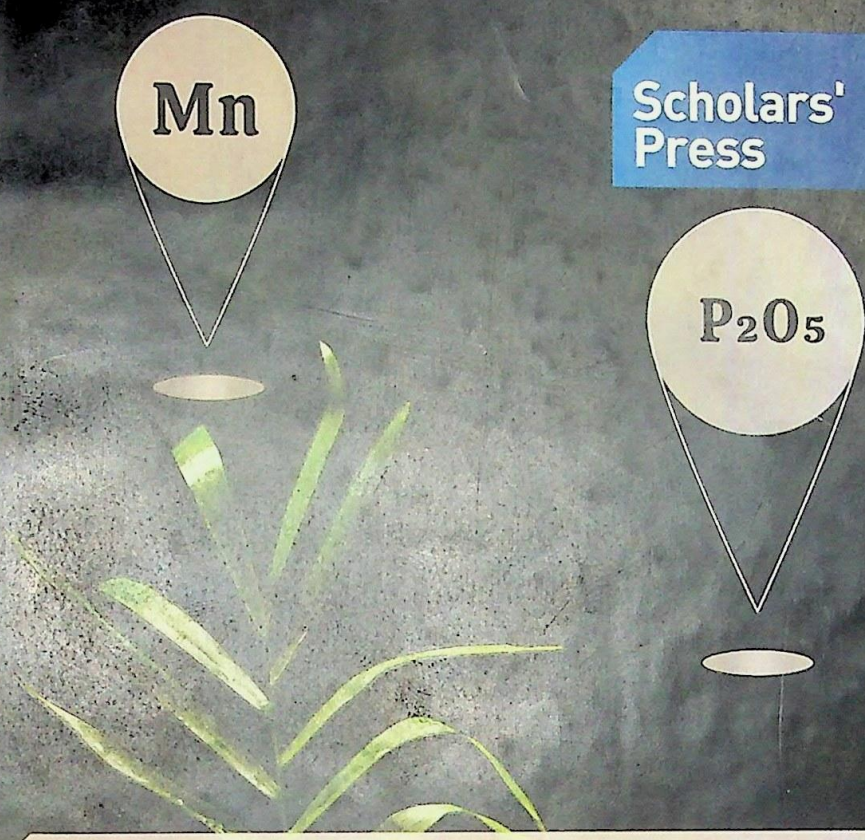




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PRODUCTION OF POTASSIUM FERTILIZERS BY FLOTATION METHOD

Sirojiddin Zoirov
Sarvar Tursunov
Murodullo Nurullayev

PRODUCTION OF POTASSIUM FERTILIZERS BY FLOTATION
METHOD

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PRODUCTION OF POTASSIUM FLUORIDE BY FLOTATION
METHOD

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Sirojiddin Zoirov
Sarvar Tursunov
Murodullo Nurullayev

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**MINISTRY OF HIGHER EDUCATION, SCIENCE, AND INNOVATIONS OF
THE REPUBLIC OF UZBEKISTAN
TERMEZ INSTITUTE OF ENGINEERING AND TECHNOLOGY**

**Zoirov Sirojiddin Sakhomiddin ugli, Tursunov Sarvarbek Anvar ugli, Nurullayev
Murodullo Olimjon ugli**

PRODUCTION OF POTASSIUM FERTILIZERS BY FLOTATION METHOD

MONOGRAPH

Termez – 2024

TERMIZ DAVLAT MUHANDISLIK VA AGROTEKNOLOGIYALAR UNIVERSITETI AXBOROT-RESURS MARKAZI
INV. № <u>2147</u>
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No. 13/3-2 of the Termez Institute of Engineering and Technology on 30.05.2024.**

The agrochemical complex is considered the main component of our country's economy, and one of the important factors of its acceleration is chemicalization, first of all, the wide use and effective use of mineral fertilizers.

In Uzbekistan, there are large reserves of natural raw materials for the production of potassium sulfate, which can be used as potassium chloride of "Dekhanabad Potash Plant" JSC obtained from sylvinite of the Tubegatan mine, mirabilite of the Tumruk mine, sodium or ammonium sulfates. However, until today, optimal, continuous technologies for obtaining potassium sulfate from the above local raw materials have not been developed in the Republic, at the same time, the republic's need for chlorine-free potassium fertilizers exceeds 100,000 tons per year.

The existing methods of obtaining potassium sulfate are multi-stage, the complexity of the technological scheme, high energy costs, the formation of by-products of little-used products, and the high cost of the resulting products. In addition to chemical and physicochemical (x-ray phase and scanning electron microscopic methods) analysis to determine the phase composition of intermediate products and finished products and the interaction of the double salt solution with potassium chloride. Optimal, economical, waste-free production of potassium sulfate, development of continuous technology is an urgent problem for the republic.

The monograph is intended for use by independent researchers, basic doctoral students, research interns, master's and bachelor's students, as well as professionals working in this field in training courses.

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CHAPTER I. CURRENT STATE OF PRODUCTION AND USE OF POTASSIUM FERTILIZERS.

§ 1.1. Application, demand, production volume of potash fertilizers

Potassium is one of the most important nutrients for agricultural crops, and its deficiency in the soil leads to a significant decrease in soil fertility. Uzbekistan's specialization in the production of agricultural products, in particular, cotton, grain, vegetables and fruits, created the need to create and develop the chemical industry in the republic, and to subordinate it, first of all, to the tasks of intensification of the agro-industry network.

Plants producing nitrogen fertilizers and phosphorous fertilizers were built. The need for potassium fertilizers was met by the supply of potassium chloride from the Urals.

According to estimates, the scientifically based need for potash fertilizers of agricultural crops in Uzbekistan is 313.6 thousand tons per 100% d.v., and the need for cotton growing, fur growing, and irrigated land is 173.4 thousand tons or 55% of the total need.

Ore mining is carried out underground (mining) using a mining combine of the Ural type. Mined ore is transported to the surface by a conveyor belt and then to the surface, using a reloading hopper and a self-propelled vehicle. In 2021, the productivity of the sylvinit ore complex was 1,548,000 tons, the amount of KCl was 22-26%.

Until now, the issues of obtaining chlorine-free potash fertilizers, the ideas of efficient production of specialists of the CIS and developed foreign countries remain relevant. Currently, all potash-producing countries, as well as Japan and Belgium, which do not have their own potash raw materials, produce or plan to produce.

According to the recommendation of agrochemists, 220-250 kg of nitrogen, 100-120 kg of phosphorus pentoxide (P_2O_5) and 75 kg of potassium fertilizers were given to each hectare of soil. As a result, 75% of the irrigated lands of Uzbekistan are depleted of exchangeable potassium due to insufficient doses of potassium fertilizers, removal of potassium by crops and annual washing of saline lands. As a result, not only the yield of

raw cotton decreased, but also the quality of the fiber deteriorated, the efficiency of using nitrogenous and phosphorus fertilizers decreased, and resistance to wilt decreased. Proper use of potash fertilizers provides an increase in the yield of raw cotton in non-saline lands by 1.9-3.0 s/h, and in saline lands by 2.5-7.0 s/h. It has been proven that not only cotton, but also other crops need to increase the standards of potash fertilizers, which further increased the demand for potash fertilizers.

Currently, the world's largest producers of mineral fertilizers are China, which occupies more than 25% of the world market, India (about 13%), the United States (about 10%) and Russia (about 8%). In recent years, the share of the United States in the world fertilizer market has been gradually decreasing. The global market for mineral fertilizers includes three main segments: nitrogen, phosphorus and potassium fertilizers. The share of nitrogen fertilizers in the world market is about 59%, phosphate - 24% and potassium - 17%.

Thus, according to the UN, the production of fertilizers ($N + P_2O_5 + K_2O$) increased from 292.429 million tons in 2016 to 310.389 million tons in 2018. Production of nitrogen fertilizers increased from 180.496 million tons in 2016 to 186.974 million tons by 2018, phosphorus from 57.295 million tons to 61.951 million tons, potassium from 54.638 million tons to 61.951 million tons.

Potash market: From 2010 to 2017, the balance of production and consumption in the potash market showed a slight advantage over production, which in turn means that it is saturated. The main exporting countries of potash fertilizers in the world are six countries, which account for 85% of the total production: Canada - 38%, Russia - 24%, Belarus - 10%, European Union - 9%, USA - 7% and Israel - 6% [8].

The market for potassium fertilizers has been saturated in recent years, as production has exceeded consumption since 2010. This is primarily due to increased potash production in Canada, which averaged 27% of total world production, followed by Russia and Belarus, with an average share of 16% for each country, respectively. China's share is about 13%, Germany - 8%, there are no strong changes in the context of the countries.

Chlorine and sulfate anions strongly affect agricultural crops and their productivity in the saline lands of Central Asian countries. If the amount of chloride ions in the soil exceeds 0.01%, the negative effect on the plant is significant. If the amount of sulfate anions exceeds 0.2-0.3%, plants will be damaged.

The composition and amount of water-soluble salts in soil, their movement and relationship with plant species remain complex scientific problems. Soil salinity is determined by the amount of Cl^- and Na^+ ions. Sulfate salinity is determined only by dry residue, chloride-sulphate and sulfate-chloride - by dry residue and chlorine, and chlorine - by the amount of chlorine.

A lack of potassium in the soil leads to a significant decrease in its productivity. When determining the doses of potassium fertilizers, the availability of potassium in the soil, the biology of the crop, the granulometric composition of the soil, the level and quality of the planned harvest are taken into account. 60-90 kg/ha is sufficient for most crops, 90-150 kg/ha for beets, potatoes and vegetables. Doses are slightly higher in peat soils. However, potassium minerals (sylvinit, kainite, nepheline, feldspar) are used as raw materials for feeding crops with potassium fertilizers.

On October 12-16, 1992, the 23rd Colloquium "Potassium in Ecosystems" at the International Potassium Institute (Prague) was held by Prof. G. Beringer noted that the reduction in the use of potash fertilizers in the CIS countries will have unpredictable consequences not only economically, but also ecologically. In this regard, one of the most important tasks of agrochemistry is to determine the minimum dose of potassium fertilizers that can maintain the maximum permissible level of potassium in the soil, and to ensure the appropriateness of using other chemicals and a complex of agricultural practices. A sufficient level of potassium in the soil is one of the guarantees of a sustainable harvest that is not only high, but also less prone to extreme effects.

The lack of potassium fertilizers is aggravated by the removal of large amounts of nutrients from the soil along with the harvest. It is known that one ton of raw cotton removes 50 kg of nitrogen, 15 kg of P_2O_5 and 50 kg of K_2O from the soil every year. One ton of wheat annually removes 35 kg of nitrogen, 10 kg of P_2O_5 and 24 kg of K_2O from the soil. Gross cotton raw material is 3 million 400 thousand tons and wheat is 6.1

million tons, each year only these two crops are removed from the soil, yielding 364.3 thousand tons of nitrogen, 112.1 thousand tons of P_2O_5 and 299 thousand tons of K_2O . But other crops also remove large amounts of nutrients from the soil and must be replenished in the soil.

Another important problem of the potash industry is the expansion of potash fertilizers. In agriculture, potassium losses in the soil are replenished by the application of potassium-containing fertilizers. The characteristics of man-made effects of potash production should be taken into account when planning new enterprises and developing environmental measures for existing ones. With the development of greenhouses, hydroponics, and drip irrigation, the demand for water-soluble chlorine-free NPK fertilizers using potassium nitrate, sulfate, or phosphate as the potassium component has increased dramatically.

The destructive effect of salts on cultivated plants is well known, and the most harmful are chloride salts. Easily soluble sulfates are 2 times less toxic than chlorides. Cotton is one of the most salt-resistant cultivated plants, it tolerates up to 6 g/l of chlorine in the soil solution. Industrial crops, citrus fruits, grapes and many vegetables are very sensitive to chlorine. It is resistant to the action of chlorine and sulfate ions, and shows relative resistance to drought and soil salinity. The third group of trees and shrubs includes species resistant to the toxicity of chloride-carbonate salinity.

During growth, plants use a variety of nutrients (zinc, copper, etc.), molybdenum, silicon).

Plants get the main amount of oxygen, carbon and hydrogen from air and water, and the rest of the elements are taken from soil solutions by the root system. Nitrogen, phosphorus and potassium play an especially important role in mineral nutrition of plants.

Potassium affects a number of physiological functions that control growth and metabolic processes in plants. It helps the formation, breakdown and movement of starch, enhances the use of ammonia nitrogen in the synthesis of amino acids and proteins, regulates the activity of other elements of mineral nutrition and enzymes, as well as the water regime of plants.

According to the degree of assimilation of plants, nutritional potassium: 1) dissolves in water; 2) sharing (absorbed); 3) insoluble in plant body.

Water-soluble compounds include nitrate, sulfate, chloride, carbonate, phosphate, and potassium humates. The content of water-soluble forms of potassium is on average 10 mg per 1 kg of soil.

Exchangeable potassium is produced by absorption by soil colloids, which act as ion exchangers. Plants absorb this potassium, but much more slowly than water-soluble potassium. Depending on the type of soil, the amount of exchangeable potassium varies from 40 to 500 mg per 1 kg of soil and is an indicator of the availability of the nutrient in a plant-available form.

Insoluble forms of potassium are represented by various potassium-containing aluminosilicate minerals (orthoclase, muscovite, biotite, etc.) that are included in clay, feldspar, and mica. Potassium, which is a part of these minerals, is absorbed by plants only in small amounts.

Harvesting removes a large amount of potassium from the soil. This is due to the fact that it is a part of all tissues and organs of plants. In addition, providing plants with adequate potassium increases their winter hardiness, disease resistance, and drought tolerance. Vegetables and fruits obtained from fertilized fields are well tolerated by storage and transportation.

The main parameters describing the quality of mineral fertilizers are chemical composition, concentration of nutrients and physical-mechanical properties (granulometric composition, solidity of granules, miscibility, flexibility and hygroscopicity). Powdered potassium chloride is obtained by flotation (F) and halurgic dissolution and crystallization methods (K) in the form of small or large grain, fine or large grain product.

Potassium chloride is the main potash fertilizer produced in the world. However, the specific characteristics of the chemical composition (the presence of chloride ion in the composition) limit its use in agriculture, especially in horticulture and greenhouses, where non-chlorine potassium fertilizers such as potassium sulfate, nitrates and phosphates are needed.

Potassium nitrate KNO_3 (potassium nitrate) is a white (sometimes yellowish-gray tinged) anhydrous crystalline salt with a density of 2.11 g/cm^3 and melting at 334°C . Above 338°C , it decomposes into potassium nitrite and oxygen. Two crystal modifications of KNO_3 are known: rhombic crystals are formed at low temperatures, and rhombic crystals are formed at high temperatures. Solubility of KNO_3 in water (in $\text{g/100 g H}_2\text{O}$): at 20°C - 31.5 at; at 30°C - 45.6; at 40°C - 63.9; -109.9 at 60°C ; -312 gr at 114°C .

Potassium nitrate is a necessary raw material in agriculture and the glass industry. In the glass industry, potassium nitrate is mainly used in the production of glass and crystal products. Potassium nitrate is a component of smoke powders and pyrotechnic compositions, and is used for the production of enamels, hardening of metals, etc. In agriculture, potassium nitrate is an important fertilizer for the cultivation of potatoes, beets, sunflowers, grapes and other plants.

Potassium Nitrate (Potassium Nitrate) is a water-soluble, chlorine-free nitrogen potash fertilizer containing 13% nitrogen and 36% K_2O . The solubility of KNO_3 in nitric acid solutions decreases with increasing acid concentration, reaches a minimum level, and then increases; The minimum solubility of KNO_3 at 50°C is 24.91% when HNO_3 is 27.63% and H_2O is 47.46% in solution.

Potassium sulfate - potassium sulfate, K_2SO_4 , salt; colorless crystals, density 2.66 g/cm^3 , $t = 1074^\circ\text{C}$. Solubility is 11.1 g per 100 g H_2O at 20°C , 24.1 g at 100°C . Potassium sulfate is part of natural potassium salts, for example, chenite $\text{K}_2\text{SO}_4 \cdot \text{MgSO}_4 \cdot 6\text{H}_2\text{O}$, from which it is obtained. It is used to obtain potassium. In agriculture, potassium sulfate is used as a concentrated, chlorine-free potassium fertilizer; contains not less than 45-52% K_2O , not more than 1% MgO and not more than 10% moisture. It is mainly used for crops sensitive to chlorine (potatoes, tobacco, flax, grapes, citrus fruits, etc.). The presence of sulfate ions in fertilizer has a positive effect on the productivity of cruciferous plants (cabbage, swede, turnip, etc.) and legumes that consume a lot of sulfur.

Also, the new technologies of growing crops in greenhouses set completely new requirements for the range and quality of mineral fertilizers. The inclusion of the main

nutritional components in the composition of the so-called nutrient solutions predetermines the need to use chlorine-free fertilizers and the presence of only water-soluble compounds in their composition. Potassium nitrate is a valuable non-ballast fertilizer containing potassium and nitrogen that meets these requirements. The greatest effect is achieved when applied under crops that are negatively related to chlorine.

Potassium sulfate is recommended for use on all types of soil, for all crops, and for chlorine-sensitive crops and vegetables in greenhouses. It is recommended to use under crops that do not tolerate excess chlorine (potatoes, beans, peas, beans). It is recommended for vegetables of the common family (cabbage, turnips, radishes).

When using potassium sulfate, it should be remembered that it is very soluble in water, and after application to the soil, it quickly dissolves and reacts with the soil absorbing complex. Potassium and other cations included in potassium sulfate are absorbed by the colloidal part of the soil, while chlorine remains in the soil solution and is easily washed into the deep layers of the soil.

The effectiveness of potassium sulfate is better shown in sod-podzolic soils and peat soils that do not have potassium with a light granulometric content. In chernozem soils, it is usually used for crops that absorb a lot of potassium and sodium (sugar beet, sunflower, fruit, root crops, vegetables). In chestnut and gray soils, it is used depending on the type of crop, cultivation technology and the amount of potassium in the soil. Potassium sulfate is a physiologically acidic salt, but the physiological acidity is much lower than that of ammonium fertilizers and appears only with long-term application of high-dose fertilizers for crops that tolerate large amounts of potassium (sunflower, sugar beet, potato, root). crops, vegetables).

Potassium sulfate, if it is used together with nitrogen, phosphorus and organic fertilizers, has a more effective effect on the size and quality of the crop. In acidic soils, the effect of potassium sulfate increases with the use of lime.

Potassium compounds are widely used in various sectors of the national economy: ferrous and non-ferrous metallurgy, production of building materials, pyrotechnics, electrochemistry, photography, textiles, glass, pharmaceuticals, pulp and paper, chemical industry, etc. However, only 5-6% of the produced potassium is used

for industrial purposes, and the rest of the potassium compounds obtained in the form of soluble salts are used as mineral fertilizers in agriculture. Therefore, the development of potash industry is closely related to the requirements and level of development of agriculture.

From 2012 to 2015, global production of potash fertilizers increased from 29.1 million tons per year to 31.5 million tons of K_2O , or 4.2 percent. By 2019, the production of potash fertilizers increased by 9 million tons of K_2O or 21% compared to 2014. The increase in the production of potash fertilizers is due to 7 million tons of K_2O in North America (Canada), 1 million tons of K_2O in Eastern Europe and Central Asia (Russia, Belarus) and the commissioning of new capacities in East Asia. China) - 1 million t of K_2O .

IFA estimates that global potash production will exceed 70 million tonnes in 2020, up 6% from 2019. In contrast to the nitrogen and phosphate markets, production has expanded in all major producing regions.

Strong global demand, combined with the consolidated nature of potash production, led to record sales in 2020. Global trade of chlorine chloride increased from 49 million tons in 2019 to 56 million tons in 2020. The increase in potash sales was driven by improved demand in the US, Brazil, India and China, following a decline in post-2019 sales. Potash remains the weakest market for trade, with imports accounting for 80% of global consumption in 2020. Capacity expansion was concentrated in EECA countries, contributing to a global increase of 4.6 Mt K_2O .

2020 was dominated by potash capacity growth in the EECA region, with new mines opening in Russia and Belarus. These countries added 2.3 Mt of new capacity in 2020, increasing regional capacity to 21.1 Mt from 18.8 Mt K_2O in 2019.

Elsewhere, another 450,000 tons of new capacity was added due to expansions in Canada, Israel and China. These expansions were completed with minimal delay due to Covid-19 and brought global potash capacity to 62.3 Mt K_2O .

Russia has the largest number of individual projects for forecasting IFA capacity, with three projects in the country scheduled to start in 2023. SOP expansion

continues with two Australian projects launched in 2022. These projects, along with smaller expansions, are expected to add 4.6 Mt K_2O .

