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Aluminium Technology & Production in Russia

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Soderberg technology

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Over 80% of aluminium in Russia is manufactured on the basis of Soderberg technology

ADVANTAGES:

- No process areas:

  -anode molding;

  -anode baking;

  -anode rodding;

  -processing of butts.

- Metal manufacturing cost is ~ $100 lower than for pre-baked anodes

DISADVANTAGES

- Environmental problems

  including emission of resinous substances and PAH

- Difficult working conditions
- High specific consumption of carbon
- High specific consumption of electric energy

Can Soderberg technology compete with pre-baked anode technology?

Current opportunities of Soderberg technology

Main process package currently implemented at aluminium smelters

- dry gas cleaning;

- automated alumina and fluoride point feeding

- dry anode technology;

- upgraded burners.

Introduction of automated alumina point feeding

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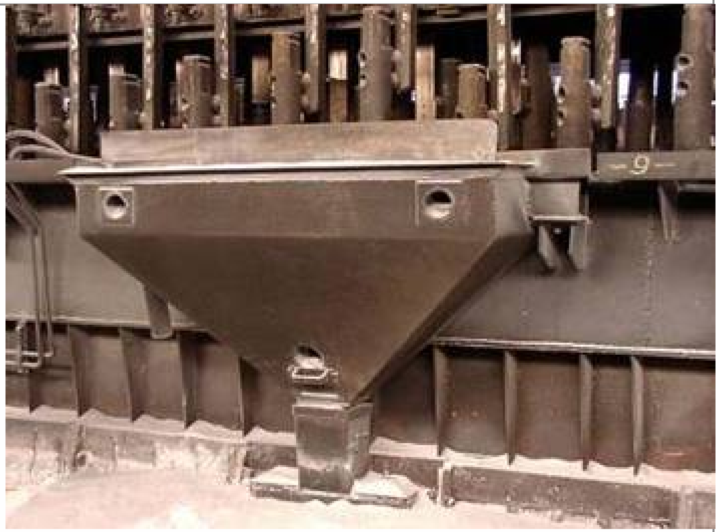
Advantages of automated alumina point feeding



Reduction of emissions due to alumina feeding without destruction of the cryolite-alumina crust between anode and wall (F total ~ 10%; dust ~ 12,5%; resinous substances ~ 3%)

- Fluorinated alumina feeding (reduction of emissions due to dry gas cleaning)
- 0,5-1,0% increase in current efficiency
- Possibility of increasing the amperage
- Reduction of fluoride consumption

Installation of dry gas treatment centres in potrooms

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- Increasing recovery of fluorine compounds ≥ 99,5%, recovery of resinous substances and benzapilene up to 95 – 97%

- Decrease of dry cleaning dust and residues ~25 kg/t Al;

- Reduction of aluminium flouride consumption ~ 15 kg/t Al;

New opportunities of Soderberg technology

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New technology on the basis of colloidal anode is being introduced in RUSAL'S pilot area and includes the following:

- «colloidal» anode technology;
- pot hood (tightness);
- use of cryolite-alumina charge;
- increasing efficiency of anode gases afterburning;
- new equipment for pot maintenance

