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Beneficiation Practices in the Sukinda Valley Area Chromite Deposits

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Abstract

Extensive Chromite deposits in Sukinda valley occur between District Jajpur & Keonjhar, Orissa. Mostly the ores are granular fines with a few soft, moist & friable lumpy masses. In these lumps chromite grains occur as discrete grains within ferruginous matrix. In few cases serpentine & quartz association are also observed. The inherent characteristics of the deposits are such that their up-gradation / value addition does not pose many problems to the natives of the area. The method of beneficiation ranges from primitive Stone Age to modern-day technology. Consequent upon quantity ceiling on export of high grade chromite ore (ROM) and no such restriction on chromite concentrate in the country, mushrooming of chromite ore beneficiation (COB) facilities took place in the leasehold sectors and also outside of it. This resulted in unscrupulous exploitation by a few equipment manufacturers, suppliers & consultants engaged for commissioning of COB facilities without a proper development of process flow sheet and metallurgical accounting. Such procurement of machinery/equipment though enhanced the throughput capacity of concentrate generation but compromised on the recovery of valuables, especially fines. Such unscientific value addition of the ROM ore jeopardized the very concept of conservation.

This paper deals with the processing technology being practiced in the Sukinda valley for the friable chromite ore, and the remedial measure needed for optimum recovery of the valuables established through extensive R&D work done at IBM laboratory.

INTRODUCTION

Majority (~98%) of chromite occurrences in the country are confined to famous Sukinda Nuasahi chromite belt, district Jajpur and Keonjhar respectively of Orissa. In this belt a number of lessees are working for winning of chromite ore for their captive charge-chrome/ ferro-chrome plant respectively. Most of these chromite mines and chromite ore beneficiation (COB) plant are engaged in exporting of chrome ore fines and chromite concentrate.

As per Govt. of India policy, high-grade chromite ore export has quantum restriction of 4 lakh ton per annum, whereas, no such restrictions are for chromite concentrates (+50% Cr_2O_3). This encouraged lessees to venture for beneficiation/value addition on their low grade chromite ore as evident from the fact of quantum jump in concentrate export of 3.22 lakh MT in 2000-01 to about 7 MT/annum in 2001-02 to 2003-04. Lions share of these concentrates were produced by only two major players namely, M/s TISCO & OMC. A small amount is contributed by other lessees like, M/s FACOR, M/s IDCOL, B.C. Mohanty & Mishrilal Jain. Besides, a sizable chunk of concentration is also carried out in private sectors namely, M/s Visa International, Pradhan Industries (P) Ltd., etc., not involved in chrome ore mining i.e., outside lease hold area.

In the Sukinda valley about 10 & 23 Chromite Ore Beneficiation (COB) facilities are operational in the leasehold area as well as in private sector respectively. Most of the new COB plant technology adhered to by the lessees was based on personal experience of a few earlier workers and/or by supplier/manufacturer of machinery engaged in sale of their equipment or by consultants engaged in erection of plants, etc. This resulted in lack of development of proper flow-sheet for optimum recovery of the valuables.

ORE DEPOSIT CHARACTERIZATION

Geologically, the chrome ore occurrences in Sukinda valley is mostly high grade, soft & friable in nature besides some amount of hard and lumpy ore also found as separate band from where merely 5% is being produced. The chromite deposits have very high depth persistence and its grade increases with depth. Most of the quarries in the area have already reached to on an average depth of 50 m. However, the grade dilution is taking place at hang wall & footwall contacts due to mechanization.

BENEFICIATION PRACTICES

The beneficiation of soft & friable chromite ore implied rejection of relatively fine iron bearing impurities (limonite, goethite & ferruginous clay), which invariably occurs as fine cementing / binding material between the various chromite grains.

In general, the crude beneficiation techniques in vogue are scrubbing, crushing, grinding, screening, classification (classifier / cyclone) & settling to produce the concentrate.

