An Approach to Beneficiation of Apatite Ore of Purulia

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Abstract

West Bengal Mineral Development & Trading Corporation operates the apatite mine in Purulia District of West Bengal. They produce three grades of samples, i.e. (i) High grade above 30% P_2O_5, (ii) Average grade of about 20% P_2O_5 and (iii) Low grade of 12% P_2O_5. The average grade is directly marketed as fertiliser for application in tea garden etc. The medium or average grade sample is mined from areas around the main ore body and contains substantial amount of ferruginous material besides other gangue minerals. The low grade ore is dumped separately and occasionally blended with high grade of ore to prepare the average grade for direct marketing. Thus every bit of apatite from the mines is used except for the top soil. But with reduced demand, the manufacturer is faced with a selling problem and reduced production. Value addition by way of making high grade product is one option to pursue with. The typical problem is of iron removal as presence of high iron hinders value addition in terms of phosphate during down stream operation. Studies on the average grade sample indicated that using suitable processing steps the phosphate content could be increased to +38% P_2O_5 with very low content of iron & silica. The present paper deals approach adopted in beneficiating the average grade apatite ore of Purulia.

Key Words: apatite, Purulia, iron, magnetic separation, flotation

Introduction

Deposits of Phosphate in India is broadly categorised into phophorite and apatite. While phosphorite constitutes major reserves in India amounting to nearly 150 million tonne scattered over Rajasthan, Madhy Pradesh, Uttar Pradesh & Gujarat, the majority of apatite is reported mainly from West Bengal with supplementary deposits of Andhra Pradesh & Bihar and also from Tamilnadu & Rajasthan. Total Reserve of apatite is about 14 million tonne out of which West Bengal accounts for nearly 11 million tonne. The major deposit of apatite is located in Beldih Mines of Purulia with extension found towards Mednitanr, Kutni, Chirugora.

The Beldih deposit of Purulia was earlier selectively mined by private industries for high grade ore but subsequently West Bengal Mineral Development & Trading Corporation took up the control of the deposit and started exploiting the same by mining the ore and blending with inferior grade to be sold as fertilizer for direct application mainly in the tea gardens. The Beldih apatite is characterised by its typical mineralisation contributing higher percentage of iron in the ore body thus making it unsuitable for phosphate fertilizer application. Many earlier attempts have been made to make this suitable by improving the grade substantially through beneficiation with very low level of iron content. Increased iron content demands high acid consumption with inferior physico-chemical properties of the fertilizer. This paper gives an account of the studies carried out to find a suitable methodology for obtaining a product conforming to the requirement of fertilizer industries.

Experimental

Sample

The sample was taken from the operating quarry. The quarry generates three type of products mainly (i) the high grade ore from the mineralised ore body much below the ground level and adjoining areas of the ore body, (ii) an average grade of about 20-22% P_2O_5 which occurs around main ore body and the (iii) the low grade ore of about 12-14% P_2O_5 at higher level but below the overburden. All the three are stacked separately. While a part of the high grade ore is occasionally sold directly, rest is blended with low grade as per market requirement. The average grade of 20-22% P_2O_5 is sold as direct application fertiliser to mostly tea gardens. The present study was carried out with the average grade sample.The chemical analysis of the Average grade sample is given in Table 1.

Table 1. : Chemical Analysis of Sample

Constituent	Weight %
P_2O_5	22.73
Fe (T)	9.25
SiO_2	16.95
Al_2O_3	3.38
FeO	0.11
Fe_2O_3	13.1
CaO	33.44
Cl	0.76
LOI	5.10

The sample was crushed to finer size. The size and chemical analyses of sample are given in Table 2.

