Up-to-date ETL technology by NIPPON STEEL & SUMIKIN ENGINEERING

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Plant & Machinery division
Nippon Steel & Sumikin Engineering Co., Ltd. (NSENGI)

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ETL: Electrolytic Tinning Line
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1. Introduction

2. Insoluble anode system

3. Advanced technologies of NSENGI ETL
   - Optimization for high speed processing
   - Each pass plating current control
   - New reflow control
   - Sludge reduction system

4. Conclusion
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   - New reflow control
   - Sludge reduction system

4. Conclusion
1. Introduction – Reference list

<table>
<thead>
<tr>
<th>No.</th>
<th>Customer</th>
<th>Line</th>
<th>Country</th>
<th>Start up</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BAOSTEEL</td>
<td>No.1 ETL</td>
<td>China</td>
<td>1997</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>BAOSTEEL</td>
<td>No.2 ETL</td>
<td>China</td>
<td>1997</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>DONGBU STEEL</td>
<td>ETL</td>
<td>Korea</td>
<td>1999</td>
<td>ET/TFS combination line</td>
</tr>
<tr>
<td>4</td>
<td>POSCO</td>
<td>ETL</td>
<td>Korea</td>
<td>2001</td>
<td>Revamping</td>
</tr>
<tr>
<td>5</td>
<td>BAOSTEEL (Yichang)</td>
<td>No.2 ETL</td>
<td>China</td>
<td>2007</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>TCIL</td>
<td>No.2 ETL</td>
<td>India</td>
<td>2008</td>
<td>ET/TFS combination line</td>
</tr>
<tr>
<td>7</td>
<td>BAOSTEEL (Meishan)</td>
<td>ETL</td>
<td>China</td>
<td>2009</td>
<td></td>
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<tr>
<td>8</td>
<td>PT Latinusa</td>
<td>ETL</td>
<td>Indonesia</td>
<td>2011</td>
<td>Revamping</td>
</tr>
<tr>
<td>9</td>
<td>Wuhan Iron &amp; Steel NIPPON STEEL &amp; SUMITOMO METAL</td>
<td>No.1 ETL</td>
<td>China</td>
<td>2013</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>No.2 ETL</td>
<td>China</td>
<td>2014</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>BAOSTEEL (New order)</td>
<td>ETL</td>
<td>China</td>
<td>2018</td>
<td>ET/TFS combination line</td>
</tr>
</tbody>
</table>

☞ Total 30 lines in the world (incl. 18 lines with insoluble anode system)

No.1 ETL supplier for latest 15 years
1. Introduction – Recent experiences

**WISCO No.4 Cold mill project**
- NSENGI contracted an erection of new 4 processing lines.
- They started up from 2013 to 2014.

**Electrolytic Tinning Line (ETL)**

<table>
<thead>
<tr>
<th>main specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production capacity</td>
</tr>
<tr>
<td>Strip width</td>
</tr>
<tr>
<td>Strip thickness</td>
</tr>
<tr>
<td>Coating weight</td>
</tr>
<tr>
<td>Products</td>
</tr>
<tr>
<td>Maximum line speed</td>
</tr>
<tr>
<td>Entry</td>
</tr>
<tr>
<td>Process</td>
</tr>
<tr>
<td>Delivery</td>
</tr>
<tr>
<td>Plating process</td>
</tr>
<tr>
<td>Electrolyte</td>
</tr>
<tr>
<td>Tin dissolution capacity</td>
</tr>
</tbody>
</table>

WINSteel, China
1. Introduction – Recent experiences

WISCO No.4 Cold mill project
- NSENGI contracted an erection of new 4 processing lines.
- They started up from 2013 to 2014.

Continuous Annealing and Processing Line

<table>
<thead>
<tr>
<th>main specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production capacity</td>
</tr>
<tr>
<td>Strip width</td>
</tr>
<tr>
<td>Strip thickness</td>
</tr>
<tr>
<td>Products</td>
</tr>
<tr>
<td>Maximum line speed</td>
</tr>
<tr>
<td>Entry</td>
</tr>
<tr>
<td>Process</td>
</tr>
<tr>
<td>Delivery</td>
</tr>
<tr>
<td>Skinpass mill</td>
</tr>
</tbody>
</table>
1. Introduction – Recent experiences

**Latinusa ETL revamping project**
- NSENGI can provide revamping project.
- It started up in the end of 2011.

<table>
<thead>
<tr>
<th>Spec.</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production capacity</td>
<td>130,000 ton/y</td>
<td>160,000 ton/y</td>
</tr>
<tr>
<td>Strip width</td>
<td>650 – 964 mm</td>
<td>650 – 964 mm</td>
</tr>
<tr>
<td>Strip thickness</td>
<td>0.15 – 0.39 mm</td>
<td>0.15 – 0.39 mm</td>
</tr>
<tr>
<td>Coating weight</td>
<td>1.12 – 11.2 g/m²</td>
<td>1.12 – 11.2 g/m²</td>
</tr>
<tr>
<td>Products</td>
<td>SR (T1 – T5), DR8, DR9</td>
<td>SR (T1 – T5), DR8, DR9</td>
</tr>
<tr>
<td>Maximum line speed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entry</td>
<td>390 m/min.</td>
<td>390 m/min.</td>
</tr>
<tr>
<td>Process</td>
<td>275 m/min.</td>
<td>330 m/min.</td>
</tr>
<tr>
<td>Delivery</td>
<td>380 m/min.</td>
<td>380 m/min.</td>
</tr>
<tr>
<td>Plating process</td>
<td>Soluble anode system</td>
<td>Insoluble anode system</td>
</tr>
<tr>
<td>Electrolyte</td>
<td>PSA</td>
<td>PSA</td>
</tr>
</tbody>
</table>

