queue. Common queue disciplines include first-in-first-out (FIFO), priority queues, and shortest remaining processing time.

4. Queueing Models. Mathematical models that represent the behavior of queues in various network scenarios. These models can be analyzed to understand performance metrics such as queue length, waiting time, and system throughput.

5. Performance Measures. Metrics used to evaluate the performance of queueing systems, including average queue length, average waiting time, and system utilization. These measures provide insights into system efficiency, responsiveness, and resource utilization.

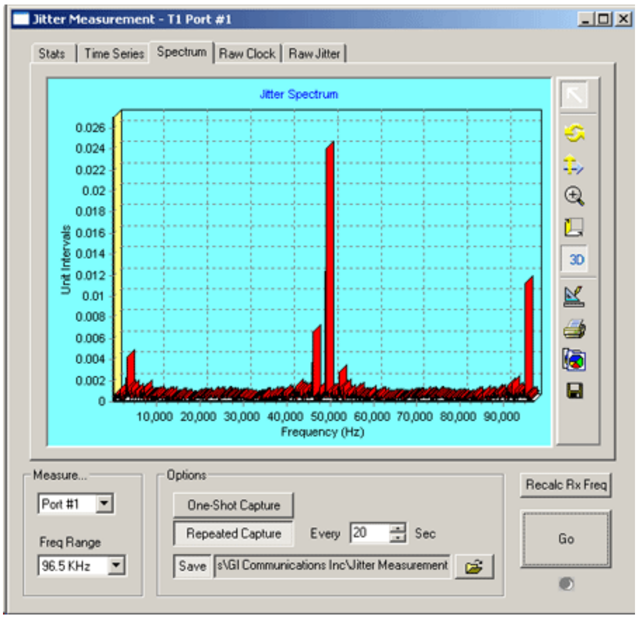
Queueing theory allows network engineers and administrators to predict and optimize the performance of computer networks by understanding the behavior of queues under different traffic loads, network configurations, and service policies. By modeling and analyzing queueing systems, network professionals can identify bottlenecks, optimize resource allocation, and design efficient network architectures to meet performance requirements and enhance user experience (Stepanov, 2010: 392).

Studying these mathematical characteristics enables network engineers and administrators to gain deeper insights into network behavior, identify issues, and optimize network operations to meet user requirements.

Practical Examples. Latency Analysis. Network engineers conduct a study to analyze the fundamental mathematical characteristics of latency in a cloud-based application environment. By collecting latency measurements from various network nodes and endpoints, they calculate descriptive statistics such as mean, median, and variance to characterize the latency distribution. This analysis helps identify latency outliers, assess the typical latency experienced by users, and optimize network configurations to reduce latency and improve application responsiveness.

Bandwidth Utilization Study. A research team investigates the mathematical characteristics of bandwidth utilization in a corporate network environment. They collect network traffic data from switches and routers and analyze the bandwidth usage patterns over time. By calculating percentiles and confidence intervals of bandwidth utilization, they gain insights into peak traffic periods, network congestion points, and resource allocation inefficiencies. This study enables network administrators to optimize bandwidth provisioning, implement Quality of Service (QoS) policies, and prioritize critical applications to ensure optimal network performance.

Packet Loss Analysis. Network analysts conduct a study to assess the mathematical properties of packet loss in a wireless communication network. Using packet capture tools and network monitoring software, they collect packet loss data under various network conditions and environmental factors. By analyzing packet loss statistics, such as mean packet loss rate and standard deviation, they identify factors contributing to packet loss, such as signal interference, network congestion, and hardware failures. This analysis informs network optimization strategies, such as adjusting transmission power levels, optimizing channel allocation, and implementing error correction mechanisms to mitigate packet loss and enhance network reliability.



Jitter Measurement. A team of researchers investigates the mathematical characteristics of jitter in Voice over IP (VoIP) networks. They conduct experiments to measure jitter values between network endpoints and analyze the distribution of jitter measurements over time (Mironov, 2010: 297). By calculating percentiles and confidence intervals of jitter, they quantify the variability of packet arrival times and assess the impact on voice quality and user experience. This study guides network engineers in implementing jitter buffering techniques, optimizing network routing paths, and prioritizing real-time traffic to minimize jitter and ensure high-quality VoIP communication.

Error Rate Analysis._A network security team conducts a study to analyze the mathematical characteristics of error rates in network intrusion detection systems (IDS). They collect log data from IDS sensors and analyze the frequency and distribution of detected security events. By calculating error rates and false positive rates, they evaluate the effectiveness of IDS algorithms and signature-based detection methods. This analysis helps improve threat detection accuracy, fine-tune IDS rule sets, and enhance network security posture against cyber threats and attacks.

These practical examples demonstrate how studying the fundamental mathematical characteristics of quality indicators in modern computer networks enables network professionals to analyze network performance, diagnose issues, and optimize network operations to meet business objectives and user requirements.

Conclusion

The research methods of the fundamental mathematical characteristics of quality indicators in modern computer networks is essential for understanding, analyzing, and optimizing network performance. Through the examination of key mathematical concepts such as mean, variance, percentiles, correlation coefficients, probability density functions, confidence intervals, and queueing theory, network professionals gain valuable insights into the behavior and dynamics of network systems.

This study has provided a comprehensive overview of how mathematical analysis techniques can be applied to assess various quality indicators in computer networks. By employing statistical methods, mathematical models, and practical examples, network engineers and administrators can effectively evaluate network performance metrics such as latency, throughput, packet loss, jitter, and error rates.

The analysis of quality indicators facilitates the identification of performance bottlenecks, optimization opportunities, and areas for improvement within network infrastructures. By understanding the statistical properties and distribution patterns of network parameters, network professionals can make informed decisions regarding network design, configuration, and resource allocation to enhance overall network reliability, efficiency, and user satisfaction.

Furthermore, the integration of mathematical analysis into network management practices enables proactive monitoring, predictive analysis, and adaptive control of network environments. By leveraging mathematical models and statistical tools, network professionals can anticipate network behavior, mitigate performance issues, and optimize network operations in real-time to meet evolving business needs and user demands.

In conclusion, the study of the fundamental mathematical characteristics of quality indicators in modern computer networks serves as a cornerstone for advancing network engineering practices, enabling the design, deployment, and management of robust, resilient, and high-performing network infrastructures in today's dynamic and interconnected digital world.

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Improvement of Devices in the Development of Catalytic Cracking Process in Azerbaijan

Abstract

The catalytic cracking process was first applied on an industrial scale in 1936 and has been an important process in the oil refining industry of many countries since then.

Among the catalytic processes proposed for the processing of oil fractions in Azerbaijan, the catalytic cracking process occupies one of the first places due to its importance.

The achievements achieved in the catalytic cracking process in the late 20th and early 21st centuries are determined by 88 years of development experience, technical and economic indicators of the market economy and oil refining enterprises. This fact requires constant improvement of the technology of the process and catalysts in order for it to take a comprehensive place among the oil refining processes and become multi-directional.

The development of the catalytic cracking process in industry is based, first of all, on the fundamental work of the Russian scientists in the field of catalytic conversion of hydrocarbons, which belongs to the school of academician N.D.Zelinsky and academician S.V.Lebedev. These works include the work of S.V. Lebedev and his students in the field of contact-catalytic polymerization and depolymerization of olefins on active aluminosilicates, the work of N.D.Zelinsky and other leading scientists of his school on the development of theoretical problems of catalysis .

L.G.Gurvich, S.V.Lebedev N.D.Zelinsky's research gave rise to the practical application of aluminosilicate catalysts in the conversion of hydrocarbons. These works were carried out before the first works on the catalytic cracking process on natural and synthetic aluminosilicates were published abroad.

The rapid development of the catalytic cracking process has created conditions for the successful combination of a wide range of processing capabilities for a wide range of raw materials, from light distillate fractions in the process to heavy vacuum gas oils and even residual fractions of oil. The results of research on the development of catalytic cracking systems with rising catalyst flow at the Institute of Petrochemical Processes named after academician Y.H. Mammadaliyev of ANAS (NKPI) were first presented at the Ufa All-Union meeting in July 1963.

The first monograph devoted to this issue was published in 1966 (Aliyev, Rustamov, Pryanikov, 1966). This monograph describes the scientific foundations of catalytic cracking in direct and partially counterflow systems, the indicators of the catalytic cracking process in various modified systems with rising flow.