Table 2 : Size & Chemical Analysis of the Average Grade (AG) Sample

Size in mm	Wt %	Assay %			
		P_2O_5	Fe(T)	SiO_2	Al_2O_3
-1.65 + 1.10	24.4	21.39	8.79	16.22	3.26
-1.1 + 0.89	13.3	25.39	8.55	17.15	3.28
-0.89 + 0.59	15.9	25.36	8.47	15.92	3.37
-0.59 + 0.42	9.5	21.01	8.21	15.24	2.76
-0.42 + 0.30	7.6	25.69	8.79	16.58	3.93
-0.30 + 0.21	8.0	24.81	9.18	18.28	3.37
-0.21 + 0.15	4.0	22.8	9.80	19.45	2.15
-0.15 + 0.10	4.3	21.74	11.04	19.85	2.23
-0.10 + 0.074	3.4	19.56	11.34	20.48	3.37
-0.074	9.6	21.61	9.67	20.11	7.46
Head(Calc.)	100.0	23.15	9.00	17.20	3.61

Results and Discussion

Mineralogical Characteristics

The apatite ore body at Beldih occurs as apatite-quartz-magnetite vein. Mineralogical examination indicated the presence of apatite as the chief phosphate bearing mineral while the major interfering iron oxide bearing mineral are magnetite, hematite, goethite limonite in association with quartz, chert and sporadically occurred pyrite. Liberation studies indicated intricate association of iron oxide with apatite and fine grind of about 150 micron would be required for nearly complete liberation.

Results & Discussion

The mineral & chemical analyses implies that the approach should be to develop a process to reduce both iron & silica substantially to improve the apatite content after grinding to a fine size for better liberation. Two route of processing was attempted, i.e., direct flotation with suitable reagent regime and magnetic separation in combination with flotation.

Direct flotation

Direct flotation of apatite involves the interaction of grind variation as well as reagents optimisation. Different reagents like emulsified oleic acid is used for flotation of apatite, but it has affinity for iron minerals also. Starch is used for suppression of iron minerals and caustic soda as pH modifier. Sodium silicate was used as depressant for siliceous material.

In respect of optimisation of grind, some levels of reagents (level 1 of Table 3) were fixed after carrying out probing studies. In all flotation test studies, roughing followed by two stages of cleaning were carried out

Table 3 presents the reagent level conditions followed for flotation studies.

Table 3: Reagent Levels for Flotation

Reagent	Level-1	Level-2	Level-3	Level-4
Oleic acid, kg./t	0.65	0.78	0.9	1.0
Sod-silicate, kg./t	0.65	0.78	0.9	1.0
Starch, kg./t	2.0	2.7	3.3	3.6
PH	8.5/7	8.5	8.5	8.5

The results of grind variation are presented in Fig.1 & 2. For Grind variation studies, level 1 of reagent dosage (pH = 8.5) was used.