Colloidal anode technology

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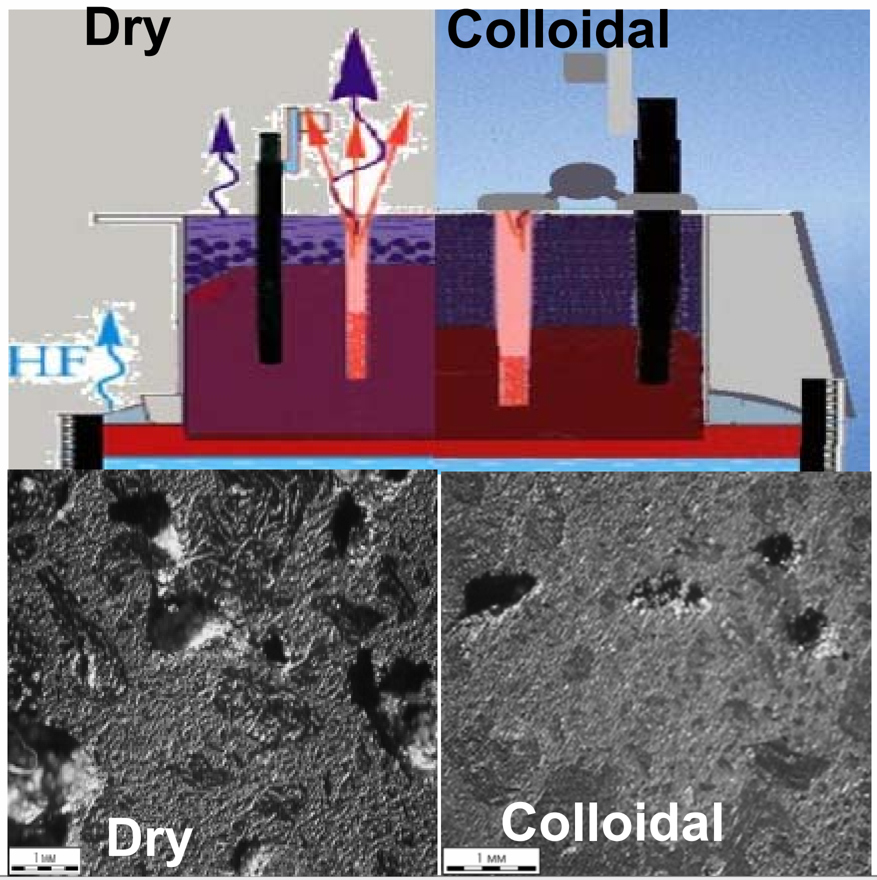
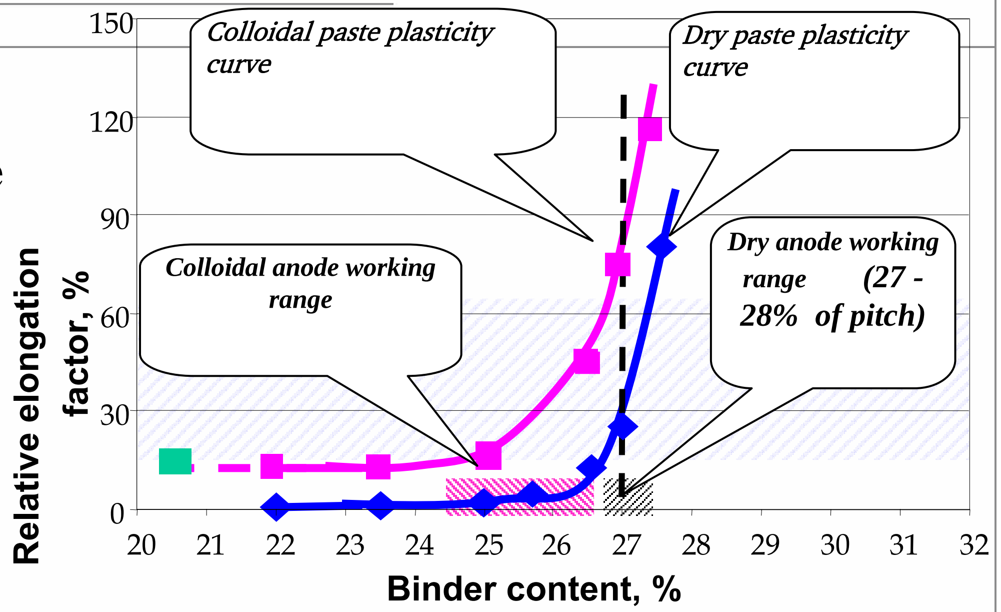
The main element– colloidal anode paste, demonstrating thermal resistance within a wide temperature range (100-400 °C)





Colloidal anode provides for stability of physical properties when pitch content is close to that of a pre-baked anode

- PAH emissions are reduced by over 50%

Soderberg technology – pot sealing

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Pot hoods:

- Provide for organised gas removal not less than 94 %;

Reduction of emissions, %:

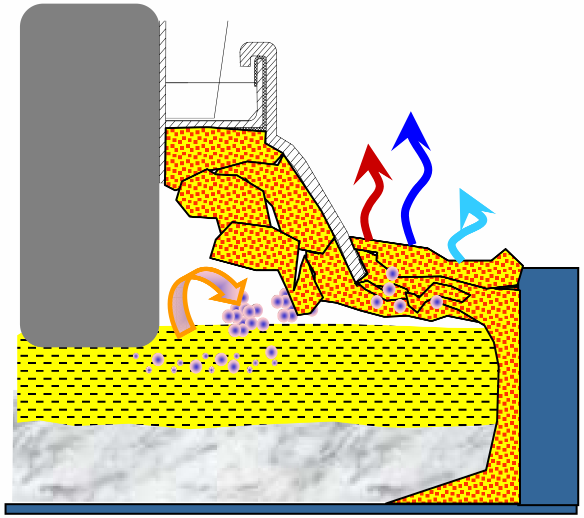
- F_{total} – 12,9
- PAH – 38,9
- CO – 57,4

Cryolite-alumina charge:

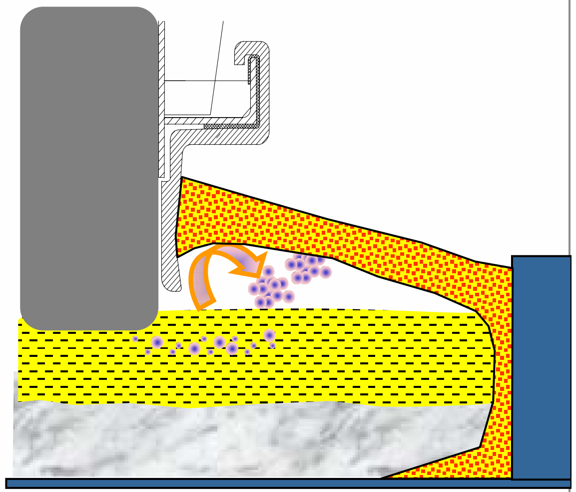
Reduction of emissions, %:

