



Best Practices on Energy Conservation

– Hindalco , Renukoot

Third Task Force Workshop
for Aluminium Sector

– Bureau of Energy Efficiency

Improved Energy Efficiency Through
Slotted Anode

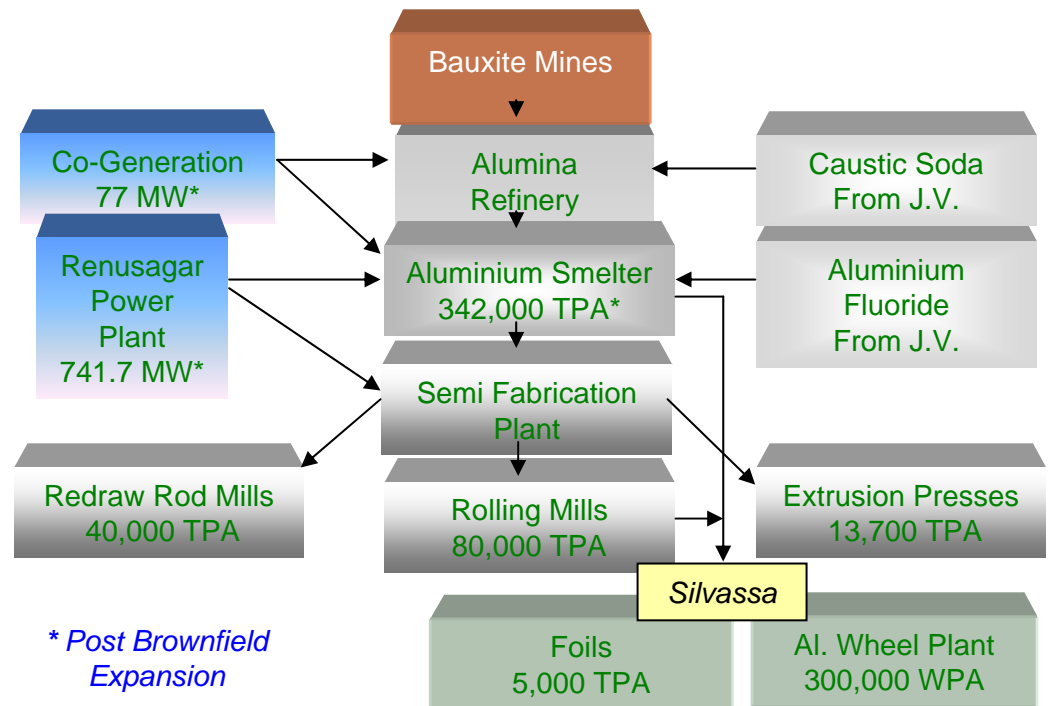


Hindalco Renukoot

– A Journey

1962▶	2005
20,000 MTPA	Production Capacity	342,000 MTPA
18.5 kWh/kg	Energy Consumption	13.998 kWh/kg

Largest Integrated Aluminium Plant
- India



Improved Energy Efficiency Through
Slotted Anode



Hindalco Renukoot -An Overview

8358 workmen, 4109 staff

ISO 9000:2000 - July'1994

ISO 14001 – Apr'1998

OHSAS 18001 - Jan'2003

Integrated Operations

Continuous Improvement
Through WCM

2500 customers

(150 international clients,
41 countries)

Improved Energy Efficiency Through
Slotted Anode



Energy Conservation Path

- Technology Upgradation
- Energy Management System
- Energy Audits
- Continuous Benchmarking
- Review

