Hirakud Smelter Journey

- 10 KTPA: 1959
- 24 KTPA: 1978
- 30 KTPA: 1990
- 65 KTPA: 2005
- 100 KTPA: 2007
- 164 KTPA: 2012
- 216 KTPA: 2014

Key Milestones:
- Old Soderberg Pot (HSS) at 55 kA
- Conversion to Prebake Potline at 85kA
- Brownfield Expansion: Addition of 80 pots at 235kA

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Hirakud Smelter

- Old end-to-end potline.
- Converted from Soderberg pots.
- High cost of metal production.
  - Low current efficiency ~93%
  - High DC energy ~14750kWh/ton

Important Aspect of Aluminium Smelter

1) Magnetohydrodynamic (MHD) stability
2) Heat balance of cell
Challenges to Overcome

Technological Challenges:

- Improper heat balance in the pot.
- Cold pot, sludge formation & high noise
- Unbalanced magnetics due to end-to-end potline.
  - Magnetohydrodynamics (MHD) instability – limits the anode-to-cathode (ACD) reduction.
- Constraint in pot controller logic.
- Lack of automation in all the shop floor activities

Solution Strategy:

- Brainstorming among team members & SWOT analysis.
- Three broad areas for improvement:
  - Heat Balance
    ✓ MHD Stability
    ✓ Other Areas
      ✓ Pot Control Logic
      ✓ Anode Assembly
  - Evaluate the design and process using validated computational models.
1. Sp. Energy Consumption in last 3 years

AC SEC (MTOE/MT)

- FY-16: 4.57
- FY-17: 4.44
- FY-18: 4.47
- FY'19(Q1): 4.44

Figures are reported as per Form-1 which includes CPP as well.

Smelter AC SEC (KWH/MT)

- FY'16: 15808
- FY'17: 15762
- FY'18: 15479
- FY'19(Q1): 15360
2. Competitors, National & Global benchmark

Smelter SEC (GJ/MT)

<table>
<thead>
<tr>
<th></th>
<th>FY'16</th>
<th>FY'17</th>
<th>FY'18</th>
<th>FY'19(Q1)</th>
<th>Hindalco(Aditya)</th>
<th>World</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>56.912</td>
<td>56.745</td>
<td>55.728</td>
<td>55.299</td>
<td>49.26</td>
<td>41.9</td>
</tr>
</tbody>
</table>

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### 3a. Energy Saving projects implemented in FY 2015-16

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Description</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Feeding Potline#1 from RS#2</td>
<td>7425000 KWH</td>
</tr>
<tr>
<td>2</td>
<td>Replace CT Fan blades from Aluminum to FRP in Smelter CT</td>
<td>10600 KWH</td>
</tr>
<tr>
<td>3</td>
<td>Optimize oxygen level in Furnaces</td>
<td>350 KL</td>
</tr>
<tr>
<td>4</td>
<td>Reduction of Lighting Voltage in Smelter RS # 3 and RS # 4</td>
<td>219000 KWH</td>
</tr>
<tr>
<td>5</td>
<td>Current density equalization by anode change for saving 20 mv/pot</td>
<td>6360000 KWH</td>
</tr>
<tr>
<td>6</td>
<td>Completion of RS#2 sixth Unit</td>
<td>492750 KWH</td>
</tr>
</tbody>
</table>

Total Investment for the energy saving projects- Rs.47.7 Million
Total Energy Savings - Rs. 66.97 Million per annum
3b. Energy Saving projects implemented in FY 2016-17

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Description</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Use of new design copper inserted collector bar to save 70 mv/pot(72 pots/yr)</td>
<td>260610 KWH</td>
</tr>
<tr>
<td>2</td>
<td>Cathode lining optimization to reduce 25 mv / pot(72 pots/yr)</td>
<td>1340280 KWH</td>
</tr>
<tr>
<td>3</td>
<td>Install FTP fan with VFD in FTP 1</td>
<td>2190000 KWH</td>
</tr>
<tr>
<td>4</td>
<td>Energy reduction in Anode Assembly (Yoke to Carbon Drop) and design change of depth of stub hole to reduce 10 mv/pot</td>
<td>1608336 KWH</td>
</tr>
</tbody>
</table>

Total Investment for the energy saving projects - Rs.12.5 Million
Total Energy Savings - Rs. 16.52 Million per annum
### 3c. Energy Saving projects implemented in FY 2017-18

