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Trend-setting modernization of the SBQ bar mill at Georgsmarienhütte, Germany

Operation of a high production tinning line with insoluble anode technology

Chinese company Jiangsu Sunshine in Dajiang has started up a new high productivity electrolytic tinning line with the most advanced insoluble anode technology and low-sludge tin dissolution process. The application of Tenova insoluble anode technology minimizes the amount of sludge produced and hence the loss of tin, increasing both quality and productivity at the same time.

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The Dajiang tinning line at Jiangsu Sunshine produces 250,000 t/year of tin plate for sale on both the local Chinese and the export markets. Material grades to be processed comprise cold rolled annealed and tempered low carbon steel, single reduced (SR) and double reduced (DR), mainly to be used for food and beverage cans and packaging. The main technical data of the line are summarized at **table 1**.

It is confirmed that the application of Tenova insoluble anode technology minimizes the amount of sludge produced and hence the loss of tin increasing both quality and productivity at the same time. Other benefits are the reduction of manpower for anode handling and therefore increase in safety during operation, improved coating quality, better process control and working environment. The dissolution process is based on the oxidation of metallic tin granules by oxygen injected into the tinning electrolyte flowing in a dissolution reactor.

Tin dissolution plant

The heart of the insoluble anode tin plating system are the tin dissolution reactors. Tenova's system incorporates a proprietary oxygen injector, and a control which precisely manages the oxygen injection rate, the electrolyte flow rate and pressure, the level of the fluidized bed, and the rate of tin pellet additions. This patented system results in total tin sludge not greater than a conventional soluble anode tin plating system.

The Dajiang Tinning Line utilizes three tin dissolution reactors **(figure 1)**, each with a nominal capacity of 130 kg/hour. However, each reactor can operate between 60 and 160 kg/hour.

The tin pellets are available in large bags, 1 t capacity each, lifted by crane on the top of the reactor and charged inside the hopper on the top of the reactor. The cut of the bag is the only manual op-

Strip thickness	0.15 to 0.55 mm
Strip width	700 to 1.250 mm
Entry/exit section line speed	700 m/min
Process speed	550 m/min
Tin coating weight	1.1 to 11.2 g/m²
Plating electrolyte	PSA-ENSA
Oil (per side)	DOS 2.0 to 12 mg/m²

Table 1. Technical data of the Dajiang tinning line

Figure 1. Dissolution reactors

eration to be performed on the plant. A proper warning advices the operator of the necessity to make a tin charge: the operator at the pulpit has only to push the "charging" button.

Make up of tinning electrolyte. When first starting up a tinning line which utilizes conventional soluble tin anodes, plating electrolyte which already contains the proper quantity of dissolved tin must be loaded into the tin plating section, from some an outside source in order to begin the plating process. Unlike soluble technology the operation of this insoluble anode system, the makeup of the plating electrolyte is done on site in the tin dissolution plant. The first step has been the production of the electrolyte at the required Sn^{2+} and acid concentrations without the necessity to store "already made electrolyte".

Necessary utilities are:
- demineralized water,
- oxygen,
- commercial PSA,
- commercial ENSA,
- metallic tin in pellets.

The tinplate electrolyte comprises:
- 30 g/l Sn^{2+},
- 15 – 20 g/l H_2SO_4 (sulphuric acid) equivalent,
- 5 g/l ENSA.

100 m³ of tinplate electrolyte were produced in a very short time, starting from a dissolution speed of approx. 60 kg/hour with only one reactor in operation. The dissolution speed is driven by the oxygen flow rate controlled by dedicated and precise mass flow regulators. The inside charge is continuously measured through the calibrated differential pressure sensor. The production was stopped when 30 g/l of Sn^{2+} were reached.

The filter was not used during the initial electrolyte production or the first weeks of plating production due to the negligible amount of sludge in the bottles of samples, even after hours of settling.