Improved Energy Efficiency Through
Slotted Anode



Improved Energy Efficiency through slotted anode

- A Case study

Improved Energy Efficiency Through
Slotted Anode

19th August 2005

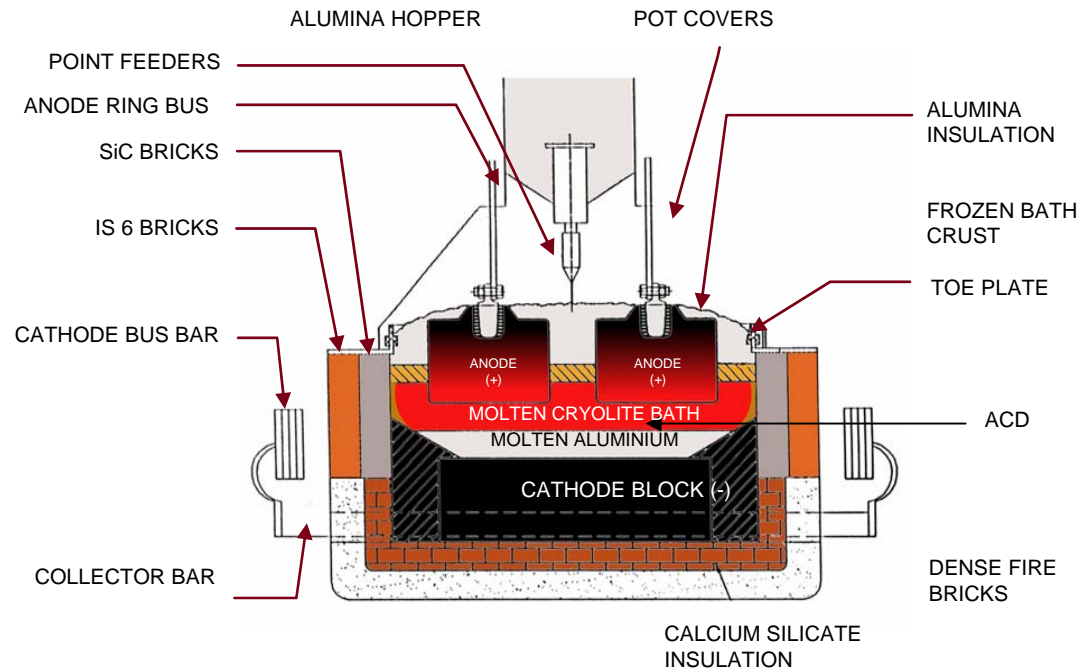
Plant Process - The Basics

Hall-Heroult Process

Pots – 2067

Potrooms – 22

Potlines - 11



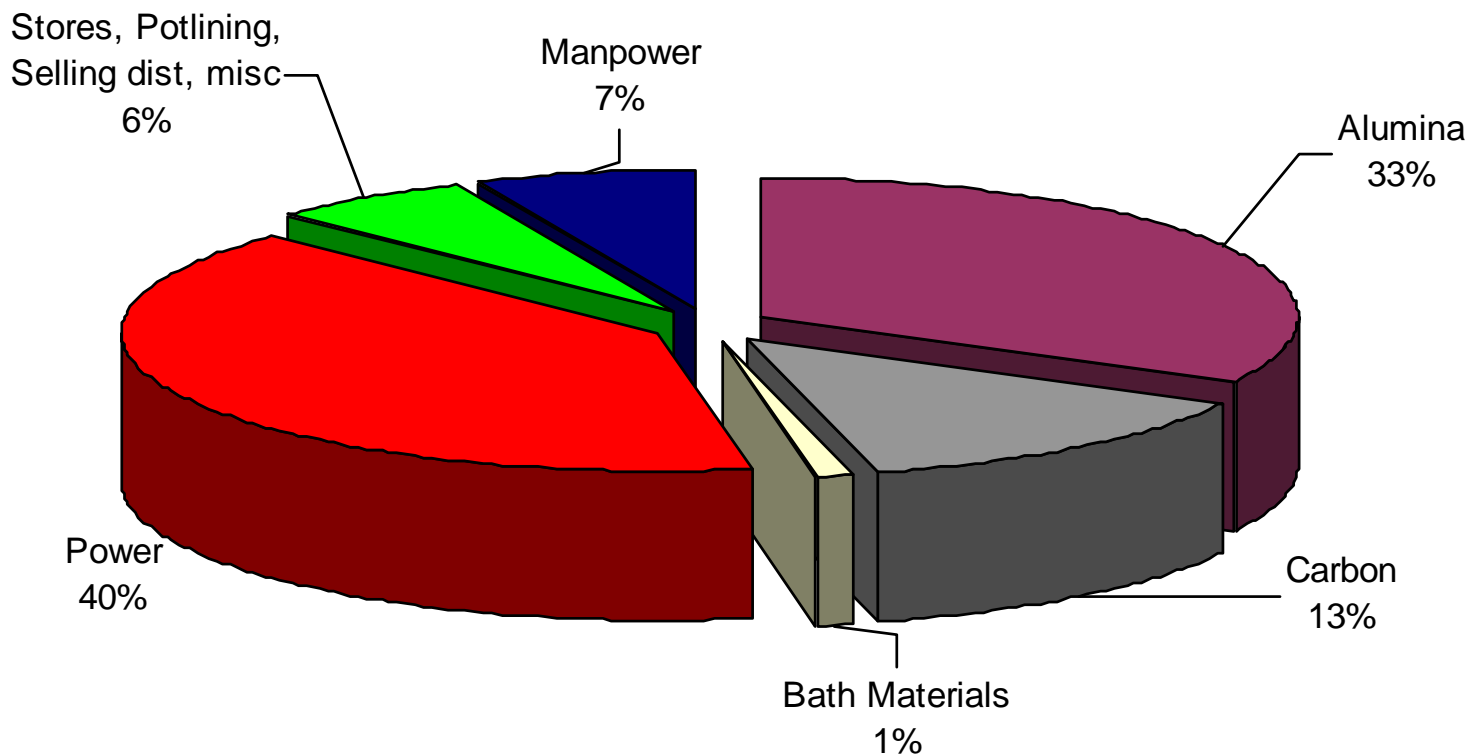
Typical Hindalco Pot

Improved Energy Efficiency Through
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Scope of Improvement

