The new Techint electrolytic tinning line at Aceralia Aviles

Aceralia is successfully completing a major phase in the modernisation of its tinplate facilities at its plant in Aviles, Spain. Modernisation has included the construction of a new 250kt/y electrolytic tinning line, which has achieved its design parameters in a relatively short period of commercial operation.

BY G ASTENGO, P COMELLI & L CORONEL

To address increased market demand and also to improve product quality, Aceralia (Arcelor Group) decided to install a new Electrolytic Tinning Line (ETL) at its plant in Aviles, Spain.

The new ETL can process strip up to 1250mm wide and has a capacity of 250kt/y. The line is mainly destined to produce very high quality materials in wide format to supply stamping lines for beverage cans. The line uses Phenol sulphonic acid (PSA) electrolyte but sufficient space has been left to convert to Methane Sulphonic Acid (MSA) and for inserting Tin Free Steel (TFS) coating tanks with relevant circuits, should the demand arise.

The contract was signed in December 2001 with a consortium consisting of Techint Compagnia Tecnica Internazionale SpA (Techint Technologies, Italy) and the locally based companies UTE Línea de Hajalata N3 composed of Duro Félguera Plantas Industriales SA, PGB Weserhütte SA, Ingemas SA and Daorje SA. A separate contract was signed with two electrical companies, TSK and Ingelectric.

Erection works started in October 2002 and shipment equipment commenced to the site. At the close of 2002. After completion of individual running tests of each part of the line, the cold run and hot run stages were performed and the first trial plating realised in October 2003. The line is now in full commercial operation and is producing first quality tinplate (Fig 1).

DESIGN PARAMETERS

The basic design parameters of the line are summarised in Table 1.

The ETL is capable of depositing coatings from 1.00g/m² to 11.2g/m². All combinations of differential coatings from 1.2/2.2g/m² to 8.4/11.2g/m² can be produced. The most common product of the equal coating per side is 2.8/2.8g/m², and for differential coating is 2.8/3.8g/m².

LAYOUT & FEATURES

The overall length from the axis of Payoff Reel No 1 to the axis of Tension Reel No 2 is 140m.

The main features of the tinning line are:
- Entry Section
  - Double Payoff Reel system
  - Two Thickness Gauges
  - Double Cut Shear
  - Narrow Lap Seam Welder with Preloader
  - Notcher

- Turret Type Side Trimmer
- Scrap Bailer
- Double Entry Loop Towers (24 strands each)

Process Section
- Electrolytic Cleaning section
- Tension Leveller
- Electrolytic Pickle section
- TFS Plating section (space provision)
- Tin Coating Weight Gauge
- Differential Markers
- Induction Reflow and Quench section
- Chemical Treatment section

Exit Section
- Exit Loop Tower (24 strand)
  - Inspection Stand
  - Instrument Stand with Laser Pinhole
  - Detector & Thickness Gauge
  - Flying Shear
  - Dual Tension Reels

ENTRY SECTION

The entry section features a dual Pay-off Reel. This arrangement, along with the

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Phenol sulphonic acid (PSA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrolyte</td>
<td></td>
</tr>
<tr>
<td>Production Capacity</td>
<td>250kt/y</td>
</tr>
<tr>
<td>Tin Free Steel</td>
<td>Space provision</td>
</tr>
<tr>
<td>Line Reference Length</td>
<td>200m approx.</td>
</tr>
<tr>
<td>Material Specification</td>
<td></td>
</tr>
<tr>
<td>Thickness</td>
<td>0.10 to 0.60mm</td>
</tr>
<tr>
<td>Width</td>
<td>600 to 1250mm</td>
</tr>
<tr>
<td>Coil Weight</td>
<td>25-6900kg max</td>
</tr>
<tr>
<td>CoiD</td>
<td>up to 2100mm</td>
</tr>
<tr>
<td>Line Speeds</td>
<td></td>
</tr>
<tr>
<td>Entry &amp; Exit Sections</td>
<td>650m/min max</td>
</tr>
<tr>
<td>Process Section</td>
<td>500m/min max</td>
</tr>
<tr>
<td>Threading Speed</td>
<td>30m/min</td>
</tr>
<tr>
<td>Exit Section Shear Speed</td>
<td>80m/min max</td>
</tr>
<tr>
<td>Coating Thickness (per side)</td>
<td></td>
</tr>
<tr>
<td>Tin Coating</td>
<td>11.2g/m² max</td>
</tr>
<tr>
<td>Oil coating Type</td>
<td>DOS and ATBC</td>
</tr>
<tr>
<td>*Space provision for Methane Sulphonic Acid (MSA)</td>
<td>2.5-20mg/m²/side</td>
</tr>
</tbody>
</table>

