Beneficiation Studies on Low Grade Chromite Ores using Multi Gravity Separator

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Abstract

Chromite is the most important mineral of chromium and is essential raw material for the production of special steel and ferrochrome alloys. From the mineral conservation point of view it is necessary to maximize the utilization of low grade ores and minimize the high grade ore consumption. Generally low grade and finely disseminated ores need fine grinding, posing problem in recovering of chromium values. In many cases the finely ground feed does respond well to process involving simple gravitational force for recovering the valuable minerals, hence processing under higher G-force may be worth investigating. Multi gravity separator (MGS) is such an equipment which uses enhanced gravitational force for processing ultrafine particles. In the present study, a laboratory Mozley MGS was used for upgrading a low grade chromite ore assaying 26.8% Cr_2O_3. The chromite ore under study contained gangue minerals such as olivine, serpentine, chrysotile and magnetite. Liberation study on different size fractions reveals that 80% liberation occurs at a size 150µm. Considering the mineralogical information, as received ore was ground separately to three top sizes, namely -250µm, -150µm and -75µm respectively and were subjected to concentration using MGS separately. The other parameters such as drum speed and wash water flow rate were also varied to get the optimum condition with respect to grade and recovery. Under the optimum operating conditions, low grade chromite sample was upgraded to 41.1% Cr_2O_3 with 62% recovery using MGS.

Keywords: Low Grade Chromite Ore, MGS, Beneficiation.

1. Introduction

Chromite is recognized as an essential mineral for the production of various types of stainless steels and special ferrochrome alloys. In addition to its application for various purposes in refractory, chemical and ceramic industries etc. It is a valuable and prime source of chromium element. Chromite ores occur exclusively in ultramafic igneous rocks. Major chromite deposits are found in two forms stratiform seams and irregular podiform deposits. With the richness of silica and iron, chromite ore deposit can be classified as siliceous type and ferruginous type (Rama Murthy et al, 2011).Chromite ores contain a variety of gangue

minerals such as goethite, gibbsite, serpentines, olivine and quartz etc., which need specific concentration techniques for upgradation to achieve marketable grades.During mining and processing operations huge quantities of low grade fines are generated.Increased demand of chromite ore,often necessitates the beneficiation of these low grade ores (Maulik and Bhattacharyya).

The processes adopted for beneficiating the chromite ores are mainly gravity and magnetic separation methods. With conventional methods depending on the liberation of particle size of the ore, significant amount of fine chromites are lost to the tailings (Çiçek et al, 2010). These methods are not much useful particularly in the fine particle size range. However, significant improvement is made in thefield of gravity separation by introducing several advancedgravity separators. These gravity concentrators utilize centrifugal force to enhance the relative settling velocity between particles with different size and density. Mozley Multi Gravity Separator (MGS) isone such unit which utilizes the centrifugal force to enhance the efficiency of gravity separation for recovery of chromite ore at fine sizes (Özgen et al, 2012).

Researchers made several attempts to understand and improve the performance of MGS (R. Singh et. al. 1997, Aslan et al. 2009, Çiçek et al. 2010,Tripathy et al. 2011, Rama Murthy et al. 2011). A study onbeneficiation of low grade iron ore fines by multi-gravity separator (MGS) using optimization studies has been discussed by Chaurasia and Suresh, 2015. In the present study, a laboratory Mozley MGS was used for upgrading a low grade chromite ore assaying 26.8% Cr_2O_3.

2. Materials and Methods

2.1. Materials

A low grade chromite ore assaying 26.8% Cr_2O_3 with 11.8% Fe was used for the present study. The size analysis of the sample crushed to -1700µmfor subsequent grinding and processing is given in Fig.1. The specific gravity of the sample was found to be 3.3.It is observed from Fig. 1 that, 80% of chromite sample is having size below 150µm.

