

# Stabilizing influence

No-contact vibration control of steel strips in galvanization

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How much zinc should a galvanizing plant apply? If the layer is too thin, quality criteria are not met and the steel is not adequately protected. If too much zinc is applied, this leads to higher costs through material consumption and makes the finished product heavier than necessary.

A generous margin in the thickness of the zinc coating is often necessary due to the difficulty of controlling the process accurately.

A main cause of this is the vibration of the strip being coated. To partly cope with this problem, galvanizers could either slow down the line to reduce oscillations, and in doing so accept lower productivity, or live with these variations and their cost.

ABB has developed a non-contact stabilizer using electromagnetic principles. Known as an EM Stabilizer, it is characterized by its speed and accuracy.

In hot-dip galvanizing lines **See Textbox 1**, the metal strip to be galvanized is moved through a bath of molten zinc. On leaving this, a so-called air-knife blows off the excess zinc to reduce the thickness of the coating to the desired value.

By reducing the vibration of the strip, the air-knife action (wiping) can be better controlled and the coating thickness made more uniform. This allows the coating to be made thinner, thereby meeting an important request from steel users – especially from car-

producers for whom weight, and especially cost reduction is a significant goal.

Vibrations in the galvanizing line originate from imperfections in the line's mechanical components. These can to some extent be controlled by the surveillance and regular maintenance of critical components and parameters such as roll bearings and alignment of end rollers. They can, however, not be totally eliminated and are accentuated at high line speeds and on longer unsupported or free strip paths.

Measures such as increased strip tension or installation of damping devices, for example air cushions, have been successful but there is still considerable potential for alternative solutions.

ABB has developed an electromagnetic strip stabilizer (known as an EM Stabilizer) that can, without touching the strip, reduce vibrations and oscillations as it passes the air knife

**See Textbox 2**. This permits better coating control and creates the potential for higher line speed.

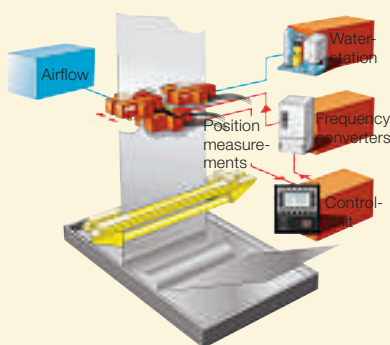
## 1 Galvanization

Galvanization is used for corrosion-protection of steel. Steel strips are treated in continuous hot-dip galvanizing lines while machine parts, tubes etc, are treated by dipping the parts in a bath of liquid zinc. In a hot-dip galvanizing line, a zinc layer is applied to the strip by running the preheated strip into a zinc pot at a speed of up to 200 m/minute. The zinc layer has a thickness of 5 to 50 microns on each side dependant on application.

The thickness of the zinc layer is controlled by an air-knife system located above the surface of the zinc bath. The air knife wipes excess zinc off the strip by blowing high pressure air through a narrow nozzle onto it. A hot-gauge measures the layer's thickness and feeds data to the air-knife control. The thickness is controlled by regulating the air pressure and the nozzle's distance from the strip. A constant distance without oscillations leads to a coating of constant thickness. In reality, however, there are always deviations from this ideal situation: Mechanical imperfections exist that induce vibrations, steels with different material properties behave differently and the strip can have a static deformation that makes it difficult to achieve a constant thickness over the entire width.

## 2 EM Stabilizer – function and equipment

The main electrical components of the new EM Stabilizer are a cubicle with three frequency converters for independent control of the three pairs of electromagnets, a control cubicle including a PLC (programmable logic controller), the six electromagnets and a cooling water station



The EM Stabilizer is also equipped with several air cooled position sensors for detecting the strip position as function of both time and space. The Stabilizer is operated by a PLC panel with alarm handling and operation control.

The EM Stabilizer works by applying three “semi”-static magnetic fields to the moving strip. The position sensors measure the discrepancy

between the strip path and the optimum path line and feed these to the PLC. Typical strip vibrations are in the range of 1–10 Hz; the control algorithm needs to be much faster to achieve damping.

The EM Stabilizer consists of three pairs of electro-magnets. Each pair has one electro-magnet on the front side and one on the back side of the strip. The top pairs are located to cover the left and the right sides of the strip. Together they effectively remove left-right vibrations (twisting) and first mode oscillations (ie, the string mode). The third pair is located below the top pair and around the symmetry line of the strip. Their main task is to compensate for static deformations of the strip; typically cross bows but also to remove the flapping mode of oscillations.

The mechanical mounting of the magnets is tailored to the line in question. The closer they are to the air-knife, the better the strip stabilization at the air-knife.

