

ELECTROMAGNETIC STRIP STABILIZATION: EMG-EMASS® - TECHNOLOGY, RESULTS, CUSTOMER EXPERIENCES, AND FUTURE DEVELOPMENT¹

Steffen Dombrowski²
Anderson Pereira³

Abstract

Homogenous surfaces and minimal coating thickness at high production throughput are the targets in hot-dip galvanizing production. Electromagnetic strip stabilization became a proven solution with in the meantime over 33 installations of the EMG eMASS® system. Over-coating is substantially reduced and eMASS® ensures a flat and stable strip between the air knives. The benefits of an electromagnetic strip stabilization solution heavily depend on the stabilization performance and the control algorithms, but also on the crucial question of the integration of the system into the production line. The combination of eMASS® with all major air knife types and with various special solutions made it the most flexible and successful strip stabilization system today available on the market. The paper concentrates on results and experiences, but also on constraints and challenges of eMASS® projects. Firstly, installation examples and specific solutions will be presented by real world projects, concentrating on challenging requests. This includes its combination with auxiliary systems like air knife wiping equipment or baffle blade control systems. Secondly, vibration reduction and crossbow elimination results as well as long term operation data will be summarized. And thirdly the lessons learned, based on a recently performed customer survey, will be highlighted. The paper shall provide future users key arguments for deciding on and planning of industrial strip stabilization projects.

Key words: Galvanizing; Zinc consumption; coating quality; Electromagnetic strip stabilization; Process improvement.

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² *Product manager, EMG Automation GmbH, 57462 Wenden, Germany*

³ *EMH Eletromecânica e Hidráulica Ltda. Belo Horizonte, MG, Brazil.*

1 INTRODUCTION

The production of hot-dip galvanized steel strips with increasing quality levels and ever reducing production costs is a prominent objective of all continuous hot-dip galvanizing plants in order to ensure and enhance market success. A measure of this is primarily the homogeneous zinc surface, i.e. an even coating thickness over the strip length and width, while ensuring minimum possible consumption of the raw material zinc and simultaneously safeguarding the required minimum coat.

These criteria, however, can only be partially achieved due to vibrations and shape variations of the strip during the zinc coating process. Such restrictive conditions can be largely compensated by using the EMG eMASS® electromagnetic strip stabilization system:

- Thanks to reduced strip movements and an optimum fixed strip position in the "pass line" it is possible to reduce the thresholds for zinc over and under coating and to generate thin zinc layers also below 50g/sqm per side.
- The air knife lips can be moved closer together. In turn the reduced blow-off pressure can result in considerable savings of air and particularly nitrogen.
- The sharper blow-off profile caused by a narrower air knife gap further contributes to an improved quality of the coating.
- In an ideal scenario contamination of the air knife lips occurs less frequently, thereby reducing the volume of scrap.

This paper concentrates on the industrial application experiences and the results achieved with EMG eMASS®. Further a short outlook into the architecture of an eMASS® system fully integrated into the design and mechanics of a state of the art air knife system is given.

2 MATERIALS AND METHODS

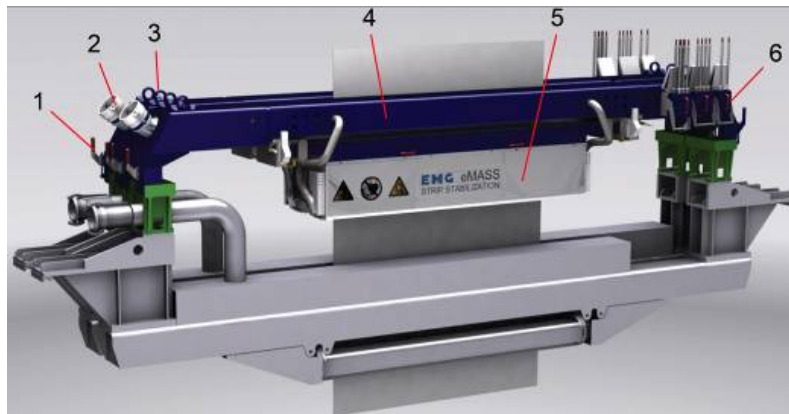
2.1 Basic System Design

EMG eMASS® is an electromagnetic system for improving the shape and reducing vibrations of the steel strip in hot-dip galvanizing or aluminizing lines of the steel industry.

