Developments and Applications of Advanced Water Treatment Techniques in CSC

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1.1 Introduction of CSC

1. China Steel Corporation (CSC), located at Kaohsiung, Taiwan, was founded in December 1971.

2. It is the largest steel company in Taiwan with annual production (in terms of crude steel) around 10 million tons.

3. The domestic market takes roughly 69% of CSC’s production and the exports take 31%. The major export destinations are Mainland China, Japan and Southeast Asia.
1.2 Water Balance in CSC

1) In 2016, the **daily raw water consumption** for production has reduced to **130,500 m³**, the **process water recycling rate** has reached **98.3 %**, and the **water intensity** was reduced to **4.73 m³/tCS**.

2) In 2016, the **total discharge** was **13,629,000 m³**.

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**Production Process**

- Raw water: 47,366 m³
- City water: 413 m³

**Admin Area**

- Condensate: 0 m³
- Rain: 245 m³
- Evaporation: 28,826 m³

**Recirculation**: 274,4260 m³

**Wastewater Treatment**

- 163 m³
- 18,819 m³

**Wastewater Purification**

- Steam: 1,596 m³
- Material yard spray BF slag quenching: 1,154 m³
- 3,560 m³
- 422 m³

**Effluent**

- 13,629 m³

Unit: 1,000 m³/yr
1.3 Development of New Water Source

1) The production water source is **solely** from Fengshan Reservoir.
2) To mitigate water shortage risk **alternative water resources** are needed.
   → a) **Municipal Wastewater Reclamation**
   b) **Seawater Desalination**

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### Production Process

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- **City water** 413

Unit: 1,000 m$^3$/yr

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- **Rain 245**
- **Evaporation 28,826**
- **Steam 1,596**
- Material yard spray BF slag quenching 3,560

- **Recirculation 274,4260**
- **Wastewater Treatment**
- **Wastewater Purification**
- **Effluent 13,629**
1.4 Cooling Water Quality Monitoring

The quality of cooling water used in production process need to be controlled
→ a) **On-line Water Quality & Antiscalant Monitoring**
   b) **Remote Diagnosis**

![Diagram showing water flow and quantities](image)

- **Raw water**: 47,366 m³
- **City water**: 413 m³
- **Condensate**: 0 m³
- **Rain**: 245 m³
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- **Material yard spray**: 3,560 m³
- **Recirculation**: 274,426 m³
- **Admin Area**: 163 m³
- **Wastewater Purification**: 3,206 m³
- **Wastewater Treatment**: 18,819 m³
- **Effluent**: 13,629 m³

Unit: 1,000 m³/yr
1.5 Wastewater Treatment and Reuse

Increase the **reclamation rate** of process water and **reduce pollutants** in wastewater

→ a) **Membrane Bioreactor**  
   b) **Ammonia Removal**  
   c) **Oil-water Separation**  
   d) **UF/RO, EDR, MD**  
   e) **Sludge reduction**

Unit: 1,000 m³/yr
2. EDR Application

2.1 Introduction of EDR

1) EDR is an electrochemical charge driven separation process that dissolved ions are separated through ion permeable membranes under the influence of an electrical potential created by an anode and a cathode.

2) It has been extensively used for the removal of salt from a variety of water
2.2 EDR Application in Hot Rolling Mill

1) The **direct cooling water** is used to control the temperature during production of slab.

2) The direct cooling water flows back to **cooling tower** after heat exchange and is concentrated due to evaporation and splashing.

3) The water in cooling tower needs to be partially discharged to control the water quality avoiding scaling and corruption of the system.
Direct Cooling Wastewater Reclamation by EDR in Hot Rolling Mill

- Cooling Tower: ~36,000 m$^3$/d
- Partial discharge
- Cooling water (Blow down)
- Sand filter
- Fine particle filter
- EDR modules: 1,200 pairs of ion exchange membrane
- Industrial water (Make up)
- EDR
- Reclaimed water
- Storage Tank
- Concentrate
- 700 m$^3$/d
  - Conductivity: 1,700 μS/cm
  - Ca-H $\leq$ 300ppm
  - Cl$^-$ $\leq$ 170ppm
- 550 m$^3$/d
  - Conductivity: <350 μS/cm
  - Ca-H $\leq$ 10ppm
  - Cl$^-$ $\leq$ 10ppm

The desalination rate and recovery rate of EDR are 80% and 78% separately.
2.3 EDR Application in Electrolytic Galvanizing Line (EGL)

1) EGL produces cold-rolled steel strips, which require alkali and hydrochloric acid to remove anti-rust oil, rust, and other impurities during production processes.