1.2. Raw material base for the production of potassium sulfate

The development of the potash industry in Uzbekistan was not possible due to the lack of studied and exploited deposits. Large potash basins are being studied in the south of Central Asia, which are not inferior to the exploited basins in the CIS countries in terms of reserves and prospects for industrial development. Most of the deposits are in favorable economic and mining conditions and are of interest in the industry [43; page-214]. According to their chemical and mineralogical composition, they are divided into sulfate-free potassium-sodium and sulfate-sodium-magnesium. The sediments of the Upper Sora halogen layer, designated Gaurdak layer, belong to the first type. The best-studied deposits of potassium salts are Tubegatan, Aqbosh, Lilimkan, Khojaykan, Karabil, Karlyuk, etc.

Uzbekistan's mineral resources make it possible to obtain not only potassium chloride, but also potassium sulfate using deposits of sulfate salts. For these purposes, the Tumruk, Kushkantov, and Akkala deposits of the Aral Sea are the most promising.

The most common mineral-natural sodium sulfate, it is mirabilite (natural Glauber's salt), decahydrate (lecahydrate) $Na_2SO_4 \cdot 10H_2O$ [46;] is known to be one of the lightest minerals, its density is 1.49 g/cm^3 . In solutions, when precipitated, mirabilite has large transparent colorless prisms, which are gradually eroded by exposure to air, lose water and turn into a white powder. Salt deposits of the mineral Mirabilit have been found, which occur in the form of crusts attached to rock salt and gypsum. Observations have shown that in winter, a large amount of mineral sediment accumulates in the waters of the Caspian Sea, located in the west of Turkmenistan. In Kuchuk Lake (Western Siberia), as well as in the salt lakes of the Tomsk region, mirabilite deposits were also found. Large deposits of about 100 million tons of the mineral are located in the central part of Canada. Located in the province of Saskatchewan. Mirabilit was found in large quantities in the 19th century 30 km from Tbilisi, this deposit is a dried lake with an area of $55,000 \text{ m}^2$, the mineral layer is about 5 meters thick and covered by

a sandy layer above. mud from 30 cm to 4.5 m thick in California (USA), Sicily, Germany, Great Malinovsky Lake (Astrakhan region) double salts with mirabilite: astrakhanite $\text{Na}_2\text{Mg}(\text{SO}_4)_2 \cdot \text{H}_2\text{O}$, leveitin $2\text{Mg}(\text{SO}_4)_2 \cdot 2.5\text{H}_2\text{O}$, vantophyte

$\text{Na}_2\text{Mg}(\text{SO}_4)_4$, glauberite $\text{Na}_2\text{Ca}(\text{SO}_4)_2$, glaserite $\text{Na}_2\text{K}_6(\text{SO}_4)_4$. Various forms of crystalline hydrates are described in the authors' publications: decahydrate, in the form of rhombic crystals, heptahydrate crystalline $\text{Na}_2\text{SO}_4 \cdot 7\text{H}_2\text{O}$ and $\text{Na}_2\text{SO}_4 \cdot \text{H}_2\text{O}$ and $\text{Na}_2\text{SO}_4 \cdot \text{H}_2\text{O}$ monohydrate salts. Scientists have reported that a large amount of sodium sulfate is found in sea water and mineral spring water [45].

Anhydrous sodium sulfate, rare in nature, the mineral thenardite is named after the French chemist L.J. Thenard. Rich deposits of thenardite have been found in Chile, Central Asia, and Arizona (USA), according to reports presented by the authors. In the Ebro River Valley (Spain), a huge layer of anhydrous sulfate (between clay and gypsum layers) with a thickness of several meters was found.

It is known that sodium sulfate is very widely used in the chemical industry: this salt is one of the main components of the charge in the production of glass, and it is indispensable in the so-called sulfate pulp in wood processing. in the dyeing of cotton fabrics, as well as in the production of viscose silk. Sodium sulfate is a raw material for the production of chemical compounds such as sodium silicate and sulfide, ammonium sulfate, soda, sulfuric acid. Sodium sulfate solutions have found applications as thermal accumulators in solar energy storage devices. Sodium sulfate is widely mined due to its high demand.

The authors show that the main part of sodium sulfate is obtained from natural raw materials - these are sea-type brines, salt deposits; a smaller part consists of by-products obtained in the production of synthetic fatty acids, fibers, chromium-containing compounds, which may also belong to raw materials for the production of sodium sulfate. The productivity of high-quality sodium sulfate is very high, because despite the fact that the production is more than 100,000 tons per year, the republic's need for it is increasing year by year. Large raw materials of sodium sulfate have been found in Uzbekistan, they are found in the salt deposits of the Aral Sea: in the Oqqali, Kushkanatuv, Tumruksoy deposits in the Republic of Karakalpakstan, as well as in the

deposits of the glauberite mineral in the depths of Fergana. and intermountain basins of Tien Shan. according to Tumruksoi is a mine of mirabilite, its composition is characterized by the minimum amount of impure salts of halite, epsomite and gypsum. In the message shows that despite the existence of a large raw material base, as well as the high demand for high-quality sodium sulfate, the product is produced in a small volume that does not meet the demand. The main reason for this inconsistency, according to scientists, is the lack of optimal technologies for processing the natural mirabilite of the Tumruksoy mine with the production of high-quality sodium sulfate.

Studies conducted by scientists revealed the possibility of obtaining the highest grade sodium sulfate from the mirabilite of the Tumruksoy mine. According to the researchers, a high yield of this commodity product can be obtained by implementing the production process as follows: it is necessary to dissolve mirabilite with juice vapors from the evaporation stage in the presence of circulating fluids, and then perform further purification. sodium hydroxide and carbonate solutions

The adjustment input proposed by the authors, according to an incomplete scheme - it is carried out only with the production of mirabilite and dehydration and drying processes have not been mastered for various reasons. The complete operation and good control of the Mirabilite crystallization process was demonstrated by the tests carried out during the operation of the installation. At the same time, a high level of sedimentation of the inner surfaces of the molds was found, which in turn causes the need for frequent washing, which is also characteristic of other schemes for obtaining mirabilite from solutions, for example, in the production of synthetic fibers, crystallization from lake salinity. According to the authors, the high energy of the process intensity is related to taking artificial cold the proposed installation is a major drawback.

Scientists determined the expediency of obtaining commercial sodium sulfate from the mirabilite of the Tumruksoy mine, first of all, by dissolving the salt, then removing the insoluble residue, crystallization of sodium sulfate decahydrate, and finally separating the product from the solution obtained by dissolving sodium sulfate decahydrate.

Researchers determined the composition of natural mirabilite of the Tumruksoy deposit, which contains 50 to 98.7% mirabilite, 8.3% gypsum, 2.4% epsomite, 0.2-0.3% halite and water-insoluble substances. the remaining 6-12%. Due to the fact that it has good quality and quantity indicators, it is definitely desirable to get sodium sodium sulfate according to the scheme, which includes dissolving and evaporating the salt from the natural mirabilite of the Tumruksoy mine, separating and cleaning the insoluble residue. The step of leaching sodium sulfate from natural mirabilite, unlike the known method, was carried out with water at a temperature of 50°C, simultaneously removing relevant impurities such as calcium, magnesium, chlorine, etc. The possibility of obtaining the highest grade sodium sulfate from the natural mirabilite of the Tumruksoy mine is shown as follows: dissolving mirabilite in water with simultaneous cleaning of solutions from water-insoluble residues and impurities; evaporation of water and obtaining the desired product. The yield of the highest grade sodium sulfate exceeds 90%, and unlike the known method, the yield of technical sodium sulfate is almost non-existent

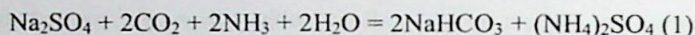
A decrease in the degree of electrolytic dissociation of sodium sulfate, an increase in the percentage of ethanol in a water-alcohol solution was demonstrated by the conductometric method. Scientists [found that the dissociation constant of sodium sulfate decreases with increasing concentration of alcohol in the solution.

The problem of processing condensed sulfur products obtained by way of production of non-ferrous metals has been widely discussed by the authors. The results of thermodynamic and experimental studies of the transformation of sulfate sulfur to obtain sodium sulfide, as well as alkali (NaOH), are presented in their work. In works scientists not only determine the conditions for the conversion of sulfate to sulphide sulfur, which provides a high conversion, but also show the effectiveness of using sodium sulfate as a basic material for the chemical production of NaOH in Na_2SO_4 . The CaO system provides nearly 100% Na_2O output.

As a result of studies compositions of liquid and plastic self-hardening mixtures are offered. Anhydrous sodium sulfate with a fineness modulus of 140 to 70 gives

molding sands with technical lignosulfonates new rheological and physical-mechanical properties: high fluidity, solidification speed, strength and easy hydro-knockout.

Using sodium sulfate to produce baking soda and ammonium sulfate allows for a sodium utilization rate of 95% instead of 70% in the Solvay method. In addition, the Solvay method is associated with large chloride emissions (up to 9 m³ per ton of soda ash). The use of sulfate instead of sodium chloride makes it possible to make soda production without waste due to the simultaneous release of soda ash and ammonium sulfate - a nitrogen fertilizer. The ammonia method of obtaining soda water from sodium sulfate is based on the reaction



In this process, instead of ammonium chloride, ammonium sulfate is formed, which is removed from the solution by evaporation and cooling. The use of raw materials here is 95-97%.

Severnaya mine has 11.4 million tons of salt reserves, an average mineral thickness of 1.5 m, an average mirabilite content of 92.85% and a mass density of 1310 kg/m³. Estimated resources of the South and East mines are 2.0 million tons, the average amount of mirabilite is 80.9 and 82.9%, respectively.

The Central Asian potash basin with an area of more than 35,000 km² is one of the largest known potash basins. Industrial reserves of potassium salts, located at a depth of up to 1200 m (available for mining), are estimated at 25 billion tons and are concentrated in the southwestern ridges of the Hisar range.

Industrial reserves of potash salts have been identified in Uzbekistan (Tyubegatan, Lyalimkan, Aqbosh, Khoja-Ikan, Khamkan, Boybichekan, etc.) and are a reliable raw material base for the development of the potash and iron industry.

Of the potassium salt deposits listed above, Tyubegatanskoye is the most interesting. Tubegatan is a mine located in the northeastern part of the basin.

The Tubegatan structure consists of three folds: Kurgontash, Karachagat and Tubegatan asymmetric structures. There are steep, almost vertical folds on the southeast slope, especially in the southeastern part, in the area of the Khojaypaq salt spring, there are traces of tectonic faults. Similar faults are present in the northeastern

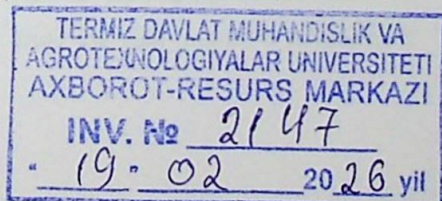
part of the mine, along which Lusitanian limestone of Upper Jurassic age is exposed in some places.

The presence of the dominant potash mineral sylvine, carnallite penetrates into separate lenses, sometimes small veins, salt clays.

In this part of the range, the Upper Jurassic Halogen Formation (Gaurdak Formation) has a three-member structure. Underlying it is an anhydrite layer with a thickness of 156 to 420 m. It forms rare contacts with the main anhydrites, and then passes gradually in the form of intermixing of anhydrites and anhydrite-halite rocks with rock salt. The upper part of the salt layer is potassium. A layer of clayey anhydrites with a thickness of 1 to 10–15 m, from tens to 300 m, containing 1–2 to 9–11 potassic layers, from several meters to 20–25 m, is laid on top of the salt layer.

Such a structure is generally preserved for all known K-salt deposits of the Upper Jurassic Halogen in southern Central Asia, but the thickness, structure and lithological composition of the packages vary and significantly depend on the position of the deposit, salt basin. In the mines located in the northeastern part of the basin (Tyubegatan, Aqbosh, Lyalimkan), potassic layers are less thick, and anhydrite and halopelite mixtures are more abundant in the salts.

In the Karlyukskoye and Karabilskeye deposits located in the southwestern part of the basin, potash layers are distinguished by their high thickness and abundance in their section. Thus, two potash horizons were recorded in the Akbash area, three in Tubegatan (one industrial layer up to 10.6 m thick), in Gaurdak - 7 layers and lenses, three of which are industrial. 18 layers, interlayers and lenses were identified in the Karluk mine salt section, including six (up to 40 m thick or more) intended for industrial use. In Tubegatan, Akbash, and Lyalimkan, the potassium mineral sylvine is dominant, and the presence of carnallite penetrates into separate lenses, sometimes small veins, and salt clays. Thick layers of carnallite were formed in the Karluk mine. In the same direction, from the northeast to the southwest, the amount of potassium also increases, which is expressed by million tons of crude potassium salts per kilometer of the studied area: 10 in the Tubegatan mine, 40 in Okuzbulakskoe, and 43 in Karlyukskoe.



The most common rock-forming mineral in the salt rocks of the studied deposits is halite, which makes up more than 80% of the salts. After halite, the second most abundant rock-forming mineral is sylvin (-10% of the total volume of salt). Usually, sylvin is found in paragenesis with halite, carnallite, gallolellites, less often with anhydrite. In the deposits of the northeastern part of the region (Tyubegatan, Akbash), sylvin in the form of monomineral compounds is very rare and forms only small interlayers with a thickness of 5-10 cm; they are more common in the southwestern parts of the basin (Khoja-Ikan, Karabil), where there are 2-3 cm thick layers composed of sylvinite with 95-98% KCl. In the mines of the northeastern part (Tübegatan, Akbash) carnallite plays a subordinate role and does not exceed 2%. In the sediments of the south-western part of the region (Khoja-Ikan, Karabil, Karluk), its role increases and it becomes a component that forms rocks.

In the study of the material composition of salt rocks, the following types of ores were identified: rock salt with sylvin inclusions (KCl<5%), rock salt with sylvinite (KCl from 5 to 10%); poor sylvinite (KCl from 10 to 20%); KCl-rich sylvinite 20% to 50%, very rich sylvinite (KCl> 50%), carnallite-bearing sylvinite (20% sylvinite, 10% carnallite), very rich sylvinite with carnallite addition (50% sylvinite carnallite) 10 %, poor carnallite (carnallite from 10 to 20%); rich carnallite (carnallite > 20%).

From the analysis of the data on the composition of magnesium chloride and its distribution in the potash deposits of the Central Asian potash basin, it can be concluded that, along with sylvinites, they contain a large amount of mixed carnallite-sylvinites, sylvinite-carnallite ores, for which, as mentioned above, the current at the moment, there is enough reliable and efficient technology for mining and processing

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Resources of sylvinites estimated at 500 million tons. Of the above-mentioned potassium salt deposits, the Tubegatan and Karluk deposits are of great interest. Tubegatan has 3 potash horizons (between 117 and 956 m below surface) intersected by 40 wells on an area of 81.3 km². The average thickness of the industrial layer (II bottom) is 5.1 m; it consists of sylvinites ores ($\text{KCl} + \text{NaCl}$), average content of KCl 36.88%, MgCl_2 0.24%, n.d. - 3.74%. Researched reserves of potassium salts in categories A, B, C - 400.3 million tons (93.4-94.0 million tons of K_2O), in categories C2 - 285.5 million tons. (65.1 million tons) t K_2O). Predicted reserves for category Pi are 500 million tons of crude potassium salts (103.6 million tons of K_2O).

The potassic unit in the Karluk deposit includes up to 16 layers, lenses and intermediate layers of potassium salts, 6 of which are industrial, but they consist mainly of sylvinites carnallite: the average content of KCl is from 27.5 to 35.0%, MgCl_2 - from 6.07 up to 10.6%. The total estimated reserves of potassium salts in this deposit are 685.9 million tons (K_2O 185.6 million tons), but sylvinites ores account for only 30.6%,

corresponding to the proportion of sylvinite-carnallite ores (from 5.4% to 14.6% with MgCl_2) will come) about 70%.

Thus, the studied reserves of K_2O in sylvinites in the Tyubegatanskoye and Karlyukskoye deposits are 158.6 and 170.0 million tons, respectively, but the possibility of increasing the reserves of sylvinite ores in the Karlyukskoye deposit is limited, while in Tube it is projected. (103 million tons of K_2O).

1.3. Technical solutions in the field of obtaining potassium-ammonium sulfate and potassium sulfate

Potassium sulfate or potassium sulfate is colorless crystals with a density of 2.66 g/cm^3 and a melting point of 1074 $^\circ\text{C}$. The solubility in water is 11.1 g per 100 g of water at 20 $^\circ\text{C}$, 24.1 g at 100 $^\circ\text{C}$. K_2SO_4 is rare in nature and is found in crystalline form with calcium, magnesium and sodium sulfates in the potassium salt of Staat Furt. It is found in natural salts such as kainite, schenite, leonite, langbeinite, glaserite, polyhalite, which are raw materials for the production of potassium sulfate.

There are many ways to obtain K_2SO_4 using natural sulfate-type potassium ores, as well as potassium chloride and sulfates of various sulfate-preserving compounds - sodium, magnesium, iron, calcium, ammonium, sulfuric acid, etc.

Most often, potassium sulfate as a fertilizer is obtained from natural raw materials - sulfate potassium ores by the halurgical method. They are based on the different solubility of the salts that make up the ores depending on the temperature. The essence of the process is to melt the crushed raw material in the processed liquid at 60-70 $^\circ\text{C}$, remove the strong liquid from the system, produce schenite from it and recycle it with water to potassium sulfate.

The conversion method for the production of potassium sulfate based on potassium chloride and various sulfate salts is of particular importance. The theoretical basis of these processes is K^+ , $\text{Na}^+//\text{Cl}^-$, SO_4^{2-} , H_2O systems; K^+ , $\text{Na}^+//\text{Cl}^-$, SO_4^{2-} , H_2O ; K^+ , $\text{Na}^+//\text{Cl}^-$, SO_4^{2-} , H_2O ; K^+ , $\text{Na}^+//\text{Cl}^-$, SO_4^{2-} , H_2O , etc.

Canada has mastered the industrial production of natural salts of potassium sulfate and sodium sulfate from potassium chloride. In the USA, a method of obtaining potassium sulfate obtained from Lake Searles was developed.

The conversion method of obtaining potassium sulfate by splitting potassium chloride with sulfuric acid is widely used. In the USA, France, Belgium, Japan, China, the conversion method of obtaining K_2SO_4 by decomposing potassium chloride with sulfuric acid is widely used.

A method of obtaining potassium sulfate by splitting potassium chloride with ferrous sulfate, hydrothermal reduction of langbeinite with coke from natural potassium-magnesium salts, and heat treatment with potassium chloride and langbeinite or other potassium-magnesium salts has been developed. salts.

Studying the ratio of components in the K^+ , $Na^+//Cl^-$, SO_4^{2-} , H_2O system L.I. Znelavsky, BETBETSinani and A.A. As a result of many years of research, Sokolov determined that it is expedient to carry out the conversion process in two stages through an intermediate product - glaserite.

The method of obtaining potassium sulfate from the hydromineral raw materials of Kuchuk Lake, Arolboi Lakes, Karabogizgala by the interaction of potassium chloride with epsomite has been developed. The basis of this process is K^+ , $Na^+//Cl^-$, SO_4^{2-} , H_2O and $K_2SO_4 - MgSO_4 - H_2O$ systems. The physico-chemical properties of the systems are based on the technology of processing minerals such as schenite, leonite, langbeinite and polyhalite into potassium sulfate. In order to achieve a high yield of potassium sulfate, it is advisable to carry out the process at $25^\circ C$ in two stages with the isolation of an intermediate product, schenite.

A method of obtaining potassium chloride and potassium sulfate from gypsum is known, based on the physicochemical properties of the K^+ , $Ca^{2+}//Cl^-$, $SO_4^{2-} - H_2O$ system. Development of technology, according to which the process is carried out in two stages: in the first stage syngenite ($K_2SO_4 \cdot CaSO_4 \cdot H_2O$) is obtained, in the second stage it is decomposed into potassium sulfate.

The processing of salt rocks of the republic is known - Kushkantov and Akkala mines. Physico-chemical justification of processing processes is based on the solubility

data of Na, Mg, Ca/SO₄·H₂O and K, Mg/Cl, SO₄·H₂O systems. To process the Kuchukanov salt state, the astrakhanite-halite mixture solution was cooled to 5°C, the mirabilite was separated into the solid phase, and the filtrate was evaporated after the filtrate was evaporated to separate pure halite, saturation and 42% MgCl₂ concentration was obtained. Considering that epsomite is one of the main rock-forming minerals of the Akkala mine, epsomite ascored technology was used to obtain K₂SO₄.