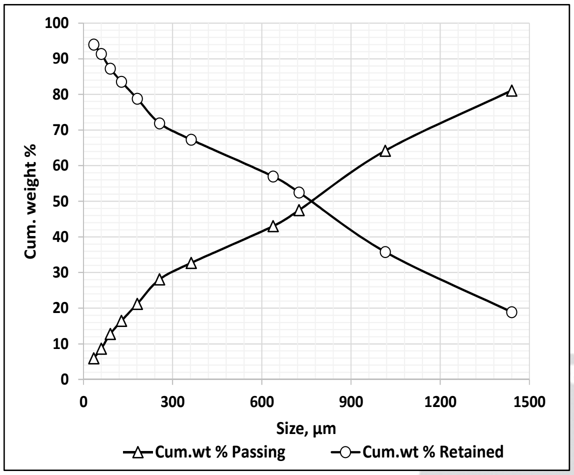

Figure 1: Particle size distribution

2.2 Methods

A series of batch tests were conducted in order to determine the optimum operational parameters and to obtain maximum concentrate grade and chromite recovery using a laboratory scale multi-gravity separator (Make: Richard Mozley Ltd, model no: C-900). The operational variables are the drum speed, washwater rate, shake frequency, shake amplitude and tilt angle. Feed slurry is introduced through a cylindrical feed vessel with an impeller agitator to mix the sample properly. A sample buckets were placed under the tailing dischargepipe, another under concentrate discharge pipe and a third under the centre spillage discharge pipe. Feeding was carried out at a fixed flow rate of 2.0 l/min for all experiments. 1 kg of the dry sample, mixed with 5 litre of water was used for each test. In all the tests, the total feeding time was maintained 3 minutes. At the completion of the feeding, wash water is continued for further 2 minutes with the separator running. At the end of the wash period, changed the tailing bucket and MGS was stopped. The remaining solids in the inner front side of the drum is washed out into the concentrate bucket and rest of the solids collected from rear side of the drum into the another bucket which is considered as middling. The effect of process variables such as feed size, drum speed and wash water rate were investigated in detailed by varying their levels whereas the other operational parameters of the MGS were kept constant. For each experiment after attaining steady state, the products weredried, filtered, weighed and analyzed for chromite content.

3. Results and Discussion

3.1 Mineralogical and Liberation characteristics

To determine the mineralogical characteristics, size wise sample was subjected to microscopic examination. Fig.2 showing the mode of occurrence of chromite at different size fractions. From the figure it is indicated that chromite grains are interlocked with silicate minerals at coarser fraction whereas iron bearing minerals are interlocked with chromite grains at finer size. The chromite ore under study reveals that it is associated with quartz, olivine, serpentine, chrysotile, pyrite and magnetite minerals.

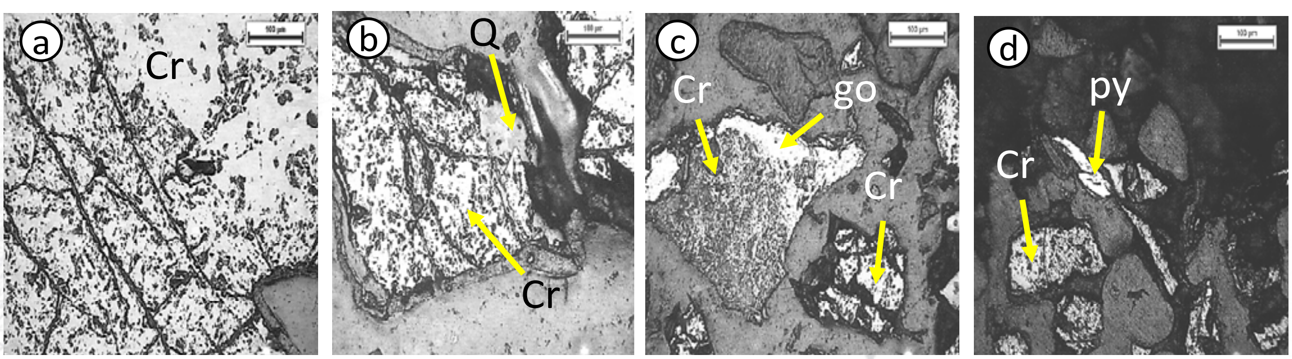

Figure 2: Photomicrograph showing mode of occurrence of chromite grains and interlocking in different size fractions viz.(a) -1700+850μm, b) -850+300μm, c) -300+150μm, d) -150+75μm.

Liberation studies (Fig.3) on chromite ore shows that in coarser fractions percentage of interlocking is very high and decreased with decreasing particle size. Complex interlocking nature of the particle shows that the liberation can be achieved below 150μm size. Proper comminution operation is required to break the interlocking to achieve the desired degree of liberation.