Latinusa, Indonesia
1. Introduction – Recent experiences

**Latinusa ETL revamping project**
- NSENGI can provide revamping project.
- It started up in the end of 2011.

**Soluble anode system**

**Insoluble anode system**

- soluble anode
- existing line tank
- insoluble anode
- edge mask
- existing roll
1. Introduction – Recent experiences

Latinusa ETL revamping project
- NSENGI can provide revamping project.
- It started up in the end of 2011.
CONTENTS

1. Introduction

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3. Advanced technologies of NSENGI ETL
   - Optimization for high speed processing
   - Each pass plating current control
   - New reflow control
   - Sludge reduction system

4. Conclusion
2. Insoluble anode system – Schematic diagram

- **O₂ flow control**
- **Tin granule**
- **Settling tank**
- **Tin replenishing unit**
- **Circulation tank**
- **Tin ion analyzer**
- **Lab. analysis (batch sampling)**
- **Sludge filter**
- **Sludge**
- **Plating cells**

**Level-I**
2. Insoluble anode system – 1\textsuperscript{st} ADVANTAGE

**Improvement of tin coating distribution**

**Insoluble anode system**

- Insoluble anode
- Edge mask
- Strip

**Soluble anode system**

- Soluble tin anode
- Edge overcoat
2. Insoluble anode system – 2\textsuperscript{nd} ADVANTAGE

**Improvement of production yield and energy consumption**

<table>
<thead>
<tr>
<th>Insoluble anode system</th>
<th>Soluble anode system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insoluble anode</td>
<td>Soluble tin anode</td>
</tr>
<tr>
<td>Edge mask</td>
<td>Edge overcoat</td>
</tr>
</tbody>
</table>

- Fixed and narrower distance
- Less Edge overcoat

**Material tin & Electric energy saving**

**Improvement of production yield**

- Uniform tin coating weight
- Less Edge overcoat
2. Insoluble anode system – 3rd ADVANTAGE

Man-power saving for anode handling

Insoluble anode system

Soluble anode system

Not necessary
2. Insoluble anode system – 4th ADVANTAGE

Flexibility in strip processing schedule

- Insoluble anode system
- Soluble anode system

Fully automated

Every time manual work
2. Insoluble anode system – 5th ADVANTAGE

**Improvement of work environment**

- Insoluble anode system
- Soluble anode system

- No need of anode handling
- No fume due to hood cover

- Anode handling near by the line
- Harmful fume
- Decline of production efficiency by line speed down or line stop
1. Introduction

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4. Conclusion
3. Advanced technologies – High speed processing

**Problems at high speed processing**

- ununiformity of tin coating weight caused by fluid flow
- contact of edge mask to the running strip
3. Advanced technologies – High speed processing

Practical data of tin coating distribution

<Conditions>

<table>
<thead>
<tr>
<th>strip thickness</th>
<th>0.22mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>strip width</td>
<td>850mm</td>
</tr>
<tr>
<td>coating weight</td>
<td>2.8g/m²</td>
</tr>
<tr>
<td>line speed</td>
<td>500m/min. * Max. speed</td>
</tr>
</tbody>
</table>

➡️ within ±4.5% against the target value

Quite uniform distribution is kept during high speed operation

±0.13g/m²
3. Advanced technologies – Plating current control

<table>
<thead>
<tr>
<th>Tin coating weight</th>
<th>Line speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>Constant</td>
</tr>
<tr>
<td><strong>Unstable</strong></td>
<td>Acc. &amp; Dec.</td>
</tr>
</tbody>
</table>

Conventional logic
TOTAL CURRENT CONTROL

Diagram:
- Added pass
- Over coated
- Under coated
- Compensation pass
3. Advanced technologies – Plating current control

<table>
<thead>
<tr>
<th>Tin coating weight</th>
<th>Line speed</th>
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<tbody>
<tr>
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<td>Constant</td>
</tr>
<tr>
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<td>Acc. &amp; Dec.</td>
</tr>
</tbody>
</table>

- **Conventional logic**

TOTAL CURRENT CONTROL

- Over coated
- Under coated
- Compensation pass
- Added pass

Coating weight (1.1mg/m²) at acceleration of line speed

- **Acceleration**
- **Over Coat**

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3. Advanced technologies – Plating current control