The air knife uses pressurized air or nitrogen to blow across the entire width of both sides of the strip. The smaller and more even the distance between the air knife lips and the strip, the more homogeneous is the resulting surface coating and the less zinc (or aluminium) is required to achieve the desired coating gauge. Strip deformations such as C- or W-shapes, passline shifts and overlaid strip vibrations naturally occur based on the properties of the line, the strip cooling system and the strip material. Due to these strip shape variations in the coating area, inhomogeneities of the zinc or aluminum layer across the strip width and along the strip length are unavoidable. The air knife system has to take these conditions into account.

The EMG eMASS® system is to be installed as close as possible above the air knife, usually directly on the existing air knife device, to cover the entire strip width spectrum with its setup. The strip passes through the 40 mm wide working gap between the housings, whereby the distance between the strip and the housings is continuously measured at up to 8 strip sectors. Electromagnets with dynamically controlled power amplifiers are used to correct and stabilize strip

position, strip shape, and to limit strip vibrations. Figure 1 shows a typical installation directly on the air knife device.



1 Mechanical adaptation to the air knife system (green brackets) and quick release clamps; 2 Cooling air connection; 3 Crane lugs; 4 Base frame with linear units and internal servomotors; 5 One separate mobile stainless steel housing (air-cooled) on each side of the air knife; 6 Industrial connector.

Figure 1. eMASS® set-up.

The basic principle of eMASS® and the movement of the magnet boxes can be also reviewed under.⁽¹⁾

3 RESULTS OF THE INDUSTRIAL OPERATION

3.1 Overview

The application of an automatic strip stabilization leads to two major benefits:

- The damping of strip vibrations and by that a much more homogeneous coating profile in longitudinal direction and
- the optimization of the strip shape, i.e. the elimination of the crossbow, leading to a much closer operation of the air knife lips and an optimal crosswise coating profile.

In summary the application of eMASS® in the coating air knife area lead to at least:

1. A damping of $\geq 50\%$ measured between the actuator boxes (for an initial standard deviation of the strip position signals ≥ 0.9 mm)
2. A strip shape correction which forces the strip to a position constancy of ± 1.5 mm over strip width (for an initial shape deviation of $\leq \pm 5$ mm over strip width)

3.2 Effects on Vibration Frequencies

Figure 2 gives a typical example for the vibration damping over a frequency range from 0 – 100 Hz. Without eMASS® one sees various frequency peaks (maximum 4 mm) up to approximately 20 Hz. After switching eMASS® on, the majority of frequencies is damped to a level close to the noise spectrum. At the same time the standard deviation of the strip movements at actuator level is reduced from 2.1 mm to 0.69 mm (factor 3!) underlining the performance values outlined above.