Table 1 Basic design parameters

The authors are with Techint, Torre Shipping, Via De Marini 55, 16149 Genova, Italy.
Techint, Via Monte Rosa, 93 - 20149 Milan, Italy.
eccentric adjustment is accomplished without reducing the drive gearing mesh (Fig.3).

There are two knife drives for the side trimmer. Each drive is mounted on an hydraulic shifting base so that the drives can be disengaged when the knife housings are rotated for changing cutters. Variable speed AC motors drive the knives.

The scrap from the side trimmer is sent to a bailer hopper located below the trimmer in the basement. The bailer takes these edge trimmings and compresses them into a ball measuring about 200 x 400mm, which is conveyed into a scrap bucket for easy handling and removal by overhead crane.

A double loop vertical accumulator tower is located between the entry section and process section. This can contain sufficient stored strip to maintain the process section at full speed during coil loading operations. Each tower has its own drive, which operate in unison with each other. Each tower contains 24 strands and has a total carriage travel of 21.6m. Eight helper roll drives are included to reduce tension buildup within the towers (Fig. 4).

**PROCESS SECTION**

The process section starts with a cleaning section to remove the surface dirt and oils that have collected during prior processing operations. This cleaning section employs electrolytic cleaning for efficient removal of these soils from the strip. To increase the cleaning efficiency, necessary especially in the case of Double Reduced strip, a brushing machine is installed downstream of the electrolytic cleaning tank. Following cleaning, the strip is rinsed and dried and then enters the tension leveller to ensure flatness.

Following the tension leveller the strip enters the Pickling Unit. The purpose of this unit is to remove oxides and rust from the strip and to lightly etch the strip to present a clean and active steel surface to the plating section. This process is also performed using electrolytic action, similar to the cleaning step. The strip is rinsed and enters the Tin Plating section following the pickling step.

The tinning process uses Phenol Sulphonic Acid (PSA) as the plating metal. Two separate plating tanks are installed and two drag-out tanks. One half of the final cell in the plating section is equipped with insoluble anodes to control the tin concentration build up in the bath. The high speed of the line made it necessary to place splashguards around the strip as it leaves the plating bath. The function of the first drag-out tank is to reduce the loss of electrolyte as it adheres to the strip on leaving the last plating tank. The second drag-out tank adds the correct concentration of flux on to the strip surface for subsequent flash melting of the coating to a bright finish.

Following the plating section there is a coating weight gauge to measure and control the coating thickness.

The electrolytically deposited tin coating has a dull matte appearance. To form the continuous surface layer of tin and create the tin-iron alloy required for good corrosion resistance, the strip is heated to above 232°C, the melting point of tin, by passing it through high frequency induction coils. The tin melts within seconds and is then quenched to produce a bright lustrous finish free of stains or films caused by plating solution drying on the surface (Fig 5). This station is equipped with mirrors and strobe lighting to view the sides of the strip. Manual inspection and a camera based inspection system are both used by Aceralia. The instrument stand consisting of a pinhole detector and a thickness gauge located in the exit section to monitor strip quality as it is recoiled.