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Description</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Use of new design copper inserted collector bar to save 70 mv/pot(72pots/yr)</td>
<td>1563660 KWH</td>
</tr>
<tr>
<td>2</td>
<td>Cathode lining optimization to reduce 25 mv / pot(72pots/yr)</td>
<td>1340280 KWH</td>
</tr>
<tr>
<td>3</td>
<td>Replacement of RS-III CT cold well pumps with Energy Efficient Pumps</td>
<td>350400 KWH</td>
</tr>
<tr>
<td>4</td>
<td>Energy reduction in Anode Assembly (Yoke to Carbon Drop) and design change of depth of stub hole to reduce 10 mv/pot</td>
<td>3909150 KWH</td>
</tr>
<tr>
<td>5</td>
<td>Current density equalization by anode change for saving 20 mv/pot</td>
<td>7818300 KWH</td>
</tr>
</tbody>
</table>

**Total Investment for the energy saving projects - Rs.16.67 Million**

**Total Energy Savings - Rs. 55.78 Million per annum**
Vision 2020 for Hirakud Smelter

- Improvement in MHD Stability through Busbar for 400 kWh/ton
- Improvement in Anode Assembly & Pot Control for ~100 kWh/ton
- Improvement in Heat Balance for ~300 kWh/ton
- Improvement in MHD Stability through Cathode & CB for 500 kWh/ton

Target of Hirakud Smelter ~13400 DC-kWh/ton

2015: 14750 kWh/ton

2016:
- Improvement in Heat Balance for ~300 kWh/ton

2017:
- Improvement in MHD Stability through Cathode & CB for 500 kWh/ton

2018:
- Improvement in MHD Stability through Busbar for 400 kWh/ton

2020:
- Improvement in Anode Assembly & Pot Control for ~100 kWh/ton
- Improvement in Heat Balance for ~300 kWh/ton

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Cu-Insert Collector Bar (CuCB):
+ Reduce cathode voltage drop by ~40 mV
+ Improves current distribution
+ Potential for reducing ACD voltage ~120 mV

- Reduced heat generation
- Increased heat loss from collector bar

✓ Cell lining modified to ensure heat balance

Patent filed on novel design of CuCB -- 2700/MUM/2014
Innovative Project: 1. Cu-Insert Collector Bar (CuCB)

- After successful trial of 5 pots in June’16, now operating 48 pots till date with CuCB.
- Reduced voltage noise level from 30 mV to 25 mV.
- Pots running at average set voltage of 4.28 offering specific energy around 13800 kWh/ton.
- ROI is less than 2 years

**Pot lining for CuCB**

- Reduced energy requirement by ~510 kWh/ton
- First time in any smelter of India
- First time in any low amperage smelter worldwide*

*Based on the information available
**Innovative Project: 2. Cell Lining Design**

**Cell Lining Design**
- ✓ Reduced & modified heat loss distribution from side.
- ✓ Improved ledge/freeze profile.
- ✓ Improved cathode temperature.

![Existing cell lining](image1)

![Modified cell lining](image2)

**Existing cell lining**

**Modified cell lining**

**Cathode block temperature (°C) with existing cell lining**

**Cathode block temperature (°C) with existing cell lining**

---

**No additional Cost Involved in new relined 256 pots**

**Reduced energy requirement by ~80 kWh/ton**
Achievements & Target

- Realized saving of 350 kWh/ton from 14750 DC-kWh/ton with partial implementation.
- 32 pots started for an year, consistently demonstrated SEC ≈ 13800 DC-kWh/ton.
- Patent has been filed on the novel design of copper-insert collector bar.

Realized Saving ~26 Cr/year
Total Benefit Potential ~68 Cr/year

(energy saving 915 kWh/t, energy cost INR 3.7 per kWh, annual production 200 kt).
We were forced to stop 1 pot line out of 5, resulting 30% reduction in the metal production.

High Metal Cost
High Power cost led to shooting up of metal cost from Rs.103000 to Rs. 132000 per MT.

Global Scenario
LME plummeted from $2800 to $1418 for per ton of Aluminium

Rise in Power Cost
110% increase in power cost from Rs.1.76 to Rs.3.71 per kwh.

High Metal Cost Questioned the Viability of FRP
China increased dumping its low cost aluminium from 30% to 50%.