Tin plating cell

The tin plating section consists of ten vertical electrolytic tin plating tanks, with eighteen plating passes followed by two drag-out/rinse tanks. Each of the plating passes include insoluble anodes constructed of mixed metal oxide coated titanium and edge masks. Because the insoluble anodes are a fixed width, it is necessary to use an edge masking system to accommodate different widths of strip.

The new generation of edge masks are designed to eliminate the center supports that restrict access to the plating cells. The edge mask supports and positioning mechanism are cantilevered from outside the plating cells and located below removable access plates under the walkway.

Insoluble anodes. Inert titanium based anodes with an active precious metal coating (of Ru, Ir, Sn and/or Ta oxides) have been used for this application. The insoluble anodes are vertically positioned in a vertical cell containing the plating solution, and spaced from a strip running through a down-pass and an up-pass **(figure 2)**. Each plating cell has four sets of insoluble anodes: on the up and down passes upper and lower sides.

The insoluble anodes are spaced from the strip by a distance of less than 50 mm, and the plating solution is blown into the gap between said anode and said strip. Due to the very high speed of the strip, the fluid dynamics of the cell tends to create a so called Venturi effect in the region between the strip and the anode which promotes undesired contact between the anodes and the strip and therefore marks of anodes on the strip. For these reasons, anodes have been designed with a regular array of orifices, with the aim of reducing such effect. While reducing the level gap between ascending and descending zone of the plating cell, the orifice distribution has also been conceived to maintain transversally evenness in current density distribution.

A particular design of the lower guide allows the possibility to control both the distance of the anodes from the strip, as well as to regulate the anodes lower position in order to be equal-distant to the strip after a sink roll grinding.

Edge masks. Insoluble anodes are of a fixed width. In order to process strips of different widths, electrically insulating plates – so called edge masks – are used to prevent the current from flowing between

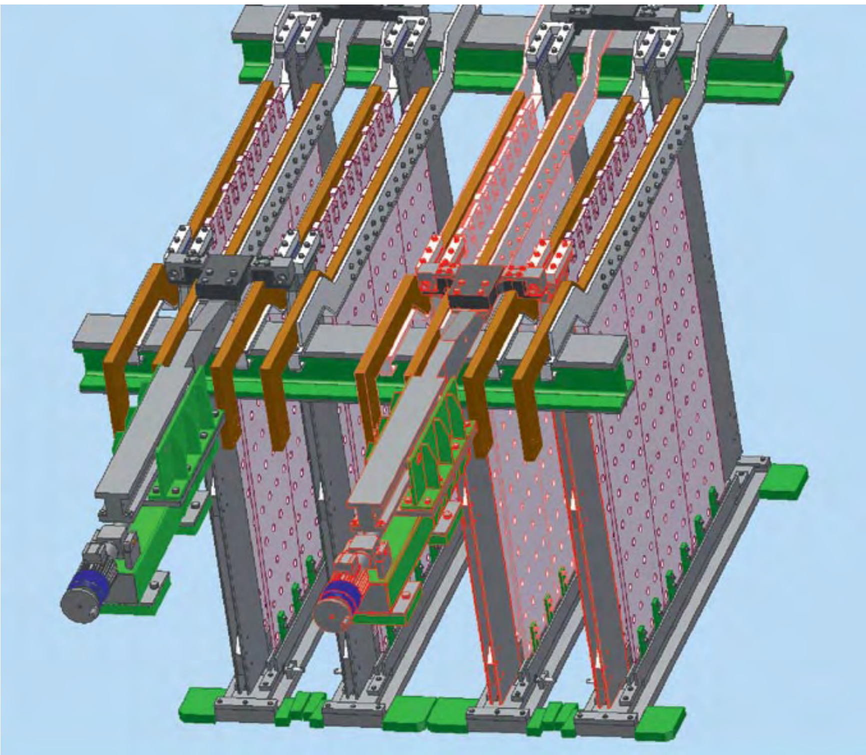

Figure 2. **3D view of a tin plating cell**

the two anodes next to the strip, thus avoiding so called white border defects.