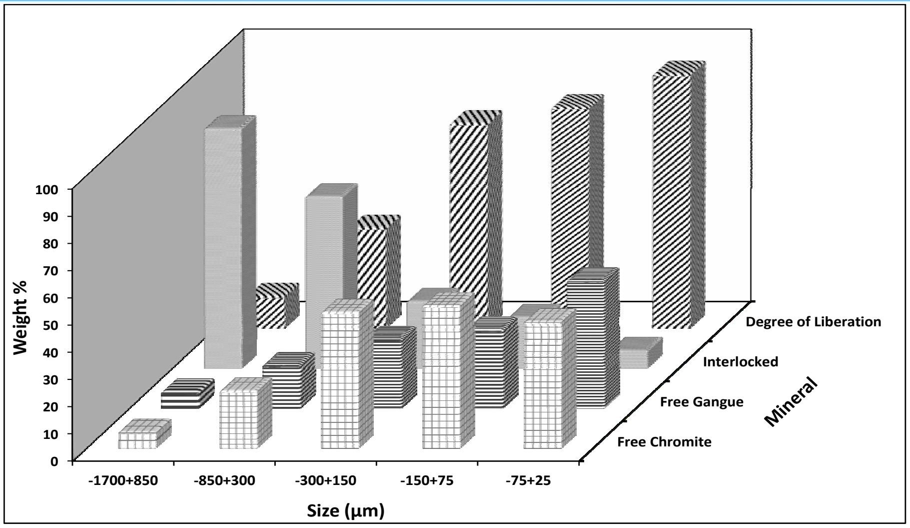

Figure 3: Liberation pattern of chromite ore

3.2 Processing of chromite using MGS

Processing of the chromite sample was carried out with top sizes, viz. -250µm, -150µm and -75µm. The effect of other process parameters on MGS were studied and performance was investigated with respect to grade and recovery of the Cr_2O_3%. Results obtained from each test was given in Table.1, it is observed that maximum grade of 39.3% Cr_2O_3 with 55.8% recovery was achieved at finer size of the material and intermediate levels of drum speed and wash water rate. Similarly, maximum recovery (84.7%) was obtained at lower levels of particle size and wash water rate, higher level of drum speed. Effect of process parameters on the performance of the MGS is discussed below.

Table 1: Experimental conditions and results using MGS.

Expt. No	Process parameters			Concentrate		Middling		Tailing		Cr_2O_3 Recovery, %
	Feed size, µm	Drum Speed, rpm	Wash water, l/min	Wt, %	Cr_2O_3 %	Wt, %	Cr_2O_3 %	Wt, %	Cr_2O_3 %	
1	-250	160	4	41.1	35.8	26.5	29.7	32.4	13.0	54.9
2	-150	160	4	51.3	36.3	21.0	25.6	27.7	10.4	69.3
3	-75	160	4	50.1	38.8	25.3	21.8	24.6	07.9	72.3
4	-75	140	4	19.0	39.2	35.2	36.7	45.8	12.5	28.6
5	-75	160	4	40.5	37.7	30.3	27.2	29.2	10.4	57.5
6	-75	180	4	62.9	32.0	20.4	18.3	16.7	12.7	77.5
7	-75	200	4	70.9	29.3	16.6	24.1	12.5	14.5	78.2
8	-75	200	2	77.5	29.1	10.4	23.8	12.1	13.2	84.7
9	-75	200	4	71.4	29.7	16.3	24.1	12.3	14.5	78.8
10	-75	200	6	67.2	30.4	18.5	23.7	14.3	14.8	75.8
11	-75	200	8	64.5	31.6	19.7	20.7	15.7	15.1	75.9
12	**-75**	**160**	**4**	**50.1**	**38.8**	**25.3**	**21.8**	**24.6**	**07.9**	**72.3**
13	-75	160	6	37.5	39.3	30.2	27.6	32.3	10.2	55.8
14	-75	160	8	38.9	39.1	27.8	28.2	33.2	10.8	57.1

3.2.1 Effect of Feed size: As mentioned above the feed size of the chromite sample was varied as 100% passing of 250, 150 and 75 µm as shown in Fig.4a. The chromite grade of the concentrate is increased from 35.8% to 38.8% as the feed size decreased while other parameters were kept constant. Similarly significant increasing trend on Cr_2O_3 recovery from 54.9% to 72.3% was observed as decreasing the feed size. It can be observed from the results that better enrichment of grade as well as recovery obtained at lower the size of the feed. It reveals that degree of liberation is achieved only below 75 µm corroborating with liberation results.

