RECOVERY OF CHROMITE VALUES FROM TAILINGS OF COB PLANT USING ENHANCED GRAVITY CONCENTRATOR

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Abstract

In world scenario, India is ranked third largest producer of chromite ore. Odisha Mining Corporation Ltd. is operating a chromite ore beneficiation (COB) plant with a capacity of 0.15 mtpa. The process route basically involves comminution, classification followed by gravity separation. The present plant practice generates tailings with some chromite values associated with it. In the present study, an attempt was made to recover chromite values from the tailings using enhanced gravity separator such as Falcon concentrator, a high g-force generating equipment. The tailing sample is very fine grained in nature and contains significant amount (~68 Wt.%) of particle below 11 µm. The chemical analysis of head sample shows a value of 20.23% Cr_2O_3. Mineralogical study revealed that chromite is the major chromite bearing mineral and clay, gibbsite and spinel are the major gangue minerals present in the material. The process parameters are optimised with respect to feed particle size, bowl rotation speed and the back water flow rate. It was observed that high rotation of the bowl and high back water flow rate favour generating a clean concentrate with Cr_2O_3 more than 40% with >68% recovery.

Keywords: Chromite tailings, Enhanced gravity concentrator, Fine particles.

1. Introduction

Chromium is an important metal in the modern steel industry and an important material for the production of metallic chromium, it is used as a special steel and ferrochrome alloying ingredient in stainless steels (Rama Murthy et al, 2011). Minimum 10.5% chromium is regarded for stainless steel. Chromium (Cr) does not occur in nature, it is present in chromite ores as an iron chromium oxide ($FeCr_2O_4$) (Gundewar et al, 2013).

Different types of beneficiation techniques are using for chromite ores to remove gangue minerals from the chromite concentrations such as gravity separation, flotation or magnetic separation (Kroll-Rabotin et al, 2013). New generation gravity processing devices such as Mozley Multi Gravity Separator (MGS), Falcon concentrator and Knelson Concentrator are promising technologies for the recovery of chromite at fine sizes (Singh et al. 1997, Rama Murthy et al. 2010). Falcon concentrator, one of the enhanced gravity separators, can generate high 'G' force up to 300 which can effectively separate very fine heavy chromite particles from the gangue mineral particles. Over the last decade, EGS have found wide acceptance to mineral industries for concentration of fines and ultra-fine minerals in particular to precious metals such as Au, Ag, Pt. (Operation and maintenance manual of Falcon Concentrator, 2007). In the years to come, the gravity concentration methods mostly the EGS will be in tremendous use for different types of minerals as EGS'S are capable of processing fine and ultrafine particles very efficiently.

In the present study, an attempt was made to recover chromite values from the tailings using enhanced gravity separator such as Falcon concentrator, a high g-force generating equipment. Falcon Concentrator was evaluated for the processing of chromite ore slime. The objective is to obtain a concentrate with minimum 40 per cent Cr_2O_3.

2. Experimental

2.1 Materials

The chromite tailings sample from OMC Ltd. was used for the present study. The sample analysed 20.23% Cr_2O_3, 16.2% Fe_2O_3, 16.35% SiO_2, 26.75% Al_2O_3, 2.12% CaO, 9.64% MgO and 6.97% LOI (Loss on Ignition). The size and size-wise chemical analysis of the sample is shown in Fig. 1. As it is evident the sample contains substantial amount of ultra-fine particles (65.8%, -11 µm).

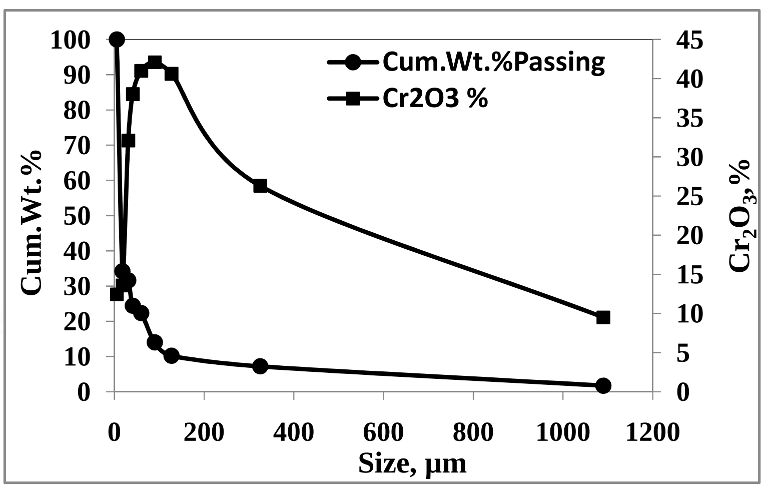

Figure 1: Size and size-wise chemical analysis of the chromite tailings sample.

