Spent Pot Liner Utilization in Cement & Steel Industry

By: Nitin Kumar Tiwari
Head Planning & Waste Mgt -Metal Business
BALCO ,KORBA (C.G)
Balco’s Vision, Mission and Core Values

Vision
- To be a world class Integrated Aluminium and Power producer generating sustainable value for all stakeholders

Mission
- To be amongst top Decile in global cost curve
- Operational excellence
- Ensure resource security with efficient supply chain management
- Effective Collaboration with stakeholders
- Unleash employee potential
- Build and Strengthen brand equity

Core Values
- Excellence
- Speed
- Innovation
- Trust
- Growth
- Sustainability
Section View of Electrolytic Cell
SPL From Aluminium Smelter
SPL- Indian Scenario

- Average Annual Aluminium Production in India in last three years: 2.0 million tons

- SPL Availability in Aluminium plants:
  - **NALCO** - 4500-5000 TPA (Quantity of SPL lying at Smelter Plant: approx 65000 MT)
  - **BALCO** - 4000 - 5000 TPA
  - **VEDANTA (VAL)** - 10,000 TPA
  - **HINDALCO, Renukoot** - 6021 TPA
  - **Hirakud** - 4035 TPA
  - **Aditya** - 2610 TPA
  - **MAHAN** - 5400 TPA (Total HINDALCO - 18000 TPA)

- **Total availability in India** - 38000 TPA (In HINDALCO, Renukoot Plant- SPL is being reprocessed in cryolite recovery plant. In that case, the **Net Availability of SPL = 32000 TPA**)

- Gross Calorific Value (GCV) of SPL is around 3500-4300 kcal/kg

- Odisha and Chhattisgarh produces 80% of Aluminium in India and none of these states have incineration facility.
Indian Current Practices

- SPL co processing trial at ACL Bhatapara completed on 15.04.16 as per MOU signed between HOLCIM & BALCO.
- Ultratech Hirmi Works got permission of 2880 MT/Year SPL coprocessing from BALCO for 5 years.
- Ongoing development for Pilot study on SPL detoxification at JNARDDC with Vedanta.
- In HINDALCO, Renukoot Plant- SPL is being reprocessed in cryolite recovery plant.
- Small Quantity is being disposed off by Subhra Chemicals, Authorized reprocessor at Hirakud.
- Agreement with TSDF being finalized by some smelters.
- Secured Landfill practice as per CPCB design adopted by Aluminium plants.
Global Practices for SPL handling

**ALBA:**
- Waste refractory bricks are crushed and used as a substitute for alumina to obtain a flat horizontal cathode shell surface prior to the start of laying insulation bricks for pot re-lining.
- At Alba, 60,000 cubic metres of spent pot lining (SPL) waste that had been generated over the past years were subjected to physical segregation into four fractions namely steel, carbon blocks, refractory and insulation bricks, and the fine fractions which cannot be segregated. All the steel was sold to a steel recycling furnace adjacent to Alba. The carbon and refractory portions are now being recycled in ways that have been approved by the environmental authorities, and which generate a financial return, to the extent that Alba alone has saved over US$1 million in the process.

**ALCOA:**
- The multiple benefit of recycling SPL is both to eliminate landfill and extract the energy from it.
- Alcoa Fjardaál has a goal to recycle 100% of SPL generated in the smelter.

**EGA:**
- Spent pot lining (“SPL”) and carbon dust, both being forms of process waste generated in the reduction process, are recycled within the cement industry in UAE.