The systematic methods used are scrubbing, crushing, grinding, screening, classification (classifier / cyclone) & gravity concentration (table / spiral) on classified feed to produce the concentrate.

Some of the basic ore processing technologies (for friable ore) used in various Indian chrome ore processing plants (ref. figure-1) are as follows:

(i) Manual screening cum washing of ROM ore by spray of water in 2 mm size screen followed by vigorous manual churning of screen under-size in a settling tank. The coarse chromite concentrates were settled nearby whereas fine ferruginous materials were washed away as slimes. The oversize stacked and or sold to near by available market for beneficiation.

(ii) Crushing & screening to all -1 mm size and
- Sluice in a narrow gentle sloping drain. Coarse concentrates settles in the slope nearby rejecting slimes of ferruginous material, which are carried away to a farther distance by action of water.
- Treatment in hydro-cyclone followed by jet-sizer, i.e. hindered settling classifiers.
- Classified (cyclone) to reject overflow slimes followed by treatment of cyclone underflow (sand) by Tabling.

(iii) Scrubbing cum screening of ROM ore to -1 mm size, followed by crushing and/or grinding of oversize to all -1 mm size and classification (spiral classifier/ cyclone). The underflow constitutes the final concentrate while the overflow is reject.

(iv) Crushing & grinding of ROM ore followed by de-sliming (cyclone), hydro-sizing of cyclone underflow into two size fractions followed by gravity concentration by spiral and/or table.

(v) Scrubbing of ROM ore followed by screening, crushing and grinding of oversize to all -1 mm size, followed by classification (spiral classifier / cyclone) to plus & minus 100 μm size, followed by gravity concentration employing spiral & table.

The first three process routes of beneficiation (practiced by minor player,), have caused grave resource waste with a low rate of recovery, which is averaged between 40 to 50 % Cr_2O_3 as it concentrated chromite grains limited to 75 μm (200 mesh) size only.

In the subsequent process routes, chromite recovery is marginally better but then again it is limited to 50 μm size only with a loss mostly at size below 50 μm & is inevitable due mainly to lack of properly developed process flow sheet & control in its process parameters. The maximum chromite recoveries in all these later process COB plants are ranging between 60 to 70% Cr_2O_3 only.