2.2 Methods

Mineralogical characterization of the chromite tailing sample was carried out by the polished sections of various size fractions were cold mounted to stubs which were polished for study under optical microscope. These polished specimen were studied under reflected light by Petrological microscope, Orthoplan model, Leica/Leitz make. Liberation study was carried out in several size fractions by Zoom stereo microscope, Wild/Leica make. Beneficiation study was undertaken on chromite ore slime sample using a Falcon concentrator, Model SB-40, Falcon Inc, Canada.

Falcon SB40 was used for conducting gravity concentration of chromite tailings sample. Falcon concentrator is an enhanced gravity concentrator, which is normally used for separation of fine mineral particles. The equipment in these experiments is a highly effective centrifugal separating machine. In Falcon concentrator, the rotating bowl is spinned at a very high speed and the materials experience a very high centrifugal force (G). The feed stream particles are subjected to gravitational force upto 300 G's and are segregated according to effective specific gravity along the smooth spinning rotor wall. The core part is a plastic inner vertical rotating drum with a slippery inner wall and an inversely tapered lower part. It supper section consists of two reflex circle slots. A ring of small holes is drilled so that water can flow into the reflex circle slots and loosen and fluidize the heavy layer (Laplante, 1994). The addition of fluidisation or back pressure water from behind the riffle beds enable heavy target particles to migrate to the bottom or outside of the bed and be retained in preference to the lighter particles (M.A. Abdel Khalek, 2012).

3. Results and Discussion

3.1 Mineralogical characteristics of the slime

Mineralogical study by XRD:

Powder X-ray diffraction study was carried out by XRD, Panalytical make, with Co-source. The mineral peaks were identified with JCPDS data base. The slime consists of magnesio chromite with and without alumina, goethite, hematite, magnetite, hematite, magnetite, spinel (ferroan), rutile (?), kaolinite, gibbsite, quartz, pyrite(?) and magnesio ferrite (?).

Mineralogical study under optical microscope:

Microscopic study reveals the presence of chromite, ochreous goethite, martite, magnetite, pyrite, and silicate phases (spinel) and clay (kaolinite and gibbsite).

Chromites of coarse fraction show typical characteristics with very fine interlocked silicates or latter weathered out to pits (Fig. 2). In some cases, they are circumscribed by thin layer of hematite or martite. In finer size fractions, it occurs as high-Al goethite intercalated with clay. Free chromite is found to be occurred in massive and homogeneous form.

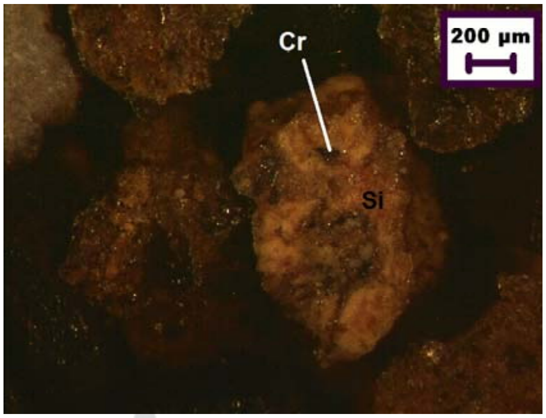

Figure 2: Photomicrograph of chromite slime from OMC.

3.2 Laboratory beneficiation studies

The chromite tailing sample was subjected to processing using Falcon concentrator for their enrichment. Here four different mesh of grind feed particle sizes were studied and these are -500µm, -212µm, -150µm, -75µm. The effects of two important variables e.g. bowl rotation frequency and back water flow rate were studied on the process performance. The results are portrayed in Figures 3 & 4.

Effect of frequency of the rotor bowl

The effect of frequency of the rotor bowl of the Falcon concentrator was studied and the results are given in Figure 3. In these experiments, the back water flow rate was kept constant at 5 psi. As it is evident that from the Figure 3, an increase in the frequency from 20 to 80 rpm, decreases the Cr_2O_3% of the underflow product. On the other hand, the recovery percent of Cr_2O_3 increases with increase in the frequency from 20 to 80 Hz for all the feed particle size.

