HOT-DIP GALVANIZING LINE
for top quality demands
U.S. STEEL KOŠICE
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### SMS SIEMAG SUPPLIES
**MECHANICAL ENGINEERING, ELECTRICAL AND AUTOMATION SYSTEMS**

In March 2005, SMS Siemag attracted an order from Slovakian company U.S. Steel Košice to supply a hot-dip galvanizing line for prime-quality products. Three months later, on June 23, 2005, our customer was delighted to lay the foundation stone. Building this new line meant U.S. Steel Košice entered the market for automotive-quality steel grades. The first coil was rolled just 22 months after the contract was signed, on February 9, 2007. Since then, U.S. Steel Košice has supplied customers in the auto and construction industries in Slovakia, the Czech Republic, Poland, and Hungary over short paths with high-quality fine sheet.

To achieve the top material properties required on this market, the individual plant components are perfectly meshed. Next to the mechanical engineering, SMS Siemag also supplied the electrical and automation systems for the plant.
HOT-DIP GALVANIZING LINE
for U.S. STEEL KOŠICE

As early as 1965, the first large steel and rolling mills were erected in Košice. The takeover of the works by the United States Steel Corporation in November 2000 was the starting shot for an investment program of USD 700 million, mainly aimed at stepping up production. Today, U.S. Steel Košice produces 5 million t of flat steel per year, making it one of the region’s biggest manufacturers. There has been a longstanding bond between U.S. Steel Košice and SMS Siemag since both companies joined forces to construct and modernize plants for steel-making and processing. The latest move is a reaction to steadily increasing steel consumption – especially for flat products – in Eastern Europe during the past few years.

The hot-dip galvanizing line produces strip with widths of 800 to 1,850 mm and thicknesses between 0.3 and 2.0 mm at a maximum process speed of 180 m/min. It is designed for an annual capacity of 410,000 t. Not only expert in standard grades, U.S. Steel Košice also manufactures high qualities such as DDQ, EDDQ, SEDDQ, HSS-CQ, HSS-DQ, BH and DP.

We are supplying the entry and exit sections, as well as an ultra-efficient cleaning stage in the entry area, and a vertical annealing furnace. Also included in the package are two galvanizing tanks with a fast and reliable zinc pot changeover system, a FOEN® air knife system, a GA induction furnace complete with heat retention and cooling section, and a skin-passing mill for excellent strip flatness and surface quality. Equally advanced is the roll-coater in the finishing train, designed to provide an anti-fingerprint coating or chromate-free passivation.

The trimming shear comes with standby cutting units that swivel quickly into place when required. Finally, the DUMA oiling machine applies an even preservation film.

Here, in this brochure, is everything you want to know about the hot-dip galvanizing line that SMS Siemag erected for U.S. Steel Košice, including lots of photos, descriptions and technical data. It also explains the process itself plus all the components in the line, then goes into more precise detail about how some of the components work. Furthermore, you can read about the electrical and automation systems and our Plug & Work service. The last two pages give you an overview of the major technical data.
The hot-dip galvanizing line in Košice.

STEP by STEP

1. COIL TRANSPORT AND PAYOFF REEL

Two coil-lifting cars transport the coils of cold strip step by step from the coil racks to the two payoff reels. During transport, the coils are turned into the right position, the strapping is removed, the coils weighed, and then measured so they can be placed precisely concentrically onto the payoff mandrel, and fed into the plant.

2. WELDING MACHINE

A mash welder joins the head and tail ends of the strip. To perform tracing of the welded seam in the line at all times, an integrated hole puncher marks it. A side punch cuts notches out of the strip on both sides so any width deviations can be compensated.

3. ENTRY LOOPER

The entry looper fills up as the coil is paid off, making sure of continuous strip feeding into the plant even though the strip has to stop for the welding process. The effective capacity of the looper is 400 m, so even if there is an interruption, it can supply the process with strip for more than 2 minutes.
The cleaning section removes residual oil and abraded iron from the strip. First in line is spray and electrolytic cleaning with alkaline solutions and subsequent brushing. And second, a hot water rinsing process removes the solution from the strip before it is dried with hot air, see page 12.
The hot-dip galvanizing line in Košice.
STEP by STEP

5 FURNACE
As soon as it enters the line, the cold strip has solidified down to the limit of its formability. That’s why it is re-crystallized in the furnace at temperatures of between 750 and 850 °C. After the strip has been fully annealed, it is cooled down in several steps to around 460 to 480 °C, the same temperature as the zinc bath.