Chinese Threat
More players in market like Madein aluminium, Sohar expansion

Line#2 Shutdown
More players

Viability of FRP
High metal cost questioned the viability of FRP

Global Scenario
Rise in Power Cost
High Metal Cost
Chinese Threat
Viability of FRP
Line#2 Shutdown
More players

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Innovative Projects 3: DC Busbar Connectivity

EXISTING 132kV MRS

132kV RS#1

132kV RS#2

132kV RS#3

132kV RS#4

100MW U#1

100MW U#2

100MW U#3

100MW U#4

GRID

GRID

GRID

GRID

P/Line-1: 70MW

P/Line-2: 70MW

P/Line-3: 70MW

P/Line-4: 70MW

P/Line-5: 90MW

GRID: 100MW

GRID: 100MW

GRID: 100MW

GRID: 67.5MW

U#1: 100MW

U#2: 70MW

U#3: 70MW

U#4: 70MW

U#5: 100MW

132kV: 132kV RS#1

132kV: 132kV RS#2

132kV: 132kV RS#3

132kV: 132kV RS#4

52T

33kV

11kV

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Integrity

Commitment

Passion

Seamlessness

Speed
Innovative Projects 3: DC Busbar Connectivity

System stability due to Fast response facility in RS-1

- Why C/L of PL#1 is higher
- Why PL#2 switched off instead of PL #1
- Is it not possible to get system stabilize through other pot lines

What is the solution

Huge energy saving potential by Connecting pot line 1 through RS#2

What are the challenges

- Very old station
- Technological limitation,
- 11 KV system,
- Thyristor Technology

Brainstorming

P/Line-1
P/Line-2
P/Line-3
RS#1
RS#2

Innovative Projects
Innovative Projects3: DC Busbar Connectivity

Step 1
• Necessary trial for Fine control” operation of diode units

Step 2
• Hardware modification in all the diode based units for CILMS connectivity.

Step 3
• Expediting the remaining old unit replacement in RS-2 for P/Line-2

Step 4
• Developing logic for counter balancing the advantage of fast load sharing through Rectifier Station-1.

Step 5
• Establishing confidence through multiple test and trials before put into operation.

Step 6
• Arrangement of DC Bus-bar connectivity through the limited space in Pot Room.

Step 7
• Implementing necessary modifications to have operational control of potline-1 at Rectifier station-2
With this Transductor control load reduction requirement has been distributed in all pot lines in comparison to the reduction in only line 1 as early case. There by impact on particular Potline has been reduced significantly.
Innovative Projects 3: DC Busbar Connectivity

During DC Busbar Erection

After DC Busbar Erection

Integrity
Commitment
Passion
Seamlessness
Speed
© Confederation of Indian Industry
Innovative Projects3: DC Busbar Connectivity

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layout finalization in running pot room</td>
<td></td>
</tr>
<tr>
<td>Designing of Busbar and supporting arrangement</td>
<td></td>
</tr>
<tr>
<td>Laying of Bus-bar in areas having space constraint. (Material lifting vehicle restricted zone)</td>
<td></td>
</tr>
<tr>
<td>Welding of Aluminum busbar in High Magnetic Field</td>
<td></td>
</tr>
<tr>
<td>Manual shifting of materials in absence of space for material handling equipment's in high magnetic field</td>
<td></td>
</tr>
<tr>
<td>Job execution near live DC busbar</td>
<td></td>
</tr>
<tr>
<td>Incorporation of Transductor control</td>
<td></td>
</tr>
<tr>
<td>Project completion within a short span i.e. 3 months</td>
<td></td>
</tr>
<tr>
<td>Completing the Project with bare minimum Outage in P/Line</td>
<td></td>
</tr>
</tbody>
</table>
Innovative Projects3: DC Busbar Connectivity

- In-house Expertise from M/s HIL, Renukoot for bus bar design
- Engagement of Plant Cross-functional teams
- Welding of Aluminum busbar in High Magnetic Field with high insulation and Faraday box
- Meticulous planning and Procurement of material with support from purchase team
- Round the clock execution of the job for minimizing project time
- Changeover is done in bare minimum time of 50 mnts with proper planning & coordination

Execution of the project by existing O&M team without engagement of any external agency
Innovative Projects3: DC Busbar Connectivity

<table>
<thead>
<tr>
<th>Reduction in conversion Loss (DC Bus bar Connectivity between RS2 to ine1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conv Loss Before Implementation kWh/MT</td>
</tr>
<tr>
<td>Conv Loss After Implementation kWh/MT</td>
</tr>
<tr>
<td>Savings kWh/MT</td>
</tr>
<tr>
<td>Avg. Production/mth MT</td>
</tr>
<tr>
<td>Saving/Year kWh</td>
</tr>
<tr>
<td>Variable Power Cost per unit INR</td>
</tr>
<tr>
<td>Total Saving in INR (Crores) INR</td>
</tr>
<tr>
<td>Project Cost in INR (Crores) INR</td>
</tr>
<tr>
<td>IRR %</td>
</tr>
<tr>
<td>Pay Back Months</td>
</tr>
</tbody>
</table>