Based on the research conducted by scientists of the National Research Institute of Chemical and Petroleum Engineering of the Azerbaijan Academy of Sciences, information is provided on the reconstruction of catalytic cracking units with finely dispersed catalysts at the refinery using direct and partially counterflow reactors.

In 1982, academicians Aliyev V.S., Rustamov M.I. Pryanikov E.I. received the Azerbaijan State Prize for the application of the two-stage catalytic cracking process of oil raw materials to industry (Aliyev, Rustamov, Pryanikov, 1966: 5-15).

Keywords: *Catalytic cracking process, oil wells, fluidized bed, small-dispersed catalyst, catalytic cracking units, improvement of catalytic cracking units*

Introduction

The catalytic cracking process was first applied on an industrial scale in 1936 and has been an important process in the oil refining industry of many countries since then.

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The achievements achieved in the catalytic cracking process in the late 20th and early 21st centuries are determined by 88 years of development experience, technical and economic indicators of the market economy and oil refining enterprises. This fact requires constant improvement of the technology of the process and catalysts in order for it to take a comprehensive place among the oil refining processes and become multi-directional (Problemi, 2000).

The main stages of development of the catalytic cracking process are as follows:

- transition from stationary catalyst layer catalytic cracking to cracking with a false layer of microspherical catalyst;
- development of a zeolite catalyst;
- hydrotreating of raw materials;
- cracking in a high-flow microspherical catalyst lift reactor;
- catalyst regeneration in a regenerator with complete combustion of CO to CO_2.

The development of the catalytic cracking process in industry is based, first of all, on the fundamental work of the Russian scientists in the field of catalytic conversion of hydrocarbons, which belongs to the school of academician N.D.Zelinsky and academician S.V.Lebedev. These works include the work of S.V.Lebedev (Gutyrya, 1968) and his students in the field of contact-catalytic polymerization and depolymerization of olefins on active aluminosilicates, the work of N.D.Zelinsky and other leading scientists of his school on the development of theoretical problems of catalysis.

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The catalytic cracking process of petroleum raw materials has undergone major changes in terms of equipment and technology up to the present time.

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Research

In the development of the catalytic cracking process in Azerbaijan, catalytic cracking units, which play a key role in this process, play an important role. These units have been improved over time. Let's look at how these units have improved below (Kon, Zelkind, Shershun, 1968: 100-111).

The first industrial catalytic cracking unit with a circulating dust catalyst of the "model 1" type, the diagram of which is shown in Fig. 1, was put into operation in 1942.

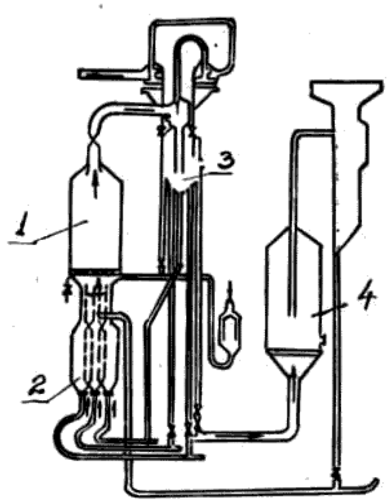

Fig.1. Schematic diagram of the installations.
Model 1. 1-Regenerator, 2-cooler for the regenerator, 3-bunker, 4-reactor

In this installation, the entire mass of circulating powdered catalyst passed through the reactor and regenerator from the bottom up and was discharged entirely from the top of these devices in a mixture with gaseous reaction products. The most characteristic feature of model 1 installations is the upper discharge of circulating catalyst from the reaction devices. The flow of air or oil vapors is separated from the catalyst in cyclone separators. These units are interesting not only as the first industrial units with a finely dispersed catalyst, but mainly because the reaction and regeneration here are carried out under flow transport conditions at relatively high densities of the gas catalyst flow. Consequently, the principles of catalytic cracking in this unit are substantially the same as those of contacting and reactions in a fluidized bed.

In 1951, after the reconstruction of one of the units of the model, its capacity was increased to 7,000 tons of raw materials per day. Judging by the literature, model 1 units were not widely used and were replaced due to the following main disadvantages inherent in them:

• Significant length of catalyst wires and high hydraulic resistance of the catalyst circulation system.

• The need to use large cyclone separators designed to capture the entire amount of circulating catalyst.

• Increased catalyst wear and, consequently, its high consumption.

• The bulkiness of the installation and its insufficient operational flexibility. The height of this installation reached 70 meters. The next step in the development of catalytic cracking technology was the appearance of installations of the model 11 type, the diagram of which is shown in Fig. 2.

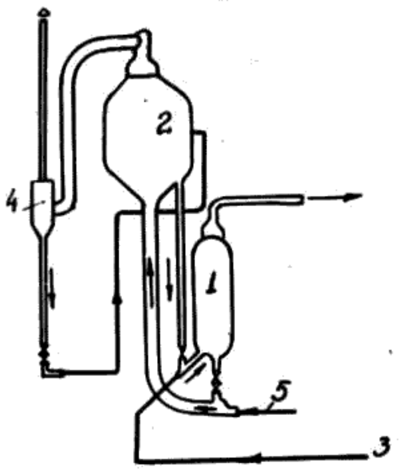

Fig. 2. Schematic diagram of the installations
Model 2. 1- Reactor, 2- Regenerator, 3- Raw material, 4- Electrostatic precipitator, 5- Air

A characteristic feature of these units was the introduction of the hydrodynamic regime of a boiling bed of finely dispersed catalyst with a downward catalyst flow into the practice of catalytic cracking. In other words, in these units the gas velocity in the reactor decreased, as a result of which the solid phase was concentrated in the gas flow, forming a dense turbulent layer with a sharply expressed upper level. Thus, here only an insignificant part (approximately 5%) of the total amount of circulating catalyst enters the cyclones for dust collection and the main part of the catalyst is in the devices.

As a result of the transfer from top to bottom of the place of catalyst output from the reactor and regenerator and the simultaneous reduction of speeds in these devices, the catalyst circulation scheme was simplified, and the hydraulic resistance of the system was reduced.

Both this made it possible to reduce the overall height of the unit to 50-55 meters, reduce metal consumption, and reduce the size of capital costs and operating costs. However, the height of the unit still remained large. The improvement of catalytic cracking units with the aim of reducing their initial cost and operating costs by reducing the height led to the development of the Model III unit, the schematic of which is shown in Fig. 3.

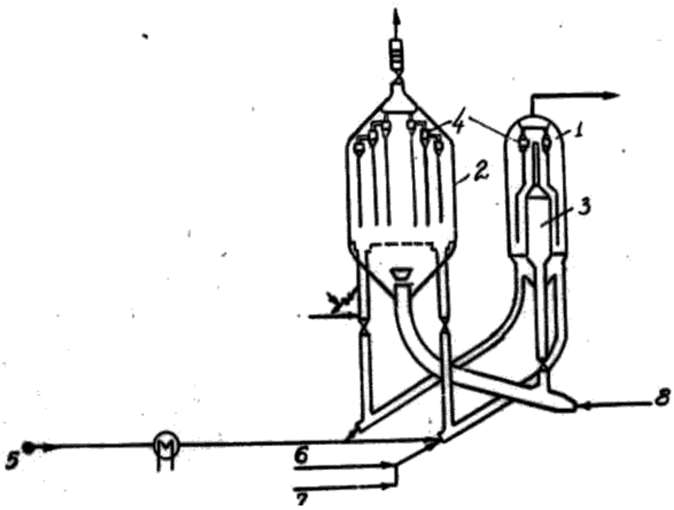

Fig. 3. Basic technical diagram of the installations.
Model 3 1- Reactor, 2- Regenerator, 3- Steam separator, 4- Cyclones, 5- Raw material, 6- Water vapor, 7- Risauk, 8- Air

The characteristic difference of this installation is the location of the reactor and regenerator on the same level, the reduced volume of the regenerator and the fact that it has a lower height - 37-40 m. All this was achieved due to a slight increase in pressure in the regenerator. In the series of model installations, the last are theinstallations of model IV, the basic diagram of which is shown in Fig. 4.