- F_{total} – 16,1
- PAH – 17,9
- CO – 34,0

Alumina



Charge



New equipment for pot maintenance

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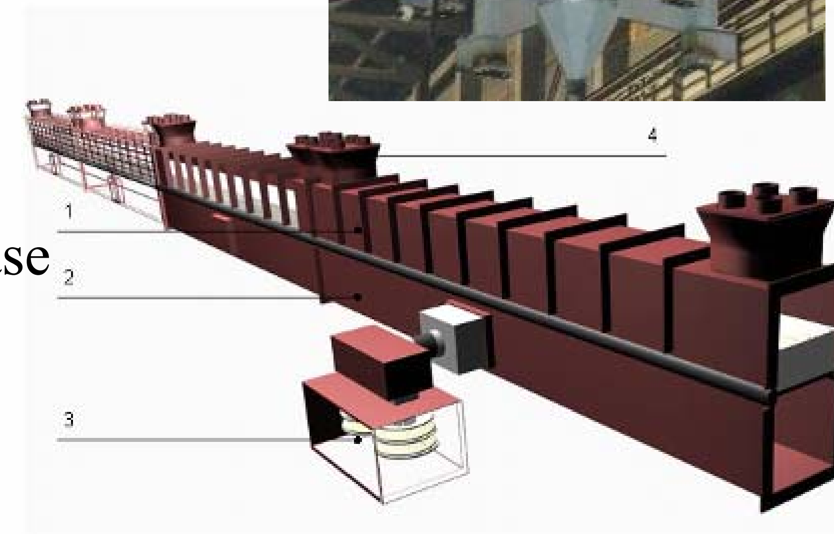
Devices and complexes for:

- AlF_3 automated feeding
- anode cutting and molding;
- anode beam racking;
-delivery and uniform feeding of anode paste;

-centralised alumina distribution, dense phase
- cleaning of studs



Soderberg technology-upgrading perspectives

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Specific emission of pollutants on the basis of colloidal anode Soderberg technology, kg/t Al

Ingredients	Soderberg technology (colloidal anode)	Recommended by OSPAR 2010 Soderberg
F_{total}	0,60	F total not over 0,6
CO	45,0	Not fixed
Dust	0,7	1,0
Benzapilene	0,01	0,01.

Soderberg technology – difficulties or perspective opportunities

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Economic values of environmental upgrading by the example of Bratsk Aluminium Smelter

Value	Transition to colloidal anodes	Transition to pre-baked anodes
Primary metal output (x 10^3 t/year)	1 100	1 100
Capital costs (x 10^3 $/t)	0.285	1.18
Production costs ($/t)	~ 50 $/t less than for pre-baked anodes	

Pre-baked anodes technology (PA-300 and PA-400)

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- COMMISSIONED:
  PA-300 December, 2003
  PA-400 December, 2005
- PA-300 technology audited by independent experts
- Plan of PA-300 technology demonstration (confirmation) to foreign financial institutions developed
- Aluminium smelter constructed in Sayanogorsk, the smelter will work on the basis of PA-300 technology

PA-300 technology

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- busbars – pot of high electromagnetic stability
- Cathode shell – minimum deformation and improved heat emission
- Lining, providing for bottom integrity and optimum energy balance of the cell
- Anode superstructure – new system of gas removal from the pot
- construction – fewer supports