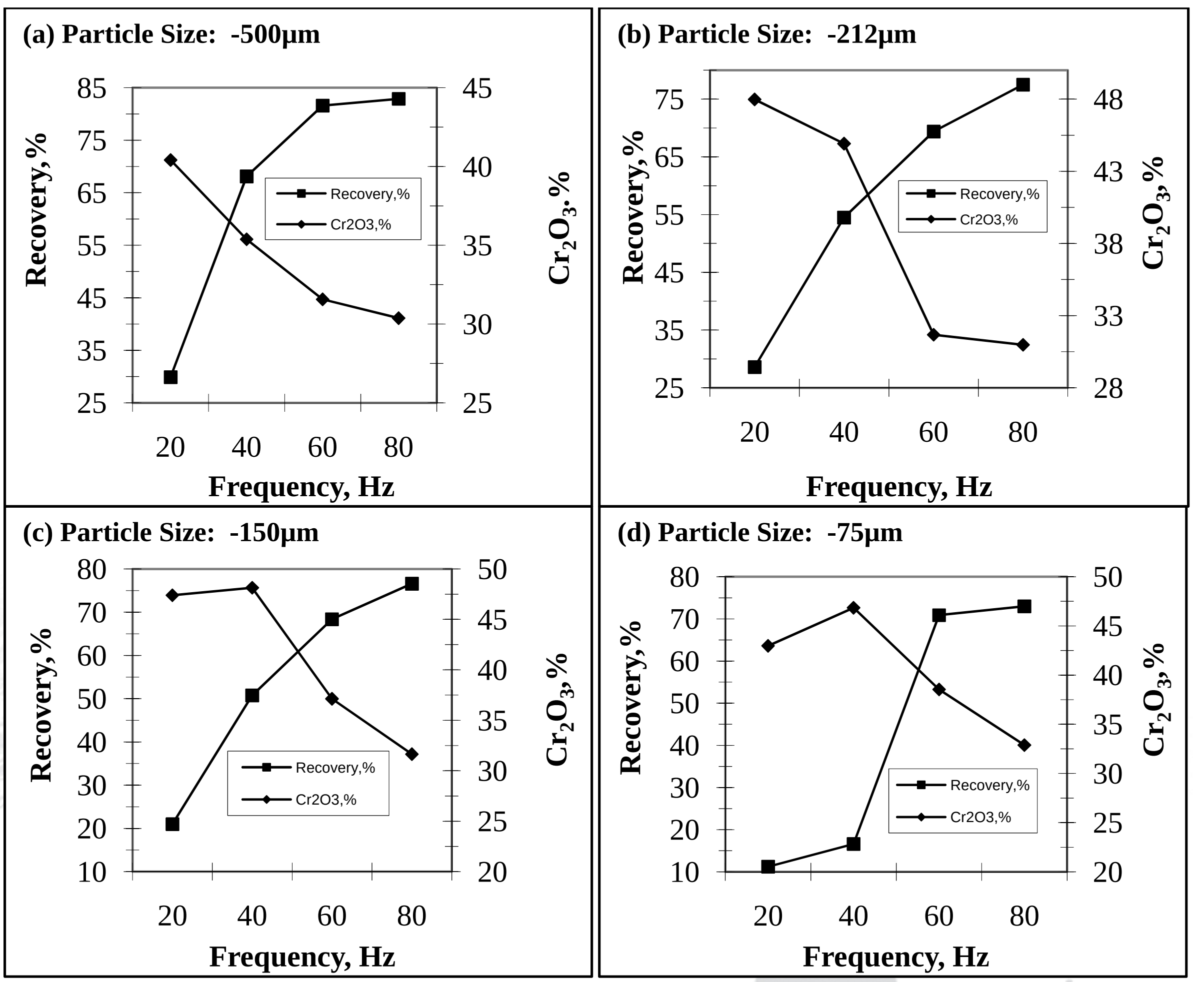

Figure 3: Results on the effects of rotor bowl frequency with varying particle size of the feed.

Effect of back water pressure

The results on the effect of back water pressure are given in Figure 4. In these experiments, the rotor bowl frequency and pulp density were kept constant at 80 Hz, and 10 percent respectively. An increase in the back water pressure from 1 to 15 psi increases the Cr_2O_3% of the falcon underflow product. On the other hand, the chromite recovery decreases with increase in the back water pressure from 1 to 15 psi for all the feed particle sizes. So it is evident from Figure 4, that grade of the falcon underflow product is higher at high backwater flow rate and high rotation of the bowl.