Several exit section components help reduce the capacity needed in the exit loop tower by minimising slowdown in this section. A flying shear is provided to shear the strip at speeds of up to 80m/min. As the strip is sheared, the shear transfers the strip from one pass line to the other, directing the strip to the next tension reel group. The shear can also be used to cut strip for up to three samples. These are separated from the passing strip and brought into the reach of the operator by an elevator device.

The tension reel ramps up to line speed as soon as...there are several wraps on the tension reel drum. The completed coil is removed from the tension reel by the coil car and the tension reel and the belt wrapper are prepared for the next coil.

**FLUIDS RECIRCULATION**

All the fluid circuits are located in the basement. The main circuits are listed in Table 2.

Filtering units to remove oil residues from the cleaning solutions and sludge from tinplating and chemical treatment solutions are provided to ensure lower consumption, reduced waste fluid disposal and better strip quality.

All circuits use acid-proof pumps (operating and stand-by), coolers and/or heat exchangers and proper instrumentation to permit complete control and operation from the main pulpits. User-friendly real-time screen pages present information on tempera-tures, flow-rates, conductivity, pH, pressures, levels, position of manual and regulating valves, pumps status (running or not).

**AUTOMATION & CONTROL**

Ingelectric supplied the electrical equipment for the project according to the motor and control lists specified by Techint.

The line is able to operate at different levels of automation:
- Full manual, giving the operator the ability to control the movement of machines so as to carry out maintenance or fine-tuning.

![3 Rotating turret edge trimmer](image)
![4 Double loop accumulator tower at Aceralia](image)
![5 Vertical Inspection Station](image)

Table 2 Main process fluid circuits

<table>
<thead>
<tr>
<th>Process Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkaline Cleaning</td>
<td>Electrolytic Cleaning</td>
</tr>
<tr>
<td>Brush Cleaning</td>
<td>Ultra filtering</td>
</tr>
<tr>
<td>Cleaning Rinsing (low and high pressure)</td>
<td>Pickling</td>
</tr>
<tr>
<td>Pickling Rinsing (low and high pressure)</td>
<td>Tinplating with Evaporator and Filtering</td>
</tr>
<tr>
<td>Drag-out</td>
<td>Quench</td>
</tr>
<tr>
<td>Condensate</td>
<td>Chemical Treatment</td>
</tr>
<tr>
<td>Chemical Treatment</td>
<td>Electrochemical Treatment</td>
</tr>
<tr>
<td>Chemical Rinsing (low and high pressure)</td>
<td>Chemical Filtering</td>
</tr>
</tbody>
</table>

16 Steel Times International January 2005
Our products are tailor-made to suit your needs

Strip Processing Lines

Advanced technology, customer service, unique products designed to meet your specific needs. In short, Techint.

Annealing, Cleaning, Coil Handling, Colour Coating, Electrolytic Tinning, Finishing, Galvanising, Pickling for steel and aluminium coils are our specialities.

With over 500 lines installed, we are constantly improving the design of our Process Lines. Engineers and designers can carry out tailor-made projects on a turn-key basis or provide engineering, supply, personnel training, know-how transfer, and operational assistance through a network of industrial plants & operating centres owned by our Group.

Techint Technologies
YOU ARE IN GOOD HANDS
Assessing the weathering performance of chromate-free coil coatings

Chromate ions, most often in the form of zinc and strontium chromate pigments, have been the mainstay of high performance anti-corrosive coatings for many years. In various forms they are used in a wide range of industries including aircraft, construction, marine and oil. Chromate compounds are used in pretreatments, etch primers and a variety of other substrate-specific primers.

However, environmental legislation around the world is moving to restrict the use of chromate pigments. As a result there is a general agreement to work towards the elimination of hexavalent chromium (Cr(VI)) compounds for corrosion protection — whilst coil coaters, naturally, are looking for maintained or improved anti-corrosion properties and continuing economy in use.