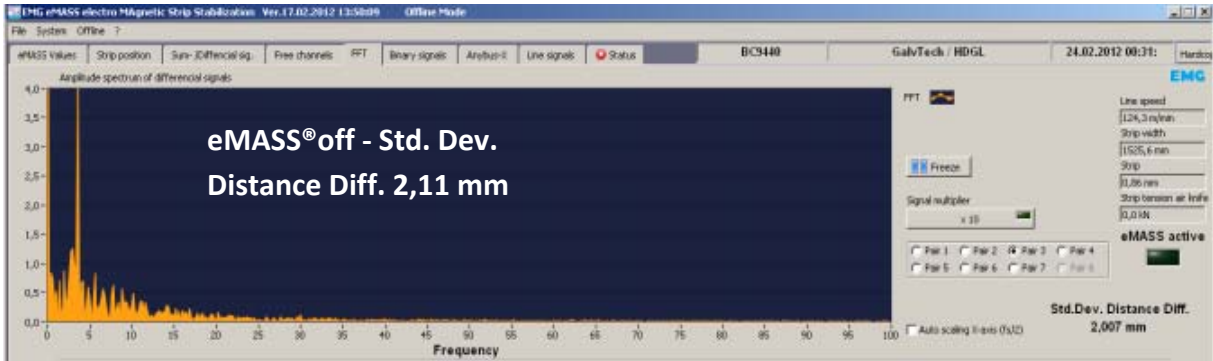


Figure 2. eMASS® effects on the frequency distribution and the standard deviation of strip vibrations at GalvTech, Pittsburgh, USA, 2012 (top image: eMASS® off / bottom image: eMASS® on).

3.3 Effects on Coating Homogeneity over Complete Coils

The effects for vibration reduction at the actuator level need to be translated to the vibration damping at the air knife level. Figure 3 shows the typical effect on the coating homogeneity over a complete coil. With eMASS® turned on the standard deviation of the coating weight is reduced by a factor > 2 (target coating was 145 g/sqm/side).

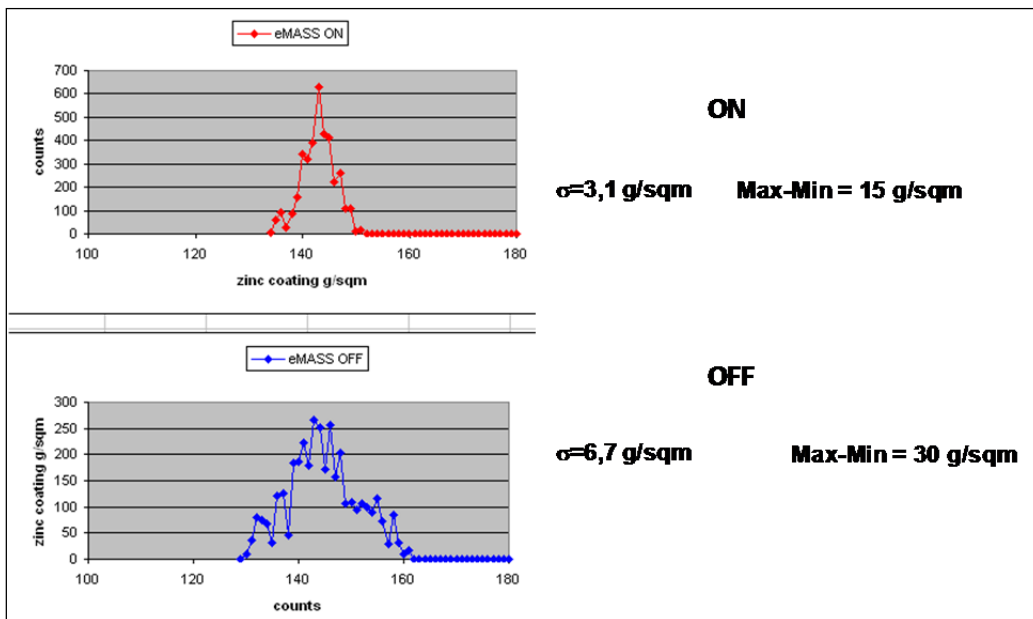


Figure 3. Standard deviation of the zinc layer with eMASS® on /off (industrial eMASS application 2009).

3.4 Dependency on Line Parameters

One important question to answer is how far the performance of eMASS® depends on changing line parameters like the correction roll(s) position, the operating height of the air knife levels or the line speed. Intensive investigations of ArcelorMittal in 2012⁽²⁾ lead to the conclusion that the damping performance is:

- independent from the correction of the roll position
- independent from the operation height of the air knife nozzles and
- independent from the strip speed.