Now Power cost has raised to Rs.3.7 in FY’18 And revised saving is 2.75 Cr
Innovative Projects 3: DC Busbar Connectivity

**Specific Energy Consumption (kWh/MT)**

- Fy-15: 15339
- Fy-16: 14802
- Fy-17: 14839
- Fy-18: 14722
- Fy-19 (P&B): 14626

**Conversion Loss (KWH/MT)**

<table>
<thead>
<tr>
<th>Month</th>
<th>kWh/MT 2015-16</th>
<th>kWh/MT 2016-17</th>
<th>kWh/MT 2017-18</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>585.14</td>
<td>373.63</td>
<td>272.64</td>
</tr>
<tr>
<td>May</td>
<td>570.86</td>
<td>389.75</td>
<td>247.97</td>
</tr>
<tr>
<td>Jun</td>
<td>562.68</td>
<td>374.43</td>
<td>265.01</td>
</tr>
<tr>
<td>Jul</td>
<td>617.56</td>
<td>368.17</td>
<td>261.49</td>
</tr>
<tr>
<td>Aug</td>
<td>618.91</td>
<td>355.66</td>
<td>265.65</td>
</tr>
<tr>
<td>Sep</td>
<td>512.79</td>
<td>370.17</td>
<td>248.94</td>
</tr>
<tr>
<td>Oct</td>
<td>579.85</td>
<td>377.28</td>
<td>251.04</td>
</tr>
<tr>
<td>Nov</td>
<td>598.46</td>
<td>339.12</td>
<td>255.20</td>
</tr>
<tr>
<td>Dec</td>
<td>607.67</td>
<td>422.96</td>
<td>231.55</td>
</tr>
<tr>
<td>Jan</td>
<td>548.96</td>
<td>348.66</td>
<td>224.02</td>
</tr>
<tr>
<td>Feb</td>
<td>348.74</td>
<td>317.37</td>
<td>212.36</td>
</tr>
<tr>
<td>Mar</td>
<td>361.40</td>
<td>276.92</td>
<td>221.44</td>
</tr>
</tbody>
</table>
Replicability & Sustainability of Gain

• DC bus bar connectivity can be replicated in any smelter plant in the world having number of units with thyristor control rectifier facility.

• Design solutions (CuCB) planned to be replicated (with customization)
  – Hirakud 235 kA smelter – 3 pots started in Apr’18.
  – Mahan AP36 (365kA) smelter – 1 pot started.

• Sustainable solutions for future
  – Step energy reduction by modifying the design.
  – Shifting the operational operating window for the process parameters.

• Enabling future improvements
  – Knowledge gained and better knowhow of the process.
  – Modify busbar configuration for improving the flow profile & MHD stability to achieve 13400 DC-kWh/ton.
5. Utilisation of renewable energy sources

➢ Established in the year 1958 and with continuous capacity enhancement in limited space, focus was on survival only, therefore no actions could be taken on Renewable Energy Sources.

➢ However we purchase REC’s as a part of RPO obligations
6. Utilisation of waste material as fuel

Uses of waste wood for bath recovery in calciner.

Uses of used carbon anode butt for metal recovery from Dross (First time in India).
7. GHG Inventorisation

GHG (tCO2/t) inclusive of CPP

<table>
<thead>
<tr>
<th>FY-16</th>
<th>FY-17</th>
<th>FY-18</th>
<th>FY'19(Q1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.92</td>
<td>20.36</td>
<td>19.82</td>
<td>19.60</td>
</tr>
</tbody>
</table>

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8. Green Supply Chain

Initiatives taken in supply chain to reduce energy consumption

- Alumina used in the process is transported by rakes.

- Anodes used in the process is purchased from Aditya which was earlier imported from China.

- No loading/unloading vehicle is entered in the plant premises without valid pollution certificate.
9. Team work, Employee Involvement & Monitoring

1. We monitor SEC in terms of ACE, DC, Conversion Loss, FTP & Auxillary on daily basis.

2. Review meeting chaired by Mr. J. P. Nayak (Smelter Head) monthly.


4. Energy efficiency / awareness training program at Business, Cluster as well as Plant Level organised by Corporate Energy cell and Plant Energy cell.