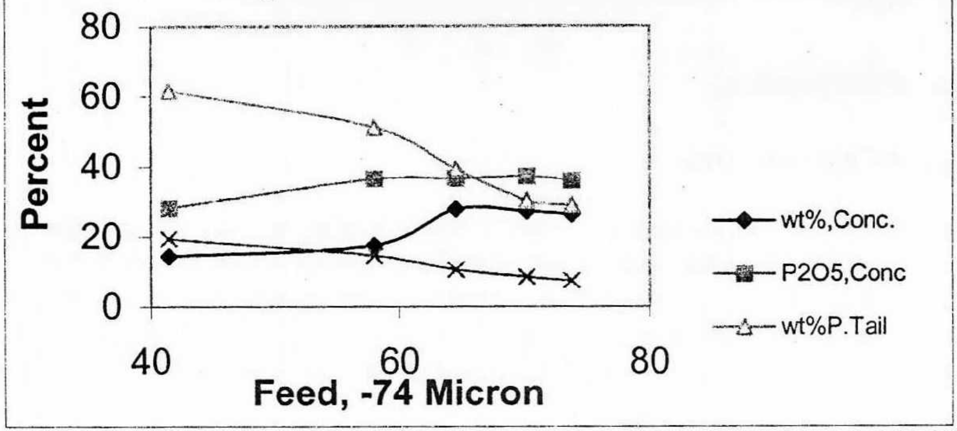

Fig.1:Effect of Grind Variation

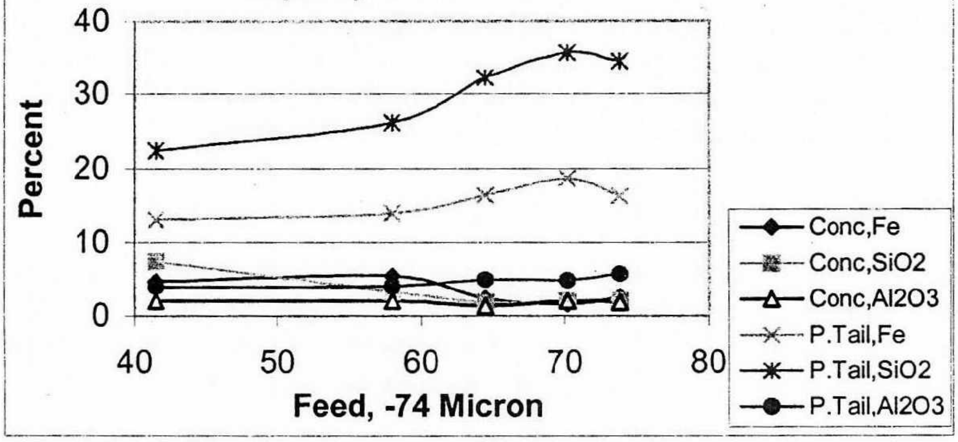

Fig. 2: Effect of grind variation on impurity level

Fig. 1 reveals that a grind between 64 % and 74 % -74 micron would be necessary to improve the grade to +36% P_2O_5 with substantial rejection in tailing. The figure indicates that losses of value in tailing was low at higher grind. But Fig. 2 indicate that still reduction of iron content was not upto the desired level although significantly reduced. Since pH has significant effect & overall improvement was noticeable from grind condition of +64.5 % -74 micron, further experiments were carried out for those grind condition with pH at 7 and same level of reagent conditions and the results are presented in Fig.3 & 4.