Power consumption (DC KWH/Kg AI)

$$= \frac{298.06 \times \text{Pot Voltage} \downarrow}{\text{Current Efficiency (\%)} \uparrow}$$



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Pot Voltage drop breakup

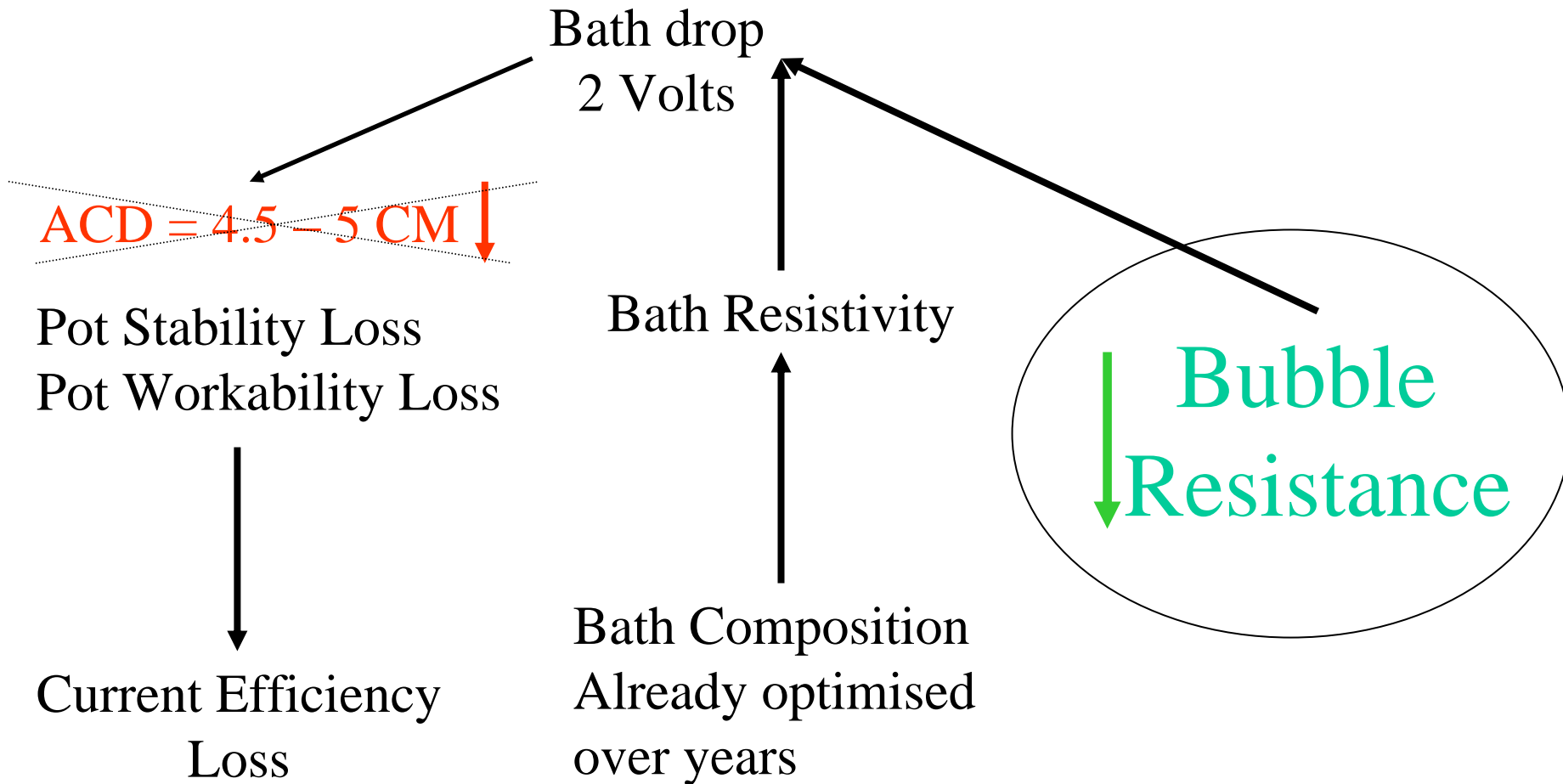
S.N.	DESCRIPTION	VOLTAGE	REMARKS
1	ANODE + CATHODE RING BUS DROPS	0.120	OPTIMIZED BY INCREASING CROSS-SECTION OF BUS BARS
2	DIAMOND DROP	0.003	MODIFIED SHAPE OF DIAMOND
3	CLAMP DROP	0.006	IMPROVED CLAMPING
4	CU-ROD DROP	0.015	IMPROVED CU-BAR THICKNESS FROM 1" TO 1.5"
5	ROD-STUB DROP	0.017	CHANGEOVER FROM NUT BOLT ASSEMBLIES TO WELDED ASSEMBLIES
6	STUB-CARBON DROP	0.126	INCREASED STUB DIAMETER TO 130 MM
7	CARBON BLOCK DROP	0.135	CARBON QUALITY OPTIMIZATION
8	BATH DROP	2.090	MODIFIED BATH CHEMISTRY OPTIMIZATION OF ACD
9	DECOMPOSITION VOLTAGE DROP	1.60	THERMODYNAMIC VOLTAGE
10	LINING DROP	0.328	OPTIMIZATION OF CATHODE CONSTRUCTION
11	BASE VOLTAGE OF A POT	4.440	TYPICAL FOR HINDALCO CELLS
12	EXTERNAL & OTHER FIXED DROPS	0.055	EXTERNAL BUS BAR, CENTRE PASSAGE & OTHERS
13	TOTAL GROSS VOLTAGE/POT	4.495	RECTIFIER TO RECTIFIER