3.3.2 Effect of Drum Speed: The effect of drum rotation on recovery and grade at different rpm (140rev/min to 200 rev/min) was studied while keeping other variables constant.The results are presented in Fig.4b. As it is evident with an increasing drum rotation, there is an increase in chromite recovery from 28.6% to 78.2% but with a lowering in concentrate grade. Actually an increased drum rotation generates higher centrifugal force causing recovery of locked as well as relatively lighter particles in addition to liberated heavy particles. This results in lowering of concentrate grade.Results shows that the drum rotation is one of most important parameter on chromite recovery as compare to other process parameters.

3.3.3 Effect of Wash Water: Wash water rate was varied from 2 to 8 litre/min while other variables such as feed size (-75µm) and drum speed (160rpm) were maintained constant. Results shows that there is an increase in the concentrate grade with an increase in the wash water rate at all combinations of other variables. It is observed from the Figure (4c)that, an increase in wash water decreases the recovery of chromite significantly. It describes that higher rate of water carries the fine chromite particles to the tailing, which results in decrease in the recovery. Improvement in the concentrate grade with an increase in wash water rate can be observed, as increasing the washing effects on the upper layers of the settled bed provides to wash away the gangue particles to the tailing end.

For improving the grade of the concentrate the rougher product was ground to 45µm and subjected to MGS test at optimized condition (Expt. No.12) such as drum speed of 160rpm and 4 l/min of wash water. Results indicated that grade of the concentrate increased to 41.1% Cr_2O_3 with 62% overall recovery.

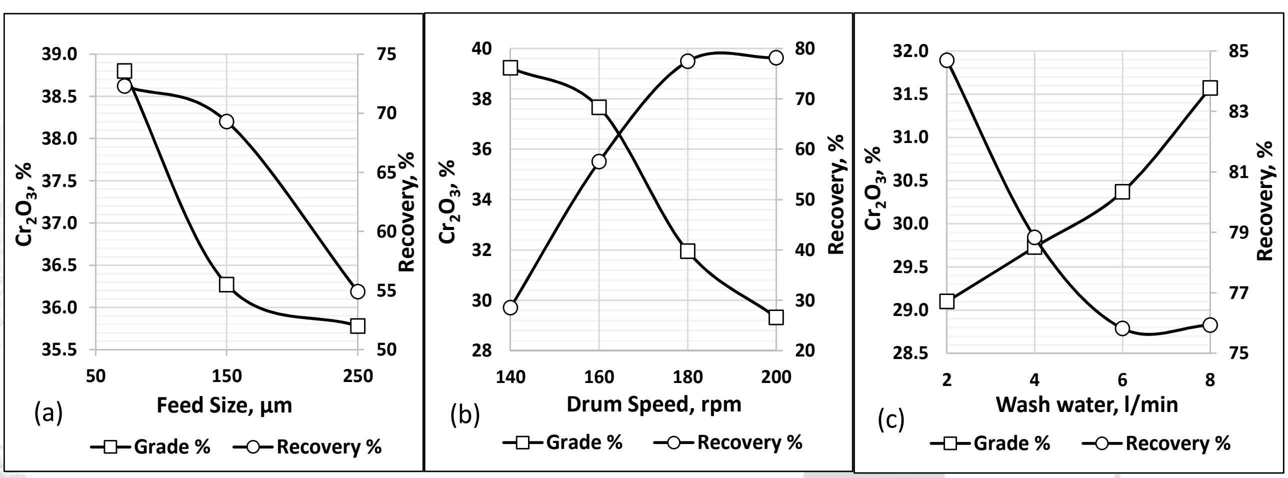

Figure4: Effect of process parameters on grade and recovery of low grade chromite ore.

4. Conclusion

In the present investigation, beneficiation of low grade chromite ore was studied using multi gravity separator. A concentrate grade of 41.1% Cr_2O_3 can be achieved with 62 %Cr_2O_3 recovery from the ore containing 26.8% Cr_2O_3.The optimum operation parameters determined for concentration of chromite ores are as feed particle size: -75µm for roughing and -45µm for cleaning, wash water rate: 4 l/min and drum speed: 160rpm. It was found that feed particle size, drum speedand wash water have significant influence on concentrate grade and chromite recovery. It is concluded that MGS can be used to beneficiate the low-grade chromite ore for producing the metallurgical grade chromite concentrate.

5. Acknowledgement

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