The Compact Strip Process (CSP) was first developed by SMS Demag in the late 1980’s and revolutionized the steelmaking process. This process allows scrap steel to be melted, cast, and hot rolled into a coil of steel all in one continuous process. The success of this process relies on the ability to cast an extremely thin slab (35-65 mm [1.38-2.56"] thick) which reduces the number of caster segments and finishing mill stands necessary to produce a coil of steel. The casting speeds required to properly extract heat for the steel solidification process at this thickness are much higher than in conventional “thick slab” casters. CSP casters typically produce slabs at speeds ranging from 4.5 to 5.5 meters per minute with peak speeds of up to 7 m/min compared to conventional slab casters that cast at below 2 meters per minute. At high casting speeds, the heat flux across the copper mold has been calculated to be in excess of 1,000,000 BTU/ft²/hr and the waterside meniscus (solidification point) skin temperature has been measured to be greater than 350°F (177°C). Waterside mold water system deposits are known to cause uneven and/or poor heat transfer that can lead to breakouts, excessive copper mold wear, and surface cracking defects. Thus, the performance of the mold cooling water system plays a critical role in the overall success of the Compact Strip Process.

A CSP caster capable of producing 3.4 million tons per year was experiencing a high rate of longitudinal cracking type surface defects, particularly in crack-sensitive grades used to produce heavy guage galvanized products. This CSP caster operates with casting speeds beyond 5.3 meters per minute to maximize mill productivity, putting additional stress on the caster cooling water systems. This CSP producer contacted Nalco after learning about the success of the Nalco Cast Clean program at two other CSP facilities. Nalco immediately conducted a 3-day audit of the mold water system that involved data analysis and benchmarking of water system Leading Performance Indicators and Key Performance Indicators against Nalco’s Global Best Practices. This audit process revealed a direct relationship between mold water quality, waterside copper mold deposition, mold wear rates, and longitudinal cracking (see Figure 1).

<table>
<thead>
<tr>
<th>CUSTOMER IMPACT</th>
<th>E ROI</th>
<th>ECONOMIC RESULTS</th>
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</thead>
<tbody>
<tr>
<td>7 fewer mold shipments and cleanings</td>
<td>$2,225,000/year</td>
<td></td>
</tr>
<tr>
<td>17,000 tons/year in reduced steel rejections</td>
<td>$1,700,000/year</td>
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eROI is our exponential value: the combined outcomes of improved performance, operational efficiency and sustainable impact delivered through our services and programs.
5. The surge tank was not part of the recirculating loop and was therefore prone to microbiological growth which captured and periodically released iron oxide, resulting in iron oxide deposition on the mold coldface.

6. The system lacked automated chemical feed to control copper and iron oxide deposition.

7. The non-uniform copper oxide and iron oxide deposits that formed on the copper mold coldface generated uneven heat transfer across the width of the mold resulting in thermal stresses on the newly formed slab, excessive copper mold wear rates, and longitudinal surface cracking on the finished product.

**KEY AUDIT FINDINGS**

1. Longitudinal face crack frequency was above Nalco global best practice level.
2. Mold copper campaign life was below Nalco's global best practice level.
3. Backpressure of the system was very low for normal operating casting speeds, resulting in the potential for nucleate boiling at the meniscus and very high coldface temperatures that exceeded the auto-oxidation temperature of copper forming copper oxide deposits.
4. Dissolved gases could not be efficiently stripped from the system in the event of air intrusion (see Figure 2) which led to poor heat transfer very high mold coldface temperatures that exceeded the auto-oxidation temperature of copper forming copper oxide deposits.

**CORRECTIVE ACTIONS TAKEN TO REDUCE LONGITUDINAL CRACKS**

Nalco provided this CSP producer with a 4-step action plan to address the mold coldface deposition that was determined to be the root cause of the longitudinal cracking:

1. The system backpressure was adjusted to the upper specification range supplied by the manufacturer to minimize nucleate boiling and meniscus coldface temperatures.
2. The surge tank was placed into the recirculation loop to minimize microbiological inoculation and growth points in the system.
3. A centrifugal Degassifier was placed in the system to remove free gas from the system.
4. The Nalco Cast Clean mold water treatment service was implemented, combining:
   - TRAC Inhibitors and Biocides Engineered for High Heat Flux Mold Systems
   - Real-time Inhibitor Control using Advanced 3D TRASAR® Automation Technology
   - Web-based Monitoring of Critical Leading Performance Indicators
   - 24/7 Mold System Health Check with Nalco 360™ Service
   - Application of Nalco Global Mold Water Best Practices

![Figure 1 - Copper Mold Coldface Deposits](image1)

![Figure 2 - Dissolved gas in Mold Water](image2)
RESULTS

After the corrective action were implemented, an immediate improvement in product quality, mold cleanliness, and mold life were noted (see Figures 3 and 4). The frequency of longitudinal crack defects dropped by more than 76% and resulted in 17,000 fewer tons of steel that were rejected either internally or externally by the customer. In addition, mold campaign life was increased by 33% without any increase in the longitudinal crack frequency rate.

TOTAL COST OF OPERATIONS SAVINGS

The Total Cost of Operations savings associated with the improvements made have been estimated at more than $2,225,000/yr:

• 17,000 tons/yr of rejected steel @ $100/ton avg cost = $1,700,000/yr
• 7 fewer mold shipments and cleanings @ $75,000/mold = $525,000/yr

Figure 3 – Mold coldface after corrective actions

Figure 4 – Reduction in longitudinal face cracking