A typical magnet is 800\_200\_200 mm with a weight of 200kg. Each magnet consists of an iron core with electric windings (hollow copper sections). The windings are series-connected and cooled by de-ionized water from a closed-loop system. The coil sections are enclosed in non-magnetic austenitic stainless steel. The position sensors are mounted on a guide in-between the two levels of magnets.

## Productivity

The project was initiated by a customer vision that recognized the potential of using electromagnetic forces for the wiping itself. ABB, as a reputable player in electro-magnetics, was the natural partner and a joint development project was initiated.

Although the electromagnetic wiping technology still has a long way to go before it can see industrial application, the EM stabilizer emerged as a spin-off from this project.

Today, an average margin of five to seven percent of excess zinc is typical and necessary on account of the variations of coating thickness. Reducing this margin by only one percent will pay for an EM Stabilizer system in less than a year.

ABB has, together with its customers, evaluated the potential in the EM Stabilizer:

- Improved quality in the form of a more even coating layer.
- Increased line speed.
- Improved work environment: The air-knife is noisy. The reduction in strip vibrations allows the knife to be placed closer to the strip, thus lowering the air pressure required which in turn reduces noise.

### 1 ABB's EM Stabilizer

The three stainless steel magnets can be seen above the ABB sign. Sensors are visible between the two levels of magnets.



- Cost savings: The excess zinc coating is in the range of 5–15 g/m<sup>2</sup> and accounts for 5–10 percent of the process zinc consumption.

Following successful development work by ABB and the steel producer SSAB, the first installation has been completed at SSAB Tunnpå AB in Borlänge Sweden 1.

### Results

One benefit of reduced vibrations and static deformation compensation is that the overcoating margin of excess zinc can be reduced. Today, an average margin of five to seven percent of excess zinc is typical and necessary on account of the variations of coating thickness. Reducing this margin by only one percent will pay for an EM Stabilizer system in less than a year.

If a thinner coating is not desired, the production rate can be raised without affecting the quality.

Experiments have shown that vibration amplitude can be considerably reduced by the EM Stabilizer 2a. Moreover the decay time of an induced disturbance is significantly reduced 2b.

On the whole, the EM Stabilizer can pay for itself in less than one year.

A decrease in vibrations at the magnets was seen during the first week following installation at SSAB in Borlänge. For example, the EM Stabilizer was turned on for about 15 seconds and 3 illustrates how the amplitude of vibration was reduced by between 2 and 3 times. What is even more impressive is that these results were recorded before the system was properly tuned.

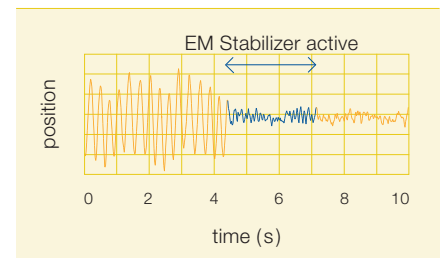
Up to September 2005, the EM Stabilizer ran on more than 100 km of strip, and since then performance has been steadily increasing. Sufficient damping at the three magnets (4a, 4b and 4c) has reduced vibrations at the air-knife by an impressive 20 percent (4d). In addition, the EM Stabilizer

reduces uneven vibrations. This is shown by the difference in vibration magnitude between 4a and 4b. Further analysis of the measurement data shows that it can also reduce cross-bow by about 40 percent.

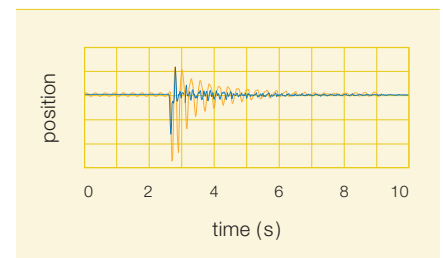
The zinc variation along the strip (5a, 5b) was recorded by the gauge sensor

2 Strip vibrations with and without stabilization. Experiments performed before shipping to SSAB:

a Position for continuous operation.

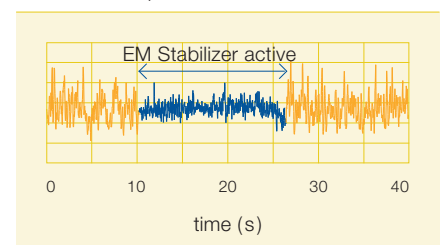


b Position for bump test  
 ■ with control EM Stabilizer active  
 ■ without Stabilizer

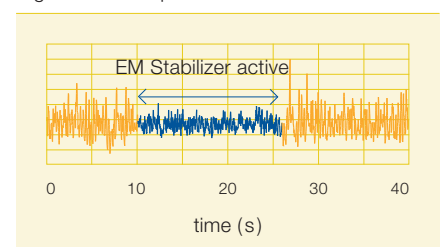


3 Strip vibrations with and without stabilization. Experiments performed at SSAB just after the installation in the line.