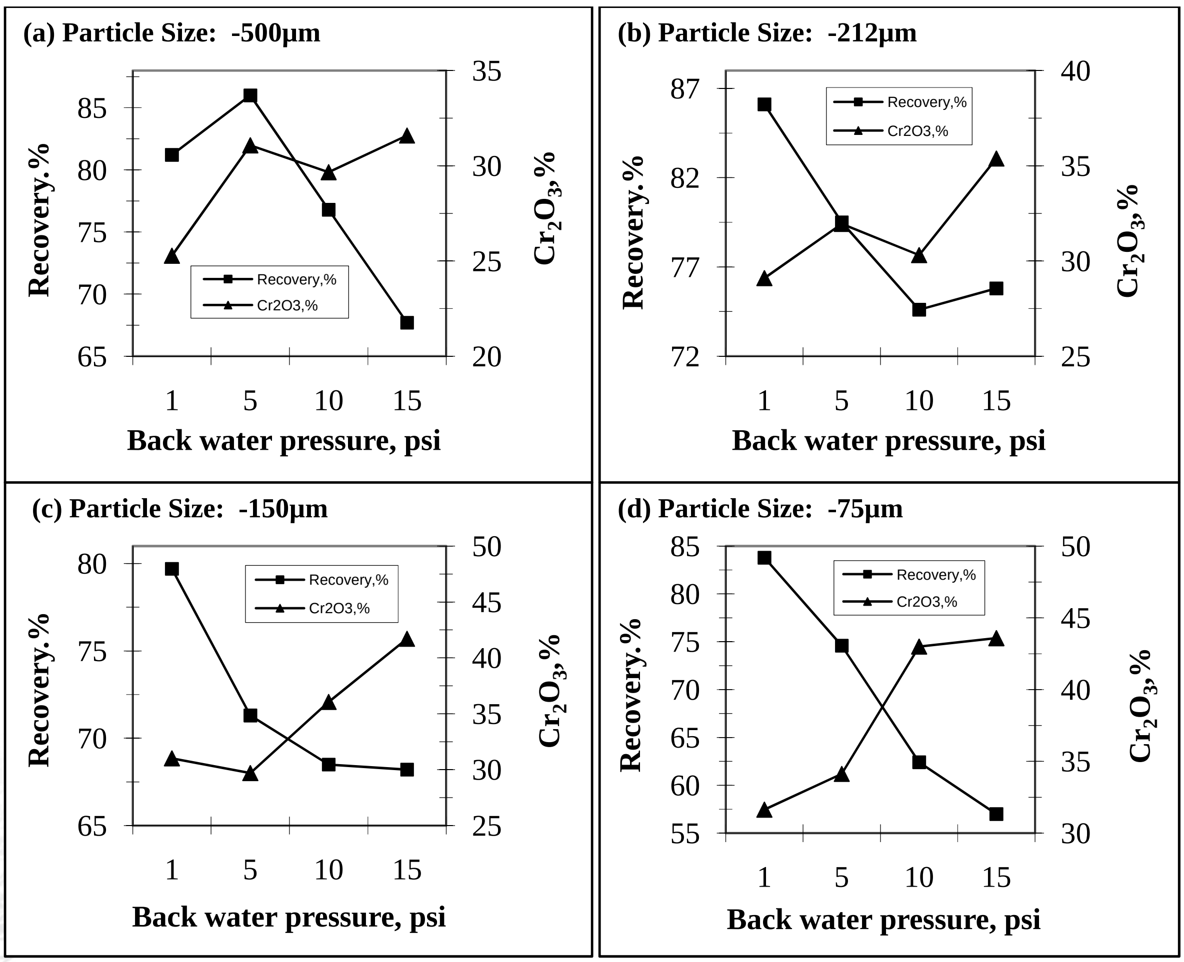

Figure 4: Results on the effects of back water pressure with feed with varied particle sizes.

4. Conclusions

The study on the chromite ore slime led to some important conclusions as given below:

- The slime consists of magnesio chromite with and without alumina, goethite, hematite, magnetite, hematite, magnetite, spinel (ferroan), rutile (?), kaolinite, gibbsite, quartz, pyrite(?) and magnesio ferrite(?). As XRD data shows, Mg and Al may be stoichiometrically present as major element in chromite grains.
- It was observed that, an increase the frequency of the rotation bowl from 20 to 80 Hz, decreases the concentrate grade but increases the chromite recovery for the particle size of -500µm, -212µm, 150µm and -75µm.
- It was also observed that an increases back water flow rate from 1 to 15 psi increases the Cr_2O_3 grade %, however the recovery decreases for the same change for all the particle size studied.
- As the particle size is decreased from 500µm to 75µm, the grade of the underflow product increases from 31.6% to 43.6%, but the chromite recovery decreases.
- The study has shown that it is possible to recover chromite concentrate assaying 41.71 % Cr_2O_3 with 68.2% chromite recovery from the tailings sample.

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