A method of obtaining K₂NO₃ containing 46-52% K₂O was developed according to a two-stage scheme. In the first step, tripotassium hydrosulfate K₃H(SO₄)₂ salt is partially formed by reaction of sulfuric acid with K₂SO₄. The resulting salt decomposes into the second in the presence of a stoichiometric amount of potassium chloride. The process is carried out in the first stage at 150-200°C, in the second at 450-500°C.

A process for producing chlorine-free potassium fertilizer is patented, including recycling of KCl, treatment of KCl with fluorosilicic acid, separation of potassium silicofluoride by filtration, and heat treatment at >975°C for >1 hour. potassium fluoride treated with a calcium-containing component to obtain water-absorbed silicon tetrafluoride and the resulting fluorosilicic acid returned to the beginning of the process to produce a chlorine-free fertilizer and calcium fluoride. Calcium nitrate or calcium sulfate is used as a calcium-containing component. The method makes it possible to create a new technology for the production of chlorine-free potash fertilizers, which can be used as potassium components for complex chlorine-free potash fertilizers.

A method for the production of potassium sulfate using sodium sulfate and potassium chloride is described. The method involves a crystallization process with the formation of a circulating liquid containing sulfate, sodium, and chloride. The circulating liquid is sent to the anion isolation module, where the lag stream or sulfate-rich retentate is collected, which is recycled and used to produce potassium sulfate. In addition, an anion isolation module produces permeate, lost in sulfate but containing sodium and chloride, which is sent to a sodium chloride crystallizer to produce sodium chloride.

The invention relates to the production technology of mineral fertilizers, including the interaction of ammonium sulfate with potassium chloride in the presence

of additives, which is used as urea in the molar ratio of urea and ammonium sulfate (3-5): 1.0.

In the method of obtaining chlorine-free potassium fertilizer by thermal treatment of a mixture of high-silicon aluminosilicate raw materials and alkaline metal carbonate, sinirsium is used as aluminosilicate raw material, and potassium carbonate or bicarbonate is used as a carbonic salt of alkaline metal, which has a molar ratio of $\text{SiO}_2/\text{K}_2\text{O} = 0.28-0.50$ and heat treatment is carried out at $800-850^\circ\text{C}$ for 0.5-3 hours.

The invention relates to the production technology of potassium-soluble silicates, that is, methods of obtaining carboxylic silicate fertilizer used in agriculture as a potash fertilizer for acidic and other soils. According to the proposed method, amorphous silica is treated and treated with an alkaline potassium-silica solution containing 180-185 g/l of etching K_2O , 220-225 g/l of carbonate K_2O and 115-120 g/l of SiO_2 , is carried out at a temperature of $80-70^\circ\text{C}$ for 20-50 minutes until the molar ratio $\text{K}_2\text{O}-\text{SiO}_2 = 0.98-1.02$. The product of hydrochemical treatment of pseudoleucite ores is used as an alkaline solution. The proposed method is easy to implement and allows obtaining a non-hygroscopic product.

According to the method for the production of nitrogen-potassium fertilizer, which includes treating potassium hydrogen sulfate with metal nitrate in an aqueous medium, then neutralizing the suspension with ammonia or ammonia water, separating the metal sulfate precipitate, and dewatering the circulating liquid, barium nitrate or strontium nitrate is used as metal nitrate. It is advisable to first neutralize the suspension with ammonia to pH 1-5, the precipitate of metal sulfate is separated, and then the solution is neutralized to pH 5-7.

Potassium hydrogen sulfate KHSO_4 contains a high content of H_2SO_4 ion - (38.2% by weight), which gives the compound an acidic environment, so this substance can be used as a ready-made fertilizer, but the neutralization step of potassium hydrogen sulfate is necessary. The study of the neutralization of potassium hydrosulfate with gaseous ammonia showed that as a result of the interaction of NH_3 and KHSO_4 , a mixture of potassium-ammonia hydrosulfate $(\text{KNH}_4\text{H})_2(\text{SO}_4)_3$ and potassium

trihydrosulfate $K_5H_3(SO_4)_4$ is formed. This indicates that the process of neutralization of potassium hydrosulphate with gaseous ammonia does not continue to the end

A method of obtaining chlorine-free potassium fertilizer by reacting ammonium sulfate and potassium chloride in the presence of an organic salting agent - dimethylformamide in the amount of 20-30 wt. %. During the interaction between potassium chloride and ammonium sulfate in the water environment, only 78% of the chlorine-free fertilizer falls into the solid phase. However, if this conversion is carried out in the presence of dimethylformamide (15 g.%), the yield of chlorine-free fertilizer is 90.8%.

The method of obtaining chlorine-free potassium nitrogen fertilizer in the form of a double salt of potassium-ammonium sulfate $[5K_2SO_4 \cdot (NH_4)_2SO_4]$ is carried out by converting KCl into ammonium sulfate according to the reaction $[10KCl] + 6(NH_4)_2SO_4 = 5K_2SO_4 \cdot (NH_4)_2SO_4 + 10NH_4Cl$ solution, saturated with NH_4Cl double salts, the suspension is heated to $90^\circ C$, then cooled to room temperature, and mixed with a cooling gradient of 0.3-0.35 degrees. /min, and separation of final reaction products (double salt of potassium-ammonium sulfate and NH_4Cl) is carried out by flotation method with the help of reagent-collector, sodium lauryl sulfate, introduced in the amount of 25-50 g per ton. floating salts.

Chlorine-free complex fertilizer is obtained by reacting the natural potassium-magnesium compound with ammonium sulfate in a saturated solution of ammonium sulfate at a temperature from 0 to $90^\circ C$ until the minimum amount of magnesium ions is reached in the formed solid phase. 6 wt. Simplify and reduce the cost of the process, providing the ability to regulate the proportions of useful components in the final product. The proposed method is as follows. Natural potassium-magnesium raw materials, such as carnallite and ammonium sulfate, are mixed in water at normal temperature, for example, $25^\circ C$, or potassium-magnesium raw materials are added to a saturated aqueous ammonium sulfate solution. In this, the process of converting the initial solid phases into a new solid phase $(KNH_4)_2SO_4 \cdot MgSO_4 \cdot 6H_2O$, potassium-ammonium shenite, is called ammonium potassium magnesium (AKM) by the authors.

The resulting target product, i.e. chlorine-free complex fertilizer, is separated from the solution and dried.

High-temperature combustion ash thermal coals are treated with caustic potash with a K_2O content of 120-200 g/dm³ at 95-105°C for 2.5-3.5 hours in a molar ratio of $SiO_2:K_2O = 0.95-1.05$, resulting in will be. as a result of the reaction, the mass is filtered and the filtrate is evaporated. The purpose of the invention is to save the environment. This is achieved by using high-temperature thermal coal combustion ash as a silicate-containing feedstock in a process that involves treating the raw material with an alkaline solution and evaporating the resulting solution of potassium silicate. with a solution containing 120-200 g/dm³ K_2O at 95-105°C in a molar ratio of 2.5-3.5 hours. $SiO_2:K_2O = 0.95-1.05$ in solution, then the solid part is separated, which is an alumina concentrate. The use of ash ensures the transition of SiO_2 to the SiO_2/K_2O -1 molar ratio due to the presence of crystalbolite in the ash, and the small transition of Al_2O_3 to the solution is explained by its dependence. with SiO_2 almost entirely in mullite.

Chlorine-free potassium-magnesium fertilizers from polyhalite ores related to the production technology of the invention. The invention relates to the field of inorganic chemistry and can be used in the processing of polyhalite ores for schenite. Crushed polyhalite ore is calcined at temperatures above 450°C, smelted to obtain a suspension, after which a mixture of halite, calcium sulfate and insoluble compounds is separated by condensation and filtration. The resulting clarified solution is cooled at a temperature of 15-25°C to crystallize schenite. Crystallization - schenite is dried at a temperature of 190-210°C, and the liquid obtained after crystallization is returned to melting. Effect: the invention allows to eliminate accumulation of polyhalite ore in the burning process, reduce energy consumption and eliminate liquid production waste.

Potash fertilizers from production waste according to the methods of the invention. This goal is achieved in a known method by filtering the mixture of sulfates with a solution of potassium hydroxide and turning the resulting K_2SO_4 into a K_2SO_4 pulp of 800-900. g of solids per 1 liter at pH 7.8-8.5 and temperature 58-60°C, $MnSO_4$ solution is added with constant stirring, then the solid phase is separated and the resulting product is dried. It is advisable to continuously stir the manganese sulfate

solution at 28-30°C for 30-32 minutes in the amount of 33.5-41.5 kg/t of solids. In order to obtain manganese potassium sulfate that meets the requirements of GOST 546578, a method of introducing manganese microelement into the K_2SO_4 fertilizer has been developed. Manganese is dosed in the form of a 24% manganese sulfate solution at the rate of 36 kg of $MnSO_4$ per 1 ton of solid matter (potassium sulfate).

1.4. Conclusions from the literature review

The production of mineral fertilizers is developing rapidly in our republic. This development has not only a quantitative, but also a qualitative aspect: the base of raw materials is expanding, technology and equipment are being improved, the assortment of mineral fertilizers is increasing and their quality is increasing.

Greenhouses, a growing branch of agriculture, need chlorine-free potash fertilizers. The republic does not produce them yet and imports them from abroad. Development of potassium sulfate production technology from existing raw materials in our republic is an important economic problem.

In recent decades, the demand for chlorine-free potassium fertilizers has increased, among which potassium sulfate occupies a special place. Its production is increasing year by year, but the demand is not decreasing. This is primarily due to the increased use of drip irrigation, growing agricultural products in greenhouses, and growing vegetables and fruits in chlorine-intolerant greenhouses.

A critical analysis of existing literature sources shows that the development and improvement of a continuous waste-free technology for the production of potassium sulfate and sodium chloride by converting flotation potassium chloride to sodium sulfates is an urgent task. Our republic's need for potassium sulfate salts is more than 100,000 tons per year, but despite the availability of all kinds of local raw materials for their production, they are not produced due to the lack of scientifically developed technology. This master's thesis is dedicated to solving this urgent problem. There is no information on these issues in the available literary sources. Solving the above issues is the main goal and task of this master's thesis.

CHAPTER II. CHARACTERISTICS OF BASIC, INTERMEDIATE AND FINISHED PRODUCTS

§ 2.1. Characteristics of used materials and methods of conducting experiments

We used flotation potassium chloride according to GOST 4568-95 [100] produced from the sylvinites of the Tubegetan mine at Dehkhanaabad Potash Plant OJSC to conduct experiments on the development of the technology for obtaining potassium sulfate by the conversion method. Sodium sulfate from mirabilite of the Tumruksoy mine according to GOST 5644-75 [101], mirabilite of the Tumruksoy mine. The Tubegetan mine, located in the south of Turkmenistan, is the largest and most well-explored, with reserves of more than 400 million tons of potash salts. The average amount of potassium chloride is 36%.

The Tumruksoy mirabilite mine is located 20 km west of the Jasliq railway station of the Kungirot-Baikeu branch in the Kungirot region of the Republic of Karakalpakstan. The Tumruksoy mine differs from other mines not only by the high concentration of mirabilite (average amount 83.3%, 92.8% in the calculation contour of the reserve), but also by favorable exploitation conditions. a saline layer lies on its surface. Mirabilit reserves are estimated at 11,403,000 tons or 5,029,000 tons of Na_2SO_4 .

Flotation potassium chloride powder (fine) contains 60% K_2O or 95% KCl .

Studies on the conversion of flotation potassium chloride with mirabilite solutions were carried out in a laboratory model unit consisting of a glass reactor equipped with a stirrer and placed in a thermostat.

The raw material used in further research - flotation potassium chloride of Dehkhanaabad Potash Plant OJSC has the following chemical composition, weight. %: KCl - 95.3; NaCl - 2.97; But. - 1.1; H_2O - 0.43; Minerality of the Tumruksoy mine, composition (wt.%): Na_2SO_4 - 44.8; MgSO_4 - 0.72; CaSO_4 - 2.50; NaCl - 0.3; But. - 0.7.

§ 2.2. Methods of chemical analysis and physicochemical research

Potassium was determined by forming a precipitate of potassium perchlorate insoluble in ethyl alcohol and determining its mass.

Sodium was determined by flame photometric method.

Calcium and magnesium were determined by the complexometric method. The method is based on the change in the color of the indicator in the interaction of calcium and magnesium ions with triton B (calcium in the determination of magnesium and dark blue in the determination of acid chromium).

Sulfates were determined gravimetrically. The method is based on the precipitation of sulfates with barium chloride in an acidic medium, followed by weighing the precipitate.

Water in solid samples was determined by oven drying at 100–105°C to constant weight.

The density of solutions and pulps was determined using a PZh-2 pycnometer. Kinematic viscosity of solutions and pulps was measured by VPZh-1 and VPZh-2 glass capillary viscometers.

The study of the equilibrium of heterogeneous phases in systems was carried out by the visual - polythermal method. The essence of this method is to visually observe the temperature of the formation of the first crystals during uniform cooling or the disappearance of the last crystals during slow heating and continuous mixing of solutions. The solubility determination device is a stoppered tube with a platinum or glass stirrer and a thermometer with a graduation of 0.1 °C. For uniform cooling, the test tube is placed in an external tube-coupling located in the coolant mixture. Heating is also carried out through the clutch. Cooling is carried out in Dewar containers with liquid nitrogen or dry ice.

Construction of polythermal solubility diagrams for the studied systems was carried out by us in the form of a right triangle. In polythermal diagrams, isotherms are plotted every 5°C using interpolation based on polythermal sections. The determination of the composition of the nodal invariant points and the crystallization temperature was

performed by projecting the polythermal solubility curves onto the corresponding lateral water sides of the system.

Solid phases were determined by chemical, X-ray phase and infrared spectroscopic methods.

CHAPTER III. STUDY OF FLOTATION POTASSIUM CHLORIDE CIRCULATION PROCESS WITH TUMRUK MIRABILITY.

§ 3.1. Solubility polyterms of systems based on potassium chloride and potassium and sodium sulfates

In order to physico-chemically justify processes of transformation of potassium chloride into sodium sulfate, $\text{Na}_2\text{SO}_4 - \text{KCl} - \text{H}_2\text{O}$ and $\text{K}_2\text{SO}_4 - \text{KCl} - \text{H}_2\text{O}$ systems were studied by visual-polythermal method.

The solubility of the components in the $\text{Na}_2\text{SO}_4\text{-KCl-H}_2\text{O}$ system was studied using eight internal cross-sections. Based on the polytherms of binary systems and internal cross sections, a polythermal solubility diagram was constructed for this system in the temperature range from -12.2 to 68.8°C , which is shown in Fig 3.1.

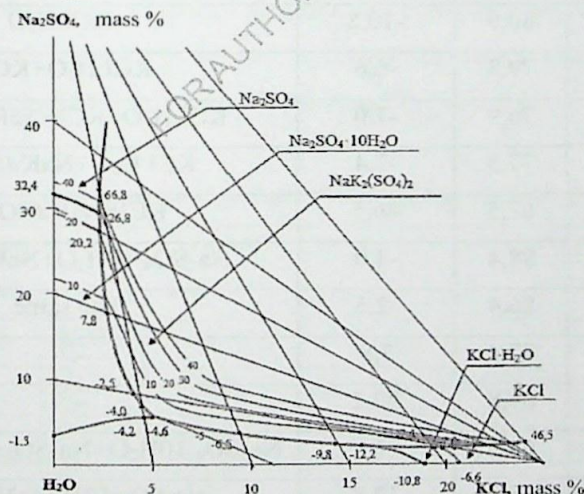


Figure 3.1. Solubility diagram of $\text{Na}_2\text{SO}_4\text{-KCl-H}_2\text{O}$ system

In the polythermal solubility diagram, the crystallization areas of ice, $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$, Na_2SO_4 , $\text{KCl} \cdot \text{H}_2\text{O}$, KCl and the new phase $\text{NaK}_2(\text{SO}_4)_2$ are delimited. To identify a new compound, we isolated crystals of the compound from the

approximate area of crystallization and studied it by chemical and physicochemical analysis methods.

The composition of two and three points of $\text{Na}_2\text{SO}_4\text{--KCl--H}_2\text{O}$ system is presented in Table 3.1.

Table 3.1

$\text{Na}_2\text{SO}_4\text{--KCl--H}_2\text{O}$ two and three points of the system

The composition of the liquid phase, %			Tembet krist, °C	Solid phase
Na_2SO_4	KCl	H_2O		
4,9	-	95,1	-1,3	$+\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$
6,2	4,6	89,2	-4,2	The same
6,2	5,3	88,5	-4,6	$+\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O} + \text{NaK}_3(\text{SO}_4)_2$
4,6	9,4	86,0	-6,5	$+\text{NaK}_3(\text{SO}_4)_2$
3,8	14,2	82,0	-9,8	The same
3,6	15,8	80,6	-12,2	$+\text{NaK}_3(\text{SO}_4)_2 + \text{KCl} \cdot \text{H}_2\text{O}$
-	19,1	80,9	-10,8	$+\text{KCl} \cdot \text{H}_2\text{O}$
-	20,7	79,3	-6,6	$\text{KCl} \cdot \text{H}_2\text{O} + \text{KCl}$
3,5	19,6	76,9	-7,0	$\text{KCl} \cdot \text{H}_2\text{O} + \text{KCl} + \text{NaK}_3(\text{SO}_4)_2$
3,5	19,0	77,5	-7,4	$\text{KCl} \cdot \text{H}_2\text{O} + \text{NaK}_3(\text{SO}_4)_2$
3,8	28,7	67,5	46,5	$\text{KCl} + \text{NaK}_3(\text{SO}_4)_2$
7,2	4,4	88,4	-4,0	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O} + \text{NaK}_3(\text{SO}_4)_2$
9,4	4,2	86,4	-2,5	The same
18,8	3,8	77,4	7,8	-//-
28,6	3,6	67,8	20,2	-//-
29,8	3,6	66,6	26,8	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O} + \text{Na}_3\text{SO}_4 + \text{NaK}_2(\text{SO}_4)_2$
33,0	-	67,0	32,8	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O} + \text{Na}_2\text{SO}_4$
34,4	3,6	62,0	66,8	$\text{Na}_2\text{SO}_4 + \text{NaK}_3(\text{SO}_4)_2$

The solubilities of the components in the system K_2SO_4 - KCl - H_2O were studied using six internal cuts. Based on the polytherms of binary systems and internal cross sections, a polythermal solubility diagram was constructed for the above system in the temperature range from -11.2 to $70^\circ C$, which is shown in Figure 1.

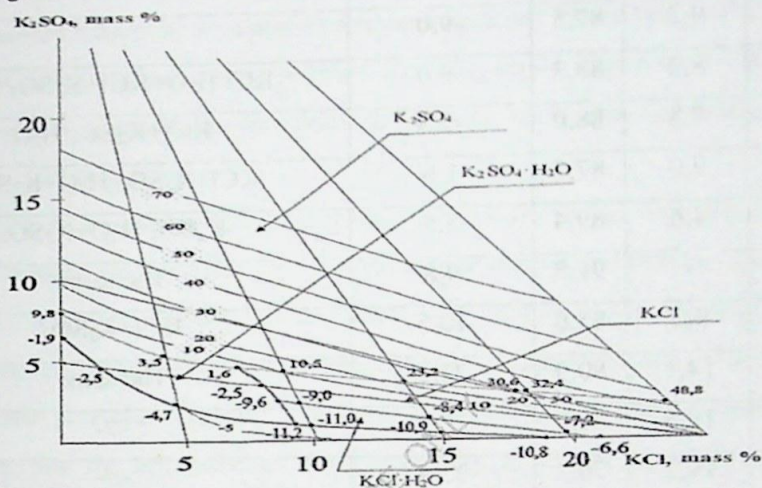


Figure 3.1. Solubility diagram of K_2SO_4 - KCl - H_2O system

In the polythermal solubility diagram, the crystallization areas of $K_2SO_4 \cdot H_2O$, K_2SO_4 , $K_2SO_4 \cdot H_2O$ and KCl of ice are delimited. The composition of two and three points of the K_2SO_4 - KCl - H_2O system is presented in Table 3.2.