5. Projects are being implemented through Kaizens (Workers and Supervisor level)
   - Timer control of Plant Lighting
   - Occupancy Sensor for offices.
Daily Energy Monitoring

### ABSOLUTE ENERGY (KWH)

<table>
<thead>
<tr>
<th>AC Energy</th>
<th>AC For Electrolysis</th>
<th>DC Energy</th>
<th>Conversion loss</th>
<th>FTP Energy</th>
<th>Total Auxiliary</th>
<th>Cast House</th>
<th>Total aux excluding cast house</th>
<th>Potline Average DC Voltage in Volts</th>
<th>Potline Average DC Current in kA</th>
<th>Metal Production in KG</th>
</tr>
</thead>
</table>

### SPECIFIC ENERGY (KWH/MT)

<table>
<thead>
<tr>
<th>AC Energy</th>
<th>AC For Electrolysis</th>
<th>DC Energy</th>
<th>Conversion loss</th>
<th>FTP Energy</th>
<th>Total Auxiliary</th>
</tr>
</thead>
</table>

### Cast House Daily MIS Format

<table>
<thead>
<tr>
<th>Date</th>
<th>Production(T)</th>
<th>FRP scrap(T)</th>
<th>Process scrap(T)</th>
<th>Hot metal(T)</th>
<th>FO Consumption(KL)</th>
<th>Solid Ratio (%)</th>
<th>Sp fuel consumption(L/T)</th>
<th>Remarks</th>
</tr>
</thead>
</table>

We monitor the absolute as well as the specific energy consumption daily & monthly for all the potlines as well as total plant.
# Budget for Energy Conservation - Galaxy -2 Projects

<table>
<thead>
<tr>
<th>S No</th>
<th>Details of initiatives</th>
<th>Responsibility</th>
<th>Start Date</th>
<th>Date of Completion</th>
<th>Annualized Savings</th>
<th>Cost Involved</th>
<th>Action Plan</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Copper insertion</td>
<td>Mahesh Sahoo/Ravi Pandey/Amit Panda/Sunil Shadangi</td>
<td>May-18</td>
<td>May-23</td>
<td>220 Kwh/T</td>
<td>Rs 1.88 Cr</td>
<td>One more vendor to be developed/visit to the TIL by Mr Mahesh &amp; Mr Amit Panda by March 18</td>
<td>In the month of March &amp; April 5 pots per month relining will be done and from May onwards in all relining pots</td>
</tr>
<tr>
<td>2</td>
<td>Modified anode with yoke</td>
<td>Bappadaitya/Sanjay Maharana/Sanjeeb Behera/Pratap Sahoo/Amit Panda/Parmarth Rai/Vinit Sinha/Sunil Shadangi</td>
<td>Apr-18</td>
<td>Jul-18</td>
<td>200 Kwh/T</td>
<td>Rs 9.20 Cr</td>
<td>7 modified pots to be started by 7th April and to be validated by 7th May and commercial team to visit the site to understand the practical execution Meeting to be done by task force to be done for freezing all the related requirements and to be submitted by April first week</td>
<td>After validation by 7th May to be incorporated in all the pots, the new mold design to be given and modification in olk in the mass level to be started, by 15th july incorporation to be started in all pots</td>
</tr>
<tr>
<td>3</td>
<td>Cathode sealing by cast iron pouring</td>
<td>Ranjan Mishra/Chinmaya Sarangi/Parmarth Rai/Amit Panda/Sunil Shadangi</td>
<td>Apr-18</td>
<td>May-23</td>
<td>60 Kwh/T</td>
<td>Rs 45 Lacs</td>
<td>By 20th March 3 additional fixtures to be made ready with that total availability of fixtures will be 7 2 shift operation for cathode sealing at Aditya to be started after 20th March PO for cast iron to be released by 18th March considering requirement of 6 months and opting staggered delivery</td>
<td></td>
</tr>
</tbody>
</table>
We are in the process of implementing ISO:50001, the first awareness & implementation training is to be held at Hirakud from 19th September’18 to 22nd September’18.

24.41% investment on Energy Saving projects on turnover in FY’18
Second runners up of ABG STRIDE-2018 (Worldwide ABG competition on Energy Conservation)

Winner of Eastern zone “REPRISM” 2017 ABG Manufacturing and was also selected in top 20 (Worldwide Competition)
THANK YOU