Fig.3: Effect of Reagent Level at different grind

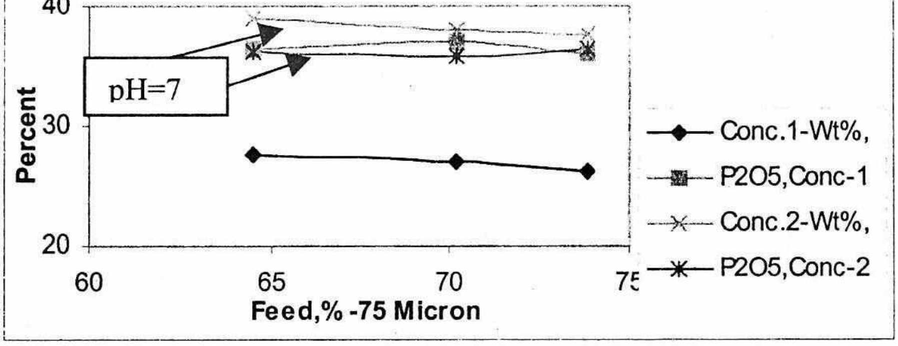

Fig.4: Effect of reagent Level on Reject Tail at Different Grind

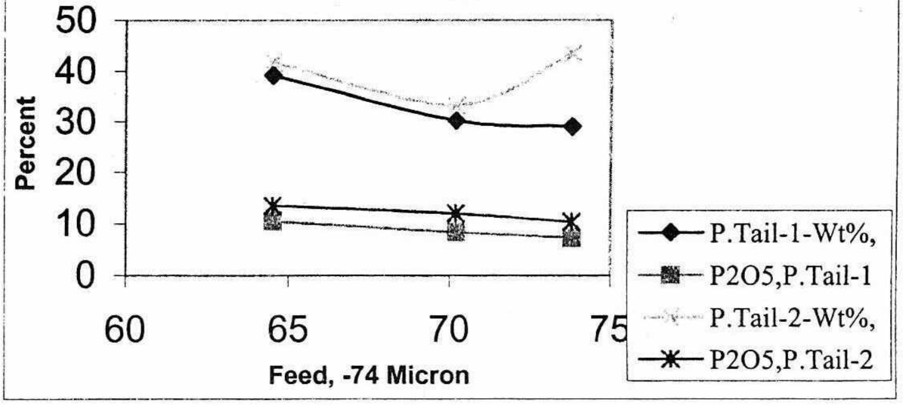

Figure 3 indicate that at pH=8.5, the concentrate obtained is marginally better grade than that at pH=7, but yield-wise low, but impurity pick up at 7 is more. Similarly, Figure 4 indicates that in terms of both yield & P_2O_5, losses are more at pH=8.5 than that at 7.0.These indicate that the roughing should be carried out at 7.0 pH to minimise the loss and subsequent cleaning of froth to be carried out at pH 8.5 for better recovery.

The above studies narrowed down the grind optimisation to two set of grindings i.e., -70% and –74% -74 micron. Further reagent level variation was carried out at these set of grinding conditions at pH 8.5. and the results are presented in Figure 5 .

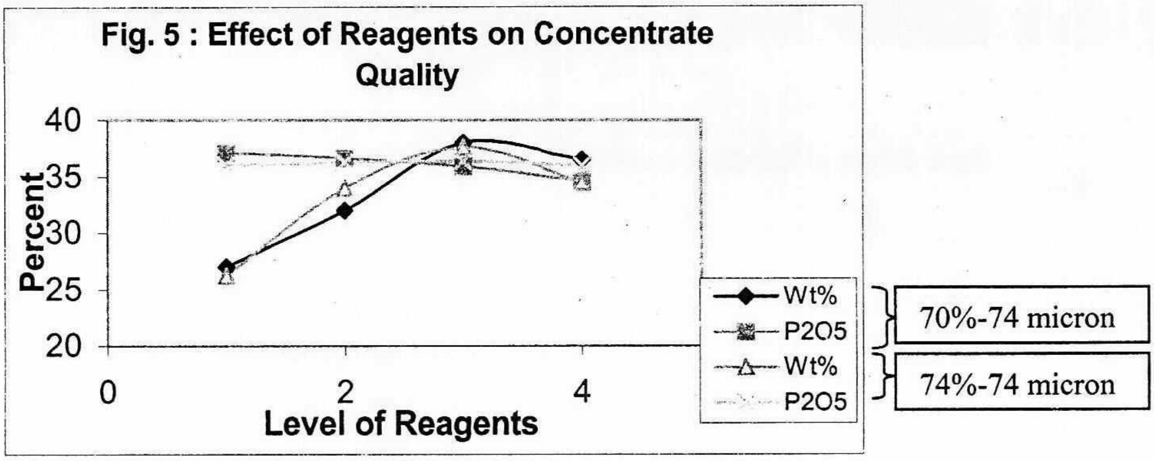
Fig. 5 : Effect of Reagents on Concentrate Quality

The results indicate that at both the grind conditions respond almost equally at all given level of reagent but at level 3, it is closest in terms of both yield and grade of concentrate. From this it can be concluded that 70% -74 micron grind could be taken as optimum. But it may be noted that still impurity level in terms of both iron & silica could not reduced to desired level of less than 1%. Both Fe & SiO_2 content in the concentrate were found to be about 1.5-2.0% each with P_2O_5 level at +36%.

Magentic Separation – Flotation

Since the original ore contains about 10% Fe in the form of magnetite, hematite, goethite, limonite etc., magnetic separation was thought to be employed first to remove iron bearing minerals as maximum as possible followed by flotation of non magnetic fraction. For this studies grind of 70% -74 micron was taken and subjected to magnetic separation at different current intensities. The results are presented in Figure 6.

