STAGES OF POTASH ORE BENEFICIATION PROCESS

Xaydarova Munira Davronovna
Assistant, Termez State University of Engineering and Agrotechnology
munira3110xaydarova@gmail.com
Allazov Rustam Yo'ldosh o'g'li
Student at Termez State University of Engineering and Agrotechnology

Abstract

Potash ore beneficiation is a crucial process in the extraction and purification of potassium compounds, particularly potassium chloride (KCl), which is vital for fertilizer production. The beneficiation of potash ores, primarily composed of silvinite (KCl + NaCl), requires a systematic approach to separate the valuable sylvite from associated gangue minerals, primarily halite. This thesis presents a comprehensive overview of the sequential stages involved in potash ore beneficiation, including crushing and grinding, desliming, flotation, dewatering, and drying. Each stage is optimized based on ore mineralogy, particle size distribution, reagent chemistry, and environmental conditions. Emphasis is placed on flotation, the most efficient separation method, along with supportive techniques such as selective crystallization and brine recycling. The thesis also explores advancements in process automation and control technologies. The outlined beneficiation stages provide a framework for enhancing recovery, improving product purity, and reducing environmental impact in potash processing operations.

Keywords. Potash ore, beneficiation, sylvite, halite, flotation, desliming, potassium chloride, mineral processing, separation techniques.

Аннотация

Обогащение калийной руды является важнейшим процессом в извлечении и очистке соединений калия, в частности хлорида калия (KCl), который жизненно важен для производства удобрений. Обогащение калийных руд, в основном состоящих из сильвинита (KCl + NaCl), требует системного подхода для отделения ценного сильвина от сопутствующих минералов пустой породы, в первую очередь галита. В данной диссертации представлен всесторонний обзор последовательных стадий, вовлеченных в обогащение калийной руды, включая дробление и измельчение, обесшламливание, флотацию, обезвоживание и сушку. Каждая стадия оптимизирована на основе минералогии руды, распределения размеров частиц, химии реагентов и условий окружающей среды.

Особое внимание уделяется флотации, наиболее эффективному методу разделения, а также вспомогательным методам, таким как селективная кристаллизация и рециркуляция рассола. В диссертации также рассматриваются достижения в области автоматизации процессов и технологий управления. Описанные стадии обогащения обеспечивают основу для повышения извлечения, улучшения чистоты продукта и снижения воздействия на окружающую среду при переработке калийных руд.
Ключевые слова. Калийная руда, обогащение, сильвин, галит, флотация, обесшламливание, хлористый калий, переработка полезных ископаемых, методы разделения.

Introduction. The global demand for potassium-based fertilizers continues to rise due to the intensification of agriculture and the need for sustainable food production. Potash ores, particularly those containing sylvite (KCl), serve as a primary raw material in the production of potassium fertilizers. However, the extraction of potassium from naturally occurring ores such as silvinite is not straightforward, as these minerals are often found as fine-grained intergrowths with halite (NaCl) and insoluble impurities. Therefore, an efficient beneficiation process is essential to isolate the potassium component and produce high-purity potassium chloride suitable for agricultural use.

In this context, the beneficiation of potash ore refers to a series of physical and chemical processes designed to increase the concentration of sylvite while minimizing losses and environmental degradation. The stages of beneficiation must be tailored to the specific characteristics of the ore body, including its mineral composition, grain size distribution, and the presence of clay or carbonate impurities. The principal goal is to maximize KCl recovery and concentrate grade while maintaining operational efficiency.

This thesis examines the critical stages of the potash ore beneficiation process, focusing on the technical, environmental, and economic considerations at each phase. It integrates industrial practices with recent scientific advancements to outline a modern, efficient beneficiation framework.

Main part. The potash ore beneficiation process comprises several interdependent stages, each contributing to the final quality and yield of the potassium chloride product. The primary stages include:

1. **Comminution (Crushing and Grinding):** The initial step involves reducing the ore to a manageable size to liberate sylvite crystals from the halite matrix. Jaw crushers and rod mills are commonly used. The target size range is usually below 1 mm to ensure adequate mineral liberation for subsequent flotation.
2. **Desliming and Classification:** After grinding, the slurry undergoes desliming to remove fine clays and insoluble particles that could interfere with flotation. Hydrocyclones or spiral classifiers are used to separate the coarse and fine fractions. Efficient desliming improves flotation selectivity and reduces reagent consumption.
3. **Flotation Separation:** Flotation is the key stage in potash beneficiation. In this step, sylvite is floated while halite is suppressed using depressants such as starch, tannins, or polyacrylamides. Cationic amine-based collectors are used to selectively attach to sylvite surfaces. The flotation is conducted in saturated brine to prevent salt dissolution, which could otherwise reduce recovery.
4. **Reagent Control and Optimization:** The performance of flotation is highly dependent on pH, reagent dosage, and temperature. Recent innovations include the use of modified collectors, frothers, and real-time process monitoring using pH sensors and online analyzers. These allow for dynamic optimization of flotation circuits.
5. **Dewatering and Filtration:** The flotation concentrate is then thickened and filtered to reduce moisture content. Belt filters, centrifuges, or vacuum disc filters are typically used. Recovered brine is recycled to reduce water consumption and minimize environmental discharge.
6. **Drying and Product Handling:** The final stage involves thermal drying of the filtered concentrate to reduce residual moisture to acceptable levels for packaging and transportation. Fluidized bed dryers or rotary dryers are commonly employed.
7. **Environmental Considerations and Waste Management:** Modern beneficiation plants implement closed-loop water systems and dry tailings disposal to minimize environmental impact. The use of energy-efficient equipment and environmentally benign reagents is increasingly prioritized.

These stages form an integrated system aimed at maximizing KCl recovery while optimizing energy usage, water recycling, and minimizing environmental footprint. Additionally, digitization and machine learning models are being gradually incorporated for process automation, further enhancing efficiency and consistency.

Conclusion. The beneficiation of potash ore is a complex but essential process in the global fertilizer industry. Understanding and optimizing each stage of the process—from crushing to flotation, and from dewatering to drying—is vital to achieve high

recovery rates and product purity. This thesis has outlined the main steps involved in the beneficiation of silvinite-type potash ore, emphasizing the central role of flotation as well as the importance of supportive steps like desliming and drying.

Technological improvements such as the use of high-efficiency collectors, closed water circuits, and process automation are enhancing the sustainability and profitability of potash production. By implementing integrated process control and predictive maintenance tools, beneficiation plants can achieve greater operational stability and lower environmental impact.

Ultimately, a well-structured beneficiation process contributes not only to the economic viability of potash mining operations but also to national goals of agricultural self-sufficiency and resource efficiency. Continued research and innovation in this area are essential to meet the challenges of future food production and sustainable resource utilization.

References

1. Wills, B.A., & Finch, J. Wills' Mineral Processing Technology. 8th Ed. Butterworth-Heinemann. 2016.

2. Fuerstenau, D.W. Flotation fundamentals and advances. Minerals & Metallurgical Processing, 24(1), 17–24. 2007.

3. Gaudin, A.M. Principles of Mineral Dressing. McGraw-Hill. 1939.

4. Zhou, H., Liu, Y., & Zhang, W. Optimization of flotation parameters for sylvite recovery from silvinite. Minerals Engineering, 173, 107149. 2021.

5. Outotec. HSC Chemistry Software for Process Simulation and Thermodynamic Modeling. Version 10.0. 2022.

6. United Nations FAO. World Fertilizer Trends and Outlook to 2025. Rome. 2021.