Threshold value of Chromite Ore.

Sukinda Chromite Mine of M/s Tata Steel Ltd. Review

IBM: 23rd Aug’2017
1. Threshold value:

**Threshold Value:**

The threshold value is a component to mineral conservation as it decides the lower limit of sub-grade ore in a mineral deposit. The threshold value of specific mineral decides the mining waste as distinct from utilizable/marketable fraction of ore zone. This value is a dynamic point value.

Under 16&18 of MCDR the lessee is required to stack and preserve unsalable sub-grade ore which are generated during mining.

Currently the threshold value for Chromite ore notified by IBM in 2009 is 10% Cr2O3.
2. Occurrence:

Commercial chromite deposits are found mainly in two forms: stratiform seams (body/layer) in basin-like intrusions, often multiple seams through repeated igneous injections, and the more irregular podiform or lenticular deposits.

**Stratiform deposit**: Bushveld Igneous Complex of South Africa and Zimbabwe associated with commercial deposits of the platinum-group metals. Madagascar and in the Orissa district (State) of India. Soft and fraible nature.

**Podiform deposits**: Generally richer in chromium than the stratiform deposits and have higher Cr:Fe ratios. Kazakhstan. Hard and lumpy Type.

**Alluvial deposits**: Formed by weathering of chromite-bearing rock.
3. Global resources:

South Africa and Zimbabwe hold about 90% of the world chromite reserves and resources.

Other Reserves and resources are in Kazakhstan, Turkey, Finland, India and minor deposits in Russia, Tibet etc.

The total Global resources is estimated to be around 11 billion tonnes.
4. Chrome ore Use:

- **5%**
  - Refractories & Foundries
    - Iron & Steel
    - Cement
    - Glass
    - Ceramics
    - Machinery
    - Others

- **90%**
  - Metallurgical industry
    - Stainless steel
    - Alloved steel
    - Nonferrous alloys

- **5%**
  - Chemicals
    - Leather tanning
    - Plating
    - Metal
    - Wood preservative
    - Pigments
    - Others
## 5. Global Source of Chrome Ore:

<table>
<thead>
<tr>
<th>Products</th>
<th>Origin</th>
<th>Cr2O3% Min</th>
<th>Cr/Fe Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chrome Ore Lumpy</td>
<td>Oman</td>
<td>32/34</td>
<td>2.14/1</td>
</tr>
<tr>
<td>Metallurgical Chromite</td>
<td>Oman</td>
<td>34</td>
<td>2.2/1</td>
</tr>
</tbody>
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<tbody>
<tr>
<td>Chrome Ore Lumpy/Concentrates</td>
<td>Philippines</td>
<td>42/44</td>
<td>1.4/1.6</td>
</tr>
<tr>
<td>Chrome Ore Lumpy/Concentrates</td>
<td>Philippines</td>
<td>40/42</td>
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<tr>
<td>Chrome Ore Lumpy</td>
<td>Sudan</td>
<td>40/42</td>
<td>2.5/1</td>
</tr>
<tr>
<td>Chrome Ore Lumpy</td>
<td>Sudan</td>
<td>36/38</td>
<td>2.5/1</td>
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<tr>
<td>Chrome Ore Lumpy</td>
<td>Sudan</td>
<td>30/32</td>
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</table>

**Description:** South African UG2 chrome ore concs  
Cr2O3: 42% basis, 40% min  
Cr:Fe ratio: 1.2:1 min

**Note:**  
Associated Minerals include Iron, silica, alumina, phos, Sulphur, MgO etc.  
The Cr/Fe ratio is the deciding factor.
6. Ferro Chrome Industry in India:

Typically the Ferro Chrome Industry in India Uses ore for:

- **HC Ferro Chrome**: $\text{Cr}_2\text{O}_3$ ranging from 48-52% and Cr:Fe Ratio of 2.4 :1

- **Charge Chrome**: $\text{Cr}_2\text{O}_3$ ranging from 44-46% and Cr:Fe Ratio of 1.8 :1

Deciding Factors:

- 0.1 increase in Cr:Fe ratio leads to an increase of 0.8 to 0.9 % in the metal content of the Ferro chrome / Charge chrome.