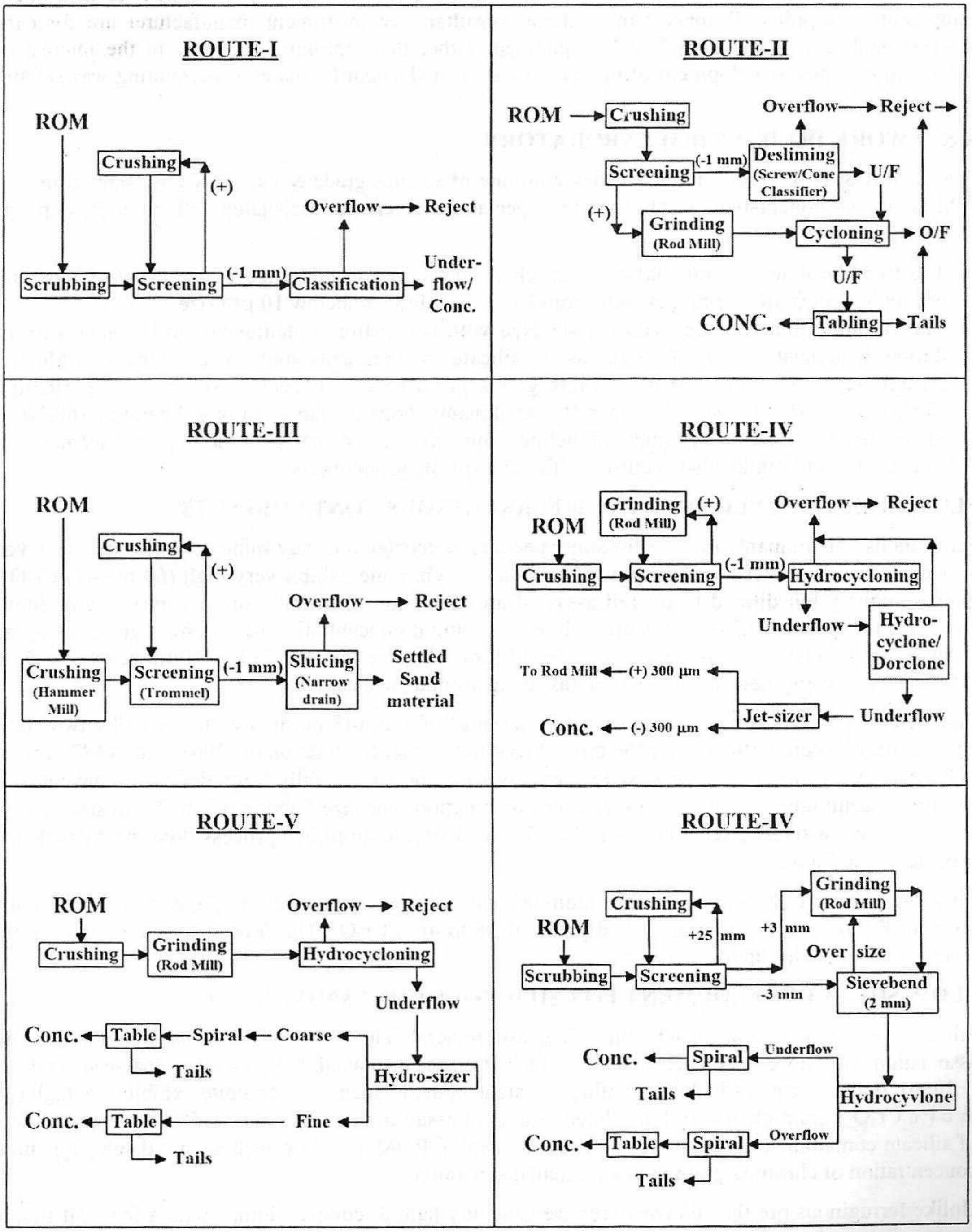

Fig. 1: Beneficiation Routes Practised in Sukinda Area, Orissa

The compromise in optimum/best possible chromite recovery by the lessees is primarily due to surplus ore reserves, readily available flourishing & unrestricted (no quantity ceiling) export market and ease of value addition, technology of which is supplied by a few engineering consultant & instrument manufacturer/ supplier. Primary aim of these consultants & instrument manufacturer are for easy recovery and sale of their machinery/ equipment rather than optimum recovery in the interest of conservation. Thus, development of proper flow sheet and scientific material accounting was seldom in their agenda.

R & D WORK DONE AT IBM LABORATORY

Extensive R & D work on Sukinda valley chromite of various grade & various COB plant tailings at IBM laboratory conclusively established two special characteristics associated with chromite deposits of Sukinda valley:

(i) The free chromite minerals having grain chemistry varied in the range of 56 to 64% Cr_2O_3 and occurs in almost all size ranges right from 1 mm size down to below 10 μm size.

(ii) The chromite minerals are mainly associated with two major contaminants, to be taken care of during beneficiation i.e., ferruginous & silicate contaminants and its combination. Mostly, ferruginous clay coating over chromite grains occurred in the coarser size range of +0.3mm (300μm) size whereas, silicate minerals contaminants showed a fair amount of liberation (60-70%) in the much coarser size range of below 3mm size. However, extremely fine dissemination (inclusion) of chromite also occurred within the silicate groundmass.

FLOW SHEET DEVELOPMENT FOR FERRUGINOUS CONTAMINANTS

Ferruginous contaminants include limonite, goethite & ferruginous clay mineral. The latter observed to occur as coating over chromite grains. In such ores chromite exhibit very high (60 to 64% Cr_2O_3) grain chemistry but diluted to overall assay of around 35 to 40% Cr_2O_3 on account of ferruginous contamination. Such friable ROM ores, showed a natural concentration of chromite grain (assaying around 50% Cr_2O_3) in the size range of –300+30μm. The size range of below 30μm & over 300μm size displayed ferruginous contamination (assaying around 30% Cr_2O_3).