6 ZINC POT
The zinc pot has a capacity of up to 330 t of molten zinc. Thermal inductors attached by flanges to the zinc pot and with a power of 500 kW keep the zinc at molten temperature. The strip enters the zinc bath from the above and travels round a guide roller that directs it up and out of the bath vertically.

7 AIR KNIFE SYSTEM
The FOEN® air knife system controls the thickness of the strip coating. Nozzles arranged on both sides blast nitrogen at a pre-determined pressure onto the strip, blowing the zinc off evenly. Control systems ensure the nozzles are always aligned centrally and in a straight position over the strip, see page 14.
GA-INDUCTION FURNACE

To produce valuable galvannealed steel strip (GA), the strip still coated with liquid zinc is heated in an induction furnace to around 550 °C, and kept there for several seconds. If GA material is not required, the furnace can be simply taken out of the line.
The hot-dip galvanizing line in Košice. STEP by STEP

9 INTERMEDIATE LOOPER
Between the process and the post-treatment sections there is an intermediate looper that can store 360 m of strip to bridge any interruptions.

10 SKIN-PASS MILL
The four-roll skin-pass mill gives the strip the required surface structure.

11 TENSION LEVELER
The tension leveler eliminates unevenness such as waviness, bows, or longitudinal and latitudinal curves. That ensures an even final product.

13 EXIT LOOPER
After passivation, there is another looper. It has a capacity of 300 m and can make up for interruptions caused by the coiling process.
Coating layers are applied to the strip by means of a pick-up roll and an applicator roll. In this way, the strip can be passivated chromate-free, or coated with anti-fingerprint coating. Subsequently it is directed vertically upwards, dried with hot air, then re-cooled, see page 16.
The hot-dip galvanizing line in Košice. STEP by STEP

14 SIDE TRIMMING SHEAR
A double-headed shear with rapid-change system cuts the strip to the desired width. A scrap winder winds the resulting scrap into balls and removes it.

15 STRIP INSPECTION
An inspection stand ensures that the strip is inspected optically both horizontally and vertically to detect any possible surface faults.

16 OILING MACHINE
The DUMA oiling machine provides the high-quality strip surfaces with a preserving layer of oil. It coats the strip with a thin film of rust protection and deep drawing oil. Combinations of oil are also possible, see page 17.
**17 FLYING CRANK SHEAR**

The flying crank shear cuts the strip, and is also used for taking samples. The samples are directed into a separate box while the scrap drops into a scrap basket.

**18 COILER**

In the exit area of the line, the galvanized strip is wound into coils by two coilers alternately. This process is step-controlled and avoids damage to the strip.
Steel strip must be effectively cleaned before galvanizing.

**CLEANING SECTION WITH SPRAY CLEANING, BRUSH CLEANING, ELECTROLYTIC CLEANING, AND CASCADE RINSING**

Due to the high quality demands placed on hot-dip galvanized steel strip from U.S. Steel Košice – especially in the context of auto manufacturers’ corrosion warranties – the surface quality of the refined sheet needs to be excellent. Even very slight strip impurities can lead to coating faults and impaired quality. That’s why it is necessary before galvanizing to remove all soiling such as abraded iron, oil and rolling emulsion residues that occur during cold rolling, transport, and storage. Worth mentioning about the hot-dip galvanizing line in Košice is that the strip is cleaned in several effective stages. The cleaning process consists of spray cleaning and electrolytic cleaning, each followed by cleaning with brushes and final cascade rinsing.

**SPRAY CLEANING**

Vertical spray cleaning involves spraying a hot alkaline solution onto the strip. That has both a mechanical effect due to the spray pressure as well as a chemical effect from the hot alkaline solution. The strip passes between several rows of brushes and is sprayed on both sides in such a way that the head of liquid breaks up the oil layer and rinses it off. It’s a process that not only cleans but also pre-heats the strip with the hot solution. Next, four rolls of brushes mechanically remove oil and dirt residues. This is where the surface is cleaned by a combination of pressure and rotation movement. To achieve even more effective cleaning, the brushes move counter to the strip.