The urgency of the problem has raised demands for fast answers through accelerated corrosion tests but there are real doubts about their value. The faster the test, the higher the acceleration factor, the lower the chances for good correlation with natural conditions. In the late 1990s the European Coil Coating Association (ECCA) carried out an exhaustive study comparing natural and laboratory-based weathering. Tests included the established ASTM B-117 salt spray test; the more recent 'Prohesion' test — with and without combinations with the QUV accelerated weathering test and specific industry protocols. Studies were made on the face of the panel, the edges, scribes, fastenings, etc in a very detailed study. No usable correlations were found for any systems on galvanised steel.

Natural weathering is not a controlled process. We can record rainfall, temperature extremes and average hours of sunlight and panel temperatures and we can attempt to incorporate this data into our laboratory testing but we cannot incorporate the element of disorder, of natural chaos. In the foreseeable future we will need the support of real-time natural exposures at aggressive locations over extended periods of time. Becker has exposed thousands of panels at Bohus Malmön on the west coast of Sweden, a severe marine exposure site (Fig 1) and, more recently, at Hainan Island in China where the higher temperatures should make the conditions even more severe. Bohus Malmön provides aggressive corrosion testing, more likely to show up primer weaknesses than, for example, one of Becker's industrial test sites. Only one external site has been used at this stage to keep the number of variables in the test down to a manageable level.

CORROSION CHEMISTRY

Anti-corrosive pre-treatments and primers aim to passivate sites susceptible to attack, inhibiting the rate of electrochemical corrosion. For steel the corrosion reaction is:

$$\text{Fe} + 2\text{H}_2\text{O} \rightarrow \text{Fe}^{2+} + 2\text{OH}^- + \text{H}_2$$

forming red rust.

With zinc coated steels the zinc coating is sacrificially consumed in preference to the steel due to its greater reactivity. The reaction involved is:

$$2\text{Zn} + 2\text{H}_2\text{O} + \text{O}_2 \rightarrow 2\text{Zn}^{2+} + 4\text{OH}^- \text{and 'white rust' is produced.}$$

HOW CHROMATES PREVENT CORROSION

Passivation or inhibition reduces the galvanic current between the zinc and iron. Partially soluble hexavalent chromate salts passivate the anodic areas of metals although there is little agreement as to the mechanism involved. One explanation is that the CrO$_4^{2-}$ ion is an anodic precipitation inhibitor and oxidising agent but there is evidence that its reduction product Cr$_3^+$ may also act as a cathodic inhibitor. Research carried out at the University of Surrey in England in conjunction with Becker has demonstrated that effectively all the hexavalent chromic in a 'chromed-rinsed' pre-treatment such as Bonderite 1303 is effectively converted to Cr$_3^+$ prior to the application of the primer. The delivery of chromate from the primer to the substrate relies on moisture permeating the coating, dissolving traces of

Chromate Solubility in water (moles CrO$_4^{2-}$/per litre) Comment

<table>
<thead>
<tr>
<th>Chromate</th>
<th>Solubility in water</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaCrO$_4·2\text{H}_2\text{O}$</td>
<td>3.3</td>
<td>Too soluble for a pigment</td>
</tr>
<tr>
<td>2ZnCrO$_4·K\text{Cr}_2\text{O}_7·2\text{H}_2\text{O}$</td>
<td>1.5x10$^{-4}$</td>
<td>Anticorrosive pigments</td>
</tr>
<tr>
<td>ZnCr$_2\text{O}_4·4\text{Zn(OH)}_2\text{H}_2\text{O}$</td>
<td>7x10$^{-4}$</td>
<td>Colour pigment — no anticorrosive activity</td>
</tr>
<tr>
<td>PbCrO$_4$</td>
<td>7x10$^{-7}$</td>
<td></td>
</tr>
</tbody>
</table>

*Laboratory Manager, Coil Coatings, BIC UK.
**Senior Chemist, BIC Long Term Development Group

Table 1 Solubility of chromates in water

Accelerated exposure tests favour chromate containing coating systems but in practice there is little correlation between laboratory-based testing and natural conditions where seven years of testing chrome-free coatings have shown some to perform equally as well as chrome based systems.

