Galvanizing support

An electromagnetic strip stabilizer to optimize zinc coating

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In the exacting process of galvanization, any movement of the steel strip outside the expected path can lead to problems. If it moves relative to the air-knife that removes excess zinc, the coating will become uneven and may fail to meet quality requirements. Strip movement may also damage surrounding installations. To address this problem, ABB has developed an electromagnetic stabilizer that can reduce vibrations and oscillations at the air-knife, without touching the strip. This solution provides better control of the coating process, leading to improved product quality and faster line speeds. The more even coating also provides cost savings through reductions in the amount of coating material used.

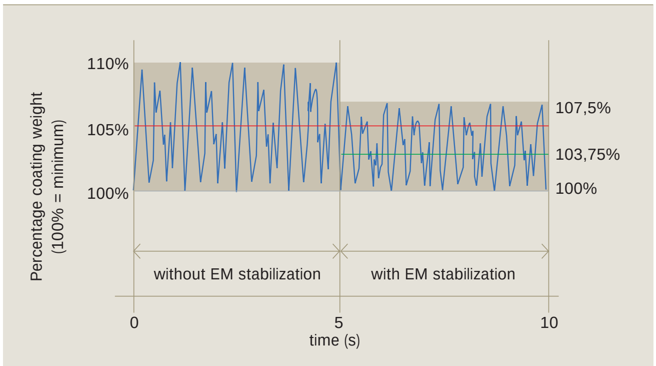
Following successful trials of the equipment at SSAB Tunnplåt AB in Sweden [1], the first electromagnetic stabilizer for a modern, high-speed, ferromagnetic-steel galvanizing line has now been installed and tested at Thyssen Krupp Stahl in Germany, with impressive results. The ABB EM Stabilizer was launched on the market in October 2006.

At the heart of a galvanizing line is the zinc pot – the area in which the steel strip is coated with a thin layer of zinc to protect it from corrosion. Everyday, operators are faced with the challenge of meeting quality requirements within specified cost-margins, while keeping up with production quotas. Apply too little zinc and the steel will be inadequately protected, apply too much and the costs will spiral.

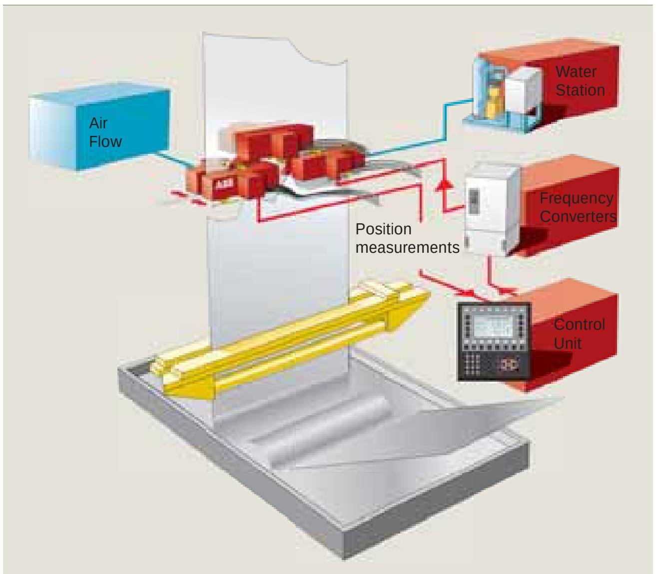
Quality is heavily dependent on the level of vibration in the strip because excess zinc is removed by the action of an air-knife. Until now, there was neither a means of measuring this vibration, nor any way of dampening it. Operators had to rely on visual inspection of the strip surface and down-stream measurements of the zinc coating. If quality was found to be poor, the only solution was to slow production – an unpopular measure in any industry.

The ABB Electromagnetic (EM) Stabilizer offers another solution. It is capable not only of monitoring vibration levels in the steel strip, but also of dampening and maintaining them at a consistently low level.

1 Schematic graph showing the variation in weight of zinc coating with (right) and without (left) EM stabilization. A reduction in variation from 10 percent to 7.5 percent, reducing the average coating (red line) from 105 percent to 103.75 percent of the minimum (green line), leads to a potential saving of 1.25 percent zinc used.



2 The ABB EM Stabilizer system



Benefits of vibration control

Reducing strip vibration improves the control of the air-knife action, making the final coating more uniform. This improved consistency means that the initial application of zinc can be reduced, helping steel users to optimize their products with respect to cost, weight and quality.

Most of the vibration in galvanizing lines arises from a small number of sources. These are imperfections in the line's mechanical components, from the long, free, unsupported strip path, the air blowers, and from the shape and properties of the strip itself. The impact of these factors can be controlled to some extent by regular monitoring and maintenance of critical components and parameters eg, roll bearings and end-roller alignment. But vibrations cannot be eliminated completely, and they are accentuated at higher line speeds and on longer unsupported strip paths.