Table 3.2

Two and three points of the K_2SO_4 - KCl - H_2O system

The composition of the liquid phase, %			Tembet krist, $^\circ C$	Solid phase
K_2SO_4	KCl	H_2O		
7,2	-	92,8	-1,9	+ $K_2SO_4 \cdot H_2O$
4,5	2,6	92,9	-2,5	The same
3,6	4,3	92,1	-4,7	-//-
1,8	9,2	89,0	-11,2	+ $K_2SO_4 \cdot H_2O$ + $KCl \cdot H_2O$
1,7	9,8	88,5	-11,0	+ $KCl \cdot H_2O$
1,0	14,8	84,2	-10,9	The same

-	19,1	80,9	-10,8	-//-
-	20,7	79,3	-6,6	KCl·H ₂ O+KCl
0,5	19,6	79,9	-7,2	The same
2,2	14,6	83,2	-8,4	-//-
2,8	9,7	87,5	-9,0	-//-
3,5	8,2	88,3	-9,6	KCl·H ₂ O+KCl+K ₂ SO ₄ ·H ₂ O
4,2	7,8	88,0	-2,5	KCl+K ₂ SO ₄ ·H ₂ O
5,3	7,0	87,7	1,6	KCl+K ₂ SO ₄ ·H ₂ O+K ₂ SO ₄
6,0	4,6	89,4	3,5	K ₂ SO ₄ ·H ₂ O+K ₂ SO ₄
8,2	-	91,8	9,8	The same
5,2	9,2	85,6	10,5	KCl+K ₂ SO ₄
5,0	14,1	80,9	23,2	The same
4,6	18,5	76,9	30,6	-//-
4,5	19,2	76,3	32,4	-//-
3,8	24,2	72,0	48,8	-//-

As can be seen from the solubility diagram of the system, K₂SO₄·H₂O and K₂SO₄ are formed as a new phase, the crystallization area of which occupies the main part of the diagram, which is explained by its low solubility in the system compared to its solubility. from other components.

The compound was isolated in crystalline form and identified by chemical, X-ray, IR-spectroscopic and electron microscopic methods of physicochemical analysis.

The chemical and physicochemical analysis of the solid phase separated from the area of the alleged presence of the compound confirmed the formation of the latter.

§ 3.2. Studying the conversion process of flotation potassium chloride with mirabilite from Tumruk mine.

The mirabilite of the Tumruksoi mine contains from 70 to 98.7% of the main substance, on average 90.53%, gypsum 0.1-8.3%, on average 2.48%, epsomite (MgSO₄·7H₂O) 0.06-2.4%, contains an average of 0.0% halite. 0.2-0.3%, m.d. 6 to 12%.

The presence of various impurities in natural mirabilite from 7 to 23% does not allow it to be used without purification to obtain crystalline potassium sulfate by the conversion method from potassium chloride and sodium sulfate. The main components of impurities are gypsum and water-insoluble residues. Studies have shown that it is advisable to dissolve mirabilite in water at a temperature not lower than 50°C to obtain a saturated solution of sodium sulfate purified from the main impurities. In this case, a high dissolution rate of mirabilite is achieved, and due to its low solubility, calcium sulfate remains in the sediment.

Flotation potassium chloride contains at least 95.0% of the main substance and up to 5.0% of impurities. Mixtures of sodium, magnesium and calcium chlorides are well soluble in water, their amount in a saturated solution is very small and almost does not affect the conversion process of potassium chloride remaining in the solution.

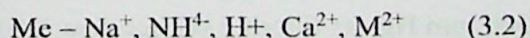
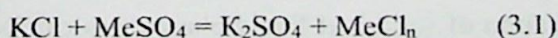
To obtain potassium sulfate from the flotation potassium chloride of the Tubegatan mine and the mirabilite of the Tumruksoy mine, we used the method of converting a saturated solution of potassium chloride (26.8%) and a solution containing 10-12% potassium chloride (Table 3.3).

Table 3.3.

Effect of temperature on density and viscosity of saturated (26.8%) and 10% potassium chloride solutions.

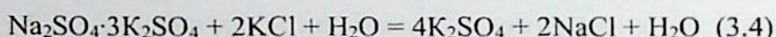
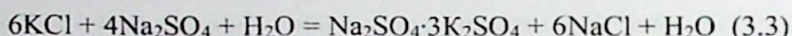
The content of KCl in the solution, %	Density, g/sm ³				Stickiness, sPz			
	20°C	40°C	60°C	80°C	20°C	40°C	60°C	80°C
26,8	1,184	1,171	1,158	1,146	0,905	0,835	0,719	0,605
10	1,058	1,050	1,044	1,038	1,021	0,811	0,665	0,583

The conversion method for the production of potassium sulfate is based on the exchange interaction between potassium chloride and various sulfate-containing salts according to the reaction:



The most optimal raw materials for the conditions of Uzbekistan are flotation potassium chloride, mirabilite or sodium sulfate, ammonium sulfate. The basis of this process is the solubility of salts in the K^+ , Na^+/Cl^- , $SO_4^{2-} - H_2O$ system. The components of this system are well studied over a wide temperature range. It has been shown that the crystallization area of potassium sulfate is much smaller than the crystallization area of glaserite $(NaK_3)_2(SO_4)_4$, so the conversion in an aqueous environment can be carried out in two stages: the formation of glaserite in the first stage and its decomposition into potassium sulfate in the second stage.

Obtaining K_2SO_4 by converting potassium chloride into an aqueous solution of sodium sulfate or mirabilite is characterized by the following reactions:



Studies on the conversion of potassium chloride with sodium sulfate were carried out using flotation potassium chloride of the joint-stock company "Dehkhanaabad Potash Plant", the composition (wt.%): $KCl - 95.3$; $NaCl - 2.97$; But. - 1.1; $H_2O - 0.43$ and the content of the mirabilite of the Tumruksoy deposit (wt.%): $Na_2SO_4 - 44.8$; $MgSO_4 - 0.72$; $CaSO_4 - 2.50$; $NaCl - 0.3$; But. - 0.7 obtained in a laboratory device consisting of a glass reactor equipped with a stirrer and placed in a thermostat.

The technology of obtaining potassium sulfate consists of two stages. In the first stage, potassium chloride was obtained from the mirabilite of the Tumruksoy mine with sodium sulfate to obtain glaserite, and in the second stage, potassium sulfate was obtained from the solution of glaserite.

If mirabilite from the Tumruksoy mine is dissolved in water at a temperature of $50^\circ C$ and above, after 5 minutes the concentration of sodium sulfate reaches 30% and more. Crystalline potassium chloride was mixed into a saturated sodium sulfate solution purified from insoluble impurities in a molar ratio of $KCl:Na_2SO_4 = 1:(0.8 \div 1.5)$ at a temperature of $50^\circ C$, observing $Q:S = 1:1$. The duration of the transfer process is 60 minutes. The separation of solid and liquid phases was carried out in a filter apparatus under a vacuum of 300 mm Hg. Its filtering surface area is 0.005 m². The obtained data are presented in Table 3.4.

Table 3.4

Effect of KCl:Na₂SO₄ molar ratio on chemical composition of solid and liquid phases.

Molar ratio KCl:Na ₂ SO ₄	Chemical composition of the solid stages, mass%					The chemical composition of the liquid Stages, mass %				
	K ₂ O	Na ₂ O	SO ₄ ²⁻	Cl ⁻	H ₂ O	K ₂ O	Na ₂ O	SO ₄ ²⁻	Cl ⁻	H ₂ O
1:0,8	41,61	8,52	50,10	4,13	4,90	10,50	12,46	2,96	16,81	62,82
1:0,9	40,86	9,04	50,36	3,97	5,07	8,68	12,07	3,21	16,56	64,54
1:1,0	40,10	9,56	50,61	3,80	5,23	6,86	11,67	3,46	16,30	66,26
1:1,1	39,21	10,07	50,86	3,68	5,53	6,40	10,28	5,60	12,78	68,75
1:1,2	38,32	10,57	51,10	3,55	5,83	5,93	8,90	7,73	9,25	71,24
1:1,3	37,55	11,13	51,35	3,42	6,00	5,57	9,29	8,35	8,74	71,24
1:1,4	36,78	11,68	51,60	3,28	6,16	5,20	9,67	8,96	8,23	71,23
1:1,5	36,02	11,89	51,84	3,15	6,33	4,86	9,97	9,62	7,75	71,23

As can be seen from the table, as the molar ratio of KCl:Na₂SO₄ increases from 1:0.8 to 1:1.5, the amount of Na₂O and H₂O in the solid phase increases, K₂O and chloride ions decrease, SO₄²⁻ ions. 50.10-51 remains at the level of 84%. Na₂O increases from 8.52% to 11.89%, K₂O from 41.61% to 36.02%, chlorine decreases from 4.13% to 3.15%. The moisture content of the solid phase increases from 4.90% to 6.33%.

In the liquid phase, K₂O decreases from 10.50% to 4.86%, Na₂O from 12.46% to 9.97%, chloride ions from 16.81% to 7.75%, and only SO₄²⁻ ions decrease to 2.96% increases to 9.62%.

The effect of Q:S on the conversion of potassium chloride with sodium sulfate was carried out at a molar ratio of KCl:Na₂SO₄ = 1:1, at a temperature of 50 °C and a duration of the process of 60 minutes. The obtained results are presented in Table 3.5.

Table 3.5

Effect of Q:S on the chemical composition of liquid and solid phases

Q:S	Chemical composition of the solid stages , mass%					The chemical composition of the liquid stages , mass%				
	K ₂ O	Na ₂ O	SO ₄ ²⁻	Cl ⁻	H ₂ O	K ₂ O	Na ₂ O	SO ₄ ²⁻	Cl ⁻	H ₂ O
1:0.8	38,08	10,31	49,10	4,24	7,40	7,87	13,20	3,27	18,67	61,73
1:0.9	39,09	9,94	49,86	4,02	6,82	7,37	12,44	3,37	17,35	63,99
1:1.0	40,10	9,56	50,61	3,80	6,23	6,86	11,67	3,46	16,02	66,26
1:1.3	41,13	9,06	51,38	3,59	5,69	6,39	10,95	3,56	14,79	68,40
1:1.4	41,52	8,24	51,11	3,11	5,92	5,83	10,54	3,50	14,02	69,70
1:1.5	41,90	7,41	50,84	2,64	6,14	5,26	10,13	3,44	13,24	71,00
1:1.75	42,15	7,21	50,87	2,62	6,14	4,81	9,32	3,00	12,14	73,75
1:2.0	42,40	7,00	50,90	2,60	6,14	4,36	8,50	2,56	11,03	76,50

As the ratio of liquid phase (Q:S) in the composition of the solid phase increases, the amount of K₂O increases, the amount of Na₂O, chloride ions and moisture decreases. So, at Q:S = 1:0.8, K₂O is 38.08%, at Q:S = 1:2.0 - 42.40%, Na₂O is from 10.31% to 7.00%, and chloride ions are 4, decreases to 24%. Up to 2.60%, moisture from 7.40% to 6.14%. The amount of SO₄²⁻ ions is in the range of 49.10-50.90%.

The liquid phase contains 7.87-4.36% K₂O, 13.20-8.50% Na₂O, 3.27-2.56% SO₄²⁻ ions, and 18.67-11.03% chlorine ions, respectively. The obtained results show that the isolated glaserite contains sodium and potassium chlorides. However, an increase in Q:S results in a decrease in Na₂O and chloride ions in the solid phase, indicating that sodium chloride moves into solution with an increase in the liquid phase. Therefore, a higher Q:S ratio should be maintained to obtain purer glaserite.

Table 3.6 shows the results of the effect of the process temperature on the chemical composition of the liquid and solid phases with a molar ratio of KCl:Na₂SO₄ = 1:1, Q:S = 1:1 and a process duration of 60 minutes.

Table 3.6

The effect of the process temperature on the chemical composition of the liquid and solid phase.

T, °C	Chemical composition of the solid stages, mass%					Stages of chemical composition of liquid, mass%				
	K ₂ O	Na ₂ O	SO ₄ ²⁻	Cl ⁻	H ₂ O	K ₂ O	Na ₂ O	SO ₄ ²⁻	Cl ⁻	H ₂ O
20	43,18	7,59	49,60	4,49	4,59	16,07	13,30	2,53	17,34	59,56
30	42,40	8,05	49,85	4,31	4,75	13,29	12,88	2,75	17,08	61,19
40	41,61	8,52	50,10	4,13	4,90	10,50	12,46	2,96	16,81	62,82
50	40,85	9,04	50,35	3,96	5,06	8,4	12,06	3,21	16,56	64,13
60	40,10	9,56	50,61	3,80	5,23	6,86	11,67	3,46	16,30	66,26
70	39,13	10,07	50,91	3,67	5,48	6,28	8,53	6,73	10,79	70,93
80	38,32	10,57	51,10	3,55	5,83	5,93	8,90	7,73	9,25	71,24

As can be seen from the table, with the increase of temperature in the conversion of KCl with sodium sulfate, the content of K₂O in the liquid phase decreases from 16.07% at 20 °C to 5.93% at 80 °C, the amount of Na₂O decreases. From 13.30% at 20°C to 8.90% at 80°C, chlorine decreases from 17.34% to 9.25%.

The content of K₂O in the solid phase is less important. Thus, the content of K₂O at 20°C is 43.18%, and at 80°C it is only 38.32%. The amount of Na₂O increases from 7.59% to 10.57% and -SO₄ from 49.60% to 51.10% at 20 and 80°C, respectively. Chlorine content is slightly reduced and is 4.49-3.55%.

Table 3.7 shows the chemical composition of the liquid and solid phases at a KCl:Na₂SO₄ ratio of 1:1 at a temperature of 50°C and a conversion duration of 10 to 90 minutes.

As the duration of the conversion process increases from 10 minutes to 90 minutes, the amount of K₂O in the liquid phase decreases from 8.4% to 4.80%, Na₂O from 12.06% to 9.84%, and chlorine from 16.56 to 7.38%. -SO₄ content increases from 3.21% to 9.60%.

Table 3.7

The influence of the duration of the process on the chemical composition of the solid and liquid phases.

t, min	Stages of chemical composition of a solid, mass%					Stages of chemical composition of liquid, mass%				
	K ₂ O	Na ₂ O	SO ₄ ²⁻	Cl ⁻	H ₂ O	K ₂ O	Na ₂ O	SO ₄ ²⁻	Cl ⁻	H ₂ O
10	40,85	9,04	50,35	3,96	5,06	8,4	12,06	3,21	16,56	64,13
15	40,10	9,56	50,61	3,80	5,23	6,86	11,67	3,46	16,30	66,26
20	39,13	10,07	50,91	3,67	5,48	6,28	8,53	6,73	10,79	70,93
25	38,32	10,57	51,10	3,55	5,83	5,93	8,90	7,73	9,25	71,24
30	37,69	11,06	51,32	3,42	6,10	5,57	9,40	8,40	8,19	71,10
60	36,78	11,68	51,60	3,28	6,16	5,20	9,67	8,96	8,23	71,23
90	36,14	12,25	50,91	3,13	6,20	4,80	9,84	9,60	7,38	71,30

With these indicators, the amount of Na₂O in the solid phase is from 9.04% to 12.25%, and the amount of chlorine and sulfate ions remains at the same level and is 3.96-3.13% and 50.35-50.91%, respectively. does.

Thus, the optimal technological parameters of the conversion process were established, i.e. Effect of KCl:Na₂SO₄ molar ratio of 1:1.0-1.05, Q:S ratio, temperature and process duration; 1:1.0-1.1; 40-50°C and 60 minutes. This will achieve maximum conversion rate.

§ 3.3. Study of liquid and solid phase separation process in glaserite production

The production and efficiency of individual stages of the process of obtaining potassium sulfate is mainly determined by the speed of separation of glaserite from the mother liquor. In this regard, studies were conducted to determine the rate of sedimentation and filtration of glaserite.

To obtain glaserite, the transfer of potassium chloride with sodium sulfate solution was carried out in the optimal technological parameters of the process: KCl: Na₂SO₄ = 1: 1, Q: S = 1: 1, in the temperature range. 40-50°C. Studies on the accuracy

of suspensions were carried out at ambient temperature (25°C) in a 100 ml measuring cylinder with divisions along the entire height. Figure 3.3 shows the data obtained on the level of detection of the glaserite suspension over time.

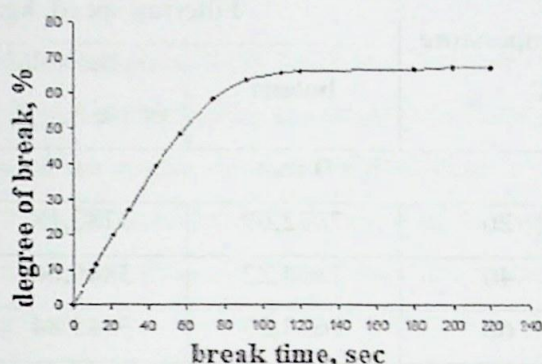


Figure 3.3. The degree of determination of the suspension depending on the time of taking Glaserit

As can be seen from the figure, it is good to separate the suspensions formed during the conversion of potassium chloride with sodium sulfate. Thus, after 95 seconds, the accuracy level of the suspension reaches 65.8%, and the maximum accuracy level reaches 67.3%.

Then, depending on the initial ratio of potassium chloride and sodium sulfate, the filtration properties of the condensed part of the glaserite suspension were studied in a Buchner funnel under a vacuum of 400 mm Hg. The area of the filtering surface is 0.002 m². Blue tape with ashless filter paper was used.

The main parameters that determine the filtration process are the resistance of the sediment and the resistance of the filter wall (fabric or filter paper). The filtration rate was calculated according to the following formula:

$$W = \left(\frac{m}{S \cdot t} \right) \cdot 3600 \quad (5)$$

Table 3.8 shows the filtration rate of thickened glaserite pulp as a function of the initial molar ratio of KCl:Na₂SO₄ and the temperature of the conversion process.

Table 3.8

Effect of KCl: Na₂SO₄ ratio and temperature on filtration rate of glaserite suspension at Q:S = 1:1.

№	Ratio KCl:Na ₂ SO ₄	Temperature, °C	Filtering speed, kg/m ² ·s		
			botana	on the solid phase	filtrate
h = 0 mm					
1	1:0,8	20	7372,69	3782,18	3590,51
		40	7504,22	3849,66	3654,55
		60	7633,23	3915,84	3717,38
2	1: 1,0	20	7571,95	3849,66	3722,29
		40	7707,04	3953,71	3753,33
		60	7839,52	4021,67	3817,85
3	1: 1,5	20	8169,74	4191,07	3978,67
		40	8315,49	4265,84	4049,65
		60	8458,45	4339,18	4119,27
4	1:2,0	20	8767,52	4497,73	4269,79
		40	8923,94	4577,98	4345,96
		60	9077,36	4656,68	4420,68
h = 6 mm					
5	1:0,8	20	3715,48	1906,04	1809,44
		40	3748,59	1923,02	1825,57
		60	3780,51	1939,40	1841,11
6	1: 1,0	20	3815,89	1957,55	1858,34
		40	3849,90	1974,99	1874,91
		60	3882,68	1991,81	1890,87
7	1: 1,5	20	4117,15	2112,09	2005,06
		40	4153,84	2130,91	2022,93
		60	4189,21	2149,06	2040,15

8	1: 2,0	20	4418,41	2266,64	2131,77
		40	4457,78	2286,84	2170,94
		60	4495,74	2306,31	2189,43

As the molar ratio increases from 1:0.8 to 1:2.0 and the temperature increases from 20 to 60°C, the filtration rate increases slightly in both the pulp, the filtrate, and the solid phase. Thus, if the molar ratio of $\text{KCl}:\text{Na}_2\text{SO}_4=1:1$, the pulp filtration rate increases from 7571.95 kg/m²·h to 7839.52 kg/m²·h as the temperature increases from 20°C to 60°C, then the initial ratio of components 1:1.5, these indicators vary from 8169.74 to 8458.45 kg / m²·s.

When the height of sediment in the filter is $h=6\text{mm}$, the filtration speed of the thickened sediment is significantly reduced, and in the temperature range from 20

$\text{KCl}:\text{Na}_2\text{SO}_4=1:0.8$ molar ratio is 3715.48-3780.51 kg/m²·h. up to 60°C, and at a molar ratio of 1:2 components, it is 4418.41-4495.74 kg/m²·s. that is, there is no significant improvement in the filtration rate of suspension with increasing molar ratio and temperature.

Thus, glaserite suspension reaches the maximum clarification and thickening level in 1.5 minutes, as well as under optimal conversion conditions ($\text{KCl}:\text{Na}_2\text{SO}_4 = 1:1$; $Q:S = 1:1$; $t=60\text{ min}$) and temperatures. At 40 and 60°C, the filtration rate for the solid phase is 3953.71 and 4021.67 kg/m²·h, respectively, which are high values.

§ 3.4. Rheological properties of solutions, glaserite production process

The efficiency of the production and implementation of individual stages of the process of obtaining potassium sulfate is mainly determined by the rheological properties of the initial, intermediate and final solutions, suspensions and pulps. Density and viscosity are the most important factors in analyzing the transport capacity of saturated solutions.

Table 3.9 provides information on the density and viscosity of suspensions obtained as a result of the conversion of potassium chloride with sodium sulfate, depending on the temperature and duration of the conversion process.