**RUSAL:**
- Spent potlining (SPL) trial taken for utilization. The behavior of cyanide and fluoride under high temperature treatment has been investigated. On the basis of this laboratory investigation, the possibilities for SPL utilization in red brick manufacturing, cement industry and thermal power stations are evaluated.
Section View of Cathode and Bottom Lining

SPL-- Cathode lining- 1st cut (Carbon Portion)

SPL--Refractory lining- 2nd cut (Refractory portion)
Section of lining of an aluminium pot during its dismantling (light line enhances carbon blocks)
No. of Large Cement Plants in India – 183
Production – 250 Million MT/Annum
Coal Consumption – 43 Million MT/Annum
Present SPL Generation – Balco + Vedanta – 15000 MT/Annum
    Nalco – 5000 MT/Annum
    Hindalco – 18000 MT/Annum
Total – 38000 MT/Annum

SPL Co-processing Requirement – 0.001 %
General Chemical Analysis :SPL

- For first cut material GCV varies from 3500 to 4500 Kcal/Kg

Table 1: Chemical composition of SPL

- HGI is 39 units.
- Total Fluorides 8-14%.
- Alumina – 16-20%.
- Sodium – 15%.
- SiO2 – 10%.
- Fe2O3 – 3%.
Advantages of SPL

The benefits of using SPL or SPL derivatives in cement kilns as an alternate fuel and raw material (AFR) have essentially consist of the following:

- First cut SPL contains sufficient carbon that it can be burnt as fuel and therefore reduce the consumption of primary fuel in the kiln.

- It has been found that fluoride is beneficial for reducing clinkering temperature by fluxing action (from 1450 deg C to 1350 deg C). Due to the presence of large quantities of lime and limestone within the kiln, virtually all gaseous fluoride is scrubbed from the kiln exhaust and fixed in the clinker as fluorspar (CaF2).

- Ammonia and cyanide from the SPL act to reduce nitrous oxide (NOX) emissions from the cement kiln by up to one-third, via the following reactions:
  Cyanide: $4\text{HCN} + 2\text{NO}_2 + 3\text{O}_2 \rightarrow 2\text{H}_2\text{O} + 4\text{CO}_2 + 3\text{N}_2$
  Ammonia: $4\text{NH}_3 + 2\text{NO}_2 + \text{O}_2 \rightarrow 3\text{N}_2 + 6\text{H}_2\text{O}$; $4\text{NH}_3 + 6\text{NO} \rightarrow 5\text{N}_2 + 6\text{H}_2\text{O}$.

- Refractory materials (silica, alumina) in the first and second cut SPL can substitute for these components in the cement kiln raw materials.
Table 2: Chemical composition of clinker

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Chemical composition (%)</th>
<th>Chemical Composition of Clinker (%) with</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>SPL</td>
<td>Raw Mix</td>
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<tr>
<td>---------------------------</td>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>LOI</td>
<td>27.20</td>
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<tr>
<td>SiO&lt;sub&gt;2&lt;/sub&gt;</td>
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<tr>
<td>Al&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;3&lt;/sub&gt;</td>
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<tr>
<td>Fe&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;3&lt;/sub&gt;</td>
<td>1.60</td>
<td>2.25</td>
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<tr>
<td>CaO</td>
<td>trace</td>
<td>42.94</td>
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<tr>
<td>MgO</td>
<td>trace</td>
<td>1.20</td>
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<tr>
<td>Na&lt;sub&gt;2&lt;/sub&gt;O</td>
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<td>0.15</td>
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<tr>
<td>K&lt;sub&gt;2&lt;/sub&gt;O</td>
<td>0.25</td>
<td>0.01</td>
</tr>
<tr>
<td>Cl</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>F</td>
<td>12.00</td>
<td>-</td>
</tr>
<tr>
<td>Al carbide &amp; nitrite</td>
<td>0.00</td>
<td>-</td>
</tr>
<tr>
<td>Cyanide</td>
<td>0.00</td>
<td>-</td>
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<tr>
<td>C&lt;sub&gt;3&lt;/sub&gt;S</td>
<td>39.48</td>
<td>40.30</td>
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<tr>
<td>C&lt;sub&gt;3&lt;/sub&gt;A</td>
<td>9.43</td>
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<td>C&lt;sub&gt;4&lt;/sub&gt;AF</td>
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<tr>
<td>Liquid</td>
<td>29.16</td>
<td>29.29</td>
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<tr>
<td>Free CaO</td>
<td>1.90</td>
<td>1.40</td>
</tr>
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</table>
1. The variation of free lime in clinker with varying dosage of SPL is given fig.1 which shows that free lime decreases with increasing SPL percentage. The Lowest free lime is found in presence of 2% SPL.