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Slotted Anode

Gains Possible

- Save 0.10 V / Pot → **Save 325 kWh / Ton** (94% current efficiency)
- 342000 MTPA x 325 kWh/Ton x Rs.1.484/kWh → **Rs. 1650 lacs per annum**
- 342000 MTPA x 325 kWh/Ton → **111.15 mU** → Power saved
- $(111.15\text{mU}/14.3 \text{ kWh/Kg}) \times 10^{-3} \times 10^6 \rightarrow$ **7773MT** → Increased Production
- Gain 7773 MT x 32000 /MT → **Rs. 2487 lacs / annum**

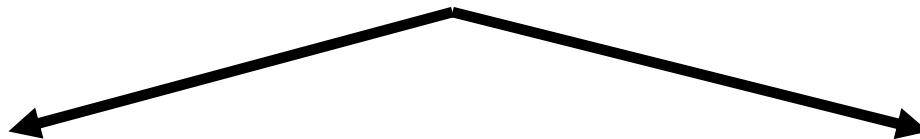
Margin for Improvement



Improved Energy Efficiency Through
Slotted Anode

The Idea

DR. S. WILKENING VISITS HINDALCO



- Idea Captured – Use slotted anode to reduce bubble resistance
 - Could not provide information of exact configuration
-
- **TASK FORCE FORMED: -**
 1. Mr. SC Tandon (Leader)
 2. Mr. OP Srivastava
 3. Mr. Arun Kumar
 4. Mr. SC Mishra
 5. Dr. RN Prasad
 6. Mr. VK Bajoria
 7. Mr. Rajesh Garg (Coordinator)
 8. Mr. Ranmal Singh



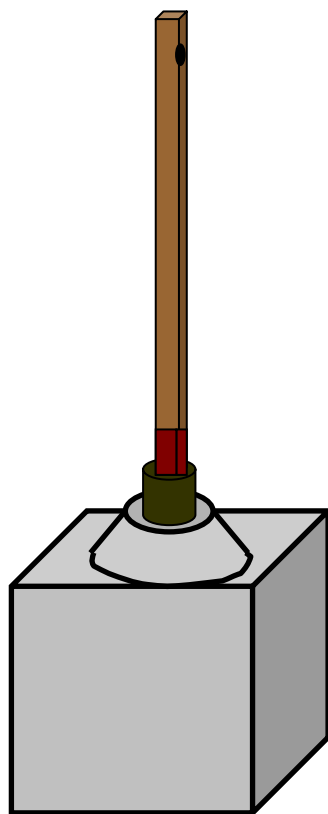
Way forward - Brainstorming

- Slot configuration
- Slot creation methodology
- Scope, size and duration of experimentation
- Strategy to be followed and parameters to be observed.

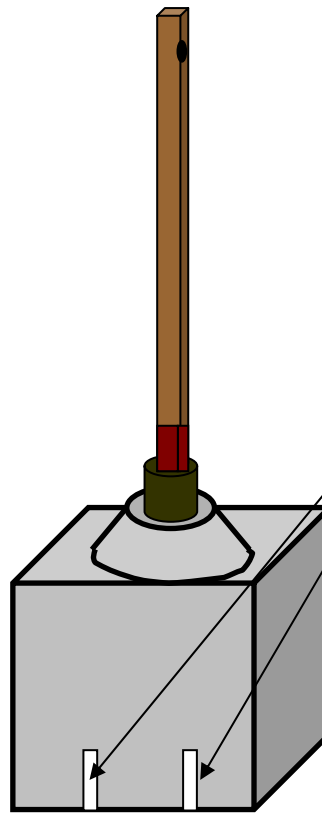
Brainstorming Solutions

- Lengthwise slot advantageous but difficult to produce
 - produce widthwise slot.
 - Look at possibilities for creating lengthwise slots.
- Initially create slots manually
- Limited slotted anode so experiment in 2 pots
- Pot voltage reduction
 - in steps of 0.010 volts/pot
 - Monitor pot performance during / after each anode cycle (25 days)
 - Pot voltage, noise, butt area, butt thickness, search time, current efficiency to be monitored for overall gains.