Designing the pot

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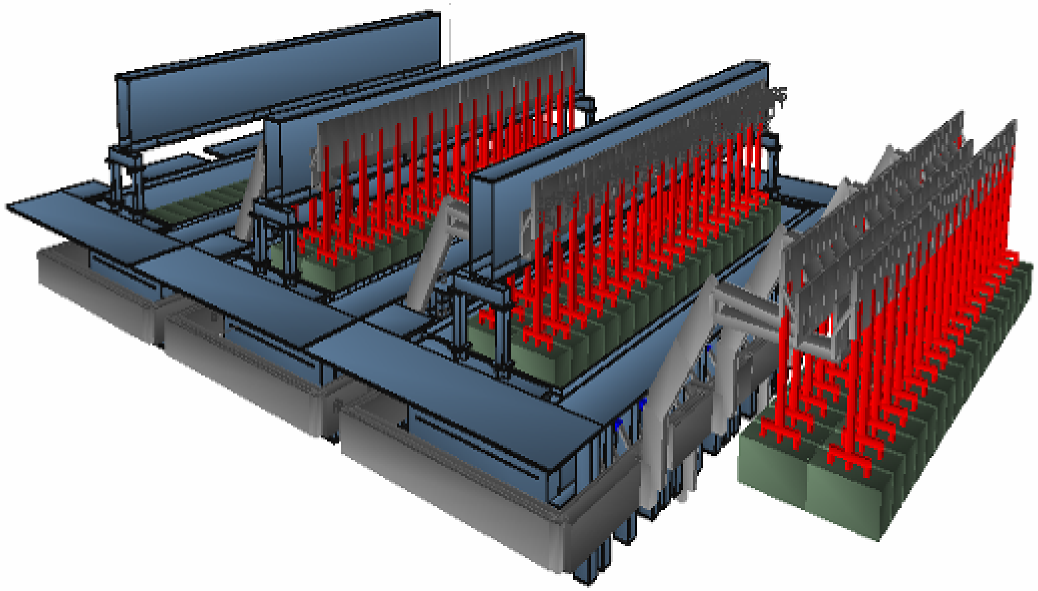
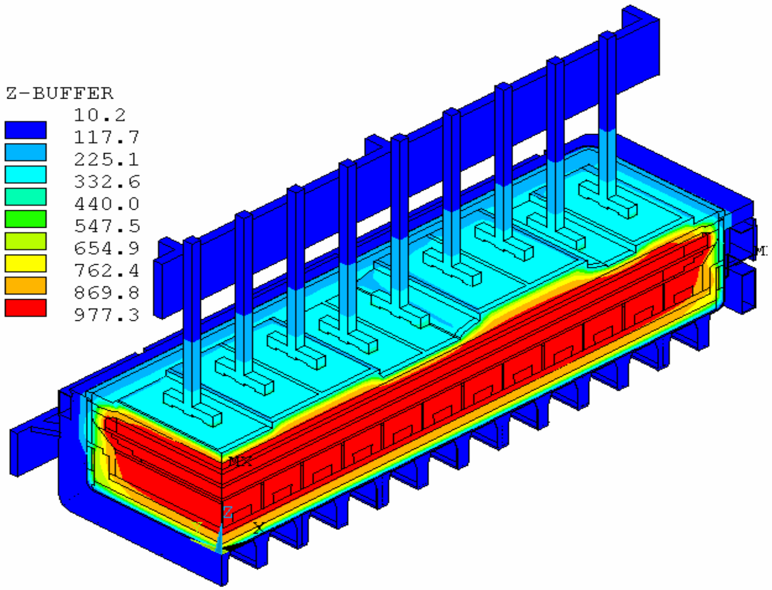
The pot has been designed with use of
ArcRusal, Blums – models of electric and magnetic fields, hydrodynamics and pot MHD-stability





The following has been used for heat balance:
ANSYS, STAR-CD – models of thermoelectric fields, strain-stress condition, aero- and hydrodynamics

Construction data

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#	Name	Meas. unit	PA300 technology
1	Number of pots in the potroom	pc.	168
2	Potroom dimensions	m	1210 x 27
3	Pot dimensions	m	15,68 x 4,76 x 1,78
4	Centre-line dimension	m	6,5
5	Number of cranes	pcs./potline	9
6	Transfer crane	pcs./potline	1,0
7	Weight of construction metalware	t/pot	37,5
8	Weight of the cathode shell	t/pot	44,4
9	Weight of the busbars	t/pot	53,1

Target project parameters

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Parameter		RA-300	RA-400
Amperage, kA		320	400
Anode current density, A/cm2		0.88	0.85
Current efficiency, %		>93.5	>93.5
Productivity, kg/day		2412	3016
Electricity consumption, kWh/t		<13 800	<13 800
Average voltage, V		4.35±0.05	4.35±0.05
Consumption of anodes, kg/t	gross	550	555
	net	425	430
Anode effect frequency, times/pot per day		0.05	0.05
Specific F emissions, kg/t		0.6	0.6

Comparison of RA-300 and RA-400 technologies

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Parameters / Technology	RA-300	RA-400
Number of pots in potline	336	336
Number of potlines	2	2
Smelter capacity, ktpa	560	750
CAPEX for construction, $ mln	1568	1875
Specific CAPEX, $ ths/tonne	2.8	2.5
Specific annual metal output from area, tonne/m^2	4.2	5.1

At use of RA-400 technology, the reduction of specific CAPEX is up to ~ 300 $/tonne of aluminium.

Principal design advantages of RA-400

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In order to improve environmental indicators, extend service life, reduce consumption of materials and improve MHD-parameters of pots, RA-400 project implements new design elements, differing from RA-300:

- **gas exhaust system;**
- **doubled anodes;**
- **graphite, two-groove bottom blocks;**
- **decreased socle height; and**
- **busbar design.**

