Phosphate Rock Upgradation by Combination of Shaking Table and High Intensity Magnetic Separator: Ghari Habibullah, Pakistan

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Abstract

Phosphate is non-renewable mineral. Estimated phosphate ores in Pakistan are 26 million ton of different range, low, average and high grade. In past, different methods were used for upgradation of phosphate ore worldwide. To make phosphate ore more valuable, one of the most dominant technique used is flotation. Assessed phosphate ores in Pakistan are 26 million of a wide range of grades. Diverse sorts of strategies were utilized as a part of past for the upgradation of phosphate mineral around the world. Considering this, froth flotation is also used as one of an attractive technique. The critical literature on preparing of phosphate ore is fundamentally survey. Froth floatation is utilized worldwide for the upgradation of phosphate ore. In light of the literature and portrayal of Ghari Habib Ullah (GHU), conservative flowsheet of upgradation was planned for GHU phosphate mineral. The ore is upgrade from 22.55% P_2O_5, 6% Fe_2O_3 to 30.22% P_2O_5, 2% < Fe_2O_3 with 60% Recovery.

Keywords: Phosphate rock; Ore Upgradation; Ghari Habib Ullah; Design; Flowsheet

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INTRODUCTION

Geological survey of Pakistan estimated 26 million deposits of phosphate ore in range of Hazara region. Add up to populace of Pakistan is 150 million and increment every year with rate of 3 million which is serious challenge in increment sustenance generation. Pakistan's requirement of compost is 1.5-1.6 million tons for every year. Neighbourhood creation meet 0.7 to 0.75 million tons for every time of the aggregate compost prerequisite and the remaining are imports to fulfil the demand (Tajamal, 2003). Phosphate is non-renewable asset for compost neither its substitute and nor reuse it in manure (Sis and Chander, 2003; Heydarpour et al., 2011; Leja, 1972; Guimaraes et al., 2005). Request of the phosphate ore for the manure are fulfil through mining and upgradation of low grade to make it attractive i.e. 30% P_2O_5 (Straaten, 2002; Wills, 1992). Phosphate rock require processing to reduce the gangue minerals such as quartz, silica, press, chert, dirt, feldspar, mica, calcite, and dolomite. It is imperative in compost fabricate for phosphate metal to have P_2O_5 content greater than 30%, CaO/P_2O_5 proportion lesser than 1.6, and MgO content under 1%. In this context, iron and aluminium. Phosphate ore which don't meet the criteria, it requires to expel contaminations by upgradation method (Sis and Chander, 2003). The calcium phosphate substance of phosphate ore are known by various name such as (Aza, 2016) BPL (bone phosphate of lime), TPL (triphosphate of lime), P_2O_5 (phosphorus pentoxide) and P (phosphorus — not normally utilized). The geological occurrence of phosphate deposit are not same everywhere but it varies. Different types of phosphate resource in world are 1) Metamorphic deposit, 2) Marine phosphate deposit, 3) Igneous phosphate deposit, 4) Weather phosphate deposit, 5) and Biogenic phosphate deposit (Straaten, 2002; Muhammad et al., 2001). The phosphate deposit worldwide distributed as 75% in form of sedimentary marine deposits, 15-20% in the form of igneous, and 2-3 % in the form of biogenic sources. distrusted as; 75% from sedimentary marine deposits, 15–20% from igneous, metamorphic, and weathered deposits, while 2–3% from biogenic sources. In Pakistan the scenario of the phosphate rock geological occurrence and composition varies. The petrology, mineralogical and upgradation techniques for the Hazara phosphate deposits were briefly reported by so many researchers (Khan et al., 2016; Raiz et al., 2001; Rashid et al., 2010). The cut of size selection is the important parameter for the upgradation upon which recovery and grade depends (Straaten, 2007). Low grade upgradation technique depends upon the various factors (Ahmad et al., 2016).

We and other researchers reported earlier that the Dolola Ghari Habib Ullah phosphate ore of low grade, need upgradation for fertilizer manufacturing (Ahmad, 2016; Khan et al., 2016). The composition and reserves of phosphate ore of Pakistan of different location are: L1= Kakul, L2= Kalue-de-Bandi and Lagarban, L3= Dolola, L4= Sirban Hill, (Table 1).

Table 1: Phosphate deposits of Hazara Division (Khan et al., 2016)

Locality	P_2O_5%	Reserves Million Tons
L1	24-32	1.8
L2	10-35	10.80
L3	22-25	9.20
L4	10-35	1.90

In this research, critical review of the literature on phosphate ore of the world was carried out and the upgradation technique used for low grade deposits are thoroughly, technically and economically studied. On the basis of literature review and characterization of GHU phosphate ore the economical flowsheet were designed and optimum liberation size for upgradation of low grade phosphate ore of Ghari Habib Ullah (GHU) were determined.