The modification



Original anode



Slotted anode

Slots, 2 Nos.
Height – 130 mm,
Width-13 mm

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The Journey of Slot creation

2 pots → potline #2 → Constraint faced → cutting slot in workshop

Solution: Slot cutting in sample cutting m/c of carbon testing lab

Widthwise 2 slots 10 cm high → Final height 13 cm [Bath ht. (18cm) – ACD(5cm)]

Pilot project after initial success → 18 cells (Potline #2)

Solution: - Use anode hydraulic press by putting 2 plates of the size of slots.

Total Time: - 2 years → Savings established : - 0.044volts/pot

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Results

Month	Avg Volts/pot for Balance Cells of line-2 with Normal anodes	Average Volts/pot for 18 pots with Slotted anodes	Saving
Aug-00, As-Is	4.598	4.498	Before using slotted anodes in pots D19 to D36
Average Sep-00 – Mar-01	4.569	4.438	0.031
Average 2001-02	4.539	4.404	0.035
Average 2002-03 (Apr-Aug)	4.569 *	4.425 *	0.044

• *Power Severity Index increased from 5.0 during FY01-02 to 5.64 during FY02-03*

Other operating parameters were also monitored for experimental pots, no significant change/deterioration was observed.

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Way forward – Mass Implementation

Mass production in hydraulic press
not possible due to high rate of rejection

Length wise slots
not possible in
Hydraulic press

Constraints Observed

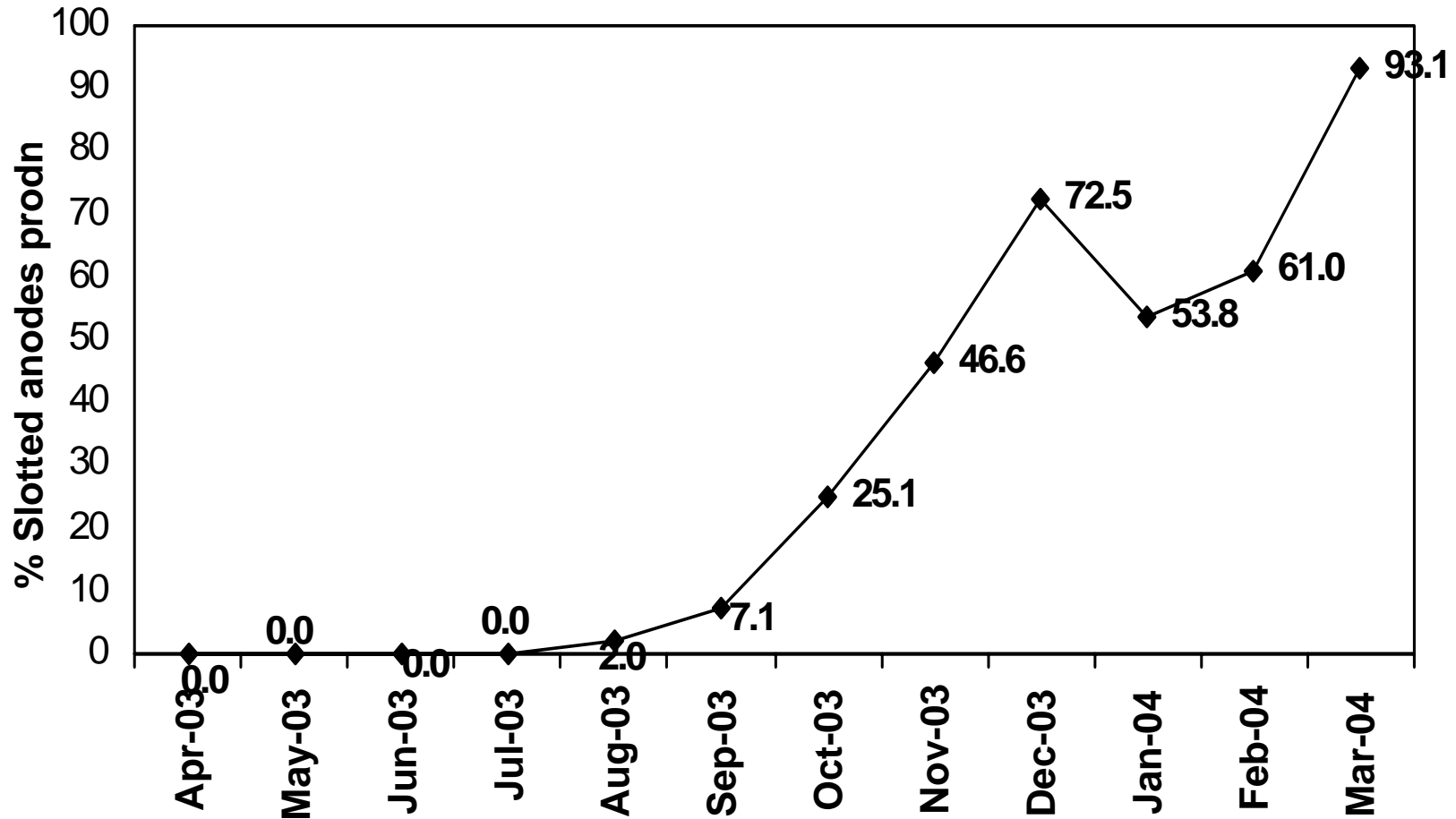
Difficulty in cleaning
of slots after baking

Voltage reducing strategy
on mass scale?