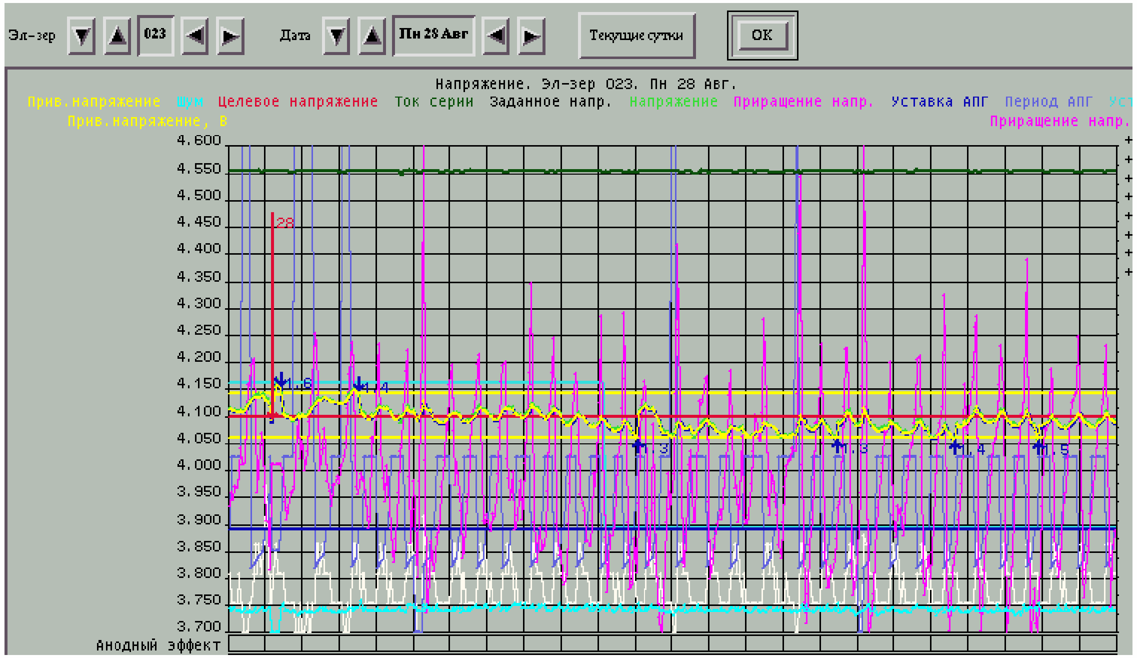
March 2004 - problem statement

December 2005 - start-up of first RA-400 pot

"SAAT" process control system

➢ **Original control algorithms (including use of Fuzzy-Logic and neuronets)**

➢ **The software package includes expert systems and control of overheating temperature.**



Point-feeding system

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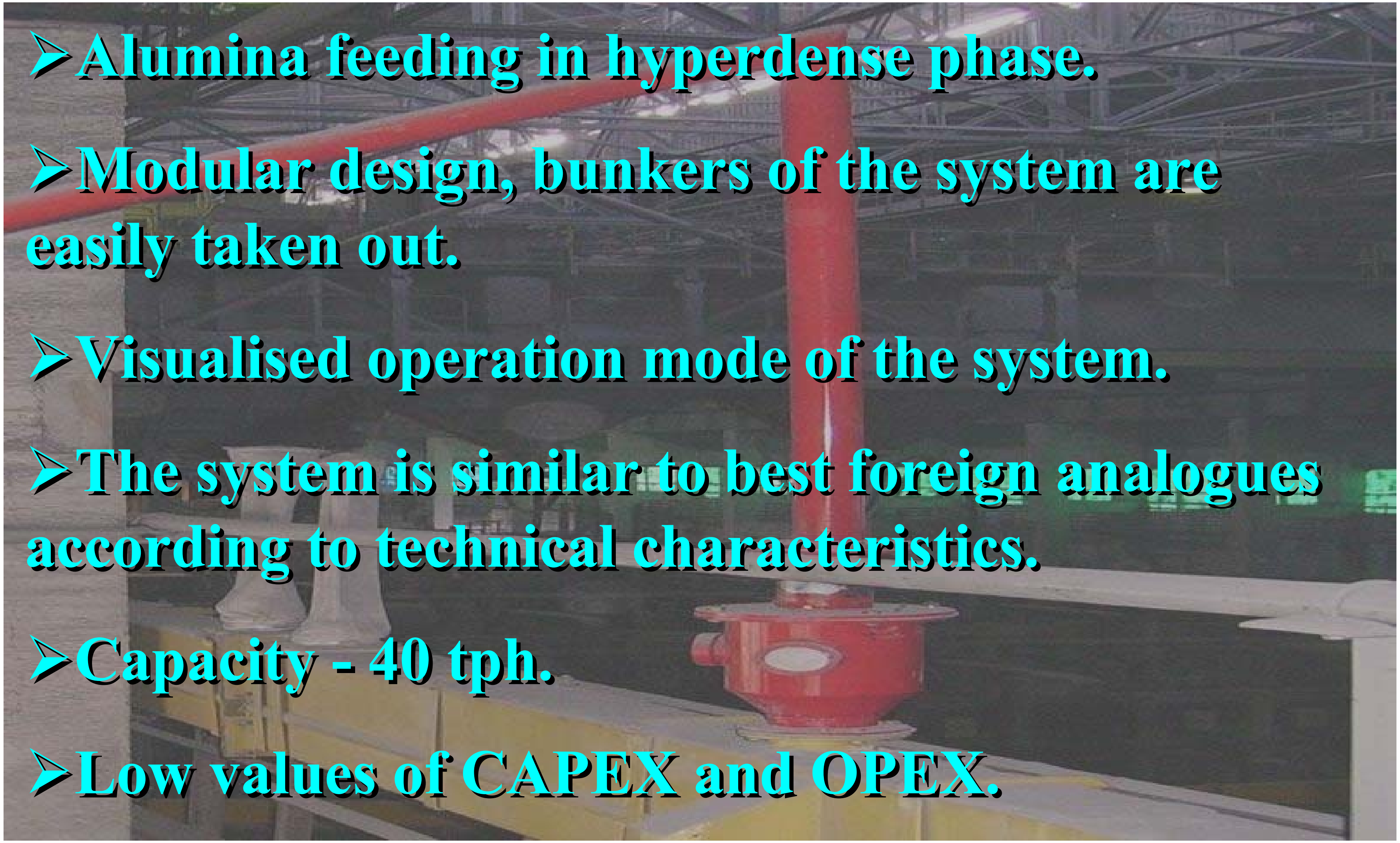

