Revamp Possibilities for Caustic Soda Plants

For Alkali Manufacturers Association of India

06.09.2017 | AMAI Conference
N.Ranga Rao - thyssenkrupp Industrial Solutions (India) Pvt. Ltd.
Topics

• thyssenkrupp Industrial Solutions (India) – tkIS India at a glance

• thyssenkrupp Industrial Solutions – tkIS Electrolysis Technologies at a glance

• Plant performance optimisation
  
  o Optimisation by technological improvements of electrolysis cell house
  
  o Optimisation by technological improvements apart from cell technology
Electrolysis @ tkIS India

- Market leader in Membrane Cell with domestic market share in excess of 75%
- Has worked as ‘partner of choice’ with almost all Indian Caustic Soda manufacturers for grassroots, expansion, conversion & technology upgradation projects
- Leveraging R&D set-up for various Electrolysis technologies yielding energy and other benefits to Customers

Over 150 projects
thyssenkrupp Industrial Solutions (India)
Core Competencies

- Fertilisers
- Electrolysis & Polymers
- Refinery Units
- Third Party Technologies (Petrochemicals, Cryogenic Storages, Metallurgy, Inorganic Chemicals and Industrial Plants)
- Life Cycle Services

650 projects in India & Abroad
thyssenkrupp Industrial Solutions (India)
tkIS’s Electrolysis Technologies

- offers solutions with “Single Point Responsibility” from concept to commissioning for all electrolysis plants
- Only one partner for Technology → Engineering → Implementation → Commissioning and 360° lifecycle services
thyssenkrupp Industrial Solutions (India)

Research & Development

- Commitment for achieving sustainability & enhancing plant performance through innovation
- Dedicated R&D team supported by strong engineering expertise at local office
- Experience in development activities spanning 2 decades, with demonstrable / proven results
- Comprehensive & systematic approach
  - Assimilation of customer needs,
  - Literature survey to understand state of art,
  - Lab testing to generate proof of concept (PoC)
  - Pilot scale testing for critical process/ component
  - Generating data for Engineering
- Management of Intellectual Property Rights (IPR)
thyssenkrupp Industrial Solutions (India)
Chlor-Alkali Electrolysis Footprint

- > 75% of market share in Caustic Soda industry in India
- > 45% market share of Caustic Soda installed capacities worldwide

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Electrolysis @ tkIS

- Market leader in Membrane Cell Electrolysis – global market share in excess of 45%
- Impressive global footprint for grassroots, expansion, conversion & technology upgradation projects
- Only global consultant to offer under-one-roof solutions for the Electrolysis industry
- Continual R&D efforts spanning several decades have resulted in many innovations benefiting customers worldwide
- Closely associated with tkIS India for projects worldwide
Conventional Membrane Chlor-Alkali Technology

Process Overview

- Brine Filtration
- Brine Purification
- Brine Saturation
- Clarification Precipitation
- Anolyte De-chlorination
- Transformer/Rectifier
- Catholyte Circulation
- Membrane Electrolysis
- Chlorine Treatment
- Chlorine Compression
- Chlorine Liquefaction
- HCl Synthesis
- Hydrogen Treatment
- Hypo Solution
- Waste Gas De-chlorination
- Chlorine Tonner Filling

Main Raw Material: Salt, Power & Water

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Plant Performance Optimisation – Cell House
Plant performance optimisation

Our spirit: “Know the potential for cheap but effective improvements?”

Key word: Revamp means

- Optimisation by technological improvements of electrolysis cell house
- Optimisation by technological improvements apart from cell technology
  - Iterative process in close contact to the customer
  - From basic study to execution of project
  - Highly effective engineering, because of…
    - …a large data base of engineering and service experiences
    - …a separate, dedicated, well experienced Chlor-alkali engineering infrastructure for project execution
Optimisation by technological improvements of electrolysis cell house
Electrolyser feature - options

BM2.7v6

nx-BiTAC
Better plant performance, less power consumption

• Improvements in BM 2.7 cell technology can pay off directly for you. We can either upgrade/retrofit your cells or simply exchange your old cells with new generation:
  