2) Demineralized water (DMW) is used to rinse the remaining acid and alkali on the strip surface (Max: 1,600 CMD).

3) EDR was applied to treat the selected EGL wastewater streams for DMW production.
Wastewater Reclamation and Reuse in EGL

1) Coagulation, flocculation, sedimentation, filtration, EDR, and IX processes were applied to treat the selected EGL wastewater for pure water production.

2) The plant is capable of supplying 540 m³/day of reclaimed pure water and the conductivity of the pure water is <10 μS/cm with ≥70% recovery rate.
3. MBR Application

3.1 Introduction of MBR

1) Membrane bioreactor (MBR) is the combination of a membrane process with a suspended growth bioreactor.

2) The microorganisms in MBR system remove organic pollutants and membrane separates water from suspended solids.

3) MBR enhances the concentration of microorganisms in the system and improves the processing efficiency.

https://www.membrane-solutions.com/Membrane_bioreactors.htm
3.2 MBR Application in Coke Oven WWTP

1) Coke oven wastewater and sanitary wastewater were mixed and treated together with activated sludge having >85% COD removal.

2) With the expansion of production line, the wastewater flow rate and COD amount were exceeding the capacity of the original design.

3) The stability of the microorganisms in activated sludge was affected leading the concentration of S.S. and COD in effluent increased.
Application of MBR to treat coke oven wastewater

1) A membrane bioreactor (MBR) system was established to increase the capacity of the coking wastewater treatment system.

2) The secondary effluent COD decreased ~20%, equal to 720 kg COD/day; the S.S. concentration decreased from ≥30 to ≤5 mg/L.

MBR module for coking wastewater treatment
3.3 MBR Application in Cold Rolling WWTP

The oily and alkaline wastewaters contain soluble oil and surfactant that contributed to approximately 80% of total COD influent.

- **Acidic wastewater**
  - Coagulation/Flocculation/Sedimentation

- **Oily wastewater**
  - Oil skimmer
  - Dissolved air flotation
  - Equalization
  - Coagulation/Flocculation/Sedimentation
  - Sand filter

- **Alkaline wastewater**
  - Dissolved air flotation
  - Oily cold rolling wastewater

- The effluent COD was 152±61 mg·L⁻¹

- **IWWTP**

- **Treatment capacity**
  - 2,000 m³/d
  - 900 m³/d
  - 750 m³/d
  - 1,650 m³/d
1) The conventional physical-chemical process cannot effectively treat cold rolling wastewater with high COD content. MBR was installed to cold rolling WWTP in 2013.

2) COD < 80 ppm, and oil < 8 ppm with decreasing COD of 449±170 kg COD/day in the effluent after instillation.

Cold rolling wastewater MBR
4. Sludge Reduction
4.1 Organic Sludge Treatment Process in CSC

1) Belt press produces ~30 tons of sludge cake per day
2) Water content of sludge cake is ~67%
3) The sludge cake is sent to incinerator in CSC

→ seeking a technique to dewater organic sludge by itself without adding inorganic sludge
4.2 Introduction of Deep Conditioning

Reagent 1
- Breaking cell wall
- Hydrolysis

Reagent 2
- Polymerization

Reagent 3
- Flocculate or gelatinous precipitate

Hydrophilic ➔ Hydrophobic material
Unevenly distributed ➔ evenly distributed particles
Loosely precipitate ➔ forming bridge structure
### 4.3 Sludge Reduction by Deep Conditioning

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<th>Volume (L)</th>
<th>VSS (%)</th>
<th>CST (secs)</th>
<th>Water content (%)</th>
<th>pH</th>
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<td>51</td>
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Filtrate

The water content of the dewatered organic sludge cake decreased to 51% without adding inorganic sludge.
5. Summary

1. EDR system reclaimed 550 m$^3$/d of cooling wastewater in hot rolling mill saving 22,000 USD/yr.

2. EDR system reclaimed 540 m$^3$/d of wastewater in EGL saving 39,000 USD/yr.

3. The MBR system reduced the COD discharge of 720 kg COD/day in coking wastewater.

4. The MBR system reduced the COD concentration in the effluent of cold rolling WWTP from 152 to 56 mg/L.

5. With deep conditioning method, the water content of organic sludge reduced to <60% without adding inorganic sludge, and the amount of sludge cake sent to the incinerator was predicted to decrease 80%.
Thank You
鹽度<1克/升時，脫鹽成本EDR<IX<RO；
鹽度介於1~2.5克/升時，則EDR<RO<IX；
鹽度>2.5克/升時，則RO<EDR<IX。