Beneficiation of such ores requires liberation mesh of 300μm (48 mesh) size followed by two stage classification to compartmentalize the ground feed to three sorted fraction of -300+53μm (+270 mesh), -53+20μm & -20μm size. The first two fractions can be successfully upgraded in a conventional gravity concentration circuit of spiral & table combination. The size fraction below 20μm size may be either rejected or stacked separately for ultra-fine recovery. A simplified process flow sheet developed is presented in Fig.-2.

This flow sheet produces a composite chromite concentrate assaying +52% Cr_2O_3 with recovery in the range of 80 to 85% Cr_2O_3 from a feed grade of 35 to 40% Cr_2O_3. The flow sheet gave a successful recovery of valuables up to +20μm size.

FLOW SHEET DEVELOPMENT FOR SILICEOUS CONTAMINANT

Silicate contaminant includes serpentine & quartz mineral. The chromite grains showed a very close association with those of silicate minerals, which at places displayed interlocking in coarse size ranges (+3mm). It also occurs as inclusion within silicate gangue. In such ores chromite exhibit very high (56 to 64% Cr_2O_3) grain chemistry but diluted to overall assay in the range of 30-35% Cr_2O_3 on account of silicate contamination (about 45% silicate minerals). ROM silicate ores does not display a natural concentration of chromite grain in any particular size range.

Unlike ferruginous ore the siliceous ores are generally hard & compact lumps with a few soft friable lumps of chromite embedded in ferruginous matrix. Mineralogical, examination reveals that chromite is the only valuable and major mineral followed by gangue minerals like serpentine, quartz, iron