- Power costs plays a major role in using inferior or low Cr:Fe ores.
7. Beneficiation at Tata Steel:

**CHROME ORE BENEFICIATION PLANT - SUKINDA CHROMITE MINE.**

**EQUIPMENT:**
- 3 stage crushing and grinding.
- Floatex Density separator
- Spiral Concentrators
- Hydrocyclones
- Screw classifiers
- Horizontal belt filters
- Tailing Dewatering.
8. Beneficiation at Tata Steel: Capability

<table>
<thead>
<tr>
<th>Date</th>
<th>Cr2O3%</th>
<th>Fe%</th>
<th>Cr2O3%</th>
<th>Fe%</th>
<th>Cr2O3%</th>
<th>Fe%</th>
<th>Moisture%</th>
<th>Yield</th>
<th>Cr2O3 (%)</th>
<th>Fe(-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-12-2017</td>
<td>15.84</td>
<td>30.48</td>
<td>0.36</td>
<td>43.78</td>
<td>15.67</td>
<td>0.67</td>
<td>22.76</td>
<td>11.97</td>
<td>37.05</td>
<td>32%</td>
</tr>
<tr>
<td>1-12-2017</td>
<td>23.16</td>
<td>32.89</td>
<td>0.63</td>
<td>43.78</td>
<td>15.67</td>
<td>0.67</td>
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<tr>
<td>2-12-2017</td>
<td>17.26</td>
<td>32.87</td>
<td>0.44</td>
<td>43.78</td>
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<td>2-12-2017</td>
<td>20.83</td>
<td>31.75</td>
<td>0.41</td>
<td>43.78</td>
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**LG Feed and recovery:**

- **Feed:** Cr2O3-24.05%
  - Fe- 26.19%
  - Cr:Fe- 0.63
- **Recovery:** Cr2O3- 47.97%
  - Fe- 16.49%
  - Cr:Fe – 1.99
- **Tailings:** Cr2O3- 12.08%
  - Fe- 30.72%

**Yield:** 31%
**Cr2O3 enhancement:** 99%
**Fe Reduction:** 37%

This product is not useful in Ferro Chrome production due to Low Cr/Fe. Utilize through blending with ore/concentrate of >2.5 Cr/Fe
BENEFICIATION STUDIES FOR CHROMITE ORE OF ODISHA
(Source: IBM Chromite Monograph)
INDIA: RESEARCH & DEVELOPMENT ON BENEFICIATION

During mining operations to raise marketable ore (+38% Cr2O3) to the tune of 4 million tonnes and more p.a., sufficient quantities of sub-grade ores (10-35% Cr2O3) are also being excavated from these mines. In order to conserve these strategically valuable chrome resources, their beneficiation is very much essential and the major mine owners in the area like TISCO, OMC, FACOR and ICCL have been able to establish Chrome Ore Beneficiation (COB) plants at their mine sites. R&D studies in this regard have been carried out by organizations like RRL (now IMMT), Bhubaneswar, BARC, IBM and NML to help the industries.

<table>
<thead>
<tr>
<th>Agency</th>
<th>Plant Location</th>
<th>Rated feed capacity &amp; grade</th>
<th>Concentrate output &amp; grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>FACOR</td>
<td>Boula</td>
<td>1,00,000 tpa, 15-21% Cr₂O₃</td>
<td>22,000 tpa, 42-45% Cr₂O₃</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cr/Fe: 1.4-1.7</td>
</tr>
<tr>
<td>TISCO</td>
<td>Bhimtangar</td>
<td>12,00,000 tpa, 30-38% Cr₂O₃</td>
<td>6,25,000 tpa, 47-50 % Cr₂O₃</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cr/Fe: 2.6-3.0</td>
</tr>
<tr>
<td>OMC</td>
<td>Kaliapani</td>
<td>3,24,000 tpa, 30-35% Cr₂O₃</td>
<td>1,50,000 tpa, 52-55% Cr₂O₃</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cr/Fe: 2.5 &amp; above</td>
</tr>
</tbody>
</table>

Source: IBM Chromite Monograph
The Institute of Minerals & Material Technology (IMMT), Bhubaneswar (CSIR) conducted roasting studies for Tata Steel Ltd, Sukinda, to recover the chromite values from plant tailings and based on the results pilot plant column was designed & installed at the COB plant.

Laboratory tests indicated possibility of recovery of 44% Cr2O3 from a feed grade of 17- 18% Cr2O3.

Source: IBM Chromite Monograph
IBM has carried out a number of bench and pilot plant scale studies using these equipment. Salient achievements of Chromite beneficiation studies carried out during 2004 to 2012 are:

**Study 1:**

Pilot plant scale study on a ROM chromite ore sample from Sukinda mine, Jajpur District, Odisha for M/s Tata Iron & Steel Company Ltd, Dist. Jajpur, Odisha.

The sample assayed 38.15% Cr2O3, 14.60% Fe(T), 23.50% Al2O3, 2.98% Silica, 6.10% MgO, and 7.8% LOI. The process adopted comprises grinding at 28 mesh size followed by hydro - classification employing Floatex Density Separator and separate treatment of classifier overflow, underflow and regrinding of coarse (underflow) followed by gravity separation.

The composite concentrate assayed 54.03% Cr2O3, 11.46% Fe(T), 0.67% SiO2, 15.29% Al2O3, 7.95% MgO and 3.38% LOI with 82.2 % Cr2O3 recovery (Wt % Yield : 58.40) This concentrate is of very high grade and suitable for use in ferrochrome production.