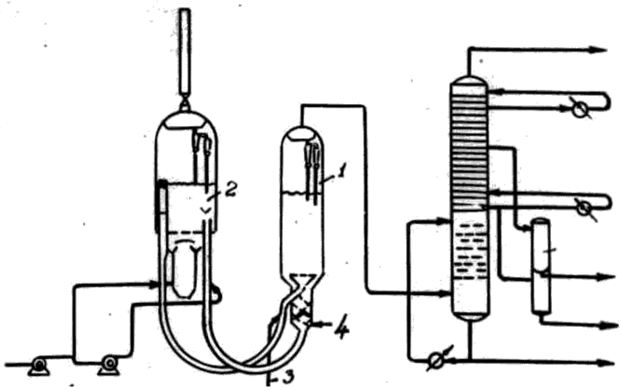

Fig.4. Schematic diagram of the installations.
Model 4. 1- Reactor, 2- Regenerator, 3- Raw material, 4- Air
Model IV resembles model III in its arrangement of equipment.

The implementation of catalyst transport in a dense layer along U-shaped catalyst pipes allowed the "model IV" type units to have all the advantages of "model III" type units without increasing the pressure of all the air supplied to the regenerator.

In model IV units, the intensity of catalyst circulation between the reactor and the regenerator is regulated mainly by changing the equality of flow densities by supplying a larger or smaller amount of air to the upper section of the spent catalyst pipeline.

The velocity of gas movement in the reactor and regenerator is approximately twice as high here as in model III units, and boiling layers in the units are formed at the maximum permissible velocities of gas-steam flows.

In addition to the above-considered cracking units of the model series, units of other types have also found industrial application. First of all, these include the Orthoflow type units and those of Union Oil Products (UOP) (Ismayilova, 2008, 126-127).

Both of the named types of installations are distinguished by the use of a combined apparatus, in which the reactor and regenerator are enclosed in a common housing, and the Orthoflow type installations have two models - "A" and "B", which are aligned in the mutual arrangement of the reactor and regenerator.

Fig. 5 shows the diagram of the Orthoflow installation of model "A", and Fig. 7 and model "B" .

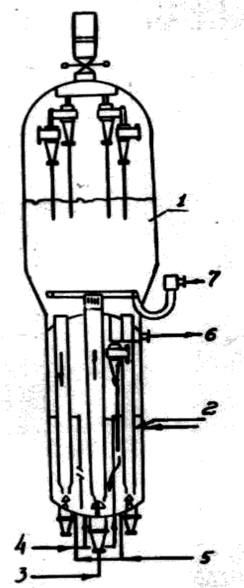

Fig. 5. Basic-technical installation of catalytic cracking orthoflow scheme "A" type
1-Reactor, 2-Regenerator, 3-air, 4-Steam, 5-Raw material, 6-catalyst, 7-air

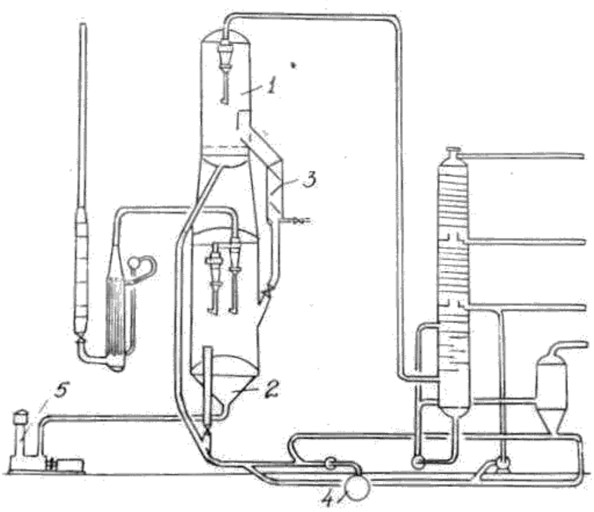

Fig. 6. Basic technical scheme of the UOP type installations.
1-Reactor, 2-Regenerator, 3-Stripping section, 4-Raw material, 5-air

When considering both schemes, it is necessary to note the original design layout and compactness of the design. The main advantage of this type of installations is the use of a vertical (without bends and turns) catalyst pipeline, which minimizes abrasive wear of the equipment.

In addition to the original design solution of the general layout of the system, Orthoflow installations differ from other installations by the presence of a direct catalyst flow without the use of a driving agent from the reactor to the regenerator for model "A" and from the regenerator to the reactor for model "B".

There is an indication in the literature that from a mechanical point of view it is easier to place the reactor under the regenerator, since the diameter of the regenerator is larger.

This principle is the basis for the modern version of the catalytic cracking process in a boiling bed of the company "UOP". A typical diagram of one of the installations of this company is shown in Fig. 6. In these installations, like Orthoflow installations, the principle of direct catalyst flow from one device to another is preserved. At the same time, the lifting catalyst pipeline in these installations is curved. In addition to the listed installations with a boiling bed of finely dispersed catalyst, a number of other installations are known abroad. For example, there is an installation in which the spent catalyst enters the regenerator not directly from the reactor but through a pressure bunker-separator and the coked catalyst is transported not by air but by water vapor. However, due to the fact that their total number is small and they represent only a modification of the installations described above, we will not dwell on them. At the same time, we note that we deliberately did not touch on industrial installations, although few, but described in the literature, in which a tendency to intensify the catalytic cracking process is outlined. These are installations for 2-stage cracking and with a sectioned boiling bed. These units will be discussed below (Ismaılova, 2024).

At the end of the 20th century, in the research conducted in the field of catalysis, a relationship was established between the surface properties of celite-containing catalysts, coking, and the influence of this factor on the activity and selectivity of the catalytic cracking process. A distinctive feature of the studies was the study of these patterns in the first seconds of contact of the feedstock with the catalyst.

The results obtained made it possible to model the catalyst by the height of the reactor and regulate the surface properties of the catalyst by its coking. This became the scientific basis for the creation of a technology for processing unstable gasolines and were confirmed during the processing of pyrocondensate at the G-43-107 catalytic cracking complex (Rustamov, 2006).

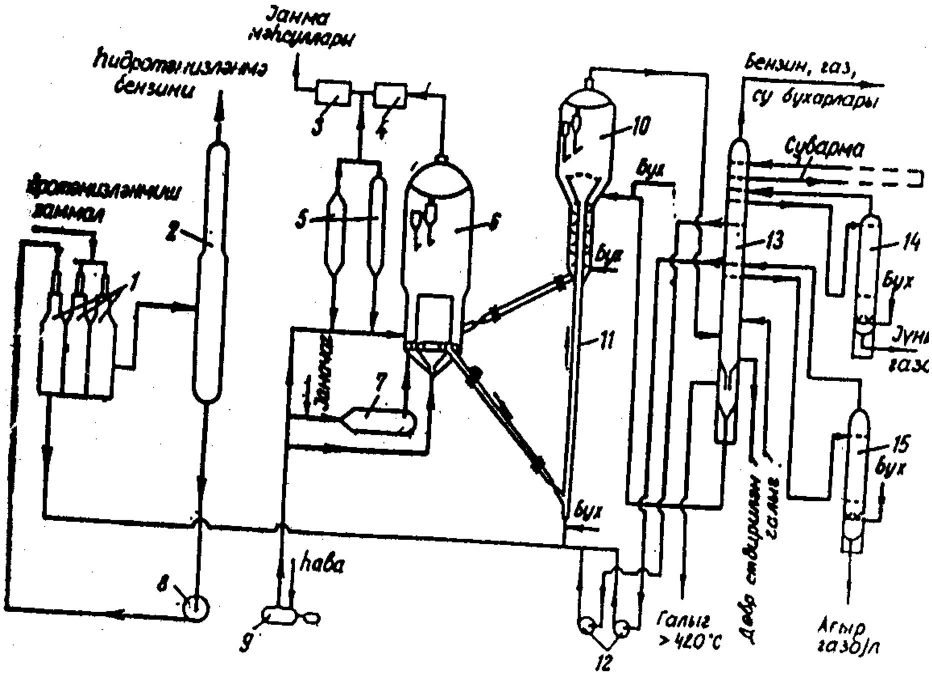

Fig. 7. G-43-107 catalytic cracking unit

The table presents data characterizing the distribution of some of the above-described units in the USA, their process parameters, characteristics of raw materials and products obtained.

To summarize the above, it becomes obvious that since the start-up of the first units, the design of the devices and units as a whole has been significantly improved. As a result of this improvement, the units have become much simpler and more compact.

Ultimately, the need for metal for the construction of units and their cost is currently approximately three times less than for the first catalytic cracking units.