• Less width elements – more elements per stack
  
• Higher voltage efficiencies – more elements per trafo/rectifier

Power consumption in kWh/t NaOH100% *)

*) at 6 kA/m² (90°C, 32 % NaOH)

Easy performance increase by retrofitting current elements or by replacing them with new elements of generation 6

No major change of periphery necessary

Higher efficiency and/or NaOH output
Optimisation by technological improvements of electrolysis cell house for BM2.7 – Element Replacement Gen.V2/V3 to Gen.V6

Our approach
Careful evaluation minimizes modifications to:
- Brine and Caustic feed system
- Electrical system
- Instrumentation

Our service package includes:
- Detailed replacement concept
- Definition of split of work
- Feasibility study and proposal
- Planning and implementation of modifications
- Assembly of new elements
- Installation, start-up and performance guarantee

Multiple benefits
Financial:
- Minimized investment
- Lowest power consumption

Operational:
- Improved safety level
- Increased current density operation
- Enhanced feed system
- Pure brine acidification possible
- No internal Δp fluctuations
Improvements in BiTAC cell technology can pay off directly for you. A few simple changes make a big difference:

- Insert new high-performance membrane
- Only cathode side is adjusted

Better plant performance, less power consumption

*Power consumption in kWh/t NaOH_{100\%}^{*}) at 6 kA/m² (90°C, 32 % NaOH)

Your added value

☑ Easy efficiency increase, directly on-site
☑ No major change of periphery necessary
Optimisation by technological improvements of electrolysis cell house for BiTAC – Simple and qualified modification of BiTAC to i-BiTAC

Anode side

- For retrofitting, no adjustments on anode side necessary
- Re-meshing of anode electrode is optional (only in our workshop)

Cathode side

- Installing of new coated cathode electrode as woven mesh (at client’s site or in our workshop)

Cell element

- Installation of high performance membrane and standard gasket

Retrofit of BiTAC can be done completely at client’s plant
Optimisation by technological improvements of electrolysis cell house
Example: Recap of cell house optimization project – execution philosophy adopted
Optimisation by technological improvements of electrolysis cell house

Example: Recap of cell house optimization project – execution philosophy adopted

Optimisation by technological improvements of electrolysis cell house

Example: Recap of cell house optimization project – execution philosophy adopted
Optimisation by technological improvements of electrolysis cell house
Example: Recap of cell house optimization project - Greenhouse Gas Emission & Economics

<table>
<thead>
<tr>
<th></th>
<th>Power Kwh/T</th>
<th>Invest. cost ₹ Million</th>
<th>Prod. loss of NaOH, matric ton</th>
<th>Savings from power ₹ Million</th>
<th>Pay back years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recoating of Gen 2</td>
<td>2335</td>
<td>470</td>
<td>~ 2000</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Replacement by Gen 5b Plus</td>
<td>1952</td>
<td>1250</td>
<td>~ 2200</td>
<td>310</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 403 (*)</td>
<td>780</td>
<td>~ 200</td>
<td>310</td>
<td>2.5</td>
</tr>
</tbody>
</table>

(*) Results in savings of 553 GWh of electricity in 8 yrs

(*) Equivalent to 210,000 ton of CO₂ reduction in 8 yrs

(*) Client has benefitted the government scheme of “Perform, Achieve and Trade (PAT)”
Optimisation by technological improvements of electrolysis cell house
Alternative to standard conventional membrane technology - NaCl ODC

25% less power consumption compared to the standard conventional membrane technology - NaCl ODC offers the 3rd quantum leap in the history of Caustic production.
Optimisation by technological improvements of electrolysis cell house
Successful market entry of NaCl-ODC technology

Demonstration
Full industrial scale

Covestro, Uerdingen Germany

2011
Capacity 20,000 t/year Cl₂
Current density 4-4.5 kA/m²
Power consump. 1,504 kWh/t NaOH

Grasim, Aditya Birla Nagda India

2013
Demonstration
Indian market

2015
Commercial plant
Chinese market

Befar Group, Binzhou, China.