- Alumina feeding in hyperdense phase.
- Modular design, bunkers of the system are easily taken out.
- Visualised operation mode of the system.
- The system is similar to best foreign analogues according to technical characteristics.
- Capacity - 40 tph.
- Low values of CAPEX and OPEX.

Package of RA-300, RA-400 technologies

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Cathode busbar

Pot design

Point-feeding system

"SAAT" process control system

Process documentation

Patents and "know-how"

High current density reduction technology

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In August 2006, RUSAL started tests of the high current density reduction technology:

Parameters	Value
Current density, A/cm²	**>1.2**
Current efficiency, % (expected)	>94
Electricity consumption, kWh/tonne (expected)	13 500-14 500
Gas hooding efficiency, %	98.5
Consumption of anode blocks, kg/tonne	430
Anode effect frequency, times/day	< 0.1

High current density technology.
Advantages of the new technology.

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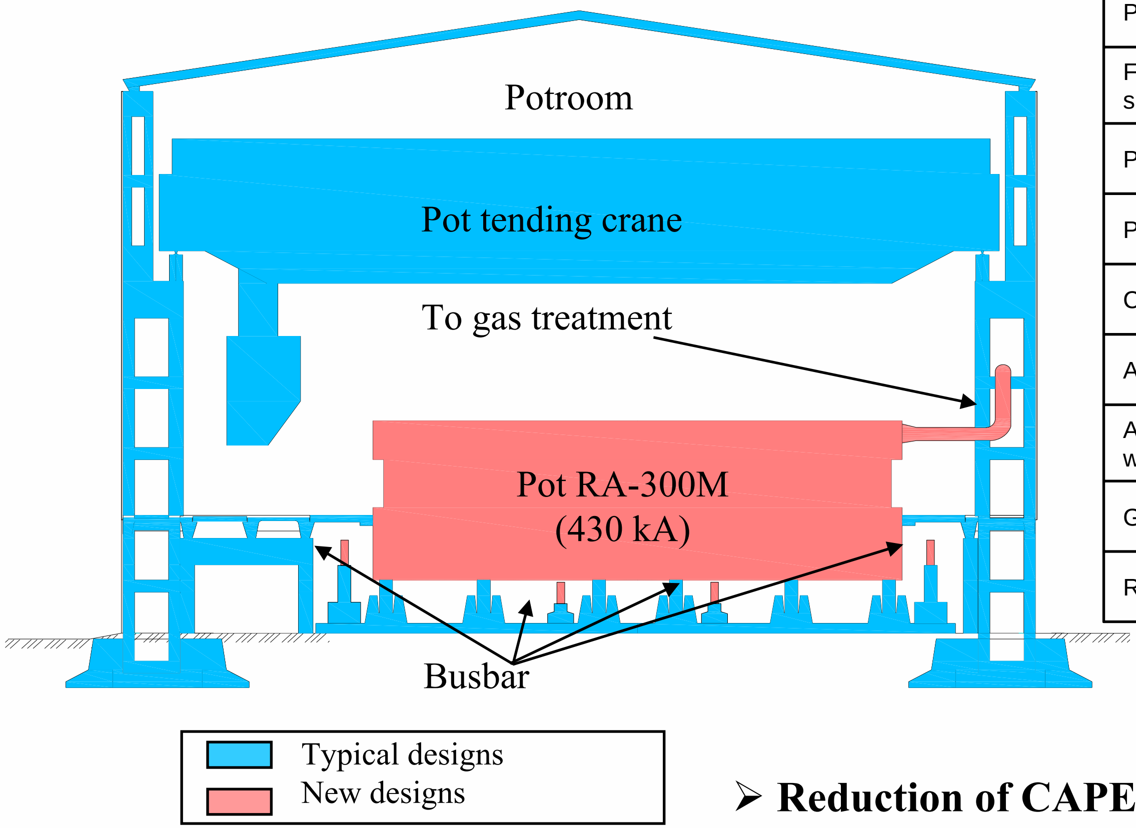
RA-300 (320 kA) → RA-300M (430 kA)
Smelter's capacity is increased by 35%