**ELECTROLYTIC CLEANING**

The principle behind the subsequent vertical electrolytic cleaning section is the electrolysis of water. Vital here is the electric current directed through the alkaline solution between the strip and electrodes positioned on both sides. That breaks down the water into hydrogen and oxygen. The gas develops in the form of small bubbles directly on the metal surface underneath the layer of soiling. As the bubbles rise, they lift the dirt off the surface, which then dissolves in the degreasing solution or forms an emulsion. The two pairs of electrodes have an electric current density of 15 A/dm². Due to the fact that the polarization of the electrodes changes constantly, no particles of dirt are able to attach to the electrodes. A subsequent brushing stage removes the dissolved residual dirt from the strip.
CASCADE RINSING

This happens while the strip is transported through three successive cleaning baths, with the rinsing water becoming cleaner in each bath. Rinsing starts with the dirtiest water, then the strip progresses through increasingly clean baths. These baths are connected in such a way that the clean water added to the final bath (clear rinsing) can flow from one to the other. In front of, between, and after each tank, the strip passes through a pair of squeezing rolls. Using the rinsing water several times, depending on the degree of soiling, means that this rinsing process is especially effective in terms of water consumption. Finally, nozzles blasting hot air at a rate of 18,000 m$^3$/h dry the strip.
FOEN® AIR KNIVES

Galvanizing under nitrogen atmosphere

**FOEN® AIR KNIFE SYSTEM CONTROLS THE COATING THICKNESS**

The air knife system for the galvanizing line at U.S. Steel in Košice was supplied by Fontaine Engineering und Maschinen GmbH (FOEN®). It was the 100th supplied by FOEN® since 1969. The purpose of the machine is to skim off the superfluous layer of zinc as the steel strip emerges from the zinc bath. This happens by using nozzles that blow nitrogen precisely onto the freshly zinc-coated strip. The FOEN® air knife comes in a modular design. That means the basic model can be retrofitted with various devices if strip quality requirements change.

**FOEN® AIR KNIVES**

To adjust the thickness of the zinc coating, air is blown at high pressure (up to 1,000 mbar) through a narrow slit in the nozzles. By altering the pressure, the distance from the steel strip, or the height of the nozzles over the zinc bath, the coating thickness can be adjusted to customer requirements. Depending on the future use of the steel strip, the zinc layer varies from extremely thin (30 g/m² per side) to extremely thick (600 g/m² per side). Thin coatings are used e.g. in the automotive industry, while thick coatings are required in the construction industry.

**SCAN-SKEW TECHNOLOGY**

The strip runs directly from the annealing furnace into the 460 °C zinc bath. There it is guided by a guide roll (sink roll) and then between two stabilizing rolls. Then, immediately above the surface of the zinc bath, the strip passes between the air knives that control the thickness of the zinc coating. Next, the strip is transported upwards and cooled. It goes past the nozzles at a rate of up to 200 m/min.

What could go wrong here is that the strip moves from side to side or skews. To combat this, the FOEN® air knife features an automatic control system that ensures it is always positioned at the center of the strip (Scan). Similarly, the nozzles automatically align parallel to the strip if it runs at an angle (Skew).
It’s a special feature of the air knives at U.S. Steel in Košice that they use nitrogen instead of air. Because the galvanizing process takes place in a nitrogen atmosphere, no oxides are formed, leading to better surface quality. That is particularly important for the subsequent finishing processes.
ROLL-COATER and OILING MACHINE

Corrosion protection, deep-drawing capability and anti-fingerprint finish

POST-TREATMENT WITH ROLL-COATER AND DUMA OILING MACHINE

To protect the zinc coating from white rust, improve the deep-drawing capability, or to add an anti-fingerprint finish, the strip is post-treated. That’s easy in Košice because a roll-coater offers the options of chromate-free passivation as well as coating with an anti-fingerprint layer. A DUMA oiling machine in the finishing train can coat the strip on both sides with rust-protection or deep-drawing oil, or with an oil that provides both properties. Depending on customer requirements, various combinations are possible. Both machines enable U.S. Steel Košice to respond to customer wishes and meet the high-quality demands from e.g. the automotive industry.