BY P HEFFER* & B LEE**

I The Bohus Malmön exposure site in Sweden, which has been used since 1997 to compare chrome-free coated panels with chrome containing systems (conventional 45° test orientation shown)

18 Steel Times International January 2005
cathodic inhibitors and (c) provide a renewable source of these salts as they are washed away or used up.

Alternative chrome-free pigments for coil primers are only part of the overall coating system. The metal pre-treatment, which forms part of the cleaning and degreasing process, is traditionally chrome-based and this also must be modified. Substrate manufacturers have also been looking at improvements to their products: In galvanised steel the removal of lead from the zinc coating has improved corrosion resistance significantly.

Becker has worked closely with major pre-treatment suppliers for many years to provide a fully chrome-free package and systems have been used commercially and in line trials across Europe over the past six years (Table 2). In all cases, panels were exposed in both accelerated test cabinets and natural external environments.

Becker's biggest project to date started in 1997. This compared the latest developments in pre-treatments and primers applied to the traditional ferrous substrates: HDG (Hot Dip Galvanised) zinc coated steel, Galvalume 45/55 zinc/aluminium coated steel and Galfan 95/5 zinc/aluminium coated steel. Table 2 shows the large number of primers evaluated, both chromated and chrome-free. Substrates from different steel producers were pre-treated with 15 different recipes. The most popular topcoats were then applied to the primed panels. The complete investigation of all permutations would have totalled 7965 systems, so an experimental design was used to whittle down the number to 770 combinations of substrate, pre-treatment, primer and topcoat.

Panels were subjected to accelerated testing in ASTM B117 salt spray (continuous fog of 5% sodium chloride at 35°C) and ASTM G85-A5 Prohesion cabinets (cyclic fog of 0.05% sodium chloride and 0.5% ammonium sulphate with 1 hour fog unheated and 1 hour dry at 35°C). In addition, natural exposure was conducted at Bohus Malmö in two orientations - conventional 45° south facing (Fig 1) and vertical north facing 'under eaves' (Fig 2). (Paint facing north under the eaves is attacked more severely because drying takes longer with no sun to warm the surface).

ECCA's lack of success in finding accelerated tests to mimic natural exposure confirms Becker's long-held view that salt spray testing alone does not provide sufficient evidence to launch a new product. Unfortunately ASTM B117 salt spray is the most widely specified accelerated test for the evaluation of corrosion resistance and hence is the driving force behind the performance criteria of many protective coatings despite strong evidence of its unreliability. The initial findings from Becker's project confirm that there is little correlation between laboratory-based testing and natural conditions. Certain formulations, which perform well in salt spray, actually perform worse in the field.

Other panels that performed poorly in salt spray are still performing well at Bohus Malmö after six years' exposure, illustrating why some primers that perform poorly in salt spray have become commercially accepted on the basis of their exterior performance.

A selection of panels that are performing well on exterior exposure compared with their accelerated test counter-parts are illustrated in Figs 3, 4 & 5 a, b, c. Each series shows, from left to right, (a) hot salt spray, (b) Prohesion, (c) scribed north-facing and south-facing panels respectively.

This extensive work shows that:

- It is unlikely a single pigment will replace stannium chromate. Combinations of two or three pigments are needed to give a synergistic effect.
- Higher loadings do not automatically lead to improved corrosion resistance. Levels need to be optimised. This is commercially important due to the higher cost of the new pigments.
- A particular combination that works in one resin system over a particular pre-treatment may not work in a different resin pre-treatment combination.
- This can lead to a self-perpetuating project in search of 'the best chrome-free primer' as 'new improved' raw materials are produced by suppliers. Hundreds of new permutations are currently being evaluated in this most recent phase of exposures.