The benefits of the ABB EM Stabilizer can be summarized as follows:

- Improved product quality resulting from a more even coating
- Increased line speed with maintained or improved coating quality
- Quieter work environment: The reduction of strip vibrations allows the knife to be placed closer to the strip, thus requiring a lower air pressure and hence reduced noise level.
- Cost savings: Additional zinc coating, required to accommodate strip vibration, is in the range of 5–15 g/m² and accounts for 5–10 percent of the process zinc consumption. Since zinc is expensive, even a slight reduction in usage will quickly compensate for the cost of the ABB EM Stabilizer.

The example in 1 illustrates how zinc saving can be achieved by reducing strip vibration. The left-hand part of the figure shows the process without stabilization and the right-hand part with stabilization. Without EM stabilization, a zinc margin of 5 percent is used, ie the average coating weight is 105 percent of that specified. This margin is chosen so that, despite variation in the coating weight (here, 105 ± 5 percent), at no point will the zinc layer be less than the specified thickness (100 percent). By reducing vibration, variations in the zinc coating are reduced from ± 5 percent to ± 3.75 percent. This allows the set point to be reduced from 105 percent to 103.75 percent, without the risk of falling below the stipulated coating weight. Hence, a total zinc saving of 1.25 percent is achieved. This equates to a 25-percent reduction in wasted zinc.

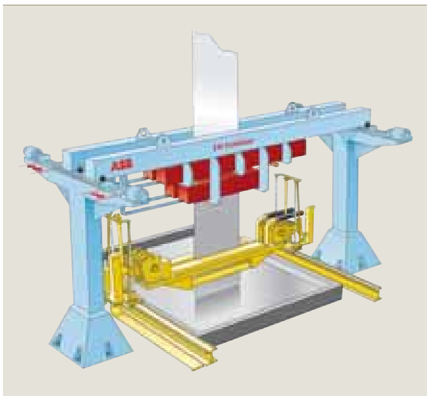
The ABB EM Stabilizer system

Equipment

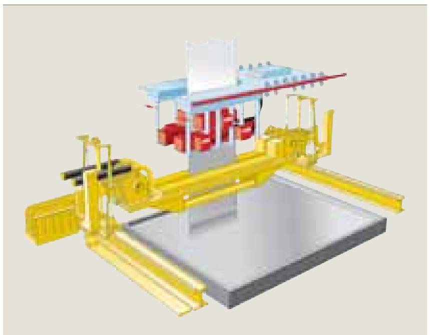
The main components of the ABB EM Stabilizer are six electromagnets, a water-cooling station and a cubicle, containing three frequency converters and a PLC (programmable logic controller). The frequency converters each control the currents to one pair of electromagnets. The stabilizer is also equipped with several air-cooled position sensors to detect the strip position as a function of both time and space. The stabilizer is operated from

Operational profitability

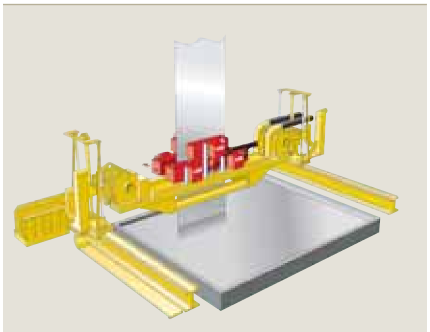
3 The ABB EM Stabilizer installed on a beam supported by two pillars



4 The stabilizer suspended from an overhead construction



5 The stabilizer installed close to air-knife



6 Hot Gauge platform with ABB EM Stabilizer magnets

the PLC panel with alarm handling and operation control 2.

Each electromagnet consists of an iron core with electric windings. The windings are series-connected and cooled by water. The magnet sections are enclosed in a stainless steel casing and are positioned in pairs to control for three-dimensional movement in the strip. One magnet from each pair is mounted at the front of the strip, with the other mounted at the back. Two pairs are arranged so that they cover the left- and the right-hand sides of the strip, and the third pair is located above or below the other two pairs. Position sensors are mounted on a guide in between the two magnet levels. The side magnets work together to remove left-right vibrations (twisting) and first mode oscillations (ie string mode). The central magnets compensate for static deformations of the strip, typically cross-bows, but also to remove the flapping mode of oscillations.

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Function

The ABB EM Stabilizer functions by exploiting the magnetic properties of ferromagnetic steel; it applies three “semi”-static magnetic fields to control the moving strip. The position sensors measure the discrepancy between the strip path and the optimum path line and feed these data to the PLC. Typical strip vibrations are in the range of 1–10 Hz; however, the control algorithm needs to be much faster than this to achieve dampening.

Installation

The mechanical mounting of the magnets is tailored to the line in question. Conceptual layouts for the installation of the ABB EM Stabilizer above the air-knife are shown in 3 and 4. The installation method in 3 was used in the first trials at SSAB Tunnplåt AB in Sweden.

To achieve maximum vibration dampening at the air-knife nozzles, the magnets should be located close to the air knife, as shown in 5. If the magnets cannot be positioned close to the air-knife, they can be suspended from the overhead construction, as shown in 4. Here, the lower magnets are approximately 1.8 m from the air-knife. This installation method was used at Thyssen Krupp Stahl (TKS) in Germany, to meet the criteria shown in the Factbox. One half of the ABB EM Stabilizer, suspended from the hot gauge platform, can be seen in 6.