2. The decrease in free lime is attributed to mineralizing effect of SPL. It is well established that fluorine acts as mineralizer in clinkerization which reduces clinkering temperature and facilitates the oxides combination [2].

3. The fluoride present in SPL acted as mineralizer while burnt with cement raw mix and mineralizing effect was increases with increasing percentage of fluoride.

4. The increase of C3S content in clinker with increasing addition of SPL confirmed its mineralizing effect (Fig.2).

5. The fluorine content was determined in clinker increases with increasing SPL (Table-2) which indicates the absorption/entrapment of fluorine in clinker mineral phases.
1. The prepared clinker showed decrease in free lime in presence of SPL.
2. The fluorine present in SPL acts as mineralizer and reduces the free lime in clinker substantially.
3. The fluorine detected in clinker confirmed its assimilation as well as mineralizing effect and increases the $\text{C}_3\text{S}$ content in clinker.
4. The carbonaceous content of SPL is well burnt at higher temperature and provides additional heat to the system. The results shows that upto 2.0% SPL can be easily used as raw mix component without affecting the quality of clinker.
5. The utilization of SPL in cement manufacturing not only offers saving of fuel and conventional raw material depletion but also provides solution to environmental problem created by disposal of SPL in plant area.
6. SPL a national Challenge & being hazardous waste should be looked through holistic view rather as a business opportunity to make money.
7. In Indian context, with new thought coming in advocacy that SPL material having good calorific value must be used for the saving of natural resources to avoid its fast depletion rather wasting its fuel value through landfiling.
8. As per authors view, it must be put in CTO conditions for related industry to close the loop by using waste of one industry as resource for another as a governance.
9. Regulators must promote such industrial tie up promptly to attain better carbon foot prints in such industry through PAT Scheme with some percentage of hazardous waste utilization in plants through compliance of CTO terms & conditions.
In Global perspective, due to heat value & fluoride contents in SPL has given following gains in Cement Plants;

1. Approximately 5% saving by substituting primary fuel inputs due to carbon value utilization from SPL into the cement kiln. SPL should be fed through separate weighed system to fuel input stream.

2. Approximately 5% saving on primary fuel input by achieving equivalent clinker properties at reduced temperature. Due to fluxing property of fluorides present in SPL, it lowers the clinker temperature by 100 degree C.

- However, this effect is dependent on the sodium content of the clinker raw materials and how much additional sodium can be tolerated with the SPL addition. The sodium limit may prevent addition of sufficient fluoride to see this fluxing effect;

- The intake of spent anode butts will result in further, considerable savings on the energy input from primary fuel.

Study suggests total energy saving potential of about 10% for a cement kiln using SPL with 55% carbon content in the first cut material.
Pioneer/Path finder Plants for SPL Co Processing

- Cement Australia – Fisherman’s Landing Plant (Queensland): SPL derivative from the Comalco COMTOR SPL treatment plant at Boyne Smelter Limited Gladstone. Ongoing since July 2004;

- Blue Circle southern cement (BCSC) – Waurn Ponds Plant (Victoria): SPL derivative “Hi-Cal 50” from the Regain SPL treatment facility at Alcoa Aluminium Point Henry smelter Geelong. Ongoing since January 1998;

- Adelaide Brighton Cement Birkenhead Plant (South Australia): SPL derivative from Regain pilot plant at Tomago Aluminium Newcastle. Trial period 2001-2003;

SPL Management – The way forward..

- As nation is poised for inclusive growth, industries should work together to reduce use of natural resources by adopting “Reuse – Recycle – Reduce” philosophy.

- SPL usage can be a promising proposal for both Cement and Aluminium industry to optimize their cost and be competitive.

- SPL usage can reduce COP of cement making, reduce use of natural resources.

- Cement / Steel and Aluminium industry should join hands and work out a ‘win – win’ solution. A part of the savings out of SPL usage by Cement industry may be shared with aluminum industry to make the SPL utilization a viable solution.

- Storage of SPL is not a viable solution due to scarcity of storage space and threat to land and water contamination.
Thank You for your attention