As can be seen from the table, the density and viscosity of suspensions increases with the increase in the duration of conversion of flotation potassium chloride to sodium sulfate.

Table 3.9

Effect of duration of conversion process on rheological properties of KCl:

Na₂SO₄ and Q:S = 1:1 molar ratio suspension.

№	time	Density, g/sm ³				Stickiness, sPz			
		20°C	40°C	60°C	80°C	20°C	40°C	60°C	80°C
1	0	1,385	1,348	1,311	1,280	2,799	2,275	1,866	0,606
2	10	1,388	1,351	1,315	1,282	2,900	2,310	1,940	0,954
3	20	1,390	1,354	1,318	1,284	3,000	2,390	2,000	1,000
4	30	1,400	1,360	1,320	1,286	3,700	2,748	2,190	1,356
5	40	1,410	1,366	1,325	1,289	4,000	2,990	2,360	1,987
6	50	1,420	1,377	1,331	1,292	5,000	3,195	2,634	2,265
7	60	1,426	1,383	1,338	1,294	5,325	3,415	2,915	2,618
8	90	1,428	1,384	1,339	1,295	5,331	3,420	2,928	2,627

So, the density of 1.385 g/cm³ for potassium chloride at 20°C increases to 1.428 g/cm³ after 60 minutes, and the viscosity of the solution increases from 2.799 cps to 5.325 cps. A further increase in the conversion time has a slight effect on the increase in the density and viscosity of the suspension. As the temperature increases from 20 to 80°C, both the density and viscosity of solutions decrease. Thus, the density of the initial solution decreases from 1.385g/cm³ to 1.280g/cm³, and the viscosity decreases from 2.799 cps to 0.606 cps.

The rheological properties of thickened precipitates obtained from potassium chloride with sodium sulfate solution KCl: Na₂SO₄=1:1 and Q:S molar ratio from 1:0.6 to 1:2.0 were studied depending on the temperature change. The obtained data are presented in Table 3.10.

With an increase in the proportion of the liquid phase from 1: 0.6 to 1: 2.0, the pulp density decreases from 1.582 g/cm³ at 80°C to 1.287 g/cm³ at 20°C, respectively, and 1.444 g/cm³ to 1.156 g/cm³.

An increase in temperature has less effect on the decrease in density than an increase in Q:S. When the same parameters are changed in these intervals, the pulp viscosity decreases from 6.149 cP to 4.505 cP at 20°C and from 3.304 to 2.006 at 80°C.

Table 3.10

Effect of L:S and temperature on the rheological properties of precipitates from the conversion of potassium chloride to sodium sulfate.

L:S	Density, g/cm ³				Stickiness, sPz			
	20°C	40°C	60°C	80°C	20°C	40°C	60°C	80°C
1:0,6	1,582	1,548	1,496	1,444	6,149	4,207	3,651	3,304
1:0,7	1,526	1,495	1,448	1,391	5,97	3,999	3,458	3,103
1:0,8	1,495	1,461	1,414	1,364	5,735	3,811	3,285	2,965
1:0,9	1,46	1,422	1,376	1,329	5,53	3,613	3,112	2,791
1:1,0	1,426	1,383	1,338	1,294	5,325	3,415	2,915	2,618
1:1,1	1,407	1,36	1,321	1,277	5,203	3,31	2,821	2,53
1:1,2	1,388	1,346	1,304	1,26	5,081	3,205	2,726	2,42
1:1,3	1,37	1,328	1,28	1,242	4,996	3,116	2,635	2,30
1:1,4	1,353	1,31	1,267	1,223	4,80	3,028	2,544	2,22
1:1,5	1,324	1,283	1,246	1,202	4,681	2,92	2,376	2,137
1:1,6	1,31	1,271	1,231	1,187	4,633	2,86	2,335	2,091
1:1,7	1,304	1,26	1,216	1,172	4,585	2,748	2,295	2,046
1:2,0	1,287	1,24	1,2	1,156	4,505	2,663	2,222	2,006

Pulps have acceptable rheological properties and are well transported.

§ 3.5. Study of processing glaserite for potassium sulfate.

The resulting glaserite was dissolved in water with the addition of potassium chloride, and potassium sulfate was obtained. The level of potassium chloride was maintained based on the molar ratio of sodium sulfate to glaserite. L:S was maintained at a temperature of 30°C and a process duration of 40 minutes at a ratio of 1:1 based on the total rate of glaserite and potassium chloride. Therefore, in the future to obtain potassium sulfate, we used the molar ratio of Na₂SO₄: KCl. Table 3.11 presents information on the composition of potassium sulfate from glaserite and mother liquor.

When the molar ratio of Na₂SO₄: KCl increases from 1:0.8 to 1:2 in the preparation of potassium sulfate, when KCl is added to the glaserite solution, the amount of K₂O in the solid phase increases from 45.43% to 47.10%, and the amount of sulfate ions increases from 51.31% to 48.14%, and Na₂O decreases from 4.13 to 2.01%. With an increase in the initial molar ratio, the content of chlorine ions increases from 1.10 to 2.31%, and the moisture content increases from 6.84% to 9.00%. The composition of the liquid phase is enriched with K₂O, Na₂O, chloride ions and decreases with sulfate ions.

Potassium sulfate was washed on the filter with cold water at Q:S = 1:1. The chemical composition of potassium sulfate after washing and the composition of washing water are shown in Table 3.12.

Table 3.11

The effect of the initial ratio of KCl and Na₂SO₄ on the chemical composition of potassium sulfate and the liquid phase in the production of glaserite.

Na ₂ SO ₄ :KCl	The chemical composition of the solid before washing steps, mass%					Chemical composition liquid phase, mass%			
	K ₂ O	Na ₂ O	SO ₄ ²⁻	Cl ⁻	H ₂ O	K ₂ O	Na ₂ O	SO ₄ ²⁻	Cl ⁻
1:0,8	45,43	4,13	51,31	1,10	6,84	3,19	7,80	7,61	5,72
1:0,9	45,74	3,73	51,16	1,15	7,29	3,26	8,35	7,39	6,45
1:1,0	46,05	3,22	50,94	1,27	7,73	3,33	8,91	7,18	7,42

1:1,25	46,52	2,64	49,93	1,46	8,30	3,51	9,575	6,6	8,52
1:1,5	47,01	2,15	48,92	1,70	8,87	3,70	10,24	5,90	10,13
1:1,75	47,05	2,03	48,46	2,01	8,93	3,895	10,29	5,12	10,97
1:2,0	47,10	2,01	48,14	2,31	9,01	4,09	10,31	4,35	11,70

The amount of K_2O remains at the level of 53.05-53.47%, sulfate ions - 54.62-54.24%, the amount of Na_2O decreases from 0.46% to 0.15% in the ratio of 1:0.8 to 0.15% in the ratio of 1:2.0 chlorine content increases from 0.20% to 0.50% and moisture content varies between 0.78-0.82%. All this indicates that the purity of potassium sulfate increases with increasing initial molar ratio of Na_2SO_4 : KCl . The best results were obtained in the molar ratio of Na_2SO_4 : KCl =1:1. The resulting product (mass %) contains: K_2SO_4 - 98.44, Na_2SO_4 - 0.22, $NaCl$ - 0.45, H_2O - 0.89. In this case, the conversion rate for potassium is 86.65%.

Table 3.12

The effect of the initial ratio of Na_2SO_4 : KCl and a single water wash on the chemical composition of potassium sulfate and the wash solution.

mole ratio Na_2SO_4 : KCl	Chemical composition of the solid phase after washing, mass%					Chemical composition of the washing solution, mass%			
	K_2O	Na_2O	SO_4^{2-}	Cl^-	H_2O	K_2O	Na_2O	SO_4^{2-}	Cl^-
1:0,80	53,05	0,46	54,62	0,2	0,82	3,72	3,71	8,46	0,8
1:0,90	53,11	0,39	54,54	0,23	0,85	4,095	3,3	8,24	0,85
1:1,00	53,18	0,33	54,46	0,27	0,89	4,67	2,89	8,03	0,9
1:1,25	53,26	0,28	54,38	0,34	0,8635	5,45	2,35	7,74	1,08
1:1,50	53,35	0,24	54,3	0,41	0,84	6,24	1,82	7,46	1,29
1:1,75	53,41	0,187	54,27	0,455	0,81	6,54	1,83	7,305	1,54
1:2,00	53,47	0,15	54,24	0,5	0,78	6,63	1,85	7,21	1,8

Table 3.13 presents the rheological properties of pulps in the production of potassium sulfate as a function of Q/S and temperature. Density decreases from

1.570g/cm³ to 1.399g/cm³ at 20°C with increasing liquid phase ratio and Q:S changes from 0.6:1 to 2:1.

Table 3.13

Effects of Q:S and temperature on the rheological properties of pulps in potassium sulfate production.

Q:S	density, g/sm ³				Stickiness, sPz			
	20°C	40°C	60°C	80°C	20°C	40°C	60°C	80°C
1:0,6	1,570	1,535	1,506	1,471	6,205	5,096	4,115	3,152
1:0,7	1,553	1,519	1,491	1,453	6,167	5,047	4,061	3,096
1:0,8	1,534	1,502	1,475	1,439	6,090	4,981	3,993	3,030
1:0,9	1,515	1,484	1,458	1,425	6,045	4,933	3,942	3,000
1:1,0	1,500	1,470	1,441	1,408	5,987	4,869	3,882	2,912
1:1,0	1,500	1,470	1,441	1,408	5,987	4,869	3,882	2,912
1:1,2	1,482	1,454	1,427	1,392	5,933	4,815	3,816	2,836
1:1,4	1,466	1,437	1,411	1,377	5,884	4,762	3,767	2,793
1:1,5	1,447	1,420	1,395	1,362	5,842	4,708	3,715	2,743
1:1,7	1,433	1,404	1,377	1,343	5,788	4,659	3,651	2,670
1:2,0	1,399	1,369	1,341	1,305	5,691	4,572	3,564	2,554

At these parameters, the viscosity decreases from 6.205 cP to 5.691 cP. As the temperature increases from 20 to 80°C, the density changes from 1.500g/cm³ to 1.408g/cm³ and the viscosity from 5.987 to 2.912 cps at Q:S = 1:1. Potassium sulfate pulps have acceptable rheological properties and are widely transported.

Table 3.14 presents the results of determining the density and viscosity of suspensions in the second stage of potassium sulfate extraction after dissolving glaserite in water with the addition of potassium chloride, depending on the temperature and duration of the process. As the time of the isolation process of potassium sulfate increases, the density at 20°C increases from 1.462g/cm³ to 1.504g/cm³, and the viscosity increases from 4.788 cps to 6.265 cps.

Table 3.14

Effect of temperature and process duration on the rheological properties of solutions in the stage of obtaining potassium sulfate at Q:S = 1:1.

Conversion time	density, g/sm ³				Stickiness, sPz			
	20°C	40°C	60°C	80°C	20°C	40°C	60°C	80°C
0	1,462	1,430	1,400	1,378	4,788	3,880	3,118	2,361
10	1,480	1,451	1,423	1,395	4,965	4,080	3,265	2,451
20	1,491	1,460	1,430	1,399	5,362	4,335	3,463	2,583
30	1,497	1,467	1,436	1,406	5,769	4,615	3,669	2,747
40	1,500	1,470	1,441	1,408	5,987	4,869	3,882	2,912
50	1,502	1,472	1,444	1,409	6,126	4,966	3,952	2,991
60	1,503	1,473	1,446	1,410	6,254	5,050	4,020	3,080
90	1,504	1,474	1,448	1,411	6,265	5,091	1,029	3,088

With increasing temperature, the density decreases from 1.462g/cm³ to 1.378g/cm³ at 20°C, and the viscosity decreases from 4.788 cps to 2.361 cps, respectively.

Table 3.15 shows the filtration rate of thickened potassium sulfate slurry as a function of sediment height and conversion process temperature.

Table 3.15.

Effect of temperature on filtration rate of potassium sulfate at Q:S = 1:1.

№	Temperature, °C	Filter time, kg/m ² ·soat		
		bo'tana	by solid phase	filtrate
h = 0 mm				
1	20	8177,71	2943,98	5233,73
	30	8323,60	2996,51	5327,09
	40	8467,68	3048,36	5419,32
h = 6 mm				

2	20	4216,46	1517,93	2698,53
	30	4254,14	1531,49	2722,65
	40	4290,36	1544,52	2745,84

As the temperature increases from 20 to 40°C, the filtration rate increases slightly in both pulp, filtrate and solid phase. When the sediment height in the filter is 0 mm, the filtration rate of thickened sediment is significantly reduced and is 8177.71-8467.68 kg / m²·h in the pulp and solid phase in the temperature range from 20 to 40°C. 2943.98-3048.36 kg/m²·h, through filtrate 5233.73-5419.32 kg/m²·h.

When the height of the sediment in the filter is 6 mm, the filtration rate of the thickened sediment decreases significantly and is 4216.46-4290.36 kg/m²·h in the pulp and solid phase in the temperature range from 20 to 40°C. 1517.93-1544.52 kg/m²·h, through filtrate 2698.53-2745.84 kg/m²·h.

Figure 3.4 shows data on the level of refinement by process duration. Thus, in the second stage, after 95 seconds, the level of accuracy reached the maximum value - 66.25%.

The degree of suspension purification in the potassium sulfate isolation stage is approximately the same as that of glaserite isolation. This indicates that the resulting products of glaserite and potassium sulfate are homogeneous, free of foreign impurities and very well thickened.

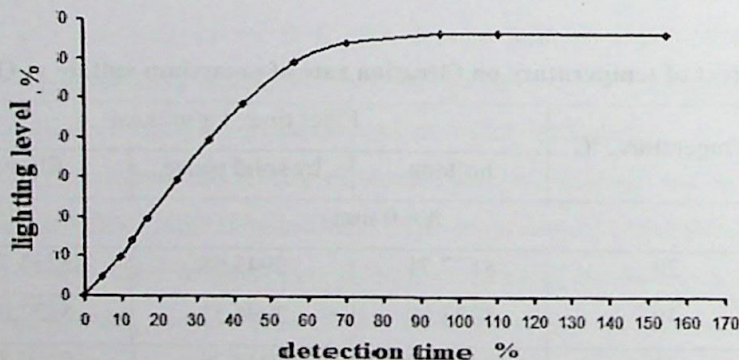


Figure 3.4. Variation of suspension determination depending on the time of extraction of potassium sulfate from glaserite

Later, the filterability of the thickened part of the suspensions of stage II was studied in a Buchner funnel under a vacuum of 400 mm Hg. Art., determining the time of filtration. The area of the filtering surface is 0.005 m².

The results obtained by filtration were the same as the detection level of the suspensions. In the second stage, the filtration rate is about twice as high as in the first stage and averages 1000-1200 and 2100-2300 for the stage of conversion of potassium chloride with sodium sulfate and the stage of isolation of potassium sulfate.

Thus, the conducted studies showed that the suspensions have acceptable rheological properties, are well filtered and do not significantly affect the technological parameters of the process of obtaining potassium sulfate from flotation potassium chloride of the Tubegatan mine and sodium sulfate of the Tumruksoy mine. The process is waste-free, does not require special and special equipment, and is technologically easy to implement.

§ 3.6. To study the process of separation of liquid and solid phases in the process of obtaining potassium sulfate.

In the process of conversion of potassium chloride with sodium sulfate, after separation of glaserite, circulating liquids enriched with sodium chloride are formed. Later, to reuse the circulating fluids, a study was conducted on steaming them at 60, 80 and 100°C, depending on the duration of the process.

After the separation of glaserite, the most intensive process of evaporation of the circulating fluid continues at a temperature of 100°C. In this case, after 60 minutes, the volume of the solution decreases by more than 50%, at 80 and 60°C, these indicators are 20 and 5%, respectively.

Table 3.16 shows data on the amount of sodium chloride precipitated as a result of changes in the composition of the circulating liquid and changes in the volume of the circulating liquid during the evaporation process.

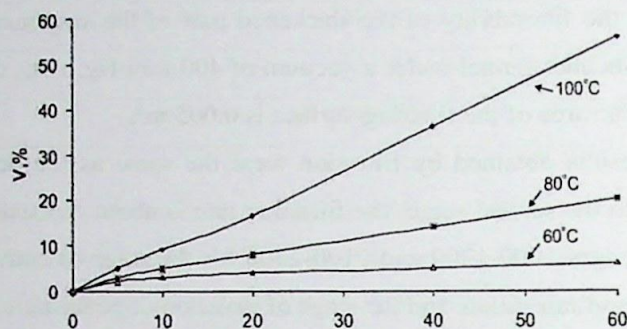


Figure 3.6. Effects of process duration and evaporation temperature on the volume of moisture evaporated

With an increase in the volume of evaporated liquid from 5% to 40%, the amount of precipitated sodium chloride increases from 3.1 to 22.9% by weight of the original mother liquor (% by weight): K_2O - 6.86; Na_2O - 11.67, $-SO_4^{-2}$ - 3.46, Cl^- - 16.02, H_2O - 66.26.

Table 3.16.

Changes in the chemical composition of the circulating liquid during evaporation.

№	Volume of evaporated liquid, %	Composition of evaporated circulating fluid, mass%				Sediment mass, %
		K_2O	Na_2O	SO_4^{-2}	Cl^-	
1	5	6,50	11,83	3,17	16,11	3,1
2	10	6,17	11,94	2,88	16,20	6,2
3	20	5,83	12,05	2,59	16,29	11,8
4	30	5,49	12,17	2,30	16,38	17,4
5	40	5,20	12,25	2,00	16,48	22,9

It is clear from the given data that the purified solution is slightly enriched with sodium and chlorine ions, and potassium and $-SO_4^{-2}$ ions are slightly reduced in the circulating liquid. The resulting precipitate mainly contains sodium chloride with mixtures of potassium and sulfate ions.

When 40% of the initial circulating liquid volume is evaporated, the K_2O content decreases from 6.86% to 5.20%, and the sulfate ions decrease from 3.46% to 2.00%. The amount of Na_2O increases from 11.67 to 12.25, and chlorine from 16.02% to 16.48%.

Table 3.17 shows the results of changes in the rheological properties of circulating fluids depending on the volume of evaporated solution and the decrease in temperature.

Table 3.17.

Rheological properties of circulating fluids evaporated after isolation of glaserite.

№	Volume of evaporated liquid, %	density, g/cm ³				Stickiness sPz			
		20°C	40°C	60°C	80°C	20°C	40°C	60°C	80°C
1	0	1,250	1,238	1,224	1,210	2,126	1,713	1,316	0,914
2	5	1,262	1,253	1,240	1,227	2,112	1,699	1,300	0,896
3	10	1,274	1,265	1,254	1,241	2,100	1,685	1,284	0,879
4	15	1,286	1,278	1,265	1,254	2,086	1,672	1,269	0,864
5	20	1,298	1,290	1,278	1,265	2,072	1,657	1,254	0,846
6	25	1,312	1,302	1,292	1,280	2,058	1,642	1,237	0,830
7	30	1,325	1,315	1,306	1,295	2,042	1,626	1,221	0,813
8	35	1,341	1,330	1,322	1,311	2,025	1,611	1,204	0,798
9	40	1,358	1,350	1,340	1,330	2,007	1,594	1,187	0,785

With the increase in the volume of the resulting solution, the density of circulating fluids increases from 1.250g/cm³ to 1.358g/cm³ at 20°C and from 1.210g/cm³ to 1.330g/cm³ at 80°C. As the temperature increases, the density of circulating fluids decreases, regardless of the amount of vaporized fluid. After the sodium chloride precipitate separates, the viscosity of the solutions decreases with increasing volume of evaporated liquid and increasing temperature. Thus, the viscosity

decreases from 2.126 cPs to 2.007 cPs at 20°C, 40% moisture evaporation, and from 0.914 cPs to 0.785 cPs at 80°C.