ArcelorMittal measured the strip damping directly at the nozzle level which also showed that the damping at the actuator level is well transmitted to the nozzle area (damping > 35%). Figure 4 reflects the behavior for an increase of the line speed from 80 – 120 m/min. The absolute increase of vibrations is due to the intensification of the performance of the cooling blowers.

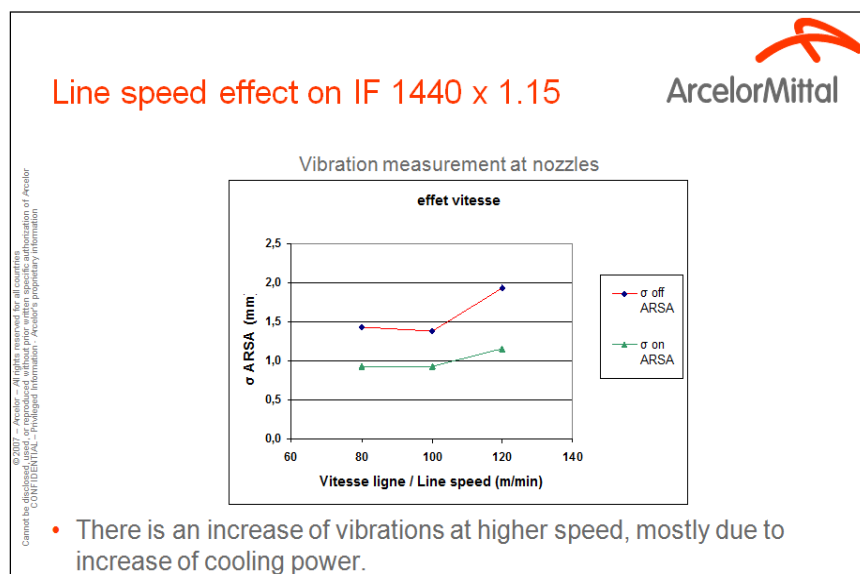


Figure 4. Line speed effects on eMASS® performance, the ratio on/off even improves for higher line speeds⁽⁵⁾ (ARSA: French term for eMASS®)

3.5 Effects on coating Set-up and Zinc Consumption

Figure 5 shows qualitatively the effects on the coating weight targets after the application of eMASS® at the hot-dip galvanizing line of ArcelorMittal Columbus, USA, 2010.⁽³⁾ According to ArcelorMittal, after set-up of the eMASS® system the target coating could be reduced by 1 g/sqm/side in average, leading to a significant material cost reduction.



Figure 5. eMASS® and coating weight targets.⁽²⁾

Figure 6 gives another example for substantial zinc consumption reduction at the Galvtech Line, USA, 2012.⁽⁴⁾