The main improvement of the units was aimed primarily at reducing the cost of the process by reducing capital investments and consisted of the following:

• the catalyst capture system has been simplified;
• the dimensions of the units have been reduced and the overall height has been reduced;
• the catalyst circulation system has been simplified and made more compact;
• the layout of the units has been improved;
• the productivity of the units has been increased.

However, this improvement did not have any significant effect on the essence of the process itself and the yield of target products (as can be seen from the table), therefore, along with the above improvement of the units, a lot of work was done to further develop the catalytic cracking process. The most important moments in the development of the process were the work on deepening the process, involving high-boiling gas oil fractions for cracking, developing new types of catalysts, etc. At that time, as a result of generalizing a large number of research works and accumulated experience in the operation of units with a boiling catalyst bed, serious shortcomings inherent in this method of contacting were revealed. It was necessary to outline ways of further intensifying the process based on a deep study of the catalytic cracking process occurring in hollow contactors using a boiling bed of finely dispersed catalyst (Ismayilova, Gasimzade, Huseyinova, 2008: 52-56).

Academician M.I. Rustamov, together with GrozNI II and VNNII NP, developed a new catalytic cracking complex Q-43-107, which is distinguished by its higher productivity and metal capacity, using rising-flow reactors. The Q-43-107 unit is a combined unit that includes a vacuum gas oil hydrotreating unit, catalytic cracking of hydrotreated vacuum gas oil in a vertical lift reactor, and gas fractionation. This system is very effective, as it allows using all the advantages of zeolite-containing catalysts, providing high yields of gasoline, propane, propylene, butane and butylene fractions. Currently, the Q-43-107 unit has been successfully used at oil refineries in Moscow, Mozheyky, Burgas, Ufa, Pavlodar, Angarsk, Lisichansk. One of the technical specifications of the process has been sold abroad under license. Over the past 3 years, the use of the Q-43-107 complex in Baku has brought 750 billion manats to the state budget. According to European experts, at present this facility is on a par with its foreign counterparts and is the only facility in the former USSR oil refineries that does not need any serious modernization (Ismaılova, 2024).

Conclusion

The results of numerous scientific research works of Azerbaijani scientists were the first experimental-industrial catalytic cracking unit with a circulating finely dispersed catalyst, which was put into operation in Baku in the middle of the 20th century. Based on the experimental results obtained, it was recommended to design the first industrial catalytic cracking unit of oil raw materials with a powder catalyst. Here, the kerosene-gasoil fraction of Baku oils boiling at a temperature of 200-350 ^{0}C was used as raw material.

The technology of the catalytic cracking process developed by Azerbaijani scientists made it possible to solve the problem of high-quality gasoline production. This technology found wide application in the former USSR and abroad. The product of the catalytic cracking process was gas, which, along with high-octane gasoline, was a valuable raw material for petrochemical synthesis.

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Basic Technologies for Emergency Management

Abstract

In our modern era, emergencies are inevitable. Emergency situations are situations that have arisen in a certain area as a result of military operations, accidents, natural or other disasters that may or have caused human casualties, damage to human health or the environment, significant material losses and disruption of people's living conditions.

In order to manage emergencies and take adequate measures against them, they are classified according to their types, types, scale, severity of consequences, as well as other characteristics. When we look at the development of human society, it becomes clear that emergencies have occurred in all historical periods. Historical facts show that most emergencies have resulted in disruption of life, numerous human deaths, serious changes in the natural world, and great damage to people and the environment. In the early stages of human society, emergencies were mainly natural in nature and were associated with spontaneous disasters.

All types of emergencies go through 4 stages (phases) in their development:

1. The emergence and accumulation of circumstances that differ from the normal situation or state. This situation can last for several days, months, and in some cases - for years and decades.
2. Initiating the situation that is the basis of the emergency.
3. The process of the occurrence of an emergency - this is the process of releasing risk factors (energy or matter) that negatively affect the population, objects, and the environment.
4. The stage of reduction, extinction - the reduction of the impact of residual factors of the emergency that has occurred. This stage covers the period from the prevention (reduction) and localization of the source of danger to the complete elimination of its consequences. The duration of this stage can last for years.

Keywords: *emergencies, human, safety, management, event*

Introduction

The modern period of development of society is characterized by increasing contradictions between man and his natural environment. The technosphere and the method of management created by it have become powerful factors affecting nature. Demographic explosion, industrial production, which is becoming obsolete from year to year, agriculture in a state of deep crisis, urbanization of territories and all this are some of the challenges that man poses to nature and have led to a high degree of aggravation of contradictions between society and natural environment. Natural disasters and catastrophes aggravate them even more. A sharp increase in the population increases anthropogenic pressure and poses a serious threat to environmental safety.

There are many known objective and subjective reasons for the steady trend of an increase in the number of emergencies from year to year and an increase in their severity. In the fight against emergencies, their prediction and prevention, as well as management, should be at the forefront, which is actively carried out by the relevant state-level services (Ministry of Emergency Situations of the Republic of Azerbaijan), but the objective reality is that it is impossible to completely prevent them. It can be said with confidence that emergencies in Azerbaijan are inevitable. Therefore, the elimination of emergency situations that have already occurred is considered one of the most important tasks set in the unified state system for the prevention, management and elimination of the consequences of emergency situations. They are based on the creation of a regulatory legal framework and the implementation of measures to protect the population and territories from emergency situations during wartime, as well as on the conduct of state expertise and control in the field of protecting the population and territories from natural and man-made impacts (Anas, Wikantika, Ali, Abujayyab, Hashempour, 2024: 1-3).

Emergency situations management is a comprehensive concept that covers all aspects of the management activities of the unified system for the prevention and elimination of the consequences of emergency situations and, above all, the knowledge and skills of their leaders. It is based on a number of principles, the main of which are the following:

a) centralization of management with the provision of broad initiative to subordinate structures in determining the rules for the implementation of the tasks assigned to them;

b) firmness and determination in the implementation of decisions and plans;

c) prompt and flexible response to changes in the situation;

d) personal responsibility of managers for the decisions made, the use of subordinate forces and the results of the fulfillment of the tasks assigned to them.

All of the above indicates the relevance of the study and indicates the management of emergency situations and, accordingly, the sphere of management of the prevention of emergency situations and the elimination of their consequences.

It is necessary to determine the goals and ways of implementing the management strategy in the field of prevention and elimination of emergency situations, and here the main goal and strategy are determined, which include the prevention of the causes of emergency situations, as well as the prevention of the events themselves and minimizing their consequences.

In order to implement Civil Defense measures in emergencies in a short time and in an organized manner, it is necessary to plan their implementation in advance. The scope, sequence and implementation terms of work to be carried out during emergencies are determined in the civil defense plan. This plan is an action plan for fulfilling the tasks arising during emergencies and is the main document for managing civil defense in such cases. Currently, Civil Defense Plans are being developed in the civil defense system, including in most industrial and social facilities. The civil defense plan determines the procedure for organizing work to be done to protect workers, production, and eliminate the consequences of these events during emergencies (Seyfullayeva, Ələkbərova, Məmmədova, 2006: 43-89).

Research

In the Republic of Azerbaijan, a unified State Emergency System (SESS) operates to provide civil protection, protection of the population and territories from emergencies, as well as prevention and elimination of the consequences of emergencies, and ensures the management of this area. The SESS includes relevant ministries, state committees and companies, as well as state groups equivalent to them.

SESS means the purposeful activity of management bodies at all levels to prepare all forces and means for the prevention and elimination of emergencies and to maintain them in a constant state of readiness for the population, economic facilities and personnel who will lead the elimination of emergencies.

Management is a field of scientific research and practical activity, based on approaches to management problems in terms of management skills. The basis of the mathematical approach is the formal quantification of models and the implementation of algorithms. Management is an intellectual skill based on existing heuristic procedures for decision-making, that is, logical and methodological methods of theoretical research, which are associated with the knowledge, experience, worldview of the management staff, heads of services and other persons participating in the management process. Together, these two approaches constitute a systematic approach to the issue.

The practical activities of officials in the management bodies of the Ministry of Emergency Situations (MES) at various levels are based on guiding documents. The basis of these documents is the results of research conducted using a systematic approach in the field of management. In order to understand them and use them creatively, all MES specialists must know the features of the civil protection system and the basics of management theory (Moe, 2012: 42-51).

Identification of the main concepts of civil protection management, definition of concepts and stages of the management process, characteristics of the management process in various conditions; understanding of the general theory of decision-making, quality and effectiveness of decisions; the essence of decision-making and types of their support. These concepts are considered basic (basic) concepts for further consideration of the stages of the process of managing the activities of the SESS in various regimes in peace and war conditions and the decision-making process.