Partial use of typical designs at construction:

	Typical design	Modernisation, extra costs
Potroom	✓	
Foundations and supports	✓	
Pot tending crane	✓	
Pot relining shop	✓	
Casting area		✓ 15%
Anode plant		✓ 30%
Alumina transport and warehouses		✓ 10%
Gas treatment		✓ 20%
Rectifier		✓ 20%

➢ **Reduction of CAPEX by 15%**

Key results of studies of high current density reduction technology

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- Busbar design allowing for high MHD-stability at low ACD (reduced by 20-30%) was created;
- Cathode with increased heat dissipation and improved uniformity of current distribution was created;
- Anode superstructure for operation at high current density was developed;
- Bath composition for operation at high current density was developed; and
- Special heat and mass balance control algorithms were developed.

Organization of pilot area for technology tests

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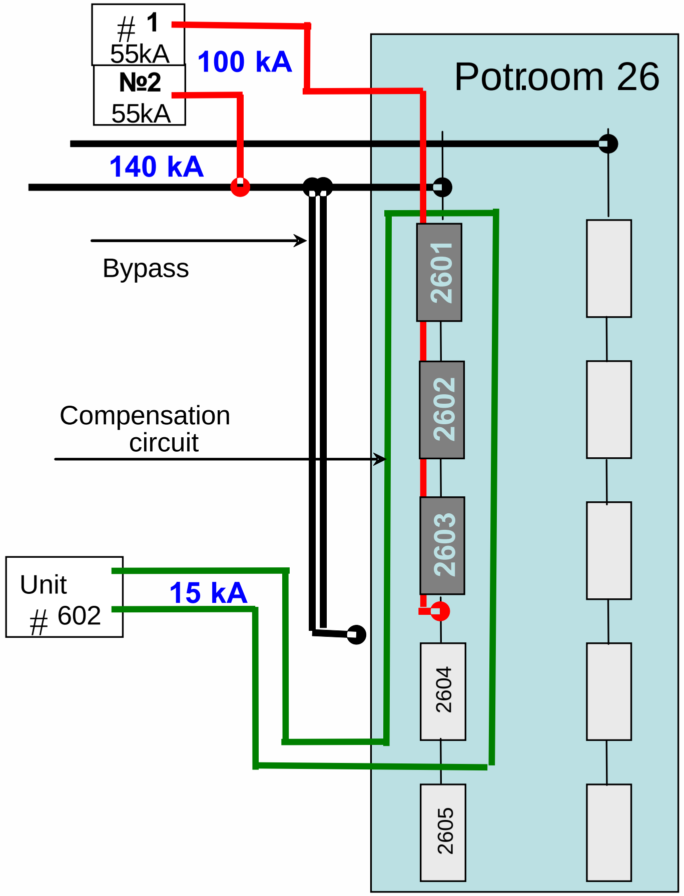
Schematic diagramme of infeed and compensation of pilot area



- ✓ August 2006 – start-up of pilot pots.
- ✓ September 2006 – achieved amperage 200 kA in a cell of pot 120 kA.
- ✓ 2006-2007 – technology development, achievement of stable indicators.

Future technology.
Pots with vertical inert electrodes

Materials and technologies for wet (inert) cathodes were developed. Specific cost is ~230-250 $/m^2

Stage: experimental-industrial tests

5 pots of S160M4 type with wet bottom are operated:

Estimates:

- **Service life of coating – 4-5 years**
- **Extension of pot service life – ≥ 6 months**
- **Increase of current efficiency by 1-1.5% (CAPEX ≈ 200…300 $/t Al)**

Development of inert anode material

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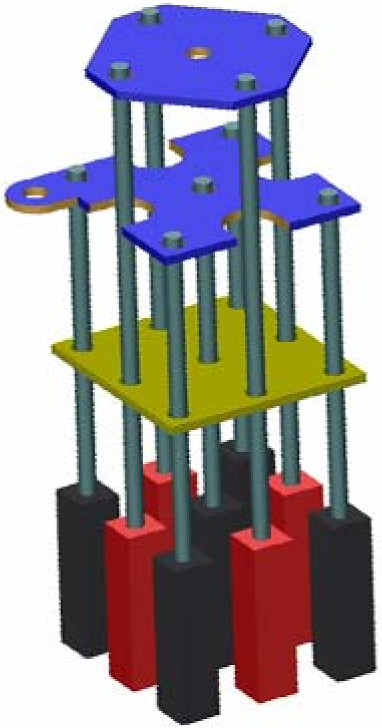
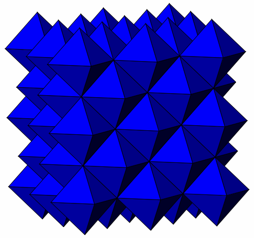
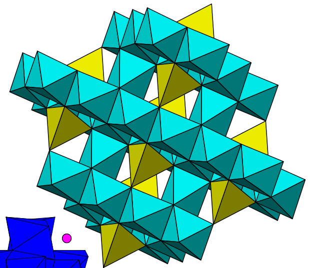
New metal and ceramic inert anodes were developed and tested in traditional conditions

