IMPROVING THE PROCESS OF EXTRACTING PHOSPHORIC ACID FROM PHOSPHORITES OF THE LOCAL KARAKATIN DEPOSIT

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Abstract: This paper examines scientific and technological approaches to improving the production of extraction phosphoric acid from phosphorites of the local Karakatin deposit. Particular attention is given to the chemical and mineralogical characteristics of the raw material and to the factors governing its decomposition by sulfuric acid. The effects of key process variables—including acid concentration, reagent ratio, temperature, mixing intensity, and reaction time—are considered in relation to phosphorus recovery, raw-material utilization, and the generation of process residues. A systematic optimization strategy is proposed to identify operating conditions that may enhance the transfer of phosphorus into the liquid phase and improve the subsequent separation of phosphoric acid from calcium sulfate. The study framework may support more efficient use of local phosphate resources and contribute to the development of the domestic raw-material base for phosphate-fertilizer production.

Keywords: Karakatin phosphorites, extraction phosphoric acid, phosphate raw materials, sulfuric acid decomposition, phosphorus recovery, process optimization, calcium sulfate dihydrate, solid–liquid separation, phosphate fertilizers.

INTRODUCTION

Phosphoric acid is an important intermediate in the chemical industry and is widely used in the manufacture of mineral fertilizers, phosphate salts, and various phosphorus-containing products. One of the principal industrial routes for its production is the wet-process, or extraction, method, in which phosphate-bearing raw materials are decomposed using mineral acids. This route is widely applied because it is suitable for large-scale production and can be integrated into fertilizer-manufacturing processes.

The efficient use of domestic phosphate resources is important for strengthening the raw-material base of the chemical industry, reducing dependence on imported materials, and supporting the production of phosphorus-containing fertilizers. In this context, the development of an appropriate process for obtaining extraction phosphoric acid from phosphorites of the Karakatin deposit is a relevant scientific and technological task.

The performance of phosphate-rock decomposition depends on the mineralogical composition of the feed, the structure and reactivity of phosphate minerals, and the presence of carbonate and other accessory components. These characteristics can affect the rate of acid attack, phosphorus recovery in the liquid phase, and the filtration properties of the resulting phosphogypsum. Therefore, process improvement requires an assessment of the relationship between the properties of the raw material and the operating conditions.

AIM AND OBJECTIVES

The aim of this study is to identify suitable conditions for improving the extraction of phosphoric acid from phosphorites of the Karakatin deposit, with particular emphasis on increasing phosphorus recovery and improving the technological, economic, and environmental performance of the process.

The principal objectives are:

- to determine the chemical and mineralogical composition of Karakatin phosphorites;

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- to evaluate how major and accessory components of the raw material influence the extraction process;
- to investigate suitable conditions for decomposing phosphorites with sulfuric acid;
- to assess the effects of temperature, acid concentration, liquid-to-solid ratio, and reaction time on phosphorus recovery;
- to examine options for improving phosphoric-acid separation from phosphogypsum and enhancing filtration;
- to evaluate opportunities to reduce raw-material and reagent consumption and improve the management of process residues.

METHODOLOGY AND TECHNOLOGICAL PRINCIPLES

In the extraction process, phosphate minerals in the raw material react with sulfuric acid to form phosphoric acid and calcium sulfate. A simplified reaction for the decomposition of fluorapatite under dihydrate-process conditions can be represented as follows:

$$Ca_5(PO_4)_3F + 5H_2SO_4 + 10H_2O \rightarrow 3H_3PO_4 + 5CaSO_4 \cdot 2H_2O + HF$$

This equation provides a generalized representation of the reaction. In an actual process, additional reactions may occur depending on the composition of the phosphate rock and the behavior of its mineral phases.

The proposed investigation begins with sample preparation, including crushing or grinding and characterization of particle size. The chemical composition of the raw material should be assessed, including P_2O_5, CaO, MgO, SiO_2, Fe_2O_3, Al_2O_3, and carbonate components. Where appropriate, X-ray diffraction can be used to identify phosphate minerals and other crystalline phases.

The decomposition stage can then be studied by varying sulfuric-acid concentration, reagent ratio, temperature, mixing intensity, and reaction duration in a controlled manner. Following reaction, the resulting slurry is filtered to separate the liquid and solid phases. The P_2O_5 content of the liquid phase and the residual phosphorus in the solid residue should be measured to establish a material balance and evaluate extraction performance.

The phosphorus recovery into the liquid phase can be estimated using the following expression:

$$\eta(P_2O_5) = [m(P_2O_5, \text{liquid phase}) / m(P_2O_5, \text{feed})] \times 100\%$$

Here, $m(P_2O_5$, liquid phase) is the mass of P_2O_5 transferred into the liquid phase, while $m(P_2O_5$, feed) is the initial mass of P_2O_5 in the phosphate-rock feed. The calculation should account for solution volume, dilution, sampling losses, and other relevant material-balance factors.

The resulting data can be used to compare phosphorus recovery, acid consumption, filtration behavior, and the concentration of P_2O_5 in the product solution. Replicate measurements and consistent analytical procedures are recommended to improve the reliability of comparisons.

EXPECTED RESULTS AND DISCUSSION

Optimization based on the characteristics of Karakatin phosphorites may help improve the decomposition of phosphate minerals and increase the proportion of phosphorus transferred to the liquid phase. Reducing particle size can increase the contact area between the solid and the acid; however, excessive grinding may produce fine particles that hinder filtration. Particle-size selection should therefore consider both extraction efficiency and the behavior of the slurry during solid–liquid separation.

Sulfuric-acid concentration and dosage are also important process variables. Insufficient acid may leave some phosphate minerals incompletely decomposed, whereas excessive consumption can increase

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production costs and alter the composition of the process liquor. The appropriate dosage should be established from the chemical composition of the feed and stoichiometric requirements, and then verified experimentally.

Temperature and reaction time may influence reaction kinetics, crystallization, and the physical characteristics of phosphogypsum. The size and morphology of calcium sulfate crystals can affect filtration and the retention of liquid within the solid cake. Accordingly, process optimization should not focus solely on phosphorus recovery; it should also consider filtration rate, phosphorus losses with the solid residue, reagent consumption, and product-solution quality.

In the final stage, the relationships among operating variables should be evaluated using experimental data, and suitable operating conditions should be selected. Relevant criteria include phosphorus recovery, sulfuric-acid consumption, filtration performance, and P_2O_5 concentration in the extraction liquor. Any claim that a particular regime is superior should be supported by measured results and a consistent material balance.

CONCLUSION

Improving the extraction of phosphoric acid from phosphorites of the Karakatin deposit is of practical importance for more efficient utilization of local phosphate resources. A systematic assessment of the raw material's chemical and mineralogical composition, together with controlled investigation of acid dosage, acid concentration, temperature, particle size, and reaction time, can provide a basis for selecting suitable process conditions.

The proposed research approach focuses on increasing phosphorus recovery in the liquid phase, reducing phosphorus losses with the solid residue, and improving filtration. Operating conditions identified through laboratory experiments may provide a scientific basis for further development of an extraction process tailored to the properties of Karakatin phosphorites. The effectiveness of the proposed improvements must ultimately be demonstrated by experimental data.

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