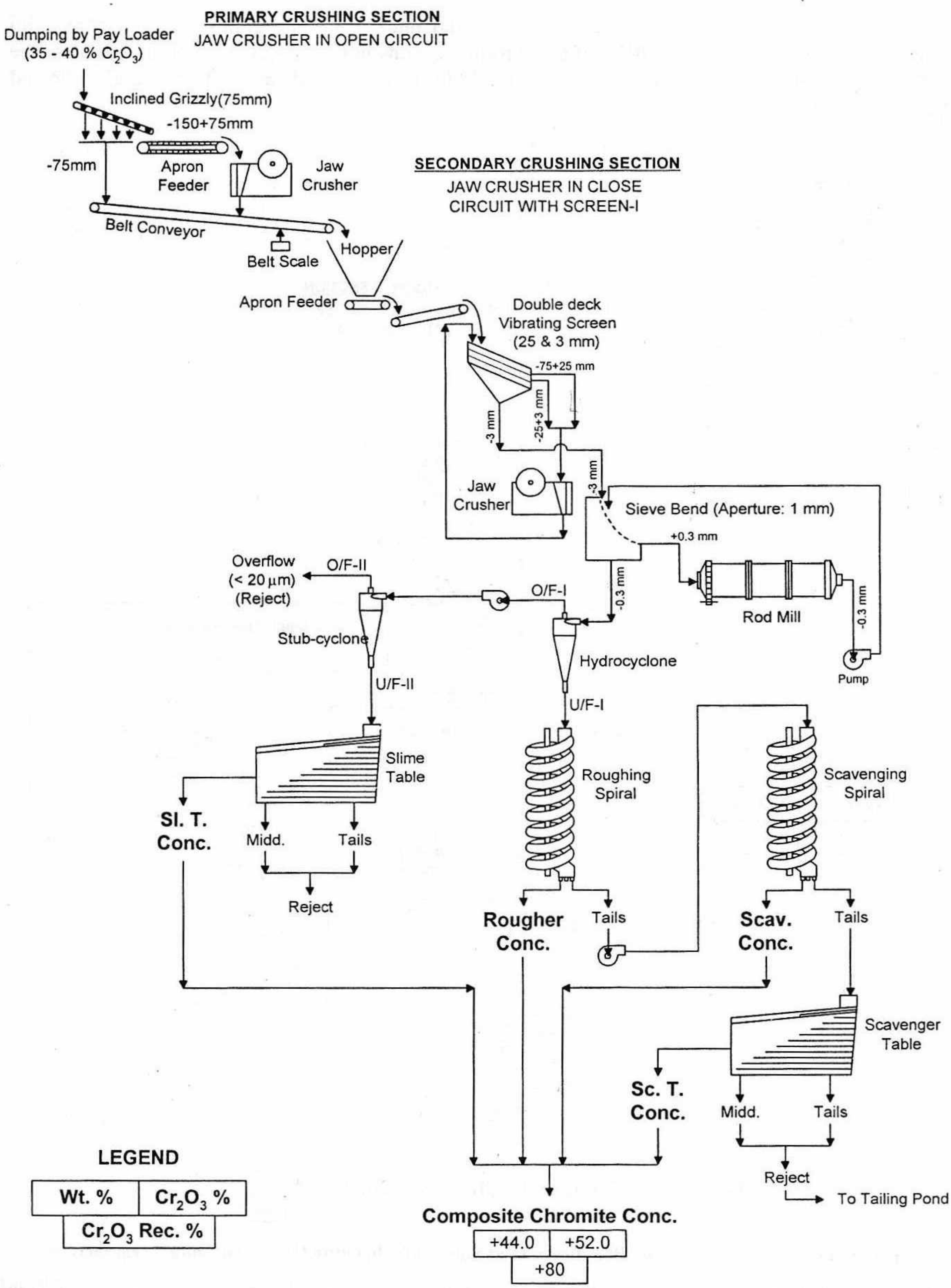

Fig. 2: Typical Flow-Sheet for Beneficiation of Ferruginous Chromite Ore of Sukinda Area, Orissa

minerals (goethite/limonite, hematite & magnetite) and mica. Chromite grains are fine to medium grained. At -3mm size, most (60-70%) of the chromites grains in the sample were observed to be free in nature. Remaining, present as embedded grains within silicate groundmass and a few grains showed interlocking with silicate minerals.