**New logic**
**EACH PASS CURRENT CONTROL**

<table>
<thead>
<tr>
<th>Tin coating weight</th>
<th>Line speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>Constant</td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td>Acc. &amp; Dec.</td>
</tr>
</tbody>
</table>

**Conventional logic**
**TOTAL CURRENT CONTROL**

<table>
<thead>
<tr>
<th>Tin coating weight</th>
<th>Line speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>Constant</td>
</tr>
<tr>
<td><strong>Unstable</strong></td>
<td>Acc. &amp; Dec.</td>
</tr>
</tbody>
</table>

**Management of coating weight**

- **Tracking point generation**
- **Output position**
- **Control area**
- **Strip flow**
- **Coated weight**
- **Weight to be coated**

**Coating weight (1.1mg/m²) at acceleration of line speed**

- **Accelerations**
  - **Conventional logic**
  - **Over Coat**
  - **Each Pass Control**

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Tin coating weight is kept constant even when the line speed changes.

**Improvement of production yield**
3. Advanced technologies – New reflow control

Miss heat-up around strip connection point is minimized with “New Reflow Control”

[Tin Alloy Weight]

- Conventional technology
  - Normal operation: OK
  - Welding point: NG

- New technology
  - Normal operation: OK
  - Welding point: OK
3. Advanced technologies – New reflow control

Miss heat-up around strip connection point is minimized with “New Reflow Control”

Conventional technology

- Large size strip
- Small size strip

New technology

- Conduction reflow

Induction heater

earth roll

earth roll

WQ

Conduction

INDUCTION

CONDUCTION

T[^°C]

T[^°C]
3. Advanced technologies – New reflow control

Practical data of reflow control

- Conduction reflow Power
- Induction heater Power
- Strip Temperature
- Reflow condition change

Actual strip temp. is stable during reflow condition change

±3℃
3. Advanced technologies – New reflow control

Alloy weight control considering the line speed

Dominant factor of tin alloy weight
- strip temperature
- time before quenching

Temperature rise by induction heating
Temperature rise by conduction heating

Alloy weight can be kept constant regardless of the line speed.
3. Advanced technologies – Sludge reduction

**Tin consumption**

\[ S_{kg} = \Sigma (S_{nn} [kg/h]) \times (T_n - T_{n-1}) \]

**Production schedule**

<table>
<thead>
<tr>
<th>Coil No.</th>
<th>Weight (ton)</th>
<th>Production Speed (mpm)</th>
<th>Thickness (mm)</th>
<th>Width (mm)</th>
<th>Coating (g/m2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>170201157</td>
<td>18.5</td>
<td>400</td>
<td>0.28</td>
<td>900</td>
<td>1.1</td>
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<tr>
<td>170202072</td>
<td>16.0</td>
<td>350</td>
<td>0.20</td>
<td>880</td>
<td>2.8</td>
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<tr>
<td>170202457</td>
<td>17.5</td>
<td>350</td>
<td>0.32</td>
<td>1,020</td>
<td>5.6</td>
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<tr>
<td>170203375</td>
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<td>380</td>
<td>0.25</td>
<td>950</td>
<td>11.2</td>
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<td>170205982</td>
<td>20.0</td>
<td>400</td>
<td>0.28</td>
<td>900</td>
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<tr>
<td>170207821</td>
<td>10.0</td>
<td>350</td>
<td>0.32</td>
<td>1,020</td>
<td>5.6</td>
</tr>
</tbody>
</table>

**Optimal O2 feeding**

\[ L_{1} [L/min.] = \frac{S_{1} [kg/h]}{T_{e}[h]} \]

More sludge generation
3. Advanced technologies – Sludge reduction

**Level - II**
- Production schedule

**Level - I**
- Actual plating current [A]
- Actual Sn$^{2+}$ conc. [g/L]

**Sludge reduction system**

- Tin granule
- Settling tank
- O$_2$ flow control

- Tin replenishing unit
- O$_2$

- Circulation tank
- Tin ion analyzer
- Lab. analysis (batch sampling)

- Sludge filter
- Sludge

- or
- manual correction

- Plating cells

- Actual plating current [A]
- Actual Sn$^{2+}$ conc. [g/L]
3. Advanced technologies – Sludge reduction

### Conventional manual operation

- **Tin granule volume in replenishing unit**
  - **Average 75%, Min. 60%**

### New system

- **Tin granule volume in replenishing unit**
  - **Average 90%, Min. 83%**

**More Sludge**

- **Average 75%, Min. 60%**

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**Hopper**

**Tin replenishing unit**

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4. Conclusion
Conclusion

✓ NSENGI introduced recent experience of up-to-date insoluble anode ETL erection including revamping project from soluble anode system.

✓ NSENGI technologies improves…
  ➢ Coating weight uniformity along width direction
  ➢ Coating weight stability during acceleration and deceleration
  ➢ Less reflow problem at during condition change
  ➢ Tin loss due to sludge generation
Thank you.

NIPPON STEEL & SUMIKIN ENGINEERING
Takuya ARAIKAWA