*Source: IBM Chromite Monograph*
Study 2:

Bench scale beneficiation studies on chromite ore (sub-grade) sample from Sukinda, Jajpur District, Odisha for M/s Indian Metals & Ferro Alloys Ltd. (IMFA).

The received sample assayed CrO3 34.25%; Fe(T) 22.39%, Al2O3 14.57%; SiO2 5.90%; MgO 4.98%; CaO 0.28%; TiO2 0.35% and LOI 7.17% with an objective to develop bench scale beneficiation process flow-sheet for obtaining a marketable grade chromite concentrate (+48% Cr2O3).

The final chromite concentrate obtained assayed Cr2O3 50 to 52%, Fe(T) 15 to 16%, Al2O3 10 to 11%, SiO2 1.5 to 2.0% MgO, 6.5 to 7.0% and LOI 3 to 3.5% with overall Cr2O3 recovery of around 80% (Wt% yield 52 to 55). Thus the bench-scale beneficiation studies in IBM indicated that the sample is amenable to beneficiation and capable of producing a high/marketable grade chromite concentrate (+50% Cr2O3) with high Cr2O3 recovery (80%).

Source: IBM Chromite Monograph
Study 3:

Upgradation of Low Grade Dumped Chrome Ore

Chrome ore assaying 35 to 40% Cr$_2$O$_3$ are treated in the chrome ore beneficiation plant of M/s OMC to produce chromite concentrates assaying around 48-50% Cr$_2$O$_3$. Ores assaying 28-35% Cr$_2$O$_3$ generated during mining to the tune of 10 lakh tonnes are being stacked separately over the years as sub-grade material. IBM authorities in compliance with the Mineral Conservation Policy decided to take up beneficiation studies on this stacked subgrade material identified during the joint inspection by Ore dressing division and MCCM division.

The studies carried out in Modern Mineral Processing Laboratory and Pilot Plant at Nagpur indicated that from the dumped material assaying around 30% Cr$_2$O$_3$ a composite concentrate assaying 50-51% Cr$_2$O$_3$ could be produced with a Cr$_2$O$_3$ recovery of 75%, thus paving the way for the utilization of this sub-grade material for the production of marketable concentrate.

Source: IBM Chromite Monograph
CONCLUSIONS:

• The feed grade for COB at TSL currently ranges from 15 to 35%. As the lower fraction of concentrate product cannot be used stand alone for producing Ferro Chrome, So the concentrate is blended (to get an average of 2.4 to 2.6% Cr:Fe) before despatches.

• The lab test by IMMT indicated possibility of recovery of 44% Cr2O3 from a feed grade of 17-18% Cr2O3 which cannot be used as stand alone for producing Ferro Chrome grade chromite ore.

• For producing >59-60% Cr marketable Ferrochromie, chromite ore grade required is >47% Cr2O3 and >2.4 Cr/Fe as per studies by TSL R&D.
Based on the present exploratory data & statistical analysis, the distribution of Chrome ore in Sukinda Leasehold is given us under.

<table>
<thead>
<tr>
<th>GradeRange</th>
<th>Tonnage %</th>
<th>Cr2O3%</th>
<th>Fe %</th>
<th>SiO2%</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-15 %</td>
<td>0.73</td>
<td>13.41</td>
<td>8.71</td>
<td>23.79</td>
</tr>
<tr>
<td>15-20 %</td>
<td>2.26</td>
<td>17.57</td>
<td>9.45</td>
<td>22.20</td>
</tr>
<tr>
<td>20-25 %</td>
<td>5.34</td>
<td>22.72</td>
<td>10.79</td>
<td>21.22</td>
</tr>
<tr>
<td>&gt;25 %</td>
<td>91.68</td>
<td>43.70</td>
<td>11.29</td>
<td>11.57</td>
</tr>
<tr>
<td>Grand_Total</td>
<td>100.00</td>
<td>41.77</td>
<td>11.21</td>
<td>12.42</td>
</tr>
</tbody>
</table>
CONCLUSIONS: (contd.....)

• The majority of Chromite resources established in India under various categories is stratiform in nature (97%) and the Sukinda valley chrome ore has higher Fe% than any other deposits in the world due to limonite association.

• In South Africa and Turkey, low grade chrome ore have high Cr/Fe due to low Fe content and thus beneficiation is relatively easier compared to India, where more percentage of Fe needs to be separated from low grade chrome ore to make it beneficial.

• Also cut off grade for chrome ore in Kazakhstan and Turkey seems to be 20% as per findings.

• Different beneficiation studies carried out for Low grade Chrome ore indicate that Chrome ore with minimum 15% Cr2O3 can be beneficiated to >40%, which can be subsequently used by blending.

• Resource proportion of 10-15% Cr2O3 is very low as compared to the total resource in Sukinda.

• Currently the lowest grade produced in the world is 18% Cr2O3 (Alabania). The current Threshold value is much lower than the world average.
Thank You