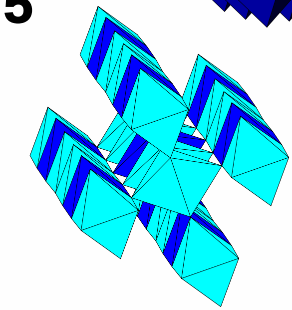


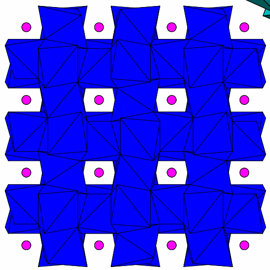
A series of oxide-based anode materials was laboratory developed and tested.

Expected results in 2006:
Usage of materials based on complex oxides - 0.5 years









Advantages of pots with vertical electrodes

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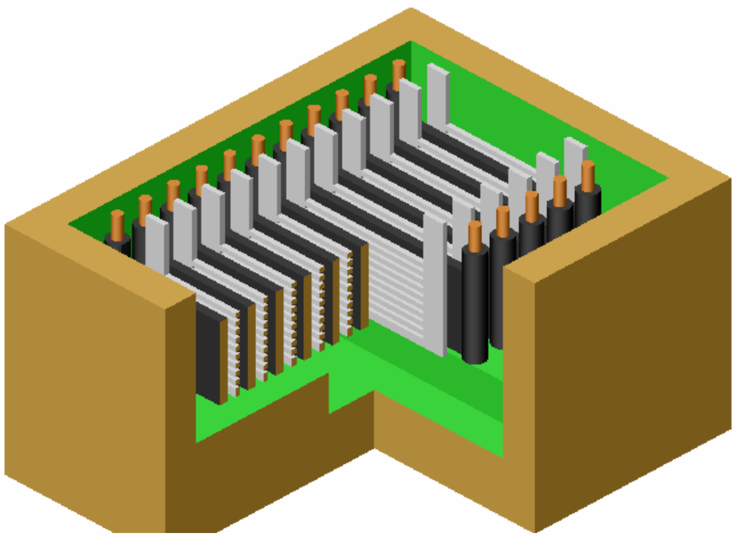
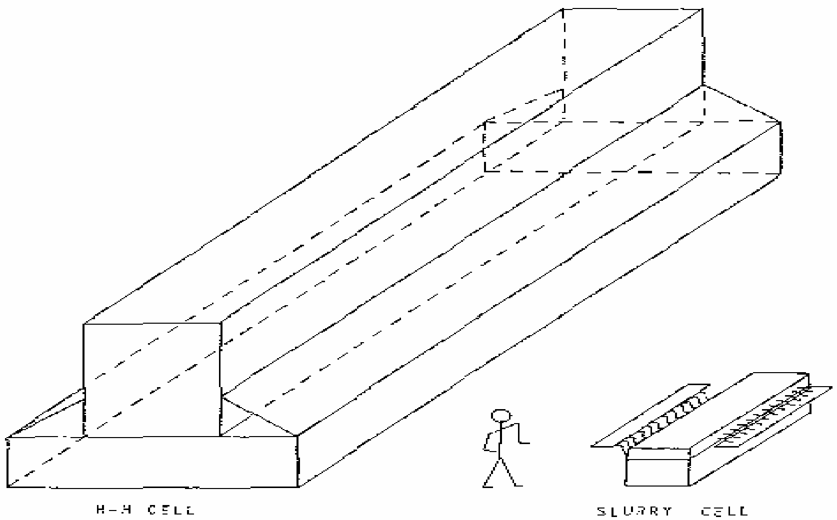
- Increase of specific capacity from ~10 to 50-100 kA/m^3
- Reduction of specific electricity consumption to < 12 kWh/kg of Al
- Possibility of conversion to low-temperature reduction
- Expansion of the range of used types of anode materials!
- Significant decrease of CAPEX (pot and potroom dimensions are decreased by 3-5 times; specific costs for busbar are reduced)





"Vertical" pot. Concept

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Pot type	Horizontal pot	Horizontal drained pot	Vertical pot
Specific capacity	–	–	+
Reduction temperature	about 950^{0C}	about 950^{0}C	about 800^{0}C
Anode service life	–	–	+
Pot service life	–	Bottom with cathode coating +/-	Bottom is not cathode, less corrosion of materials +
Environment	Oxygen emissions +/-	Oxygen emissions +/-	Oxygen emissions, less salt evaporation, less exhausted lining +
Construction CAPEX	–	–	+
Production cost	–	+/-	+

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Thank you for attention!

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