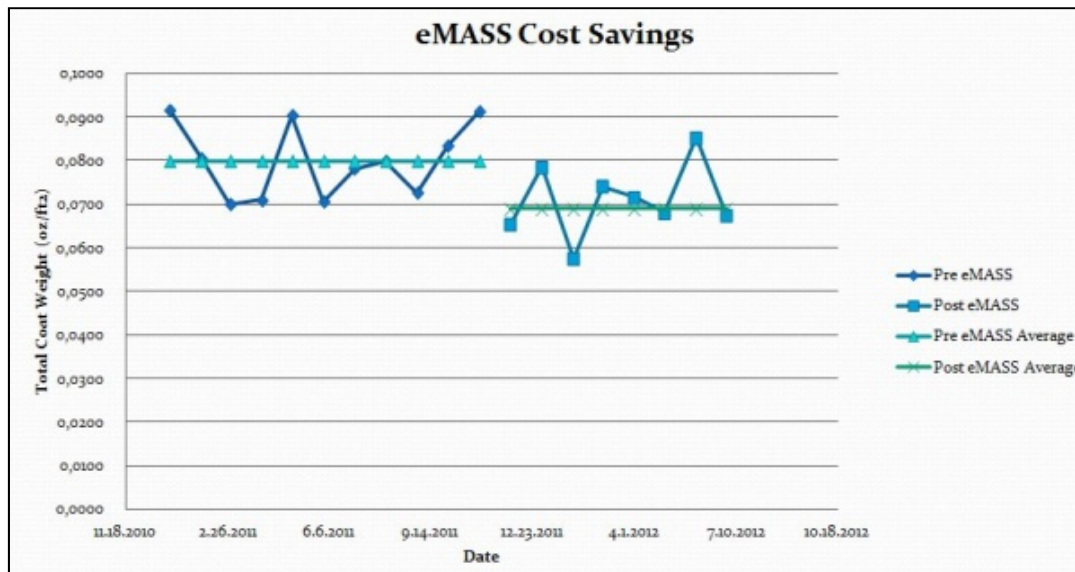


Figure 6. Coating weight reduction with eMASS®: y-axis total coating weight in oz/sqft, x-axis production dates.⁽⁴⁾

After installation of eMASS® the target coating weight could be reduced by roughly 10-12%.

3.6 Crossbow Reduction

Figure 7 shows the dramatic effects on the crossbow elimination in one of the more recent applications at GalvTech, Pittsburg, USA, 2012 (upper image: eMASS® on, lower image eMASS® off, strip position signals and envelope at actuator level). The envelope of the strip shape was reduced by a factor 3!

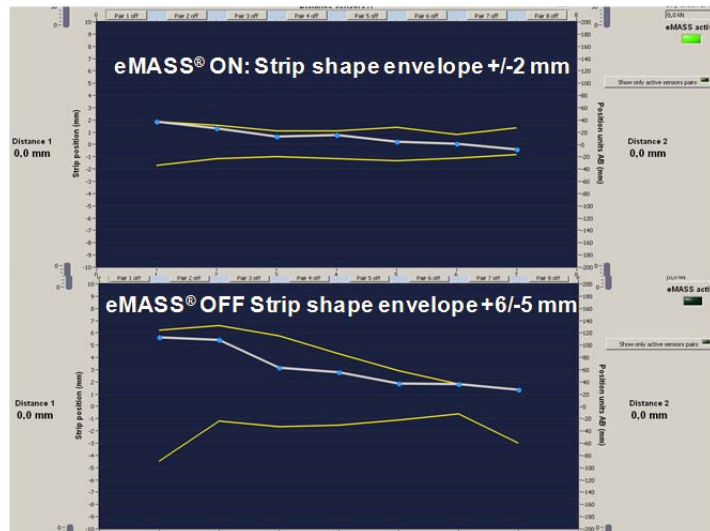


Figure 7. eMASS® crossbow reduction - yellow lines: envelope of strip movements / grey lines: actual strip shape and position.

Figure 7 shows the dramatic effects on the crossbow elimination in one of the more recent applications at GalvTech, Pittsburg, USA, 2012 (upper image: eMASS® on, lower image eMASS® off, strip position signals and envelope at actuator level). The envelope of the strip shape was reduced by a factor 3!

3.7 Outlook: The integrated Solution

In order to get the best out of two worlds the combination of EMG eMASS® and a leading air knife design is a consequent step in the further technological roadmap. EMG Automation GmbH and Duma-Bandzink GmbH – the leading provider of high end coating equipment – formed a technology partnership to provide an integrated electromagnetic strip stabilization solution for the coating industry.