Left side of strip



Right side of strip



directly in the line. An active EM Stabilizer can decrease variations by almost 25 percent. In principal, such a reduction suggests that any excess zinc can be reduced by the same amount, ie, a typical overcoating margin of 5 percent can be reduced to 3.75 percent. However, only a few strips have been evaluated with a gauge sensor and some of these measurements have shown lower reductions in zinc variations. It is clear that more experience is needed before an excess set-point margin can be decreased.

Full EM Stabilizer performance is expected after a few months in operation.

During this period the EM Stabilizer will show that zinc consumption will drop by one or more percent: a reduction that translates into large savings for SSAB. On the whole, the EM Stabilizer can pay for itself in less than one year.

This technology offers solutions to long-standing problems in what is largely a traditionally minded industry. As a leading niche product it has considerable market potential.

This technology is not limited to air knifing. Potentially, EM stabilization can be used in other parts of the galvanizing line and other types of strip lines. An interesting idea is its use on painting lines: an EM stabilizer can guide the strip through slots into a drying chamber – an application where the strip cannot be supported on rollers and where unintended contacts on the entrance or exit slot can cause quality degradation.

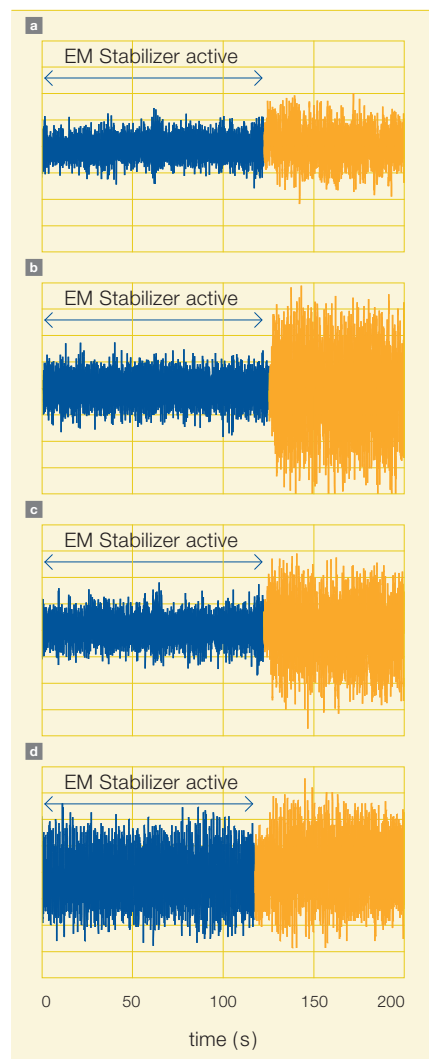
#### Conclusions

ABB's EM Stabilizer is the result of a substantial research effort that included many thousands of hours of simulations, in-house tests and finally, verification at SSAB. The installation of the EM Stabilizer at SSAB has shown that it has the potential to significantly reduce excess zinc. It is also believed that further substantial improvements can be made because equipment control and the distance from the EM Stabilizer coils to the air knife have yet to be fully optimized.

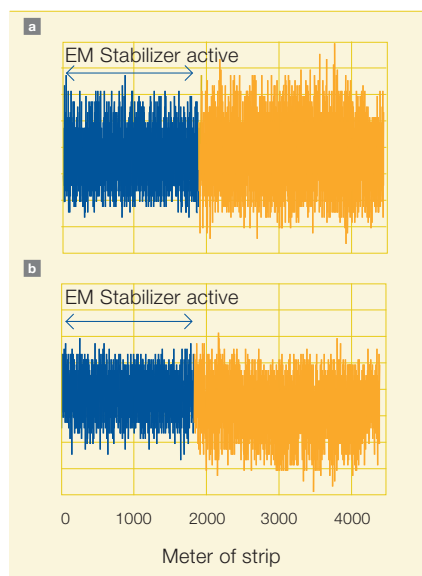
This technology offers solutions to long-standing problems in what is largely a traditionally minded industry. As a leading niche product it has considerable market potential.

Enthusiasm for the product is certainly growing. More than 20 large steel companies around the world are now waiting for its market launch, which is expected during the second half of 2006. The next installation is scheduled for completion by the end of 2005. It is estimated that more than 100 modern galvanization lines in Europe alone can benefit from the EM Stabilizer. There are twice as many around the world, and in China new lines are built every year.

4 Vibrations at **a** the left magnet **b** the right magnet **c** the middle magnet and **d** the air-knife (center of the strip).



5 Variations in zinc coating weight measured by the hot-gauge sensor for the **a** front side and **b** back side of the strip. (Same strip as shown in 4)



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