The organization of emergency management is a set of interconnected measures and actions of control bodies and forces aimed at ensuring the efficient use of forces and means for various purposes in order to carry out rescue and other urgent work in full, in the shortest possible time, with minimal loss of population. An emergency begins from the moment an emergency occurs and ends after its elimination. is carried out in daily periods, each of which includes the following:

1. collection of information about the situation;
2. analysis and assessment of the situation;
3. preparation of opinions and proposals for making decisions on the conduct of work;
4. making (clarifying) decisions and delivering tasks to executors;
5. organization of interaction;
6. ensuring the movement of forces and means.

Emergency situations are carried out in accordance with the plan of measures for the prevention and elimination of emergency situations, prepared in advance at each level and regulated by the occurrence of a specific emergency situation. On this basis, taking into account the characteristics of the emergency situation, the emergency person makes a decision on the elimination of the emergency situation, rescue and other urgent work. When preparing the decision, planning of emergency rescue and other urgent work is carried out.

The organization of management during emergency situations is carried out as follows:

• locations, composition, protective measures and rules for the operation of operational groups at the point of main, reserve and auxiliary control points;

• rules for equipping control points with communication, warning and information means and using them;

• rules for notifying management personnel and employees about the expectation or occurrence of emergency situations;

• organization of management of civil defense forces and means in the modes of "daily operation", "high readiness" and "emergency";

• organization of communication with civil defense forces, measures for restoring control in case of disruption.

A management stage is a part or time interval of a management process during which an intermediate goal (for example, assessment of the situation, etc.) is fully achieved within a given period of time. Stages in the management process sequentially replace one another, that is, the completion of a previous stage ensures more effective implementation of more important tasks at the next stage, and thus creates conditions for achieving the final goal of the management process. It is possible for stages to overlap in time, therefore, the total duration of the management process is not equal to the sum of the durations of all its stages. However, no previous stage of the management process can be completed later than the stage following it (Kaneberg, 201: 350-374).

The task of management is the desired result of management activities within a given period of time (time interval). The function of management is the total sum of management activities performed to ensure the achievement of the set goal.

A phase of management is the state of the management process over a certain period of time. This means that the concepts of “stage” and “phase” can be used synonymously.

An approximate diagram of the main management stages in the SESS is given in Figure 1.

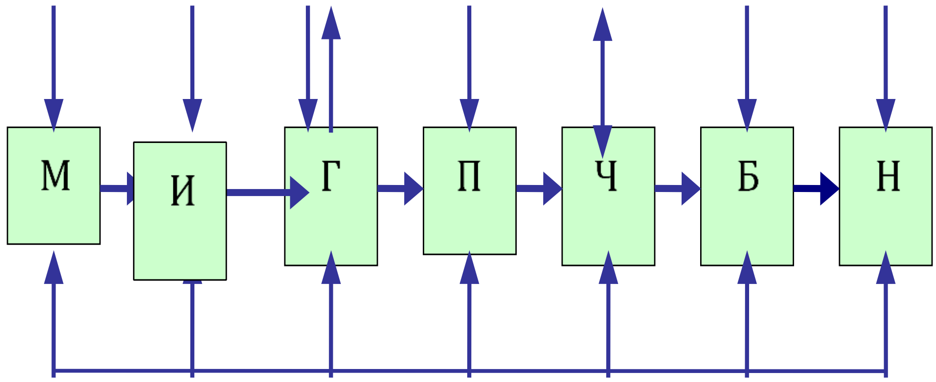

Figure 1. Stages of the management process

The management cycle (full management process) shown in Figure 1 includes the following management stages (phases): 1. clarification of the task (goal) (goal stage - M); 2. collection of information and assessment of the situation (conditions) (information stage - I); 3. stage of making a decision that determines the most effective way to fulfill the task (goal) (decision stage - Q); 4. planning of work (activity) to be done in accordance with the adopted decision (planning stage - P); 5. stage of delivering the adopted decision to subordinate executors, i.e. detachments, military units, lower headquarters, etc. in the form of orders, orders, commands, etc. (delivery stage - Ç); 6. stage of direct management of the implementation of the adopted decision (direct management - B); 7. the stage of control over the implementation of the adopted decision by subordinates (control stage - N).

The content of the management stages largely depends on the operating modes of the objects. However, in the theory of process management there are general rules and principles of their content. These rules include the following:

1. Clarification of the set goal.

At this stage, the management leader (head of the commission, head of the management team, squad commander, etc.) fully clarifies the management task (goal) set by the superior (higher management body) or arising in accordance with the situation arising during the operating mode of the management body (for example, the daily operating mode). At this time, he assesses the capabilities of the forces and means subordinate to him in accordance with the order (order, instruction) of the superior on management, in accordance with the requirements of the official regulatory document determining the operating mode of the management body in the relevant operating mode; clarifies for himself the issues of comprehensive provision of the upcoming activity and interaction with other forces (squads); draws preliminary conclusions about the timely and quality implementation of the task (or planned action); in cases where the implementation of the task is extremely difficult or impossible, he must inform the superior about this, with justification (Ahmad, 2022: 3-19).

2. Information collection and assessment of conditions.

At this stage of management, the manager, taking into account the time allocated for the implementation of this work, collects all the necessary information to fully achieve the upcoming goal and assesses the conditions (situation) to be implemented in the subsequent stages of management. At this time, he collects and assesses the following information:

a) the nature of the probable or actual emergency (Emergency Situation); information about his own forces and forces that will interact;

b) the condition of the equipment and the availability of reserves;

c) the climatic and geographical characteristics of the regions where the operation will be carried out;

d) the environmental consequences that may arise when achieving the set goal. The manager also involves the operational and working groups of the relevant management body in studying these issues. After that, the manager summarizes the information obtained, formulates the main essence (essence) of the upcoming activity, and determines various alternative options and methods for achieving the goal.

The selection of action options during a series of operational emergencies is based on the experience and knowledge of the leader and the employees of the involved management body (MO). This requires the ability to predict the course and results of each option of action in advance. The creation of a “management information” bank helps in this. Such a “bank” is created on the basis of generalizing the experience gained during previously canceled operational emergencies, as well as conducting commander-staff training and exercises. Mathematical modeling of the specified activity during operational emergencies can also be of great importance in this area. Currently, such modeling is called Headquarters Mathematical Modeling (HMM). Such HMM should be implemented in the “operation plan during operational emergencies”. Based on the general goal of the decision developed by all these methods, preliminary orders are given to the forces and management bodies (MO) on preparation for action.

3. Decision-making.

Decision-making is the most complex and responsible stage of the management process. The result of this stage of management is the selection and determination by the management of the most effective method of achieving the set goal. The decision is based on the analysis and study of the initial information obtained about the situation (conditions), proposals received from the heads of subordinate services, from the heads of detachments and sections. The basis for the development and preparation of the decision is the application of decision-making methods, computational technical means, the experience and skills of the management staff, as well as intuition (Albattat, Som, 2019: 7-54).

The content of the decision depends on the type of SE and the situation, as well as the tasks set. In general, the decision may cover the following issues: the main goal of the leader regarding the upcoming activity, the tasks facing the subordinate detachments, units, sections, etc. at this time; the organization of interaction, comprehensive support, direct management and communication. The decision must be agreed upon and approved by the superior.

4. Planning of activities in accordance with the decision.

This stage of management is carried out in accordance with the adopted decision. In the planning process, the tasks of subordinate forces and management bodies are specified, the implementation periods of these tasks are calculated, the sequence of implementation, the rules of interaction between the forces in the grouping, the issues of comprehensive provision of the upcoming activity, the necessary reserves are determined. The decision of the leader and the prepared action plan are usually drawn up in the form of a map, and explanatory notes are added to this map (Schneider, 2002: 141-147).

Depending on the operating mode of the Ministry of Emergency Situations (daily activity, high readiness or FH mode), as well as the scale of the SE, planning can be envisaged for a long and short term. Long-term planning - determines the process of managing the facility for a significant period of time, when the conditions in the environment remain largely unchanged. This type of planning is characteristic of the daily activity period, as well as for the conditions in which regional, national and global SE occur. Short-term planning (sometimes called operational planning) is carried out in conditions of relatively short-term management of the elimination of the consequences of SE.