Results

The effect of the ABB EM Stabilizer was evaluated by comparing vibration levels and variations in the thickness of the zinc coating, with and without the use of the stabilizer. The stabilizer was tested on a variety of strips (eg galvannealed/galvanized, exposed/unexposed, thin/thick, narrow/wide) and line parameters (eg thin/thick coating, fast/slow strip speeds, high/low strip tensions). All evaluations were made on individual coils, one half of which was subject to EM stabilization, the other not. Whether the first or second half of the strip was stabilized was varied at random.

Variations in coating weight were measured using a cold gauge (ie measurements are taken after the strip has cooled), and strip vibrations, both with and without stabilization, were measured using either the sensors of the ABB EM Stabilizer or mobile sensors mounted on the air-knife beam.

Results presented here are typical of those obtained and can be considered

Factbox Line data TKS GL #4

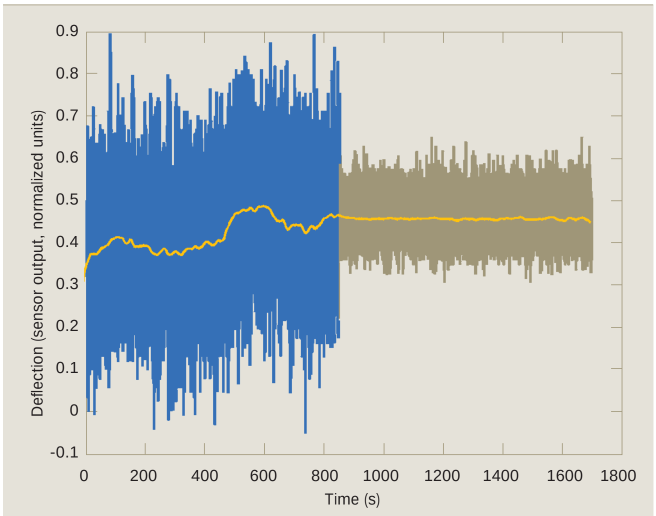
Qualities produced	Exposed/unexposed automotive, galvanized/galvannealed
Line Speed	Up to 180 m/min
Width	1100–2040 mm
Thickness range	0.6–1.6 mm
Yearly production	500,000 ton

as average results over the coils that were stabilized.

Vibrations and zinc variations

Typical strip vibrations, with and without stabilization, are presented in 7. Stabilization typically reduced vibrations by a factor of two or more. It also reduced low frequency movements of the strip ("snaking", with a period of several minutes).

7 Typical strip vibrations without (blue) and with (green) stabilization



The potential for saving zinc by strip stabilization was investigated in great detail. 8 shows the distribution of zinc coating weight, with and without stabilization. The ABB EM Stabilizer reduces the variation of coating weight significantly, leading to a reduction in the over-coating margin of 25 percent (from 4 g/m² zinc to 3 g/m²) and an overall saving of two percent.

Other observations

ABB EM Stabilizer was installed on a TKS automotive line. This line produces a lot of exposed material, and hence extremely high quality surfaces are required. Because of this, the stabilizer could not be allowed to adversely affect the surface in any way. During these tests:

- no negative effect on the surface quality was detected, either by visual inspection or the use of stone tests[1)].
- the distance between the magnets on each side of the strip was shown to be sufficient.

Results also confirmed that the ABB EM Stabilizer is well suited to the tough industrial environment of the zinc pot. It can tolerate the presence of zinc dust and temperatures rising to 100 °C.

The current positioning of the stabilizer, approximately 1.8 m from the air-knife, produced significant results. Further performance improvements are expected from installations that are positioned closer to the knife.

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In summary

The installation of the ABB EM Stabilizer on a galvanizing line at TKS in Germany has demonstrated the benefits of reducing vibration and snaking of steel strips during galvanization. Results from a substantial number of coils showed that significant improvements in terms of cost savings and improved product quality can be made with no adverse effects being recorded. These improvements were seen with the stabilizer installed approximately 1.8 m away from the air-knife. Further improvements would be expected from installations closer to the knife, where the stabilizing effect would be enhanced. The ABB EM Stabilizer was launched at the Galvanizers' Association meeting in Columbus, OH in October 2006.

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Footnote

[1)] The stone test is a flatness test whereby a flat soft sand stone is run along a surface. If the surface is not sufficiently flat, the intensity of the resulting scratches varies visibly.

Reference

[1] Olof Sjöden, Peter Löfgren, Hans Sollander, Mats Molander, 2005 "Stabilizing influence, No-contact vibration control of steel strips in galvanization". ABB Review, 4/2005

8 Typical coating weight distribution without a and with b stabilization and potential zinc saving δ (no stab)-δ (stab). b has been adjusted for a possible decrease in zinc coating set point. (99 percent of the values are captured by the blue bars, ie only 0.5 percent of the values are allowed to be larger or smaller.)