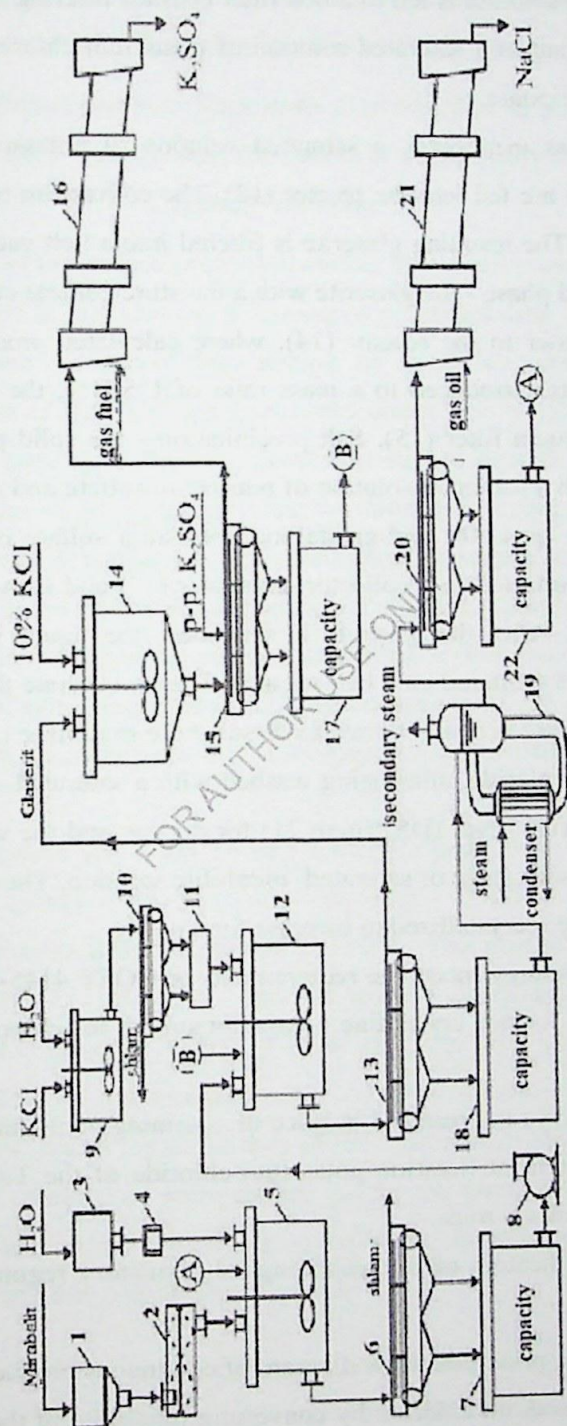
Thus, the obtained results show the optimal rheological properties of the circulating fluids after the separation and evaporation of glaserite, which allows them to be transferred to the next stages of the technological process through pumping devices.

§ 3.7. Technological scheme and material balance of potassium sulfate production

Based on the research, a technological scheme for the production of potassium sulfate was developed, which is shown in Figure 3.14.

The essence of the technological process is as follows: natural mirabilite is supplied to the receiving hopper through a conveyor and dosed to the reactor through a belt feeder, where water is supplied for dissolution. delivered at the same time. The resulting sodium sulfate solution is filtered from mechanical and insoluble impurities. The filtered sodium sulfate solution is collected in a collection tank and then sent to obtain the first conversion to get glaserite. From the tank, the flotation potassium chloride is fed to the washing reactor and water is introduced from the pressure vessel here to obtain a saturated solution of potassium chloride.

The resulting solution is fed to a belt filter for filtering into a liquid phase - a suspension consisting of a saturated solution of potassium chloride and a wet part - into an insoluble precipitate.



Picture-3.14 - Technological scheme of the process of obtaining potassium sulfate from potassium chloride and mirabilite of Tyumruk mine: 1st bunker; 2-supplier; 3rd tank; 4-flow meter; reactors 5, 9, 12, 14; 6, 10, 13, 15, 20 filters; 7, 11, 17, 18, 22 containers; 8th pump; 16, 21 drum dryer (BS); 19-Vacuum Evaporator (VA)

The resulting solution is fed to a belt filter (10) for filtering into a liquid phase - a suspension consisting of a saturated solution of potassium chloride and a wet part - into an insoluble precipitate.

In addition, as mentioned, a saturated solution of potassium chloride and a solution of mirabilite are fed into the reactor (12). The conversion reaction takes about 60 minutes at 40°C. The resulting glaserite is filtered into a belt vacuum filter (13) for separation into a solid phase - the glaserite with a moisture content of 6-8% is fed to the second stage of transfer to the reactor (14), where calculated amounts of potassium chloride and water are introduced to a mass ratio of L:S=1:1, the pulp is mixed and filtered on a belt vacuum filter (15). Salt precipitation - the solid phase of potassium sulfate is washed with a saturated solution of potassium sulfate and / or water and then sent to a drum dryer (pos. 16) and crystalline potassium sulfate is obtained and the circulating liquid is collected in a collector. container (17) and then returned to the I - conversion step (12). After the glaserite is separated, the liquor is evaporated in a vacuum evaporator (19), filtered on a belt vacuum filter to separate the sodium chloride (20), and the liquid phase is also returned to dissolve the mirabilite (5). In addition, the solid phase - sodium chloride, after being washed with a saturated solution of sodium chloride, is fed to a drum dryer (DS) (item 21) for drying, and the washing solution is returned to the conversion stage or saturated. mirabilite solution. The resulting technical sodium chloride can be recrystallized to increase food purity.

Thus, the technology meets the requirements of GOST 4145-74 for continuous, cyclic and waste-free, formed crystalline potassium sulfate for chlorine-free potassium sulfate.

Figure 3.15 shows the material balance of obtaining potassium sulfate for 1000 kg of finished product from flotation potassium chloride of the Tubegatan mine and mirabilite of the Tumruksoy mine.

The optimal indicators of the technological regulatory regime for the material balance are presented.

Thus, a flexible, principled flow diagram of continuous production of crystalline potassium sulfate and sodium chloride by converting mirabilite of the Tumruksoi mine

and flotation potassium chloride was developed, the norms of the material balance and technological mode of production and potassium sulfate were obtained.

§ 3.8. Technical and economic basis of production of potassium sulfate and sodium chloride by converting mirabilite of Tumruksoy mine to flotation potassium chloride.

Production of crystalline potassium sulfate obtained by conversion of mirabilite and potassium chloride includes the following steps: dissolution of mirabilite in water, filtration of undissolved precipitate, mixing of mirabilite and flotation potassium chloride, separation of glaserite, separation and conversion of glaserite. crystallization and separation of potassium chloride, potassium sulfate crystals, return of circulating liquids to the initial stage of the process; washing and drying crystalline potassium sulfate; evacuate the circulating liquid formed after the separation of potassium sulfate and sodium chloride, return the circulating liquid after the separation of sodium chloride and wash to the initial stage of the process; crystalline sodium chloride wash and dry.

The cost of obtaining potassium sulfate consists of the cost of mirabilite and flotation potassium chloride from the Tumruksoy mine, as well as processing, energy, marketing, etc.

Accepted prices for 1 ton of raw materials and energy resources: potassium chloride flotation GOST 4568-95 (K_2O - 59-61%) - 1,920,000 soums (according to <https://old.uzex.uz/uz/trade/offerssum>, 20.12.2022); The mirability of the Tumruksoy mine ($Na_2SO_4 \cdot 10H_2O$ - 93-95%) - 500,000 soums (according to the data of "Ustyurt sodium sulfate" LLC dated 12.20.2022); 1 kW of electricity - 411 soums; 1 Gcal pair - 269,320 soums; 1000 m³ of processed water - 434477 soums; 1000 m³ of compressed air - 111,100 soums (according to the data of JSC "Ammofos-Maksam" on 07.12.2022).

Feasibility calculations were carried out for the production of potassium sulfate and sodium chloride. According to the calculation, the cost of 1 ton of crystalline potassium sulfate is 7,469,688 thousand soums.

The price of potassium sulfate on the commodity exchange is 13,500,000 soums (<https://old.uzex.uz/uz/trade/offerssum>, Uzb., 20.12.2022). Savings per ton of potassium sulfate compared to imports are:

$$13,500.0 - 7,469,688 = 6,030,312 \text{ thousand soums}$$

60,303,120 million soums will be saved with the release of 10,000 tons of K_2SO_4 .

Thus, the carried out technical and economic calculations show a good profitability of the production of potassium sulfate and sodium chloride based on the conversion of mirabilite of the Tumruksoy mine into flotation potassium chloride obtained from the sylvinite of the Tyubegatan mine.

Summary of Chapter 3

As a result of studying the interaction in the $Na_2SO_4 - KCl - H_2O$ and $K_2SO_4 - KCl - H_2O$ systems by the visual-polythermal method from the full freezing temperature to $70^\circ C$, it was found that the systems can be reduced to simple eutonic type, components. they maintain their low profile and have a corrective effect on each other. A new compound $NaK_3(SO_4)_2$ and $Na_2SO_4 \cdot H_2O$ is formed as a new phase. The crystallization area of the new compound occupies the main part of the diagram.

In the conversion of potassium chloride with sodium sulfate, $Na_2SO_4 \cdot K_2SO_4$ compound is formed. Optimum technological parameters of the process

KCl: Na_2SO_4 = 1:1, L:S = 1:1 ratio and process temperature $40-50^\circ C$

Studies on the separation of liquid and solid phases of the conversion step of potassium chloride with sodium sulfate have shown that the best separation of glaserite suspension by precipitation method is from 95 to 65.8%, with a maximum accuracy of 67.3%. The filtration rate of the condensed part of the glaserite suspension is from $7571.95 \text{ kg/m}^2 \cdot \text{h}$ to $7839.52 \text{ kg/m}^2 \cdot \text{h}$ at the initial molar ratio of $KCl:Na_2SO_4$ = 1:1 by pulp at $20^\circ C$, $60^\circ C$ and Q:S = 1: 1.5 these figures increase from $8169.74 \text{ kg/m}^2 \cdot \text{h}$ to $8458.45 \text{ kg/m}^2 \cdot \text{h}$.

Optimum technological parameters of glaserite processing into potassium sulfate were established - molar ratio $KCl: Na_2SO_4$ = 1:1, in which the conversion rate for

potassium is 86.65%, the purity of potassium sulfate increases, its composition (weight): K_2SO_4 - 98.44; Na_2SO_4 - 0.22; $NaCl$ - 0.45; H_2O is 0.89.

Material balances were drawn up, basic technological schemes and norms of the technological mode of obtaining potassium sulfate by converting mirabilite into flotation potassium chloride were developed. The technical and economic efficiency of their production is calculated.

The guarantee of abundant harvest from agricultural crops is their complete and sufficient nutrition. Light, heat, water and nutrients are very necessary for the life of plants. All these conditions are equally valuable and very necessary. The need of plants for nutrients depends on the type of plant and the forms of these substances.

The composition of the plant includes more than 70 elements, but 16 of them are very important for life. For example, such elements include the so-called organogens: carbon, oxygen, hydrogen and nitrogen. In addition, this series includes phosphorus, potassium, calcium, magnesium and sulfur - ash elements and metalbdenum, copper, boron, zinc, cobalt - trace elements, iron and manganese. Each element performs its function in the plant, and therefore one element cannot be replaced by another element. The main elements passing through the atmosphere to blue-green (green) plants are carbon. Oxygen and hydrogen are considered. These three elements account for 93.5% of the plant's dry weight: that is, carbon - 45%, oxygen - 42%, and hydrogen - 6.5%.

Potassium (K) - plays the most important physiological role in plant carbohydrate and protein metabolism, improved the conditions of absorption of nitrogen in ammonia form. Feeding plants with potassium is a powerful factor for the development of individual plant organs. Potassium creates an opportunity for the shaker plant in the juice of the host, which increases the winter resistance of the plant, allows the development of vascular bundles and the development of hosts. In addition, it increases the strength of the stems and increases their resistance to lodging.

a) Relevance of the topic.

From August 26, 2010, phosphorus, nitrogen, and potassium fertilizers are produced from microfertilizers in the Republic of Uzbekistan. But according to scientific data, on May 1, 2007, the President of the Republic of Uzbekistan I.A.

Karimov's decision "On organizing the construction of the plant of potash fertilizers in Dehkanabad at the base of the Tubegatan mine of potassium salts" was issued. According to this decision, the production of potash fertilizers is planned for 2010. [2]

The production of nitrogenous and phosphorous fertilizers has been started in the Republic of Uzbekistan, but even though there is a raw material base, potash fertilizers are not being produced.

Before 1965, two groups of salt mines were opened in the Republic of Uzbekistan:

Gaurdak - Tyubegatan, Aqbosh, Cheurkalgen, Chekar, Kaypantu - Baysurkhan, Kantiu, Gulgan, Kyzilmazar, Baybi - icon, Surakhan.

N.P. According to Petrov, Gaurdak's halogen pharmacy is divided into three main horizons: lower anhydrite, medium salt, high gypsum anhydrite [3]

The lower horizon consists of alternating layers of limestone and gypsum, containing sulfur in the form of nests. Layers of sulphurous limestone pass into marble anhydrite. In the upper part of the anhydrite horizon with a thickness of 30-35 m, a lens of sulphurous rock salt with a thickness of 3-5 m appears.

The second horizon is composed of salt, divided into several layers of 300-350 m. Together with potassium salts, it is located in the layer of red salt in the lower layer of rock salt. The amount of KCl in sylvinite can be from 2-4 to 8% [4]

The main layer of rock salt with a thickness of about 24 m consists of sylvinite and carnallite - sylvinite layers. Above the rock salt layer there are 3 classes of potash salts, the thickness of which is 1.5 - 4 m, high and low grade sylvinite and layers of rock salts, the thickness of which is from 30 m to 100 m, carnallite appears in some places. The amount of KCl is 14 - is 34% [3]

Thus, in Gaurdak district, the power of the high-halogen pharmacy can be up to 700-800 m, the power of the salt garizant is 300-350 m.

Tubegatan mine is located 35-40 km from this tectonic [5].

The tubegatan structure consists of three layers:

Kursantam, Koragagat and the asymmetrically structured tubegatan itself. In the north-eastern part of the mine, limestones are exposed, on which there are layers of

gypsum anhydrite. Above there is a halogen layer (300-350m), where there are three horizons of potassium salts [3].

The strength of the salt layer increases in the south-west direction.

It can be concluded that there is a sufficient amount of sylvinite deposits in Uzbekistan, and it is possible to organize our own production of potash fertilizers based on it. At present, potash fertilizers are bought in foreign currency in our Republic. Therefore, the production of potash fertilizers based on local raw materials is an urgent issue.

b) Purposes and tasks of work.

Consists of:

- the manufactured product, its characteristics and technical and operational requirements for it:

- selection of raw materials and materials for product production:

- calculation of raw materials and materials to ensure the annual production volume:

- selection of technological equipment and their characteristics, structure and operation procedure:

- calculation of the work output and the necessary number of technological and auxiliary equipment:

- Construction area calculation:

- Selection of building elements and their explanation:

- Plan of the facility:

- Description of the designed technological process:

- Energy accounts:

- Basic equipment account.

c) Scientific and practical significance.

Production technology of potash fertilizers from sylvinite from Tyubegatan mine by flotation method was created and relevant technological issues were solved.

Technological scheme of production of potash fertilizers by flotation method from Tyubegatan mine sylvinite.

Tubegatan mine sylvinite, potassium chloride, sodium chloride ammonia, magnesium chloride suspensions.

To determine the optimal technological parameters for the production of sylvinite from the Tubegatan mine, potash fertilizers by flotation method, and to obtain relevant information for the creation of the technology.

a) Gallurgic method of potassium ore processing.

Gallurgy is a branch of chemical technology, consists of natural salting, composition and properties of raw materials, as well as methods of obtaining mineral salts from it. [6] There are the following main types of raw materials for the gallurgy industry:

Natural salts (potassium and magnesium), mineralized waters, natural brines formed as a result of evaporation of sea water, salt brines, underground brines [7].

The main tasks of gallurgy are as follows: studying the formation conditions of salt deposits, their mineral composition and structures; physico-chemical properties of salts and their solutions: creation of artistic methods of production of various products from salt deposits as follows: K_2SO_4 , KCl , $MgSO_4$, $MgCl_2$, Na_2SO_4 , $NaCl$, Na_2CO_3 , boron, iodine, bromine and other elements compounds [8]

To solve these problems, gallurgy is used as a method of physical-chemical analysis. Processes that take place in concentrations of water-salt systems are studied using solubility diagrams. The same diagrams are used to create gallurgy production. With the complex use of raw materials, gallurgy is described. Sodium, magnesium, potassium chlorides and sulfates are produced from slag. [9]

Production of potassium chloride from sylvinite ore in the gallurgy method is carried out by melting and separate crystallization. This process is based on the difference in solubility of KCl and $NaCl$ in water.

The melting process is carried out at a temperature of $90-100^{\circ}C$, and then the temperature is reduced to $20-25^{\circ}C$ [10]

In solutions saturated with both salts, with increasing temperature, from $20-25^{\circ}C$ to $90-100^{\circ}C$, the amount of potassium chloride approximately doubles, while the

amount of sodium chloride decreases. This property of KCl and NaCl solutions was used in the cyclic process of obtaining potassium chloride from sylvinite.

The main stages of the production of potassium chloride in a closed cycle:

1. Grinding of sylvinite ore.

2. Extraction of potassium chloride from sylvinite with a hot circulating solution.

3. Separation of the hot curd from the sediment and its removal from the salty and muddy slurry.

4. Crystallization of potassium chloride when the solution is cooled.

5. Separate potassium chloride crystals from the solution and dry them.

6. Heat the solution and return it to the sylvinite solution.

This technological scheme for the production of potassium chloride from sylvinite ores by the method of melting and crystallization serves as the basis. Some differences in process regimes and technological schemes are related to changes in the composition of raw materials and the use of different construction devices [11]

The properties of the KCl - NaCl - H₂O system serve as the basis for the production of potassium chloride by the method of melting and crystallization.

Comparison of isotherms at 25 and 100°C shows that the amount of eutonic solution sodium chloride increased at low temperatures.

According to the composition of E100 eutonic solution at 100°C, the figurative point of the system is in the field of potassium chloride crystallization.

Therefore, as a result of cooling a solution saturated with KCl and NaCl, only KCl falls to the sediment, adding solid NaCl to the saturated solution of KCl, a part of KCl is squeezed out of the solution into the sediment [2].

When the 1000 eutonic solution is cooled from 100 to 25°C, the composition of the solution changes as a result of KCl precipitation, its figurative point of crystallization goes up to n along the Sn - E100 line. After separating the precipitate of KCl, if the solution is heated to 100°C, it becomes strongly unsaturated with potassium chloride and slightly unsaturated with sodium chloride. Therefore, if sylvinite is treated with this hot solution, it mainly dissolves with potassium chloride [13] But this depends

on the conditions of treating slivinite with a solution in the opposite flow. In the case of a solution containing almost all potassium chloride, more sodium chloride dissolves than potassium chloride, then only potassium chloride dissolves, and therefore sodium chloride precipitates from the solution. After separation of solid sodium chloride, a hot E100 eutonic solution is obtained, and potassium chloride is separated as a result of its cooling. From this, sylvinite can be separated into KCl and NaCl using a cyclic process.

In order to completely separate KCl from sylvinite, its amount introduced into the cycle should be in accordance with the amount of the circulating solution, if it is assumed that the composition of sylvinite consists of 25% KCl and 75% NaCl. [14]. After melting and crystallization, the actual composition of the solid and liquid phases differs from the processes seen above. After sylvinite melting, the composition of the hot solution differs from that of the eutonic solution. According to the melting method, its saturation level with potassium chloride is 90-96%, therefore, as a result of cooling the solution, only sodium chloride crystallizes first. After reaching the temperature corresponding to saturation, the crystallization of KCl begins, the previously separated NaCl can dissolve again in active mixing, but it is covered by KCl crystals and therefore it does not dissolve. [15] For this reason, the product is contaminated with sodium chloride. When the degree of saturation of the hot solution with potassium chloride is 96%, its content in the crystallized salt is 99.3%, from a solution saturated to 90.6%, a salt with 94.3 is formed. This shows the importance of the hot KCl solution to the perfect saturation level and proper flow melting. In this case, the amount of NaCl separated after small crystals in the solution is small. As a result of desalination of sodium chloride with potassium chloride in the opposite flow, the amount of fine crystalline NaCl in the solution is relatively higher [16].

In the process of cooling the hot solution under production conditions, it is slightly cooled and a certain amount of NaCl crystallizes from it and is removed with salty-sludgy slurries, where the phenomenon of self-cleaning of the hot solution occurs, its saturation with potassium chloride level increases [17].

As a result of vacuum cooling the solution from 100 to 20°C, theoretically, 12% of the water can be evaporated without contaminating the crystallized KCl with NaCl.

In practice, the sodium chloride separated at the beginning of crystallization is covered with a potassium chloride coating when the water evaporates and cannot go into solution again; therefore, the filtered liquid is not saturated with NaCl, even though it is mainly in the solid phase, because it is not contaminated with KCl and NaCl, water-condensate is added to the solution at the beginning of crystallization or before [18].