The strip edges engage in U-shaped sections arranged at the end faces of the electrically insulating plates. The degree of edge plating depends on the insertion depth of the strip edges into the U-shaped sections. Accordingly, it is necessary that the U-shaped sections accurately follow the strip travel.

The edge masks must follow the strip very exactly, the expected accuracy being less than 1 mm. Inductive sensors moving jointly to the masks are used to detect the strip penetration and vary the edge mask position accordingly. The working principle of the system is depicted in figure 3.

Edge mask control is obtained by means of a local PLC communicating constantly with the PLC of the line. Edge masks open also when the line was stopped or when the line speed was below a threshold value (30 m/min).

The strip edge position was monitored accurately by the inductive sensors and edge mask drives regulated the mask position accordingly. The whole edge mask control system and the inductive sensors were completely designed, developed and manufactured by Tenova.

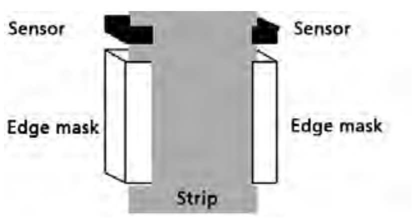

Figure 3. **Edge masks**

When the line was ready for the operation, the first coil was charged obtaining tinplate of commercial quality. Since the first coil produced in the line the tin coating tolerances were in the range of standards. In a few steps the line was able to run at the maximum process speed.

Conclusions

There are various advantages of using insoluble anodes compared to soluble tin anodes as following:

- reduced manpower requirements,
- reduced hazardous operations,
- lower environmental impact,
- higher production schedule flexibility,
- better quality of the final product in terms of better control of the coating weight and more homogeneous distribution of the coating along the cross section of the strip,
- improvement in line production yield in terms of lower deposition defects, higher line availability and higher line productivity,
- better electrolyte solution control and management,
- lower tin and energy consumption.

With conventional soluble tin anodes it is necessary to drain off the plating solution because of the different electrochemical efficiency in plating and dissolution. An increase of tin concentration in the plating solution is unavoidable with the use of tin anodes, and dilution of the solution generates overflow and discharge, with loss of expensive material and possible water pollution, unless adequately treated.

The conventional equipment used in soluble anode lines worldwide for the control of the tin concentration in the plating solution is the insoluble anode. Many producers today have one half cell equipped with insoluble anodes, but the control of the solution is very difficult. Concerns about a rapid decrease of tin and an increase of free acid in the plating solution make the use of insoluble anodes in this way less practical. Other disadvantages in the conventional lines are the fumes exiting the plating tanks, the labour requirements for handling the tin anodes and the low productivity. Additionally, market demand is towards tinplate with thinner coatings; indeed for some uses tin coatings down to 0.2 – 0.4 g/m² are required, causing production problems.

With conventional electroplating technology the homogeneity of tin coating thickness decreases as the coating weight decreases, due to the particular geometry of the tin anodes, which do not present a continuous surface. In fact, each anode is formed by a series of vertical bars drawn against each other so as to leave only a minimum space between the bars, which may produce a lower tin thickness.

Another cause of irregular tin coating with soluble anodes derives from non-uniform consumption of tin bars, which in turn gives rise to preferential current distribution. For thicker coatings such situations are alleviated since more cells are employed in the sequence of electroplating steps, thus allowing the tin coating to grow more uniformly.

The solution to these problems is to equip the tinning line with insoluble anodes. They have a continuous surface and therefore very thin tin coating layers can be produced with high thickness homogeneity. Much higher tinplate production is possible with insoluble anodes in countries where unions impose to slow-down the line while inserting and regulating the tin anodes in the cells. With insoluble anodes no operators are required along the plating section of the line. ■