- Solution: - Vibro Compactor (w.e.f. Aug'03)



Slotted Anode Production - Vibro compactor



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Live Implementation

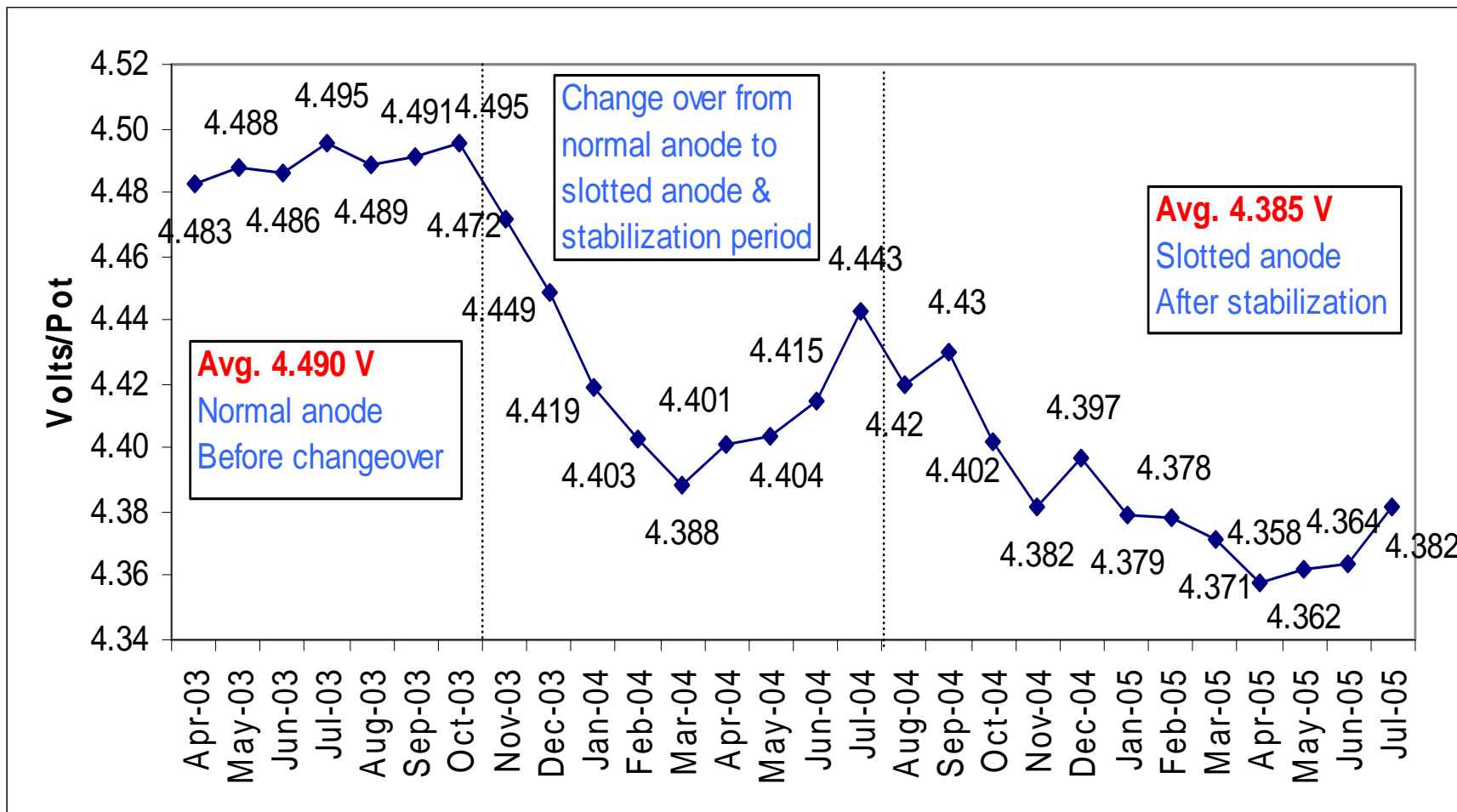
(Voltage reduction)