Capacity 35,500 t/year Cl₂
Current density 4kA/m²
Power consump.1,480kWh/t NaOH

More than five years of reliable operation in industrial plant scale

1) Average over 5 years, picture copyright of company Covestro
2) guaranteed values

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## Optimisation by technological improvements of electrolysis cell house

Successful market entry of NaCl-ODC technology

### Power Consumption in kWh/t NaOH

<table>
<thead>
<tr>
<th>Year</th>
<th>Power Consumption (kWh/t NaOH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>BM 2.7 v4: 2,130</td>
</tr>
<tr>
<td>2008</td>
<td>BM 2.7 v5: 2,070</td>
</tr>
<tr>
<td>2011</td>
<td>BM 2.7 V5 plus: 2,055</td>
</tr>
<tr>
<td>2012</td>
<td>BM 2.7 v6: 2,020</td>
</tr>
<tr>
<td>2013</td>
<td>Demo: 1,550</td>
</tr>
</tbody>
</table>

1) At 6 kA/m², 90°C, 32 % NaOH

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**“Quantum leap”**

Demo

ODC

June 2013
Optimisation by technological improvements of electrolysis cell house

Electrolyser Automation

Feed Brine Flow Auto control
Feed Caustic Flow Auto control

Automatic Anolyte & Catholyte Header - Bypass valves

Uhde Evaluator™

Open modular system (hard- and software)
Permanent power supply even during shutdown
Measurement range from -1V to +5V
SIL 1/2 classified safety functions
Includes TK Uhde’s electrolysis expertise
Remote condition monitoring possible
Optimisation by technological improvements of electrolysis cell house
High pressure operation of Electrolysers

Advantages:
- Minimize aux. power consumption
- Effective utilization of downstream equipment
Plant Performance Optimisation – Outside Cell House
Cost effective sulfate removal especially for small plants

Limitation:
- High CaCl2 excess in primary brine plant?
- Quality of Gypsum?
Optimisation by technological improvements apart from cell technology
Adaption to steam price

Cost reduction for caustic concentration

Steam price is a decisive factor for the cost of caustic concentration – so you directly push your margin by cutting these costs. Reduction of steam consumption depends on a number of effects:

- 2 effect concentration: 710 - 750 kg / t NaOH 100%
- 3 effect concentration: 475 - 520 kg / t NaOH 100%
- 4 effect concentration: 380 - 400 kg / t NaOH 100%

Combination of shell & tube and plate heat exchangers

Medium steam pressure necessary (10-12 barg)

Your added value

- Reduced cost for steam
- Optimized to your local setup and surrounding conditions
- ROI acc. your conditions at site
Optimisation by technological improvements apart from cell technology
Integration of skid-mounted units

Skid modules for cost-effective debottlenecking

tkIS offers you standardized, pre-assembled modules in steel skids, which come in a standard container size for ease of transportation. Individual skids can be installed in existing plants for modernization / debottlenecking purposes, for example:

- Brine filtration
- NaCl electrolysers
- Chlorine Cooling / Drying / Liquefaction
- Waste gas dechlorination
- Sulfate Removal System (SRS)
- Sodium hypochlorite production skids

Our process and technology expertise in complete plants is also ideal for cost-effective, small-scale plants.

Skid-mounted plants: Capacity of 5,000 to 15,000 mt/a of NaOH

Your added value

- Cost-optimized - thanks to standardized engineering & skids
- Process simplification to reduce operating costs
- Easy delivery, fewer civil & erection works on site
- Much faster project schedule
Thank You for your attention!

Contact
thyssenkrupp Industrial Solutions (India) Private Limited (formerly Uhde India Private Limited)
Uhde House, LBS Marg, Vikhroli (W), Mumbai 400 083, India
Tel : +91 22 4047 8020 / Fax : +91 22 2578 6187
e-Mail : tkisindia.mktg@thyssenkrupp.com
Website : www.thyssenkrupp-industrial-solutions-india.com