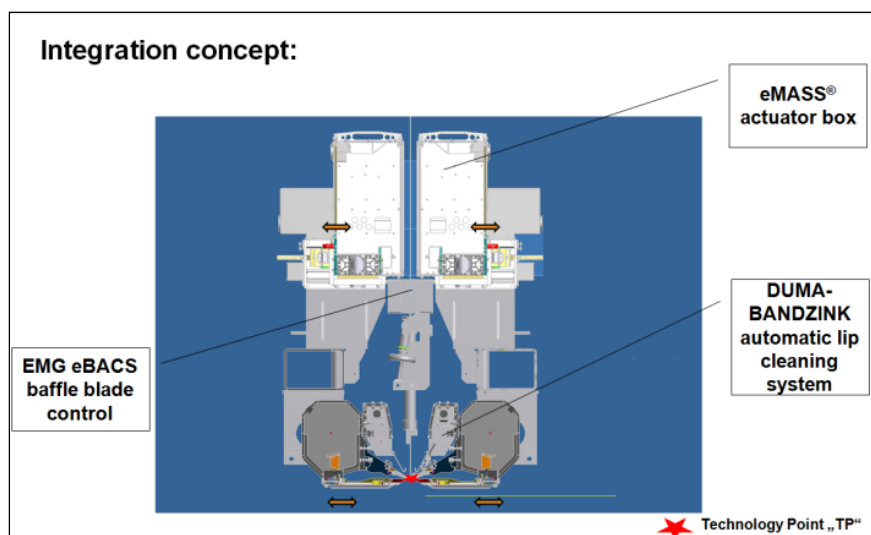


Figure 8. eMASS® combined system principle set-up.

The solution, shown as a principle in figure 8, combines four high end technology elements: the DUMA air knife and equipment, the EMG eMASS® strip stabilization system, the EMG eBACS baffle blade control system and the DUMA automatic air knife wiping system. This combination provides the optimum with respect to the

coating process quality, process control, and operational safety.

The integrated system eMASS®/DUMA is currently under development. Interested users may contact EMG Automation GmbH or DUMA-BANDZINK GmbH for further details.

4 DISCUSSION

4.1 Application Summary and Lessons Learned

The following benefits of the eMASS® solution have been confirmed so far:

- Vibration and damping targets achieved
- Standard deviation of coating weight distribution reduced accordingly
- Lower coating weights possible
- Air knives can operate closer to the strip (less nitrogen consumption, less noise, less zinc splashes, less cleaning cycles)
- Strip skewing reduced for better parallel alignment of coating equipment
- More robust passing of welding seams.

By investing into EMG eMASS® users participate in the know-how acquired in manifold successful projects based on very different starting conditions at the respective line. However, in order to achieve the mentioned benefits user should take into consideration some important points before starting an eMASS® project:

- The project targets should be set properly and shared open and clearly with EMG. Zinc consumption reduction is not the only possible target, increase of line speed and throughput, minimum air knife gap, reduction of nitrogen consumption, less zinc splashes etc. are further or alternative targets.
- From the beginning on the ways how to measure the system performance and which kind of data can be exchanged and used need to be clarified. A coating weight gauge and customer expertise to interpret the data is highly recommended. Without that a clear statement about the project targets and the measurement of results may become very difficult.

Further, the system integration is a crucial question. Users should

- mount the system as close to the air knife lips as possible,
- take into account changed, constraint, or limited possibilities for the manual air lip cleaning process or general access to the air knife equipment,
- take into account possibilities for alternative system movements (e.g. an installation below existing moveable structures as pre-coolers or comparable devices), and
- plan and take into account the necessary steps and time for taking the system out of the production line for line maintenance stops.

EMG provides all required consultancy for achieving optimal project results. For further information about major project milestones and integration examples may be obtained from the eMASS® Whitepaper.⁽⁵⁾

5 CONCLUSION

EMG eMASS® has undergone a technical substantial development within the last 6 years. That includes not only the industrial proof of the system performance under various installation scenarios, but also the consideration of multiple user demands for the system handling and utilization. That is reflected by modified and improved hardware and software components as well as a comprehensive consultancy

package around the system. Taking into account the 33 installed systems the new user can build upon more than 50 years accumulated system operation time in industrial settings. Besides the continuous iterative improvement of EMG eMASS® itself, the concept of an integrated eMASS® / air knife set-up gives a promising outlook for the future.

Acknowledgements

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