Experimentation: - 0.01 volts/pot



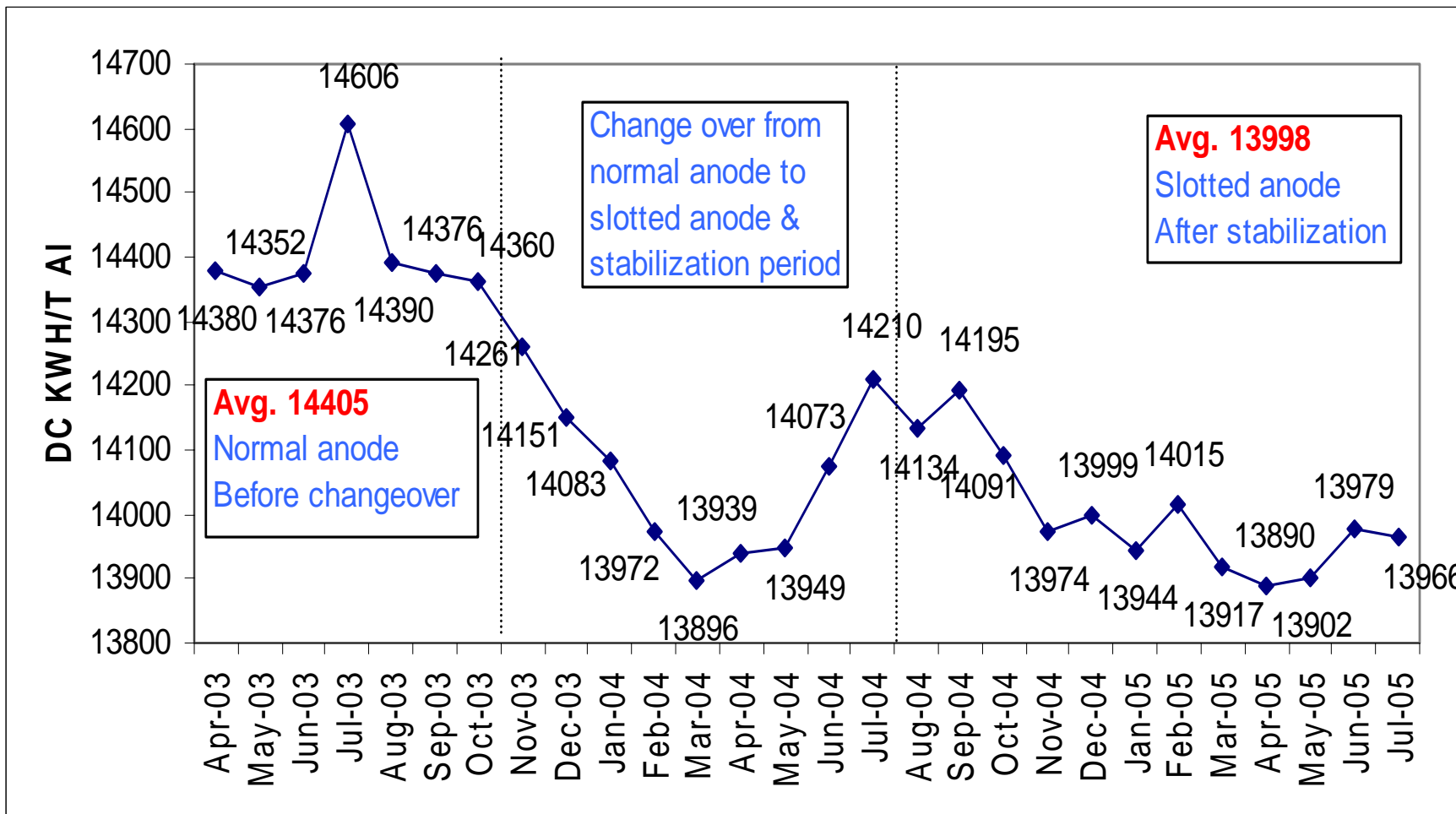
Live: - As high as 0.05 volts/pot

The Impact



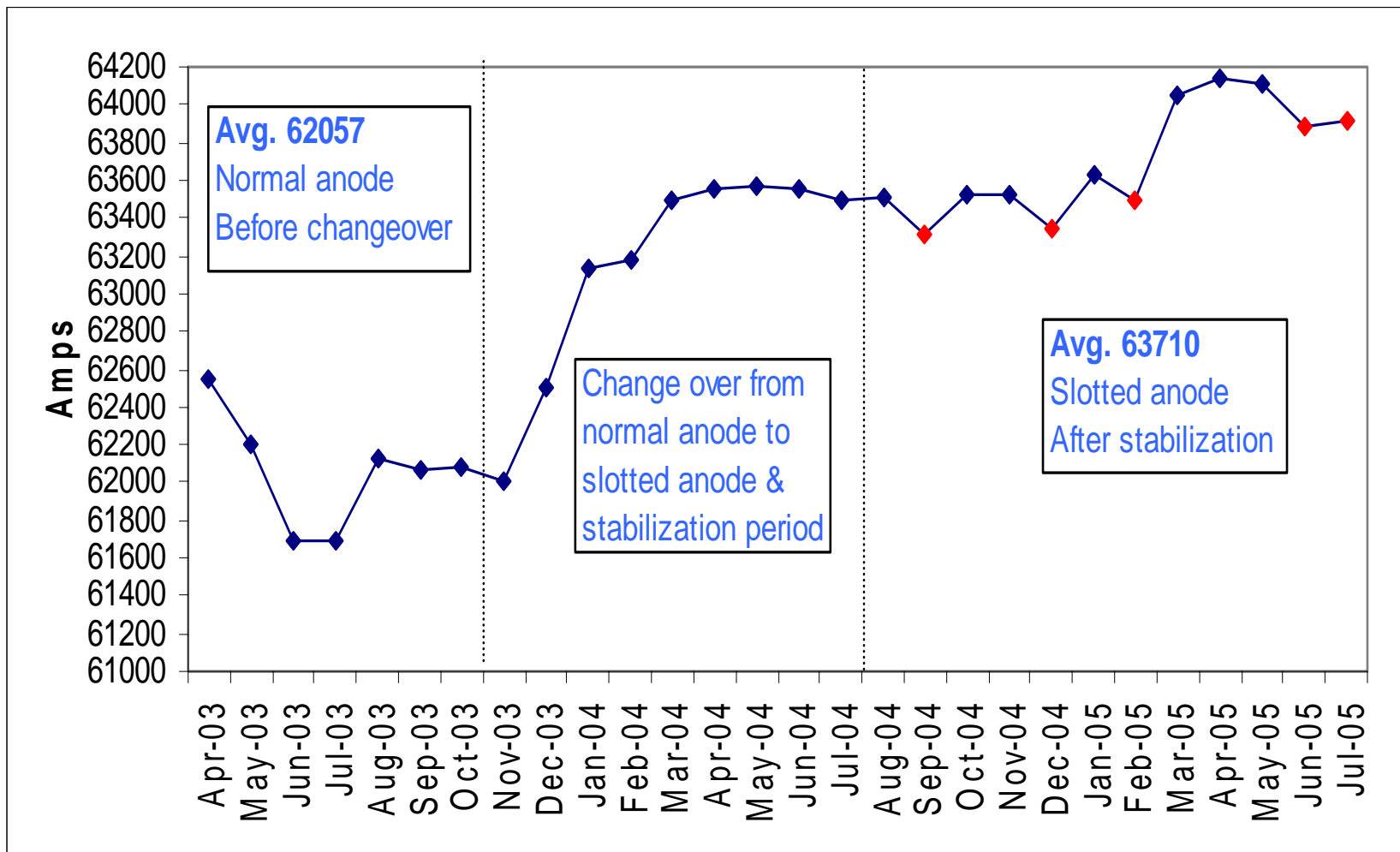
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The Impact



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The Impact



Improved Energy Efficiency Through
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The Result

Saving: - 0.105 Volts/Pot

(4.490 – 4.385)

Power Consumption below 14000 DC kWh/MT

Hindalco Smelter → better than 60% world production
in power consumption

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Comparison

Power consumption figures (DC KWH/T Al) for global players:

- Guaranteed by Aluminium Pechiney, France (AP-30) - 13065
- Guaranteed by GAMI, China, GP-320 - 13460
- Benchmark, Alouette, Canada (AP-30 Technology) - 12600
- For Hindalco New Potlines 9,10 & 11, (Mar-04) - 13726

(Up-graded Vintage 1940's Kaiser Technology, Small Size pots)

- Hindalco Average for all 11 Potlines (Mar-04) - 13896

(Up-graded Vintage 1940's Kaiser Technology, Small size pots)

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Financial Gains

Financial gains can be divided in two parts:

A. Reduction in energy Cost

Reduction in Voltage/Pot	- 0.105 V/pot
Energy saving from Formula (@ 94.0% CE)	- 341 KWH/T Al
Monetary benefits (@342000 MT/annum prod)	- <u>Rs. 1731 lacs/ annum</u>

B. Increased Production Capacity:

It has already been established that increasing potline amperage can increase Smelter production capacity.

Total power saved	- 116.62 million Units/annum
Additional production using this	- 8155 MT/annum
saved power (@ 14300/MT) Monetary benefits	- <u>Rs. 2610 lacs/annum</u>
(@Rs. 32000/MT additional prod)	

Total Annualized benefits can be as high as Rs. 4341 lacs/annum

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Intangible Gains

- Environment: This initiative resulted in significant reduction of Green House Gases emissions by almost 357.03 Kg CO₂/MT or 122104 T CO₂/annum (@ Smelter capacity of 342000 MT, CO₂ Emission factor is taken as 1047 gms/KWH based on IAI guidelines).
- In house designing of slots configuration, size & shape built lot of confidence amongst employees.



Key Learnings

- The huge financial savings of **Rs. 4341** lacs/annum with hardly any investment
- First plant in world using slotted anodes on commercial scale to reduce energy consumption.
- In house design of slots, size, shape etc, no external reference used to design slots

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Thank You!!!

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19th August 2005