After detailed planning of the activity, the decision on this becomes the authority of the law of management.

5. Delivery of the decision to the executors.

The decision is usually delivered to subordinates in the form of an order (order, directive, command), in writing or using communication means. The executor who receives the relevant order confirms receipt of the order, and after executing it reports on the results of the execution.

6. Direct management.

It is carried out at the objects of management and directly directs the activities of the management bodies to fulfill the tasks specified in the decision. This stage is carried out by issuing management instructions to the executors once, repeatedly, or continuously. This can be of a situation-dependent and independent (autonomous) nature. The situation-dependent nature is that while eliminating the consequences of the SE, the situation (conditions) may change dramatically, and in this regard, it may be necessary to make changes to the action plan, often partially adopt new decisions and implement them immediately. The independence of the management stage is due to the fact that in large-scale SE conditions, some detachments and units may operate at considerable distances from the higher management bodies and communication breakdowns are possible. The situation-dependent and independent activity of the direct management stage is more characteristic of SE in peacetime and wartime. Direct management is usually carried out by management bodies located in mobile control points (SCCPs), as well as by detachment and unit leaders (chiefs) in separate areas of the SE zone. Direct management is carried out by making specific decisions, giving specific instructions, personally leading the implementation, and by personal example (Ojagov, 2010: 350-367).

7. Control over the implementation of the decision.

This stage of management is carried out by the chiefs who have made the decision - personally, or by their deputies or a specially appointed commission, based on information from subordinates about the results of the orders received. According to the results of control, measures are taken to improve the effectiveness and quality of the decision implementation.

Adoption and development of decisions in the management process, requirements for their content.

Decision-making is the most complex and responsible stage of the management process and consists in choosing the most effective method to achieve the set goal. Let us interpret the concept of decision-making in a broad and narrow sense (Ojagov, 2011: 192-200).

In a broad sense, decision-making is one of the stages of managing any object in the MES system. Decision is the most important concept in management theory and has the following characteristics:

- It is the result of the implementation of one of the stages of the management process and is one of the options for exerting a managerial influence on the managed object in order to achieve the goal or to achieve the upcoming goal;
- Decision is made when the goal (tasks) of management are determined and there are several alternative methods and options for influence that ensure the achievement of the goal;
- When the goal (tasks) of management or the conditions (situation) change significantly during management, the decision is allowed to be clarified accordingly.

In a narrow sense, decision-making is the result of the management activities of a leading person (head of a facility, chairman of a commission, squad commander, etc.), on the basis of which the preparation and readiness of the MES forces to prevent and eliminate the consequences of a MES, bringing these forces to various readiness regimes, drawing up plans, orders, etc. documents for the performance of tasks in peace and wartime, and ensuring their implementation are organized.

Decisions are usually made by chairmen of commissions of various levels, heads of facilities, squad commanders and superiors. Decisions are usually drawn up in the form of a map with an explanatory text. In order to more effectively achieve the set goal, it is necessary to consider the development of a decision in close interaction with the general management process. Thus, individual stages of the management process may coincide with the processes of developing a decision and its implementation (Ojagov, 2005: 200-216).

The structural composition of the management system and the requirements imposed on them.

Management system.

The effectiveness of the management process at all levels and periods of the functioning of the SESS depends on the quality of the management tools and system. They consist of specific and purposeful activities, but all types of activities take place in some "material environment". Such an "environment" for management is created by the management system. Just as the environment and the activities performed there are inseparable from each other, the management system is also inseparable from the management process, forming a single unit. Let us consider the essence of the concept of "management system". In general management theory, "management" means "the development and implementation of management rules". So, system management is carried out through the formation (determination) of special management (rules). Let us conventionally denote them by U(t). The effect of U(t) is shown by another system, which is not included in the composition of the management system and is considered one of the elements of the "environment". A general idea of \u200b\u200bthe composition of the management system is depicted in Figure 2. The system that forms the control U(t) is called the controlling system. The system that feels the controlling effect is called the controlled system (controlled object). Taking into account their mutual interaction, these two systems together form a new system - the control system.

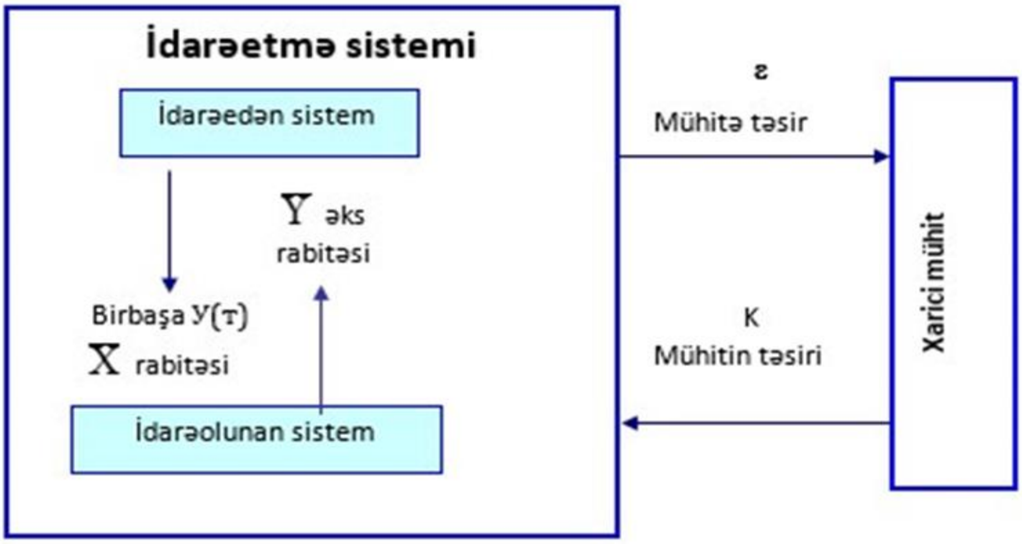

Figure 2. The composition of the control system

The connection between the controlling and controlled systems is carried out in direct (direct connection) and feedback directions.

The main elements of the SESS are: control bodies, control points, communication between them (control system); controlled objects (controlled system); physical-geographical, meteorological parameters of the SESS zone and the environment in which the CD forces are located and operate.

One of the main concepts encountered when studying the control system is the concept of the structure of the control system. In this case, usually the organizational (functional) structure and the system-technical structure are considered.

The organizational (functional) structure is the relationship between the control bodies (the functional tasks they perform).

The system-technical structure, on the other hand, is the relationship between the control points and the communication between them, and the interaction between the control means and control complexes.

Typical system-technical structures are: Linear (sequential), circular, the organizational structure of the management systems of military units, headquarters is single-level or multi-level, but in all cases multi-purpose. Such types of organizational structures are linear, linear-functional, linear-staff, hierarchical, etc. structures.

An example of a linear structure is shown in Figure 3. In such a structural environment, the leader directly manages his subordinates. Such a structure is used in individual cases - in simple management systems with a small flow of information on management, for example, when managing specialized units within the forces of the CD of the object (Ojagov, 2003: 167-189).

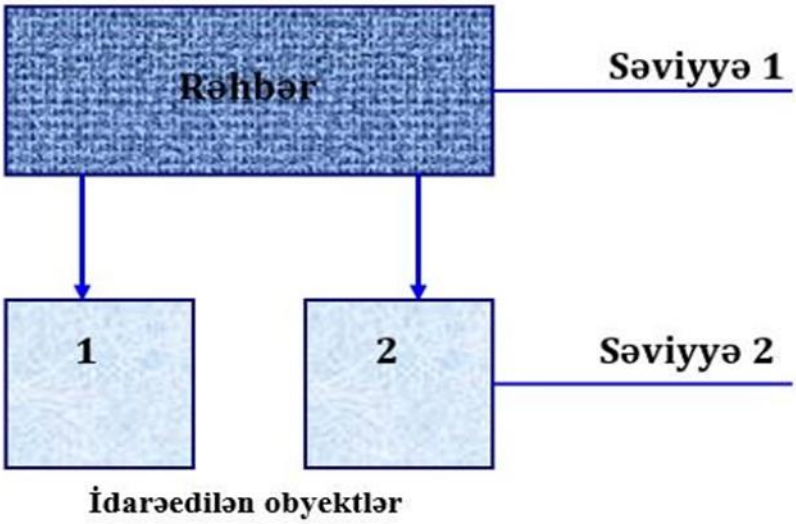

Figure 3. Linear structure

In a linear-functional structure (Figure 4), functional management is carried out by heads of services in various directions, while the head coordinates the activities of the services.

