UPGRADING OF LOW GRADE EAST SEBAEYA PHOSPHATE ORE

By

Eng. Mohamed Mohamed Eid Ahmed El-Esh

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
MINING ENGINEERING

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Title of Thesis:

UPGRADING OF LOW GRADE EAST SEBAEYA PHOSPHATE ORE

Key Words:

Phosphate ore; Attrition; Flotation; Collectors; and depressant.

Summary:

About 90% of the phosphate produced is used in the manufacture of fertilizers. The run of-mine material is mostly of lower grade, needs upgrading. The aim of this work is to upgrade the low-grade East Sebaeya phosphate ore to achieve the desired product, which is utilized as a raw material for fertilizer. Attrition scrubbing was performed to clean the surface of ore from coated slimes and break the carbonates followed by flotation process to upgrade the phosphate concentrate. Statistical designs were used for both attrition scrubbing and flotation processes. The attrition of phosphate improves the phosphate grade and recovery up to 27.72% and 98.56%, respectively from a feed contains 21.6% P_2O_5. The size (-0.4 +0.075) mm from attrition scrubbing was used as a feed for reverse flotation which improve P_2O_5 % grade to 29.77% at the optimum conditions. More attempts were tested to increase the grade more than 30% P_2O_5. Several stages of attrioning up to 4 stages increase the grade to about 31 % P_2O_5. Furthermore, four-stage attritioning followed by flotation produces a concentrate contains about 32 % P_2O_5.

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IR	Insoluble residual
LOI	Loss of ignition
ROM	Run of mine
Rpm	Revolution per minute
wt.	Weight

Abstract

Phosphate rock is the main source of phosphorous, which is essential in many industrial applications. About 90% of the phosphate produced in the world is used in the manufacture of fertilizers. The marketable phosphate is usually 30% P_2O_5 or higher. The run-of-mine material is mostly of low grade, which needs processing, or upgrading.

In this thesis run of mine phosphate sample was collected from East Sebaeya. Crushing of phosphate sample was carried out using primary and secondary crushing in closed circuit with sieve 6.63 mm and 3.36 mm in order to prepare size less than 3.36 mm. The work index was calculated (16.38 KWh/t) as a primary step to calculate crushing power consumption. The total power consumption for crushing 100 ton phosphate to pass 100 % from size less than 3.36 mm was 188.74 KW.

Sample was selected and prepared for mineralogical characterization. At the same time, another representative sample was finely ground to less than (74 µm) for XRD and XRF analyses. XRD analysis showed that phosphate ore sample are composed of main mineral apatite in the form of collophane with anhydrite, calcite and quartz. While XRF revealed that it contains 21.66 % P_2O_5 and 13.1 % LOI. The petrographical investigations showed that, phosphate samples are composed of phosphatic grains with angular to subangular detrital quartz grains cemented by calcite and anhydrite. Then the following was performed:

1- **Attrition scrubbing**: to clean the surface of ore from coated slimes and break the carbonates . Three devices (Denver cell, attiritor mill, and attrition scrubber) were used for attrition scrubbing test.

   15 experiments were performed on Denver cell by using Design Expert-6 -0-5.in Denver cell. The various combinations of studied variables performed on the attrition experiments were the solid % by weight, attrition time and impeller speed. The experimental results were fitted to a statistical model, which enables the prediction of the output responses (P_2O_5 %, Loss of ignition, insoluble residual, and phosphate recovery). It was found that the best result from Denver cell was 27.72% from 21.66 for P_2O_5 and 98.56 % for P_2O_5 recovery at 60 % solids, time of attrition 10 min and impeller speed 1200 rpm.

   It was observed that the result from Denver cell (P_2O_5 = 27.72 %) is relatively better than the results from attritor mill (P_2O_5 = 27.1 %), and this is due to the different in design of each device

2- **Reverse flotation process:** Two samples were conducted to flotation process, the first for original ore and the second for scrubbed product. The flotation process for scrubbed product is more effective than flotation process for original sample (without attrition). The P_2O_5 grades increased by 6.2 % and LOI decreased by 5.6 %, respectively when phosphate sample exposed to attrition scrubbing before flotation process. This means that attrition process cleans phosphate ore surface from slimes and decreases the size which increases the flotation efficiency.

   Therefore, 13 revers flotation experiments for scrubbed samples were performed using design expert-6 -0-5 program. The effective parameters such as dose of

collector (oleic acid), doss of depressant (phosphoric acid) and pH were studied. It is observed that higher P_2O_5 % grade of phosphate product is obtained at pH 4.5, 1kg /t oleic acid and 3.5 kg /t phosphoric acid . At these conditions, P_2O_5 %, and LOI %, are 29.77 %, and 7.52 %, respectively.

3- Some experiments were carried out on phosphate samples to increase P_2O_5 grade ≥ 30%:

- A concentrate product from flotation process was subjected to another reverse flotation process (pH 5.5, 2kg /t oleic acid and 3.5 kg/t phosphoric acid), that leads to upgrade the P_2O_5 to 30.33 % and reduce the LOI to 7.5 %.
- P_2O_5 was increased to 31.06 % and LOI was reduced to 6.13 % after fourth stages of attrition scrubbing in acidic media.
- Finally, the highest P_2O_5 (31.69 %) and the lowest LOI (6.02 %) were obtained when the product of fourth attrition stage conducted to reverse flotation process (pH 5.5, 2 kg /t oleic acid and 3.5 kg /t phosphoric acid).

It is concluded that, the attrition and flotation of low-grade East Sebaeya phosphate ore produced a high-grade phosphate product (31.69 % P_2O_5) suitable for fertilizers and other phosphate compounds. The economics of each process need to be assessed to help in developing the best flow sheet for this type of phosphate ores.