Resin developments form a further piece of the puzzle. High-build non-PVC systems are becoming more popular, generally using polyester or polyurethane primers that can be applied at higher film thickness, typically around 20-25 microns. This situation generates further formulation problems with differences in rates of release of the separate ions from the different anti-corrosives when combined in thicker resin films.

**UNDERSTANDING THE SCIENCE**

Becker's primer evaluations have not been confined to exterior performance testing. Work is being done to better understand the mechanisms of adhesion and the physical and chemical interactions between paint, pre-treatment and metal surface, including the roles of the different formulation components. This work uses the surface analytical expertise of the University of Surrey with X-ray Photoelectron Spectroscopy (XPS) and Time of Flight Secondary Ion Mass Spectroscopy (ToF-SIMS) analysis.

XPS interrogates the top five nanometers of a surface by exposing it to a beam of X-rays, which then eject electrons from the inner electron shells. The energy of the electrons gives information of the element and its oxidation state.

ToF-SIMS is even more surface-specific, analysing the top two nanometers of a surface. A beam of ions - an element such as gallium is directed on to the surface and the secondary ions ejected are categorised in a time of flight analyser. These techniques identify the chemistry of the surface and, using a combination of the two processes, we are better able to understand the adhesion mechanisms (and failures) at the pre-treatment/primer and primer/topcoat interface.

In conclusion, Polyurethane primers, both conventional and high build, are generally most successful when it comes to incorporating the new chrome-free pigments. Some systems perform at the same level as chromates.

Chrome-free epoxy primers can be produced but their inherently lower flexibility introduces points of weakness for adhesion initiation at micro cracks in severely formed areas. If a chrome-free pre-treatment is to be used, the ongoing exposure series must be checked for compatibility and interactions.
Tinning line at Aceralia...

- Semi-automatic, when the operator just has to start one of the sequences.
- Automatic, when the sequences are automatically started up by the process events.

Eighty sequences have been foreseen by Techint to control the automatic coil and strip handling, most of them are configurable so that the operator, via the HMI, can provide the link to more sequences to create powerful macro sequences.

The system that manages the recirculation tanks are organised in several subsystems, each consisting of more instrumentation loops.

The rectifiers to supply the DC for cleaning and electroplating are controlled through the automatic implementation of algorithms appropriate to the particular process (cleaning, plating, post treatment, etc.). This provides a variable set (current reference) that satisfies as best as possible the preset values such as current

### Coating

<table>
<thead>
<tr>
<th>Coating Variation</th>
<th>Across strip width</th>
<th>±10% of nominal weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>±15% for 1+1.5g/m²</td>
<td>coating weight</td>
</tr>
<tr>
<td>Along strip</td>
<td>±3% of nominal coating weight</td>
<td>(tin coating)</td>
</tr>
</tbody>
</table>

**Trimming & Coiling**

<table>
<thead>
<tr>
<th>Trimming width accuracy</th>
<th>+0.30/-0.00mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coil winding</td>
<td>±0.5mm (lap to lap) &lt;1.0mm (max cumulative)</td>
</tr>
</tbody>
</table>

Table 3 Product tolerances

or Coulomb density, while taking into account the actual status of the plant depending on variables such as strip width and process speed.

All these auxiliaries are managed by sequences that allow manual intervention but, more commonly, operation is automatic.

The automation system is complete with a multi level troubleshooting system able to signal-up faults and investigate their possible causes, sometimes deriving from incorrect operations or machine or system faults.

**OPERATING RESULTS**

The operation at Aceralia has shown a steady increase in productivity since the initial commercial start-up of the new line in October 2003. The line has produced first quality coils within the design tolerances indicated in **Table 3** since the beginning of commercial operation.

Aceralia continues to gain experience with the operation of the new line and has a continuing programme of data collection and fine-tuning of operating practices to achieve optimal quality over the range of line speeds.

This facility has been designed and constructed in the modern environment of 'global' design, supply, construction and financing activities. The co-operative effort between several international companies and the close attention of a dedicated project management team were essential to the success of the project.