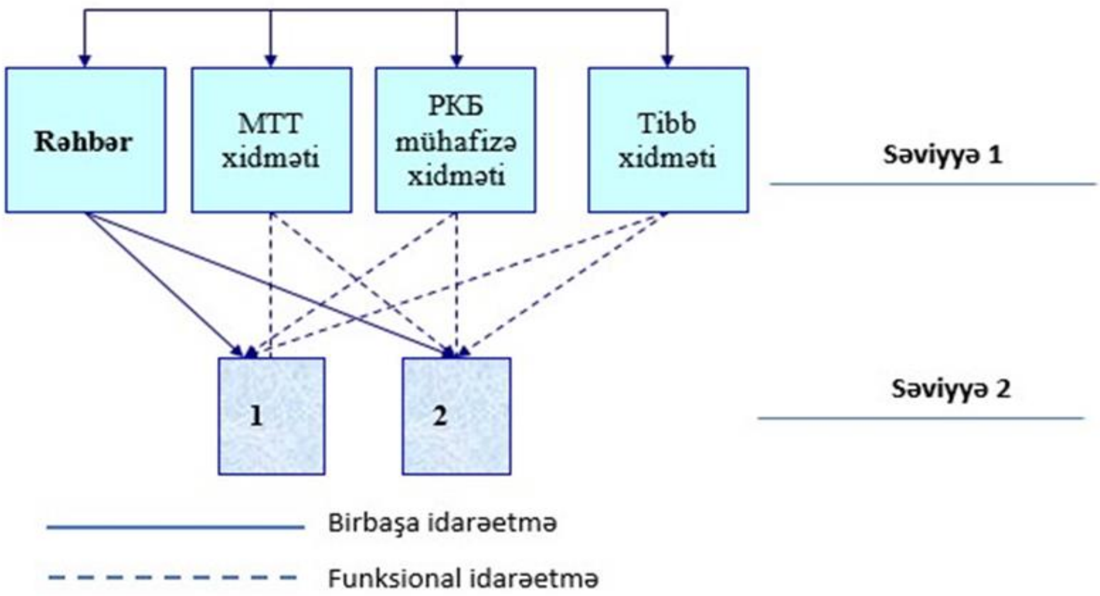

Figure 4. Linear-functional structure

These structures are characteristic of the management systems of the district and facility levels of the CD. The disadvantage of such a structure is that the bulk of the specialized work on the management of service structures (SS) falls on the head. In this case, the responsibility of service structures for the final result of management is reduced.

At the city and higher levels of the CD system, as well as in the CD military units, a linear-staff management system is used (Figure 5.). This structure is characterized by the fact that direct (indirect) management of subordinates is carried out according to a linear scheme. Functional management bodies (services) are engaged in functional management, and the coordination of their activities is carried out by a special coordinating body - the headquarters.

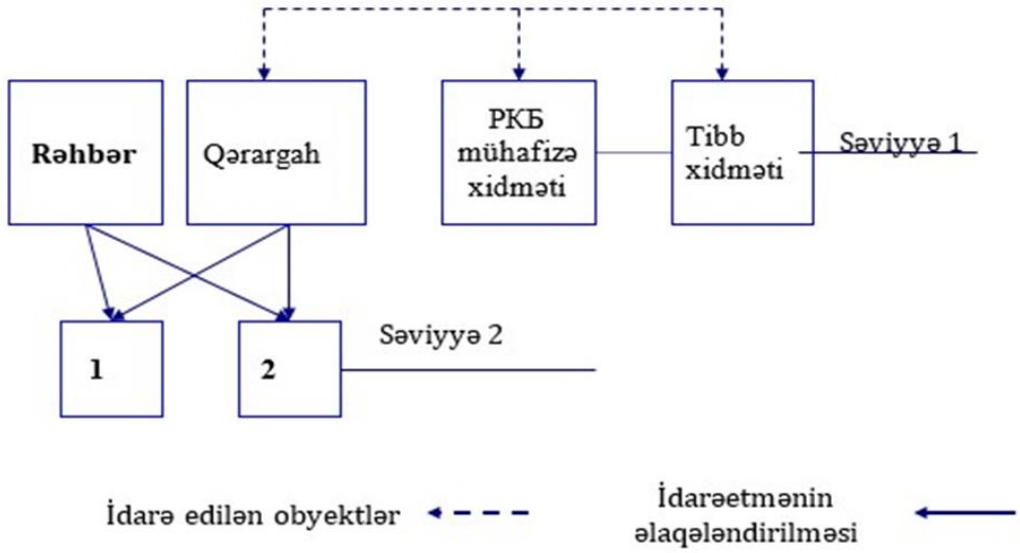

Figure 5. Line-staff management structure

A characteristic feature of this bottom-up subordinate structure is that the management process (decision-making) here is distributed not only according to a linear scheme (vertical division of labor), but also according to a functional scheme (horizontal division of labor). It should be noted that a multi-level organizational structure is not always hierarchical.

In the management system of the Ministry of Emergency Situations: structures at the facility, regional and republican levels are considered hierarchical systems. The scheme of such a management system is shown in Figure 6.

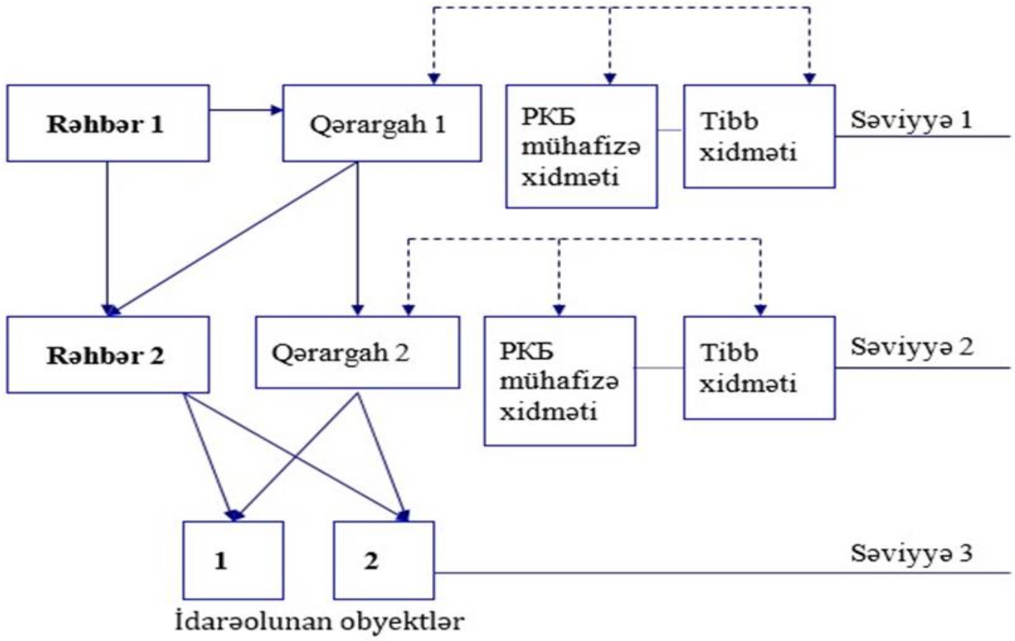

Figure 6. Hierarchical structure

The main drawback of the above-considered organizational structures of management systems is that they implement only the functional division of labor (resource management). In this case, the main efforts of the management staff are directed to improving the quality of management, which occurs due to the strengthening of the specialization of management bodies. This leads to a decrease in the responsibility of the functional management body.

To eliminate this drawback, it is necessary to create organizational structures that ensure efficient management of resources.

In addition to linear (reserve) subordination, such a structure also provides for the implementation of temporary functions (duty, reconnaissance, etc.). Such a system, called matrix management, is organized on the basis of the commander's order in the military units of the Ministry of Emergency Situations that perform only special tasks.

Requirements for the management system.

It should be noted that at present the requirements for the management systems of the Ministry of Emergency Situations have not been sufficiently developed. However, it is possible to make some general comments about these management systems.

These requirements can be divided into four groups.