If sylvinite is not contaminated with carnallite, as a result of circulation of the solution, magnesium magnesium chloride will gradually accumulate in its composition. In this case, it is necessary to renew the solution, because the solubility of potassium chloride decreases in the presence of magnesium chloride, when the concentration of magnesium chloride is greater than 100 g / 100 g of water, the solubility of NaCl in saturated solutions of potassium chloride decreases with a decrease in temperature (it increases with the load of magnesium chloride). This leads to contamination of potassium chloride, while cooling the hot solution with sodium chloride, potassium chloride crystallizes. When sylvinite contains 1.106% $MgCl_2$ and 4% water evaporates during cooling of the solution, 87% KCl is formed in the product, the concentration of $MgCl_2$ in the filtrate is 137g/1000g water and the 80% concentration is 213g/1000g water. In raw materials, KCl is 90.3% in the first case and 92% in the second case [19].

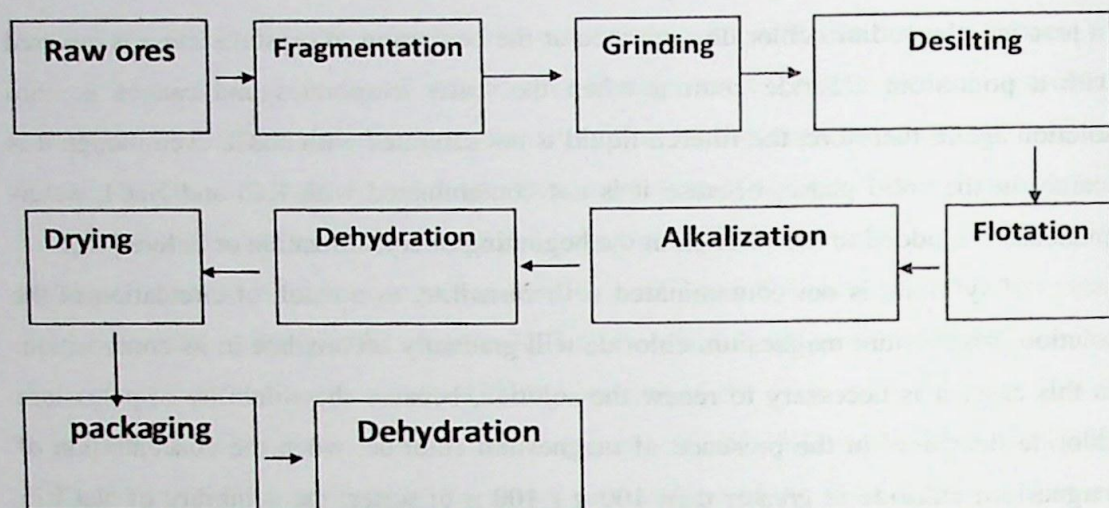
b) General information and protective measures.

The working days of the processing complex are 330 days. Production and auxiliary production systems work in 3 shifts a day, each shift consists of 8 hours. The processing complex has 701 employees.

The area of the processing complex is 20.16.

According to this project, it is planned to produce 200,000 tons of potassium chloride for agriculture using flotation technology. As a raw material, potassium salts from the Tyubegatan mine, located in the Kashkadarya region, are used as a raw material.

The technological scheme of the production system is presented below:



All production processes are carried out at normal temperature, only the drying process takes place at high temperature.

Raw materials for production: ore of potassium salts, flotation reagent, hydrogen hydrochloric acid, water preparation reagents.

Fuel: Natural gas

Auxiliary materials: oxygen acetylene, electrode, steel materials, diesel fuel, gasoline, grease, bags for packing.

Finished product: potassium chloride for agriculture.

In addition to the production of potassium chloride, the processing complex has the following main equipment; crusher, rod mill, flotation machine, concentrator, horizontal belt filter machine, recirculation dryer with hot air oven, cooling machine, automatic packing machine, gas boiler, equipment for conveying liquid materials (pumps), etc.

The processing complex under construction is located 3 km from the city of Dehqonabad. A residential district of the processing complex will be built in the construction area, and there are no other residents there. Therefore, the environment of the processing complex does not affect labor safety and hygiene.

The shape of the area of the processing complex is a right angle. The area occupies 20.16 hectares of land. The signs of the surfaces on which the devices are

installed correspond to the signs of other places and roads of the processing complex. The area of the processing complex will be prepared on the spot, there will be no need to bring or take away the soil. In the area of the processing complex, rainwater is sent through the collector to the sedimentation collector, and then it is sent to the bottom of the north-west corner outside the plant.

The following rules are observed in the composition of the master plan:

- as a result of ensuring the continuity of the technological process and the short-term connection of the technology, the length of the construction leads is maximally reduced;

- the composition of buildings and devices is fully determined by the following conditions: fire and explosion protection, medical assistant, etc. According to the terrain of the plant, after the leveling of the area, its location is intended to be very flat, in this regard, it is determined by a straight vertical slope.

The transitions of the processing complex are designed according to the relevant norms. 3 categories of streets are designed in the area, the width of the main roads is 10 m (the width of the street surface is 8.0 m) and 6 m (the width of the surface is 4.0 m). the width of the small street is 4 m (the width of the street thickness is 3.0 m)

The turning radius of the main street is 12 m, the auxiliary street is 9 m, the small street is 7 m, the intersection is 1-3 m.

The vertical slope is usually designed as 0.3%, while the horizontal slope for drainage is 2%.

The master plan composition, safety distance, lighting vitilizations are carried out according to project norms.

Out of auxiliary buildings, the following are located in the area of the processing complex: the domestic housing of the filtration shop, the domestic housing of the auto repair shop with a service radius of 150 m for the convenience of workers. In addition, in order to accustom the personnel of all corps to hygienic requirements, in some production buildings, dressing rooms and toilets are designed as auxiliary rooms.

Kitchen medpoint and other devices are seen in the processing complex.

Among all the materials and raw materials used in the processing complex, hydrochloric acid has a corrosive effect on humans, other materials do not cause direct harm. In the production process, flotation reagents are prepared using hydrogen chloride acid, consumption of this acid is 16.2 tons.

In the production process, foaming, grinding, drying and packaging departments generate dust. This has a certain effect on the operator.

The reverse dryer operates at a high temperature, which can burn a person.

Grinding mill, reciprocating dryers emit noise and this can have a negative impact on human health.

Natural gas, acetylene and oxygen used as fuel can cause an explosion, which can have a negative impact on human health.

1. The master plan of this project was developed in accordance with fire, explosion and safety standards and regulations. On the basis of centralization, equipment is installed according to technological processes, it is installed in a centralized manner in relation to similar equipment. It is useful for safe handling and ease of production.

2. Fire resistance level of buildings according to fire regulations II. The structures of the devices are made of reinforced concrete tower frames and frames. The materials of the buildings are fire and explosion resistant students.

3. Central control and automatic fire alarm system are designed. The main unit is installed in the SPU. District alarms are not intended for production devices. In different regions, according to the requirements of different conditions, detectors are designed, fire fighting telephones reacting to smoke and fuel gaseous substances, radio, alarm buttons are installed. The group system is not designed, the fire alarm in the area of the processing complex works through non-automatic and automatic alarms. An automatic alarm system with control over temperature rise and smoke.

4. Fire fighting pipelines and fire hydrants are designed on the roads of the processing complex and in certain factory rooms, and a certain number of chemical fire extinguishers are designed in accordance with the fire prevention norms of the buildings. A fire depot is planned in the processing complex.

Dust protection.

1. In order to eliminate the negative impact of dust on human health, the raw material supply system and material transportation systems are placed in the open air with a frame structure.

2. In order to prevent the accumulation of harmful substances, a reliable ventilation system will be designed in the production rooms in accordance with the relevant norms. In workshops where a large amount of dust is generated, it is released into the atmosphere after ventilation and dedusting.

3. In the developed process, protection management, technological operation disciplines will be strengthened. In places where a lot of dust is generated, employees should wear protective equipment against dust.

Corrosion protection

1. Chlorine ions of raw ores, intermediate products of the production process, and finished products have a corrosive effect on buildings, devices, equipment and materials. Measures necessary for the design of material selection and protection of equipment are intended.

2. Hydrochloric acid used for melting is transported by tank. A person should be protected from scalding by corrosive liquid (hydrochloric acid). Hydrochloric acid has corrosive properties, it reacts with ordinary metal and corrosion occurs with fiber, in this regard, the materials of buildings, pipelines and pipelines are made of fiberglass. Centrifuge was selected as a transport and discharge pump with a fluorine plastic pad. The hydrogen chloride storage tank is designed as a closed loop, with a breathable roof on top, the pipes are in contact with air through a dense material, and impossible amounts of hydrogen chloride vapors cannot escape into the atmosphere. To find out the level of hydrogen chloride, there are devices that show the level.

Noushes are designed for details, roasts and contact parts of hydrogen chloride acid.

Containers are installed in a separate place, the fire dam and the floor are protected against hydrogen chloride acid in these places, the fire dam is made of non-

combustible metals and withstands the static pressure of the product located. Acid protection is designed on the basis of the container. In the storage area, special curtains are installed for protection from the sun, a bathtub for quick assistance, a washing machine. Showers etc. for first aid outside the storage area. are installed. Purchased cask alkalis for acid neutralization are stored in the storage area.

In the room for preparation of reagents, a washing machine and a storage tank for sodium bicarbonate are installed. Employees must wear protective gloves and other protective equipment. In case of splashing of hydrochloric acid on a person, it is necessary to wash quickly with a large amount of water. In case of splashing of hydrochloric acid on a person, it is necessary to wash quickly with a large amount of water, from which it is necessary to wash with a 0.5% solution of sodium bicarbonate. If acid splashes into the eyes, it is necessary to quickly wash with plenty of water and send the employee to a medical center. In the necessary places, pipes for washing the eyes are installed. In addition, a sodium bicarbonate reservoir is installed in the reagent preparation room.

c) The manufactured product, its characteristics and technical and operational requirements.

Potassium chloride KCl is a colorless crystal with a cubic lattice ($\alpha = 0.629$ nm, $z = 4$ Fm³m group); At 2980 C and 1.95 MPa, a cubic modification similar to Cs Cs is formed. Boiling temperature 1500⁰ C density 1.989 g/cm³; $C^0_r = 51.30$ Dj

These BMI raw materials include: sylvinite from the Tubegatan mine, flotation reagents, starting water, natural gas, diesels, gasoline, grease and bags.

The electrical supply of the facility is provided by I and II buses of 6 kv with PS 110/35/6 kv under construction.

The chemical composition of the initial (raw) ore is as follows (%): KCl - 31.93; NaCl - 64.46; MgCl₂ - <0.35; CaSO₄ - <1.26; e. k - < 2.0.

The following enrichment reagents are used in this processing complex: depressor (SL - 1), collector (amine S16 and S18), multifomer (glygal ether or oxal), apolar (catalytic gasoyl,) flocculant (PAA 23 - with a molecular weight of 17 million a.e.t.), dust suppressant (industrial oil U-40), hydrogen chloride acid (30%).

Initial water is taken from the Pachkamar reservoir in the volume of 669.97 m³/d. It is necessary to purify domestic and industrial water, because the original water contains a large amount of salts.

Medical gas is used as household and industrial fuel. In the normal mode of operation, the consumption of natural gas is 1030 st.m³ /g (annual consumption of gas is 4.8*10⁶, output pressure is 0.6 MPa).

Large grain flotation technology is used in this work. The size of raw ores entering the flotation process is 1 mm.

The flotation process comes after crushing, crushing, classification and de-slurrying of raw ores. For the flotation process, basic flotation and triple retreatment are used. From the basic flotation foam product classification, the first re-cleaning of the product under the grid is used. From the main flotation foam product classification, the under-grid product is fed to the first retreatment, and the under-grid product and the foam product of the re-treatment III are mixed and the initial potassium chloride is formed.

After dewatering, the initial potassium chloride is converted into a concentrate. The concentrate is fed to the drum cooler with a belt conveyor for cooling, so at the same time dust suppressants and anti-sticking agents are added to the entrance of this cooler to prevent the presence of dust and the finished product from sticking. The temperature of the product decreases from 80 - 100°C to 40°C with the help of a smoke extractor for cooling. After cooling, the potassium chloride product is fed to the finished product hopper of the packaging department by a belt conveyor.

As a packing machine (XW 0801 A/B) 1 worker and 1 reserve are used.

After drying and cooling, the potassium chloride product is sent to the packing machine (XW 0801 A), which is located under the hopper of the packing plant (V 0801 A), or with the loader (M 1601) to the packing plant, which is located under the hopper of the packing plant (V 0801 B). (XW 0801 B) is sent to the car. With the help of an automatic stacker, the finished product, packed in bags, is made into a stack with a weight of 2 tons. After that, the forklift bags (L 0803 A/B) are placed in the finished product warehouse. 1 worker and spare are designed for stacking.

A dust collector with a sleeve is designed to suppress dust. A sleeve filter works due to vacuum in the unloading and packing area of the belt conveyor. The dust caught in the filter is returned as a finished product.

Compressed air for packaging comes from the compressor station of the factory.

This B.M.I. The design volume of the construction part consists of the following industrial facilities: Raw ore storage with raw ore hopper Belt conveyor N1 – N6 Grinding station Crushed ore hopper Production body Drying section Cooling unit with finished product storage Packing section Sludge thickener Filtrate reservoir Butts thickener emergency swimming pool filtration housing and production auxiliary equipment VOS, compressor room, boiler room, circulating filter pump room, car repair shop, oil storage complex warehouse, compressor room, block of repair shops, GRP, substation PT N2, fuel supply station operator's room, SZL, fire depot and household service facilities - administrative building, kitchen, household building, etc.

The main industrial buildings of this project include: packing department with finished product warehouse, crushing station, crushed ore bunker, production building, filtration shop and boiler department. These buildings are made of reinforced concrete structures with a frame and a row of masonry.

Auxiliary production equipment consists of the following: drying section, cooling section, cooling unit. Belt conveyor N1 - N6 sludge thickener, butts thickener, water preparation device, compressor room, fire depot. These buildings are made of reinforced concrete structures with a monolithic frame and row frames: a raw ore warehouse with a raw ore bunker, a complex warehouse, a block of repair shops and car repair shops are made of reinforced concrete structures with a row frame: VOTS, a pump room for circulating filtrate, a fuel station with an operator's room, administrative building, kitchen, household, SZL, oil warehouses are made of brick and concrete constructions.

This B.M.I. near the construction site, a household service station was built in 0 district. In this regard, only household service devices will be located in the territory of the factory, which is necessary for production.

The total number of personnel is 701 people. The kitchen, utility building (shower, laundry room, etc.) and utility rooms will be located in 3 places. The height of each floor is 3.3 m. The kitchen is a building with a frame structure, the floor height is 4.2 m, the construction area is 796 m², 112 places are designed. 1 administrative building with concrete construction, 1 underground, 3 above-ground floors, the height of the floors is 3.6 m, the construction area of the underground channel is 730 m², the area of the above-ground channels is 2240 m², the administrative building includes a med point, a telephone switchboard room, meetings rooms and cabinets are designed.

g) Selection of building elements and their explanation.

Basis and foundation. Since there is no engineer-geological survey for this topic, we believe that the soil on the surface of the earth consists of clay according to the information received about the district where the plant is located. We temporarily consider the descriptive value of the carrying capacity of the clay base as $f_{ak}=150\text{k Pa}$.

Packing department with finished product warehouse, crushing station, crushed ore hopper, production building, filtration shop, boiler room, drying department, cooling station, belt conveyor, N1 - N6, slurry thickener, butt thickener, compressor room, fire depot, raw ore warehouse with raw ore bunker, complex warehouse, block of repair shops, auto repair facilities, separate reinforced concrete foundation is used, or reinforced concrete foundation is used, or reinforced concrete tape foundation: VOTS, pump room of circulating filtrate, fuel station with operator's room, administrative building, kitchen, household building, SZL and oil storage facilities will be built with tape foundation. A natural base is used as the foundation of factory buildings. If necessary, artificial processed bases can be used on a local scale. The second or third level IGE is used as the base layer for the foundations of the main industrial buildings with large loads. First class IGE is used for industrial buildings with industrial auxiliary low load.

It is assumed that the depth of the foundations is not less than 1.5 mm.

Anti-corrosion measures. In the fittings located in concrete and reinforced concrete constructions, the soil of the base on the site has a low and medium corrosion effect. They have medium and strong impact on metal constructions. Therefore, sulfate-

resistant cement under 0.000 is used as concrete: the strength of the foundation made of unreinforced concrete should not be lower than C25, the strength of reinforced concrete is C30, the minimum consumption of cement for concrete is 300 kg/m^3 , the maximum of water and cement the ratio is 0.5, the maximum amount of CI (percentage of cement consumption) is 0.10.

Corrosion protection of bases and foundations.

Anti-corrosion structures on the lower surface of foundations:

-removal of disturbed soils from below the foundations, 100 mm against the base layer;

- installation of a 100 mm thick layer of gravel and asphalt;

-one layer of hot asphalt;

-unrepaired 100 mm concrete.

Anti-corrosion structures on the top and side surfaces of the foundation;

- applying earth paint once:

- applying two layers of hot asphalt.

Under the foundation beams and on the side surfaces of the foundations (including the side surfaces of the wall above the foundation beams):

- transfer the earthen tank once;

- applying two layers of hot asphalt.

Surface structures are completely free from corrosive liquids:

-removal of damaged structure and water-soaked base soil, low conductivity of ash back to excavated areas and compacting it to a thickness of 300 mm, compaction coefficient 0.94; 120 mm thick installation with halka or shebenka asphalt;

-pouring and leveling of S30 class concrete with a thickness of 120 mm;

- For leveling, use a 1:2 cement solution with a thickness of 20 mm;

-Use of SBS roll material with a thickness of 4 mm as an insulation layer;

- installation of 40 mm thick sand-cement solution and asphalt.

Surface constructions of ordinary concrete surface:

-removal of damaged structure and water-soaked base soil, re-laying of low-permeability soil in many excavated areas and 300 mm thickness, compaction coefficient of 0.94;

- installation with golka or shebenka asphalt with a thickness of 1200 mm;
- pouring and leveling of S30 class concrete with a thickness of 120 mm;
- one layer of cement layer (with construction glue);
- use sand-cement solution with a ratio of 1:2, thickness of 200 mm for leveling.

Corrosion-resistant constructions of the drain plate:

-removal of the divided structure and water-soaked base soil, re-planting of low-permeability soil in many excavated areas and compacting it to a thickness of 300 mm, the compaction coefficient is 0.94. width is 1800 mm; external transverse slope 5%;

- 1200 mm thickness of asphalt or shebenka, 1500 mm wide;

-preparation of S20 class concrete with a width of 1500 mm and a thickness of 60 mm; targeting expansion and contraction joints of 10 mm every 10 meters; design deformation seams with a width of 10 mm in the longitudinal direction along the wall; all joints are covered with construction oil, bituminous sand solutions;

- leveling and densification using a concentrated solution of 1:2.5 with a thickness of 200 mm; design expansion and contraction joints with a width of 10 mm every 10 meters; along the wall;

- targeting deformation seams with a width of 10 mm in the direction; all joints are covered with construction oil, bituminous sand solutions;

Anti-corrosion constructions of channels:

- removal of damaged structure and water-soaked base soil, re-laying of low-permeability soil in heavily excavated areas and 300 mm thickness, compaction coefficient 0.94;

- 1200 mm thick asphalt installation with needle or shebenka;

- class S30 concrete with a thickness of 1200 is placed and leveled at the same time, expansion and contraction joints are designed every meter in the longitudinal direction;

- in the inner part, it is intended to put a sheet on the steel, the thickness of the channel is 4 mm along the entire length;

- at the beginning, rust must be removed from the steel sheet, the level must be SA2 or St3; Apply iron oxide red anti-corrosion paint 2 times; 40 m km each time; Applying PSQ paint against metal corrosion 3 times, each time 40 m km, the total thickness of the paint is 200 m km.

Measures against noise and vibration. In this project, due to the strong noise in the crushing station and the crushing departments in the production building, noise-insulated duty rooms are designed. In order to reduce the effect of vibration on the production body, the mill, grinder, and sieves are installed separately from the main structure.

the demand of our republic for potash fertilizers is 282 thousand per year. The production of 200,000 tons of potassium chloride per year by the unitary enterprise "Dehkhanaabad Potash Fertilizer Plant", which is currently the only one in Central Asia, is not even enough to satisfy the needs of our republic. For Suning, increasing production capacity to another 400,000 tons, i.e., total production capacity to 600,000 tons, is one of the urgent problems of today.

a) Technology of beneficiation of sylvinite deposits by gallurgical method

If melting is carried out in an isothermal condition at 100°C , NaCl will lie on the saturation line at point S1, and thus the melting of NaCl from the ore will end. At point X, the system consists of liquid phase and undissolved NaCl. We determine the composition of the liquid phase by building Ax (the crystallization light of NaCl) and continuing until it intersects the KE line. In this way, if you add the metal to the liquid phase again, KCl dissolves from the metal.