MATERIALS AND METHODS

Petrography of Deposits

Phosphate rich beds of Hazara is passing through the region of Kakul near Ghati Mera, Lagarban, Dalola near Dawlat Mar. The phosphate rich beds in the region are located near Kakul, Lagarban, Dalola and Sirban hill. Samples were collected from east of Kakul village at a distance of one kilometre. Trenching methods was used for samples collection. Phosphate deposits of Kakul region is associated with cherty dolomite of Abbottabad formation. It has been reported that Kakul region contains two stratigraphic (Viqar et al., 1987). Although in the area there are two well-defined stratigraphic perspective of phosphate deposit. Greyish colored dolomite sequence exposed at the bottom which is 5-6 m thick, dolomite limestone which bearing phosphate above are massive, dark in colored, rich in phosphate content, 7 m thick which is overlain by phosphate-bearing cherty dolomite with low concentration of P_2O_5. Moreover, lithology exposed vertically are siltstone and dolomitic limestone, having a total thickness of about 20 meters.

Dawlat Mar (GHU) phosphate ore thin section showed that the ore contain chert as shown in Figure 1. Apatite embedded in dolomite and mud matrix as shown in Figure 2. Ore are highly fracture and the fracture plan filled with quartz as shown Figure 3. The overall formation of phosphate deposits of GHU is dolomitized matrix, apatite grain contains ferruginous matrix (Khan et al., 2016).

Chemicall Analysis

Chemical analysis of the representative samples of all area of phosphate deposit was performed in accordance with ASTM methods of chemical analysis data which is represented in Table 2 (Khan et al., 2016).

Guideline for mineral dressing

Primary Cushing

The representative sample was prepared by coning and quartering methods. The maximum size of the representative sample which are submitted to the primary crusher unit is 3 cm. The crushing unit consist two stage jaw crushers. The function of the jaw crusher is to achieve optimum liberation phosphate mineral from gangue mineral (clay). The product of the primary crushing unit is 100% less than 2.4 mm which is consider as feed form grinding unit.

Grinding unit

In the present research grinding unit is rod mill. The maximum size provided to the ball mill is 2.4 mm. Sample in ball mill is subject to different grinding time: 10, 20, 30,35,40,45, and 50 minutes.

Optimum mesh of grinding

The sample of each grinding time is analysis through sieve mesh for the optimum liberation size determination. In addition to it to avoid the under grinding and overgrinding.

Table 2: Geochemistry of Phosphate Rock from Hazara division

Constituents	L1(%)	L4(%)	L2(%)	L3(GHU) (%)
SiO_2	23	30	20	40
Fe_2O_3	1.8	6	5	6
Al_2O_3	1.1	2	2	2
P_2O_5	27.8	15	28	22.85
CaO	38.6	30	45	23.15
MgO	0.28	2	1	3
F	2.7	1	0.8	1

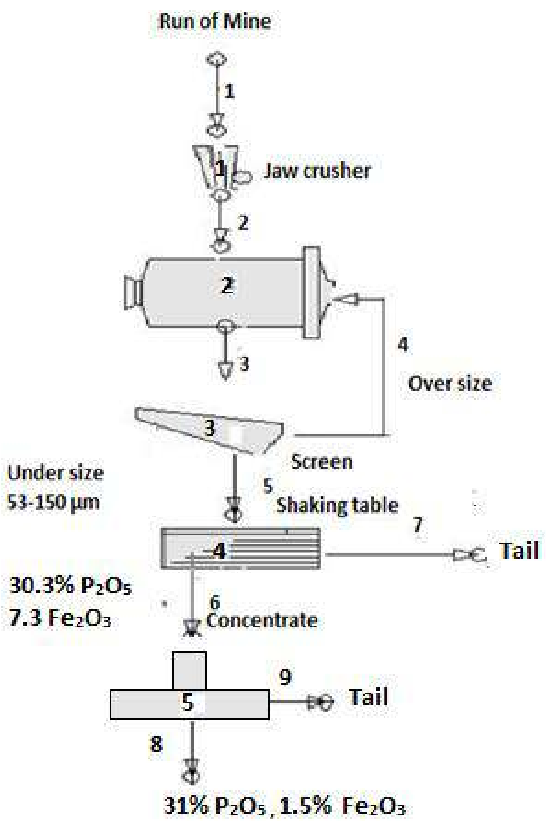

Figure 1: Flowsheet design

Shaking Table

Factors which effect the separation partition of shaking table incorporate particle size, particle density with diverse minerals, shape, riffle design, deck shape and inclination, flowrate of dressing water, feeding water, shaking table vibration, and speed. Parameter of the shaking table are optimized on the basis of different feed size. Based on mineralogical investigation 70% apatite minerals was found released in a range of 150μm-100μm. Mineralogically, Phosphate ore constitutes dolomite, quartz, fluorapatite, hematite which have specific gravity values of about 2.84, 2.65, 3.20 and 5.1 g/cm^3 respectively.