1. Operational-tactical requirements

Requirements of this group can be attributed to the forces of the MM. These requirements may include the following: the ability to conduct emergency rescue and other urgent work (ERW) in peacetime and wartime, mobility, protection from enemy intelligence, etc. The capabilities of the control system determine the purpose for which it is intended. In this case, the features and main characteristics of the objects it will control in peacetime and wartime should be indicated. The intelligence protection capability of the control system is determined by the intelligence protection capability of its elements and, first of all, the communication system used by this system. The mobility (flexibility) of the control system is usually attributed to the conditions in which rescue work is carried out.

2. Functional requirements for the control system

These requirements are important in cases where the system is multipurpose. These requirements should list all functional control modes in which the system is implemented.

3. Technical requirements for control systems

This group includes the system's launch and rapid response capabilities, as well as the features of its operation. This also includes requirements for its overall stability and operability, even in the event of a malfunction in the system. The throughput of a MM control system is determined not by the provision of information, but by its reception, processing and use. However, currently, such requirements are not taken into account in the MM control system, usually the general capabilities of the system are taken as a basis.

4. General technical requirements for the control system

With regard to the control system, the resistance of its technical means to failures and errors (inaccuracies) in the information process should be taken into account. Let's consider the concept of failure resistance of a control system. A control system may be subject to technical failures in operation as a result of various influences. The causes of the failure may be internal physicochemical processes or the human factor. Malfunctions arising during internal processes are assessed by the intensity of their occurrence during operation and are denoted by the letter □. Let us consider the concept of error (inaccuracy) resistance of a control system. The basis of errors in information flows in a control system can be technical means and humans. The assessment of error resistance resulting from the failure (breakdown) of technical means or electromagnetic incompatibility is called damage (harmfulness) in a control system. If errors in the information process occurred as a result of the human factor, it can be assessed in two ways: an error resulting from an unintentional (involuntary) action of a person can be assessed as damage, as in the case of technical reasons. If human activity is deliberately aimed at weakening the system's error resistance, such a situation is assessed as resistance to obstacles (obstacles). These two situations (damage and resistance to obstacles) are used together as an expression of the functional stability of the system.

Analysis of alternative options in making a management decision.

The preparation and adoption of a decision consists in transforming information on the situation into information on management. In this case, it is mainly a creative process, but also includes certain elements that can be formed. The sum of these elements constitutes the formed part of the process of changing information in content.

It is known that decisions can be conditionally divided into two categories (groups):

1. Decisions related to the prospects of the city, region, facility and military unit, related to fundamental issues of life and activity in them (for example, decisions on the reconstruction of a

military camp or the creation of a new camp, on transferring to a new power supply system). Such decisions are episodic in nature, non-standard and are aimed at solving certain problematic situations; for example, decisions that characterize the non-compliance of the existing situation in important areas of the military unit's activities with the required state and are aimed at eliminating it.

2. Monotonous, repetitive decisions related to the daily activities of the city, district, facility and military unit. Such decisions are made by the unit commander in order to fulfill the tasks set by the superior or unexpectedly arising.

Before making decisions related to the first group, it is required to identify (clarify) the problem, and before making those related to the second group, it is required to define the goal.

Identifying the problem is the task of the senior management and the unit commander, but all management bodies can participate in this work. Sources of information for making such a decision can be: inspections, results of the unit's activities during the training period, conclusions drawn from the implementation of individual tasks, assessments and opinions about the unit's activities given by the superior bodies and services that provide and equip it, and organizers of mutual activities (Chernov, 2022: 62-66).

Since the decision covers the volume and terms of the work performed, the forces and means involved, and other issues, it cannot be evaluated by a single indicator. A system is needed that divides indicators into three groups and reflects the following:

- estimated costs;
- expected results (effectiveness);
- time required to achieve results.

When justifying decisions, it is pointless to calculate all of the numerous indicators, since this in a certain sense complicates or makes the issue impossible.

Let us consider the rules for formulating criteria and using criteria for selecting effective decisions:

1. One of the indicators (for example, the time of work completion) has a clear advantage over the others. Such an indicator is accepted as a criterion (such a criterion is called a simple criterion);

2. The criterion is formed from two or more indicators by comparison (verification) in its composition.

An example of such a criterion is the pace of work, which is the ratio of the volume of work (Q) to the time of their execution (T):

$$V=Q/T.$$

Composition and duties of control points.

In peacetime, when a fire occurs, commissions for the prevention and elimination of emergency incidents and ensuring fire safety operate in the fire department, the working bodies of which are the operational headquarters and the operational group for the elimination of fire (Lobanov, Chernov, Dzutsev, 2021: 36-48).

These commissions usually manage the activities of their subordinates from daily control points; however, when a problem (condition) arises related to the possibility of poisoning the area where the daily control points are located, these commissions may move to reserve control points.

Military forces and equipment are controlled by the control point staff from the reserve (auxiliary) fire department. The composition of the management staff in the reserve fire department and the auxiliary fire department varies.

To manage emergency incidents from the reserve fire department, fire department staffs are created in advance - in peacetime from the composition of the relevant management bodies of cities of the rank, districts of these cities, as well as from the composition of the management bodies of the MM and fire department.

Fire department staffs occupy their workplaces and posts during a special period, that is, when a dangerous period is declared and during wartime. The composition of these teams is determined by the relevant heads (chiefs) of the MM management body in wartime, taking into account the number of employees of the MM management body, the organizational and staff structure of the body, the scope of its duties, as well as the issues of ensuring uninterrupted work there.

The composition of the IM teams may mainly consist of:

• control center;
• situation generalization and proposal preparation group;
• guidance group;
• information group;
• transfer-transport group;
• calculation-analysis group;
• communications group.

The general structure of management in the emergency regime in peacetime.

The FH regime begins from the moment the chairman of the commission (KS) or the head (chief) of the MM declares this regime. This regime can be declared when an accident, natural disaster occurs or after clarifying the situation. In terms of the characteristics of the management process, it is advisable to consider the emergency regime period in two stages:

the first stage is the initial stage, during which urgent measures are taken to protect the population, the real situation is determined and rescue forces take up their positions; The second stage is the main stage; at this time, the emergency and its consequences are eliminated (Evdokimov, Rybnikov, Chernov, 2019: 114-117).

Typical periods (cycles) of management in an emergency regime are:

• the period of management during the arrival of the chairman of the commission to the emergency management point of the Ministry of Emergency Situations (mobile emergency management center, or other emergency management center);

• the period of management during preparation for the activities to be carried out the next day.

According to their direction, that is, the objects of management, the mentioned periods of management can be divided into two types:

• the period of general management of all groups and management bodies in the emergency zone;

• the period of management of the activities of paramilitary and civilian rescue teams located in separate areas or facilities in the emergency zone.

The first period is usually carried out in a general, predetermined structure and content. The second period of management is usually considered management by the situation (by situation) among the population.

The autonomy of the management cycle means that when a situation arises that is not provided for in the decision of the superior, a decision is immediately made and implemented accordingly. The situation should be understood as a change in the situation (circumstances), the emergence of new problems and the implementation of work not specified in the plan. The following case may be an example of a situation requiring an autonomous management cycle: in the region where work is being carried out to localize and eliminate an emergency, an explosion occurred in a nearby fuel and lubricants warehouse as a result of an accident at a fire-hazardous facility. As a result, the resulting fire is rapidly approaching a nearby residential area at a dangerous distance due to the surface wind. The person in charge of the work in this area must make an immediate decision and organize the prevention of the spread of the fire with their own forces until outside help arrives. Such situations can practically occur during an emergency (Chernov, Evdokimov, 2018: 85-86).

Conclusion

1. The theoretical and practical aspects of the legal provision of forecasting, management, prevention and elimination of the consequences of natural and man-made emergencies have been studied. Specific proposals have been developed to improve the existing domestic legislation in the field of emergency management.

2. Emergency situations are the most important element of the national security systems of most countries of the world, its social purpose is to create the opportunity to eliminate certain conflict situations within the framework of the system of legal norms.

3. When conducting scientific research on the activities of the state legal mechanism for ensuring security in emergencies, it is advisable to use the results and proposals reflected in the work. The scientific results of the article work can be used. practical activities are:

- fire-rescue and other units;
- the Ministry of Emergency Situations of the Republic of Azerbaijan, authorized bodies and officials involved in the elimination of the consequences of emergencies.

4. The legal essence of the regime of natural and man-made emergencies is characterized by the efficiency and simplification of the procedure for taking the necessary organizational, economic, environmental and social measures aimed at preventing an emergency, as a mitigation of the emergency situation, and a system of measures has been developed to minimize the consequences of emergencies, including the restoration of environmentally unfavorable territories.

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