NaCl remains undissolved. Figurative point of the liquid phase is moved along the S1 UE curve. In this case, the amount of NaCl in the liquid phase decreases not only due to the weight fraction concentration (since the S1 UE curve has a negative slope everywhere), but also due to the fact that the amount of water does not change, KCl turns NaCl into crystals.

S1 V beam S1 mixture of solution with KCl S1 U1 U2 section enters the internal field of selection of NaCl. Accordingly, the addition of KCl to the S1 solution leads to the crystallization of NaCl. Halite grains do not grow when crystallizing NaCl is removed from the solution, but a thin dispersed phase of salt is formed.

Thus, the dissolution of KCl from sylvinite ore is carried out with the formation of a saline dispersed phase, and its amount is greater the smaller the melting radius of the ore is in the S0 S1 section. The formation of salty sludge during the melting of sylvinite ore is not desirable and is determined by the kinetics of salt dissolution.

The figurative point of salt without water is at infinity. In this case, it causes inconvenience in observing processes involving anhydrous or wet crystals. But, in initial cases, such diagrams have advantages.

The saturation line of NaCl (crosses the vertical axis of the coordinate) has a negative slope, and therefore it is concluded that NaCl crystallized in the presence of KCl.

On the other hand, the saturation line of KCl (cuts the horizontal line of the coordinate) is not vertical and has a negative slope.

Therefore, salt solubility decreases in the presence of KCl-NaCl. However, the decrease in NaCl concentration in the presence of KCl is more dramatic than the decrease in KCl concentration in the presence of NaCl. The effect of NaCl on the desalination of KCl is much stronger than the effect of KCl on the desalination of NaCl. You can follow the evaporation process with the help of the diagram below.

Thus, if the initial solution f_1 is at temperature t_2 (for example, 75°C), after evaporation, its composition is f_2 , temperature t_3 , it can be seen from the location of points f_1 and f_2 relative to the isotherm t_3 that f_1 - to "undissolved solution, f_2 - suspension of KCl crystals, because the point f_1 is located to the left of the isotherm t_3 . To determine the composition of the liquid phase in the f_2 suspension (solution), we draw a horizontal straight line - the crystallization ray of KCl and find the horse point where it intersects with the isotherm.

The difference between the abscissas of points f_2 and m resulting from the evaporation of solution f_1 at the rate of 1 kg of water m in solution gives the weight of KCl crystals.

After that, the total weight of KCl crystals ($m \cdot f_2$) is equal to $\{m\}$, where ($m \cdot f_2$) is the length of the crystallization beam of KCl, $\{m\}$ is the weight of water contained in m complex.

Due to the continuous formation of primary crystals and their growth, all products of crystallization are always polydisperse. The presence of foreign substances in the solution (for example, the presence of NaCl in the crystallization of KCl) slows down the mixing processes, leads to the appearance of small dispersed crystals, and especially slows down the crystallization of KCl from eutonic solutions.

During crystallization, the size of the crystals is increased by placing a tube, organizing the circulation of the crystal suspension from the crystallizers, and taking away the large dispersed fractions.

Increasing the average size of the crystals can be achieved by gradually cooling the solution. The physico-chemical characterization of KCl-NaCl-H₂O systems is used to select the technological mode of production of potassium chloride.

One of the most important operations of production of KCl by galurgy method is smelting - melting of ore in heated (alkali) re-alkali, brightening (typing) of saline suspension obtained in the previous stages - vacuum crystallization, separation of KCl crystals in strong alkali. Separate it from the saturated solution and dry it.

b) Principle scheme of sylvinite processing by galurgy method.

The movement of the ore and the solvent solution relative to each other is important, that is, the sequence of passage through the equipment and the direction of the flows inside the equipment. The first is external, and the second is called internal direct or reverse flow. In the external counterflow, metal (c) passes through the solvent in the order 1-2-3, solvent (b) in the opposite order 3-2-1. has a large driving force Therefore, the external countercurrent method is used to dissolve KCl from minerals.

Extraction of KCl from sylvinite by galurgy method is a cyclic (periodic) process, which is obtained after crystallization of KCl and a solution saturated with

NaCl ($\text{KCl} + \text{NaCl}$) is washed (dissolved) with alkali from sylvinite. The technological scheme of method B consists of the following main stages: crushing of sylvinite ore; Alkaline washing of sylvinite with reduced solution to transfer KCl into solution; separating solid halite residues from the solution, washing it to reduce the loss of KCl in waste. Separation of solid waste from a boiling solution saturated with KCl and NaCl into salty and earthy slurries; To reduce the loss of KCl, wash the earthy slurry with boiling water in the opposite flow; For the crystallization of KCl, the solution is cooled, and at the same time, the boiling solution is used to heat the reheated solution; is processed to separate KCl crystals from the circulating solution and reduce its viscosity; drying KCl crystals; the returned solution is heated for use in the washing process; disposal of waste, that is, disposal of halite waste and earthy sludge; Granulation of KSl used as fertilizer.

Crushed sylvinite comes from the 1-5 mm conveyor to the bunkier 2, and from the feeder 3, it is measured using the automatic scale 5 through the belt conveyor 4, and the ore is transferred to the auger dissolver 6.

KCl from sylvinite is dissolved with a solvent solution containing 110-130 g/dm³ KCl and 240 g/dm³ NaCl. The solvent solution heated from the heater 14 to 105-115°C is supplied to the second solvent 7. The medium solution in the second solvent flows into the first solvent 6. With the parallel movement of the solution and new sylvinite, complete saturation of the solution with KCl and NaCl is achieved. 1.5-2.5 atm to maintain the required temperature. hot steam is supplied under a pressure of 0.15-0.24 MPa.

The combined scheme of melting is shown above. Sylvinite passes through the first and second solvents and comes to the halite waste screw mixer 8, which slag heated to 70°C and the filtrate of 9 planar filters is washed in a countercurrent flow with earthy sludge washing water. This increases the output of KSl and allows 1 part heat recovery. The heated solution in the screw mixer flows into the second solvent.

The waste, which is thrown from the screw mixer to the bucket elevator, contains 12-17% rotating solution. Therefore, in order to reduce the loss of KSl, the waste is washed with hot water in the flat filter (60 l of water per 1 t of waste). The

washed halite waste, containing 5-7% moisture and 2% KCl, is taken out of the workshop with a conveyor system and sent to processing or to the place of installation. The saturated solution obtained by melting sylvinite contains 245-260 g/dm³ KCl, 213 g/dm³ NaCl, small ore particles, undissolved waste (gypsum, soil) and NaCl crystals. When sylvinite is processed by the galurgy method, 1000 kg of ore, 20 kg of earthy slag (65% ore content) and 160 kg of salt slag are taken from the Verkhnekamsky mine. The sizes of salt particles and soil slag are different: 88% of the slag by mass is 0.074 mm, and 84% of the soil particles are less than 0.05 mm in size. Their different sizes make it easier to distinguish them. A 0.25% coagulant solution is added to accelerate the sedimentation of the soil slurry. According to polyacrylamide (PAA), 125 g of 100% PAA is added to 1 t of undissolved precipitate or starch working solution. Salty or earthy particles are separated in a 6-cone separator. Condenser 13 is deposited in cones 1-2, salty sludge, and earthy sludge in the following ones. In order to reduce the loss of a large amount of KCl in the resulting salty and earthy sludge, they are washed with water. The purified saturated solution is fed to a four-stage vacuum crystallizer.

d) Basic processes in potassium chloride technology.

Flotation is one of the most widely used methods of mineral enrichment. This method is widely used in various industries: mining, biochemical and food industries. Today, flotation is used to separate ions and molecules from solutions.

The flotation process is based on wetting some minerals from the ore being enriched with water or a solution of saturated salts. The wetting angle shows the hydrophobicity or hydrophilicity of the mineral surface and is determined by the following formula.

e) Physico-chemical basis of flotation of soluble salts.

In 1932, for the extraction of halite (NaCl) from sylvinite waste, enrichment of natural soluble salts by flotation method was used for the first time in the USA. In 1934, the first industrial devices for flotation of halite from potash ore were used. Today, 50% of potash fertilizers are obtained by the flotation method in the world.

The flotation process consists of the following stages: 1) diffusion of the solvent and selective adsorption to salt minerals; 2) collision of mineral particles with air

bubbles in the mold; 3) solidification of particles in bubbles; 4) formation of mineralized foam, release of particles in the form of concentrate with foam.

The ionic lattices of KCl and NaCl, the main components of sylvinitic ore, have the same cubic shape. Currently, there are several hypotheses about the nature of the selective interaction of flotation reagents with the surface of salt minerals, which determine the possibility of separating the necessary salts by the flotation method. The previous hypotheses do not negate each other, on the contrary, they complement each other. So far, they do not allow us to derive a law that explains the selective separation of soluble salts, but they explain the specific points in detail.

Sylvinitic and sludge flotation reagents

Flotation and hydrocyclone enrichment methods are widely used in sylvinitic enrichment factories. There is also a method of enrichment of sylvinitic ore by electrostatic, thermal and ammonia methods, but thermal and ammonia methods are not used in industry.

Foam, thin layer and oil flotation methods are available. All these methods are based on the property of liquid wetting of minerals in the ore.

Foam flotation is mainly used in the production of potash fertilizers. For this, air is supplied to the suspension consisting of small particles of processed ore. Some mineral particles adhere to the formed air bubbles and form a bubbly product, while others do not have this property and settle down and form waste.

The following methods are used to obtain potassium chloride from carnallite and sylvinitic minerals:

- with mechanical beneficiation of ore - the main process in this is flotation. This method is widely used;
- melting and crystallization method based on different solubility and crystallization of salts contained in the ore (these methods are called heat, galurgic* or chemical method); (*halurgy-salt work);
- flotation enrichment can be carried out in combination with the dissolution and crystallization of small particles;

- by underground smelting and processing of ore.

Sulphated potassium salts are also enriched by similar methods.

Potassium salts are separated from natural salts, brines, by various methods depending on the composition of the salt or solution and the method of extraction. In the process of flotation, if foam is created for enrichment, that is, if the desired mineral is separated with the foam, it is called flotation. If unnecessary minerals are separated with foam - it is called reverse flotation.

The foam formed during ore enrichment by the flotation method should be solid only during the flotation process, that is, when the air is blown.

If the mineral contains water-soluble salts, a saturated solution of these salts is used as the liquid phase of the suspension.

In order for the flotation process to give a good result, the ore must be finely ground and its particles must not be connected to each other. For example, for sylvinite, the particles of the flotation ore must be 1-4 mm.

Flotoreagents are divided into the following groups according to their function:

a) collectors or collectors. Molecules of these substances can be adsorbed on the surface of flotation substances (non-polar or polar substances) and their molecules are adsorbed on the surface of the treated particle. With its non-polar part, it can be caught on the surface of water or foam. This is their ability to flotation;

b) depressor or launchers. These substances are on the surface of the particles stops adsorption;

c) activators - they collect substances on the surface of minerals increases the ability of non-absorption;

g) foaming substances;

d) regulators, in the process of beneficiation of sylvinite by flotation method changes the effect of reagents. As a result, potassium chloride turns into foam.

Methods of beneficiation of potash ores.

For this purpose, sylvinite is crushed and de-slurried, then a suspension is prepared from the solution and solid material, to which fuel oil, kerosene or other water-immiscible unbleached petroleum products are added.

In addition, reagents are also added (aliphatic amines). After that, the suspension is sent to a vibrating table and a large-grained product consisting of 79% potassium chloride is obtained [30].

Enrichment of ore by burning method.

The burning of large-grained sylvinite leads to cracking of halite crystals, while sylvinite crystals remain unchanged.

Usually, the burning process is carried out at a temperature of 400°C without mechanical influence, it is carried out in a rotary furnace at 450°C . The quality of sylvinite burned in a rotary kiln is lower than that of sylvinite burned without mechanical influence. It frees sylvinites from slush inclusions, sylvinites can be overheated during flotation enrichment. Therefore, incineration of clayey sylvinites is considered to be the best beneficiation method [31].

As a result of two planes working close to each other, they become electrified. Small-sized particles receive enough charges to deviate from the straight-line path during high-voltage electrostatic field. This is what the electrostatic enrichment of sylvinite is based on (sylvinite is separated from halite). Sylvinit initially helps to increase thermal slime discharges and eliminates the negative effects of slimes. Silvin and halite particles are treated with reagents before heating the ore to obtain charges of different sign and equal value, which helps to form coatings on its surface.

It is recommended to use the following: ammonia, fatty amines, phthalic anhydride, phthalic and benzoic acids. Initially, after the operation, silvin has a positive charge in the electric field, while halite particles have negative charges in the same absolute value [32].

The following are recommended substances for initial treatment of sylvinite prior to electrostatic enrichment:

- anhydrides of -carbon and organic sulfoacids. And their mixed anhydrides;
- anionic substances and silicone oil;
- ammonium hydroxide and crushed lime;
- organic substances with six or more carbon atoms in the molecule, and one or more SO_4Me or SO_3Me groups or mixtures of these substances;
- aliphatic cycloaliphatic and aromatic organic acids with more than three carbon atoms in the molecule, their salts and complex ethers, which may contain other carboxyl sulfoacids and various functional groups.

A combination of drum separators and free-falling multi-stage separators can be used to transfer high amounts of potassium chloride in sylvinites. This process is carried out in two steps [8]

If the speed of movement in this method of enrichment is very high and particles settle, the suspension will have the same properties as a liquid. Particles with a low density compared to the suspension will float up, high density particles will start to come out. The density of halite is 2.170 kg/cm^3 , sylvinites is 1.98 g/cm^3 .

Therefore, crushed sylvinites becomes a heavy liquid or a suspension with a density of $2.05\text{--}2.10 \text{ g/cm}^3$, sylvinites floats up, and halite settles.

It would be convenient to work with heavy liquid. But it is very difficult to get such a liquid under normal conditions. Therefore, magnetite or ferrosilicon suspensions are used in solutions saturated with NaCl and KCl [33].

Magnetite or ferrosilicon suspensions cannot coexist in a quiet state, the process of mineral separation can be carried out in an apparatus where the suspension is always in motion. A hydrocyclone can be used as such an apparatus. In this apparatus, under the influence of centrifugal forces, particles with a high density are thrown to the walls, move down the spiral and leave the lower nozzle. At the same time, small dense particles go up and leave the upper nozzle. The concepts of "Low" and "High" are not very clear here, because the hydrocyclone can be operated in a horizontal position [34].

Enrichment products fall into vibrating sieves, where salts and suspensions are separated from each other, followed by washing. The washed concentrate is sent to

drying, and the mineral containing 65% KCl 0.4% H₂O is sent to the next stages. The waste generated after washing the suspension is sent to the storage tank.

The magnetic suspension separated in vibrating grates is sent to a special collection tank. The condensed suspension formed during washing is passed through hydrocyclones, and from here the mixture is sent to the condenser, the condensed product is sent to magnetic separation. In the magnetic separation process, magnetite is attracted by a magnet and can be separated from non-magnetic materials.

The separated magnetite passes through the demagnetization filter and falls into the collecting tank, and the non-magnetic material is sent to the thickener. The solution from the thickener is returned to the process. The thickened pulp of the thickener consists of a slurry, which is washed in a counterwasher and disposed of [35].

Ammonia method. Aqueous solutions of concentrated (80% and more) ammonia and liquid anhydrous ammonia are practically insoluble, while sodium chloride is highly soluble.

M.N. Nabiyeu proposed to dissolve sylvinite ore in a concentrated (80-90% NH₃) aqueous solution of ammonia. After dissolution of halite and separation of phases, a precipitate is formed, which contains potassium chloride, anhydride and water-insoluble additives. After removing ammonia and drying, technical potassium chloride is obtained from the undissolved precipitate. It contains 86-89% of potassium chloride, 97-98% of the ore contains potassium chloride, and 97-98% of potassium is removed from the ore.

c)Combination of flotation and gallurgy methods. The use of flotation with a large amount of soluble residue in the ore leads to a high consumption of reagents and a decrease in the transfer of potassium to the final product. In some cases, potassium chloride obtained by flotation and containing a large amount of insoluble additives does not become viscous. If the amount of slurry does not exceed 3.5%, the ore can be profitably processed by flotation method [36].

Sludges do not cause any difficulties in the rebinding of sylvinities by the gallurgy method. Small crystalline potassium chloride is produced by the gallurgy method.

The disadvantages of both methods lead to the production of a new combination technological scheme. This scheme includes both flotation and gallurgy processes. This was achieved by adding a melting-crystallization cycle to the main flotation device. In the production scheme of the combination method, the initial ore is ground dry, then it is mixed with a rotary kiln and evaporated. The liquid from the classifier goes to the hydroseparator, where the fine particles of salt are separated from the sedimented slurry [37-38]. The slurry pulp from the hydroseparator is sent to the thickener, and the liquid from here is returned to the classifiers, the thickened slurry pulp is sent to the waste storage tank. The fine particles of salt from the hydroseparator are mixed with the bottoms of the main flotation and this mixture is dissolved in the heated circulating liquid. The solvent pulp is thickened and then the bottom product is centrifuged and transported.

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CONCLUSION

The main scientific and practical results obtained during the completion of this master's thesis:

1. Phase compositions in systems containing potassium chloride, sodium sulfate, and potassium sulfate were studied by visual-polythermal method from the full freezing temperature to 80°C. Polythermal solubility diagrams were constructed. In the solubility diagram of $\text{Na}_2\text{SO}_4\text{-KCl-H}_2\text{O}$ and $\text{K}_2\text{SO}_4\text{-KCl-H}_2\text{O}$ systems, new components of glaserite ($\text{Na}_2\text{SO}_4 \cdot 3 \text{K}_2\text{SO}_4$) and potassium sulfate (K_2SO_4) are separated.

2. The study of the process of conversion of flotation potassium chloride with mirabilites revealed the possibility of obtaining glaserite - $\text{Na}_2\text{SO}_4 \cdot 3 \text{K}_2\text{SO}_4$. Optimal conversion conditions are temperature - 40-50°C, Na_2SO_4 : KCl ratio - 1:1, duration - 60 min. a product containing 40.10% K_2O is obtained; 9.56% Na_2O ; 3.80% Cl^- ; 50.61% SO_4^{2-} .

3. Studying the process of conversion of glaserite with flotation potassium chloride solutions (10%) revealed the possibility of obtaining potassium sulfate. Optimum conditions for conversion are temperature - 30-40°C, ratio Q:S ($\text{Na}_2\text{SO}_4 \cdot 3 \text{K}_2\text{SO}_4$: KCl) - 1:1, duration - 60 minutes, it is indicated that the product contains 46.05% K_2O . is taken; 3.22% Na_2O ; 1.27% Cl^- ; 50.94% SO_4^{2-} . A single wash with water at a ratio of 1:1 gives a product with a K_2O content of 53.18%; 0.33% Na_2O ; 0.20% Cl^- ; 54.46% SO_4^{2-} . By additional washing, potassium sulfate with Cl^- less than 0.2% can be obtained.

4. Physico-chemical analysis methods using X-ray, IR-spectroscopy, scanning electron microscopy studied the physico-chemical characteristics of chlorine-free potassium sulfate and were confirmed by the results of chemical analysis.

5. Technological schemes for obtaining chlorine-free potassium sulfate from Mirabilit and flotation potassium chloride solutions, material balances were developed, material flow schemes, production material balances were drawn up.

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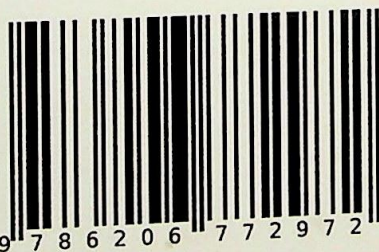
PRODUCTION OF POTASSIUM FERTILIZERS BY FLOTATION METHOD

The existing methods of obtaining potassium sulfate are multi-stage, the complexity of the technological scheme, high energy costs, the formation of byproducts of little-used products, and the high cost of the resulting products. In addition to chemical and physicochemical (x-ray phase and scanning electron microscopic methods) analysis to determine the phase composition of intermediate products and finished products and the interaction of the double salt solution with potassium chloride. Optimal, economical, waste-free production of potassium sulfate, development of continuous technology is an urgent problem for the republic.

The monograph is intended for use by independent researchers, basic doctoral students, research interns, master's and bachelor's students, as well as professionals working in this field in training courses.



Zoirov Sirojiddin Sakhomiddin ugli. Termez Institute of Engineering and Technology, the third-year student of Chemical Technology direction. Nowadays, he has published 30 articles and theses, and at the same time, he is carrying out scientific research in the field of metals, silicate materials, and mineral fertilizer production.



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