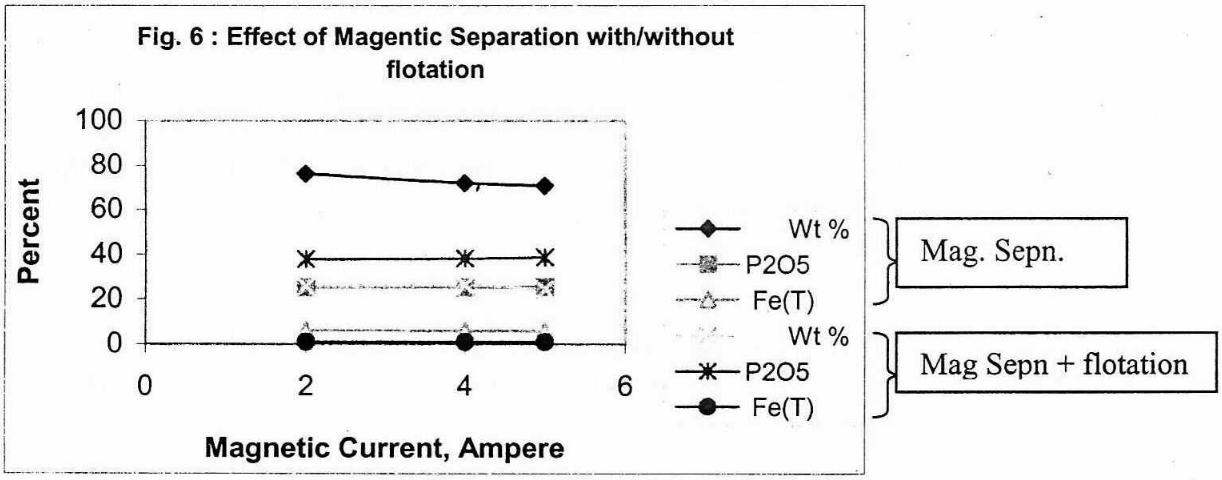
Fig. 6 : Effect of Magentic Separation with/without flotation

The results indicate that while magnetic separation could reduce the Fe content appreciably by about 50% further reduction could not be possible. Second stage of magnetic separation increases the losses. The result also indicate that after the flotation of non-magnetic, the concentrate was of acceptable grade of about 1.0% Fe and 1.0%/ SiO_2. The detail analysis of magnetic fractions and subsequent flotation concentrates from these non-magentics are given in Table No. 4.

Table 4: Detail Analysis of Non-Magnetics & Flotation Concnetrates

Current Amp	Wt %	P_2O_5	SiO_2	Fe(T)	Al_2O_3	Wt %	P_2O_5	SiO_2	Fe(T)	Al_2O_3
		Non-Magnetic				Conc, from Flotation of Non. Mag				
2	76.3	25.2	17.65	6.25	3.91	25.6	37.98	1.28	1.07	1.31
4	72.0	25.5	17.85	6.05	3.87	26.3	38.23	1.32	0.98	1.35
5	70.9	25.6	17.43	5.95	3.95	24.2	38.8	1.24	1.01	1.21

Conclusion

The average grade sample from Purulia analyses P_2O_5 22.73%, Fe (T) 9.25%, SiO_2 16.95%, Al_2O_3 3.38% and is known to have high content of iron & silica and presently being marketed by West Bengal Mineral Development & Trading Corporation as direct application fertiliser. This is possibly only deposit of its kind in India with high iron. Beneficiation studies were taken up to evaluate the sample and to develop possible beneficiation route to obtain a product of high P2O5 content with low iron & silica. Simple flotation and /or magnetic separation although removed the impurities substantially , the same were not able produce the desired results. Moreover, effect of grinding vis-a-vis reagent dosages and pH control was found to be very significant. Grinding the sample to a level of about 70% passing 74 micron followed by wet high intensity magnetic separation and flotation of the non magnetic produced a concentrate of +38% P_2O_5 with about 1% Fe, Silica and Alumina each in it. The product is almost acceptable as the feed stock for super phosphate fertilisers.

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