Several experiments were performed on shaking table at different feed size and improved other parameter of shaking table on the basis of optimum grade and recovery. Experiments were carried out to analyze different concentrate, middling and tailing in a testing laboratory of minerals (MLT) based in Hayat Abad Peshawar, for different parameters of shaking table evaluation to access high grade and also good recovery. Practically, it was inferred that the optimal deck slop was 5 degrees, feed flow rate was 4 L/min and dressing flow rate was 7 L/min.

High Intensity Magnetic Separator

Mineralogical investigation show that representative sample contain hematite 6% which exceed from the limit of fertilizer industries, which make the phosphate mineral uneconomical in fertilizer industries. Concentrate of the shaking table at optimum liberation size consist hematite 6% which is passed through High intensity magnetic separator to make the final product economical as shown in Table 4.

Flowsheet Design

Literature review of each deposit show different types of impurities therefore, the single flowsheet is not economical for each deposit upgradation. In this research a flowsheet is designed for Garhi Habib Ullah phosphate ore Flowsheet where design by using software MODSIM^{TR}.

Table 3: Shaking table grades and recovery results for different particle size

Sample	Particle size (μm)	Weight (gram)	Weight (%)	Shaking Table P_2O_5 (%)	Shaking Table Fe_2O_3 (%)	Shaking Table Recovery (%)
Concentrate	200-300	243	24.3	34	7.01	36.15
Middling	200-300	390	39	20.3	6.5	34.65
Tailing	200-300	367	36.7	18	4.8	28.91
Feed	200-300	1000	100	22.85	6	100
Concentrate	150-200	340	34	28	7.1	41.66
Middling	150-200	310	31	21.3	4.8	28.90
Tailing	150-200	350	35	19	6	29.10
Feed	150-200	1000	100	22.85	6	100
Concentrate	53-150	440	44	30.3	7.3	58.34
Middling	53-150	230	23	19	6	19.12
Tailing	53-150	330	33	15.5	4.27	22.38
Feed	53-150	1000	100	22.85	6	100

Table 4: High intensity magnetic separator for hematite upgradation

Sample	Particle size (µm)	Weight (gram)	Weight (%)	High Intensity Magnetic separator P_2O_5 (%)	High Intensity Magnetic separator Fe_2O_3 (%)	Shaking Table Recovery (%)
Concentrate	200-300	233	98.35	34.02	6.5	95.94
Tailing	200-300	10	1.64	33.54	37	4.06
Feed	200-300	243	100	34	7.01	100
Concentrate	150-200	330	97.05	28.6	5	99.13
Tailing	150-200	10	35	8.4	76.4	0.88
Feed	150-200	340	100	28	7.1	100
Concentrate	53-150	405	92	31	1.5	94.18
Tailing	53-150	35	7.95	22.2	58.3	5.82
Feed	53-150	440	100	30.3	6	100

RESULTS AND DISCUSSION

The phosphate upgradation mainly depends upon the associated gangue. The thin section of the GHU show that the formation is dolomitized. The mineralogical study showed that the apatite is embed in the mud stone. The phosphate rock are highly fracture which is filled with ferruginous. Chemical analysis showed (Table 2) that GHU phosphate rock is low grade rock which is not directly used in fertilizer industry due to low P_2O_5 and high Fe_2O_3 content. Ghari Habib Ullah phosphate contain silica (clay) as major gangue which will be upgraded by flotation is not economical because it changes froth stability, increase pulp density and consume more regent. Shaking table parameter was evaluated for the different liberation size, -150 + 53µm is the particle size on which maximum recovery with optimum grade of P_2O_5 was achieved as shown in Table 3. Product of shaking table were passed through high intensity magnetic separator which give hematite less than 2% and P_2O_5 grade 31% with 60 percent recovery as shown Table 4. The achieved end product are high grade phosphate mineral with less iron content are economical and are suitable for fertilizer industries.

CONCLUSION

Fertilizer industries need a specific quantity of P_2O_5 content more than 30% and Fe_2O_3 less than 2%. An economical flowsheet as shown in Figure 4 was designed for GHU which upgraded the low grade 22.85% P_2O_5 to 31% and degraded hematite from 6% to 1.5% with overall recovery of P_2O_5 60%.

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