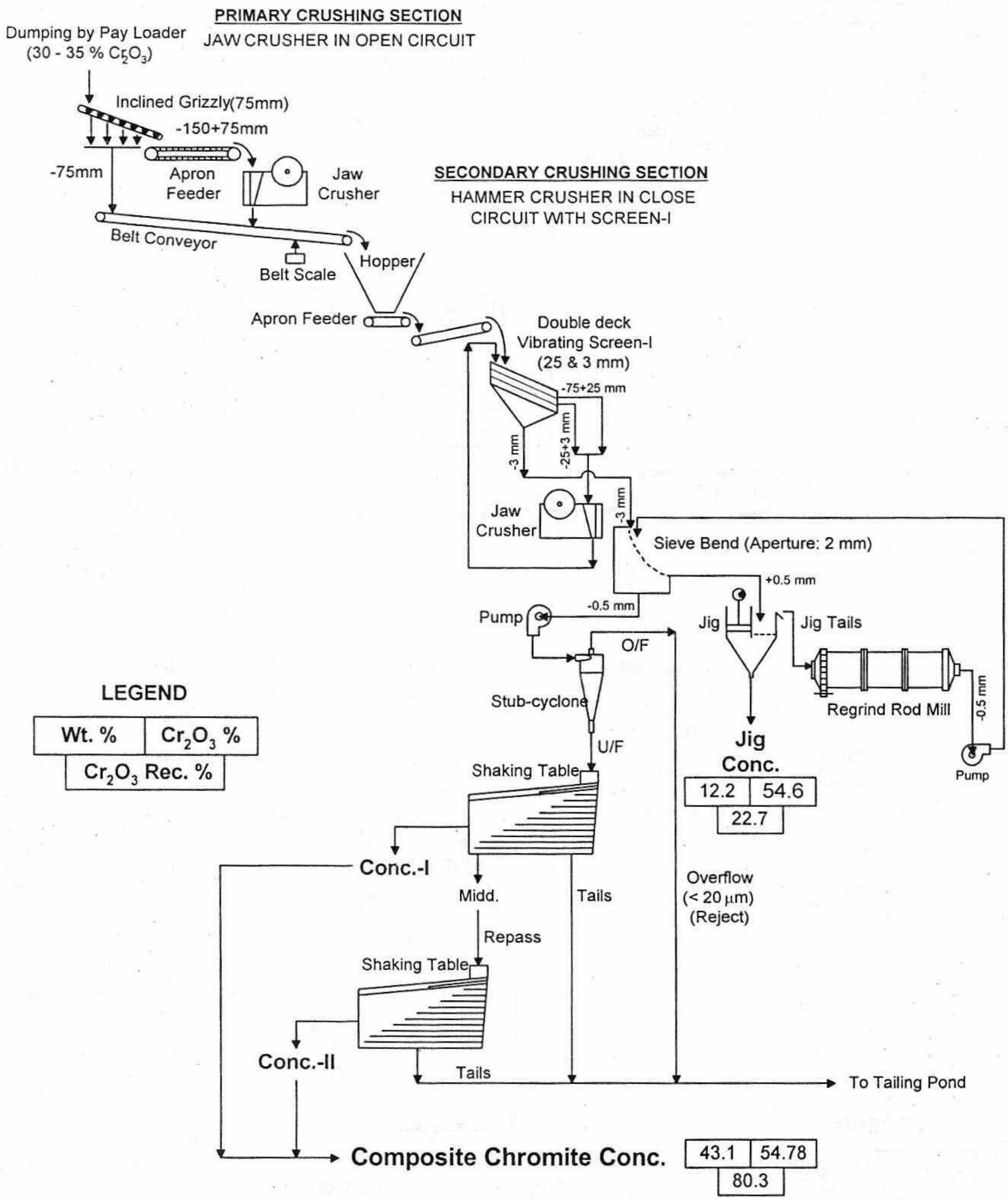

Fig. 3: Typical Flow-Sheet for Beneficiation of Solicious Chromite Ore of Sukinda Area, Orissa

Taking advantage of the coarse size liberation, the beneficiation route formulated is crushing of ROM ore to all minus 3 mm and screened through 0.5mm screen. The coarse size of -3+0.5mm was subjected to jigging. The jig concentrate constituted the finished product. The jig tails were rod mill ground to just below 0.5mm size & combined with screen undersize (0.5mm) and subjected to hydro classification to get rid of particles below 20µm size fraction as overflow. The under flow can be successfully upgraded in a conventional gravity concentration circuit of spiral or table or in combination. The size fraction below 20µm size may be either rejected or stacked separately for ultra-fine recovery. A simplified process flow sheet developed is presented in Fig.-3.

This flow sheet produces a jig concentrate assaying +52% Cr_2O_3 with recovery of around 25% Cr_2O_3 (% Wt. yield about 12) and a composite chromite concentrate assaying +52% Cr_2O_3, SiO_2 ~4%, with recovery in the range of 80 to 85% Cr_2O_3 from a feed grade of 30 to35 % Cr_2O_3 & SiO_2 ~30%. The flow sheet gave a successful recovery of valuables up to +20µm size.

CONCLUSION

The mushrooming of COB industry in the Sukinda chromite belt is primarily aimed to en-cash the boom in unrestricted chromite concentrate export market. A vast chromite reserve in the area, ease of value addition and market encourages lessees to venture for COB. But, in doing so, most of the entrepreneurs failed in their judgment of mineral conservation by not developing a proper flow sheet for optimum chromite recovery. A properly developed flow sheet will not only guarantee best possible recovery of chromite in the prevailing technology but also beneficial for utilization of sub grade ore (-30+10 % Cr_2O_3) & waste dumps.

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