ROLL-COATER

The vertical roll-coater evenly passivates the strip on both sides without chromate, or coats it with an anti-fingerprint finish. It achieves even very thin coatings. Once they are dry, the coating thicknesses are between 10 and 50 mg/m² (passivation) or between 0.5 and 2 g/m² (anti-fingerprint). The roll-coater is equipped with a separate circulation system for each type of coating. Due to the fact that the coating conditions in the vertical coater are identical on both sides, it is equally possible to coat just one side of the strip.

The coatings are applied on each side of the strip by a pair of rollers consisting of a pick-up roll and an applicator roll. The first roll picks up the solution from the bath – which is continually filled from a tank – and transfers it to the second. The applicator roll then applies the solution evenly onto the strip. An electric motor system keeps both rolls in an optimal position for even coating. A controlled electric drive makes sure the rolls turn evenly, with the rate and direction of rotation set according to the chemicals to be applied and the required coating thickness. After the coating has been applied, the strip is transported vertically up and dried with hot air, followed by cooling with cold air.
DUMA OILING MACHINE

The electrostatic oiling machine from DUMA applies an accurate, even oil film onto both strip sides. It is equipped with three separate tanks for different oils, providing for rapid changeovers between coatings. As a rule, the machine coats the strip with a high-quality anti-corrosion coating or with deep-drawing oil. There are also oils that combine both properties. Coating thicknesses vary from 0.5 to 2.5 g/m². The oil droplets are applied electrostatically – in other words contact-free – so the process does not affect the progress of the strip, and does not damage it.

The strip passes through the oiling machine between two spray beams that receive a steady supply of oil to the spraying edges. How much oil flows depends on the required coating thickness and the strip’s speed of travel. The spray beams apply the oil onto both sides of the negatively-charged strip as it runs between them. To achieve this, the beams are connected to a high-voltage generator that electro-statically charges the oil to high voltages of up to 130 kV. That produces an electric field between the spray beam and the strip. As a result, the positively-charged oil droplets are attracted to the negatively-charged strip. Due to the electric charge in the oil droplets, they burst into ever smaller droplets that spread evenly over the strip surface.
SMS Siemag also supplies the electrical and automation systems for the hot-dip galvanizing line. Included are not just the energy supply and drive control of the total plant, but also the entire automation for Level 0, Level 1 and Level 2.

The complete open-loop and closed-loop controls of the hot-dip galvanizing line are based on a Siemens hardware platform with SMS Siemag-developed S-7-type application software. The fully optimized galvanizing process with air knife and zinc thickness control features automatic threading in the entry area. There are several highlights apart from automatic threading in the entry area, such as the fully optimized galvanizing process with air knife and zinc thickness control, and the upstream electrolysic cleaning section with controlled minimum consumption. The technological controls developed by SMS Siemag ensure that the tension leveler and inline skin-passing mill are tailored to customers’ plants and requirements. Also included in the SMS Siemag scope of supply are electrical and automation systems for the exit area, consisting of post-treatment (roll-coater), inspection train, and edge-trimming shear, right up to coil transport.

X-Pact® for strip processing lines in
Level 1 essentially consists of:

- Basic automation and visualization of the entire plant including the furnace area (open and closed-loop control, covering entry, the process itself, and exit). The basic automation supplies the necessary Level 2 target values to the appropriate plant sections to ensure high speed and accurate strip tension
- Drive control of the entire strip processing line including furnace rolls
- Technological controls for skin-pass mills, tension levelers, coating and strip guidance
- Precision material tracking, starting with first coil recognition, through welded seam recognition, up to exit shear and coil transport
- Diagnosis and fault reporting system for faster fault detection and troubleshooting – exactly tailored to operating personnel
- Process data collection of all necessary data

X-Pact® for strip processing lines in
Level 2, also called process management level, consists of:

- Production data management (input coil data, production sequence data, production sequence update, finished coil information to the higher level planning system)
- Determination of set-points
- Roll data handling (checking/preparing next roll data, collecting usage data)
- Set-point injection of basic automation
- Material tracking (product tracking and data correlation, line stop detection)
- Processing measuring results, quality data collation
- Data collection and archiving
- Quality diagnoses with various, customized report systems

Also incorporated in the scope of supply were all control panels and switch cabinets of the CGL, equipped with remote I/O technology. The strip inspection line was fitted with inspection lighting and HMI for the entry of detected faults.
The integration of X-Pact® into the process and plant technology for strip processing ensures consistent prime quality of the surfaces of hot and cold rolled products as well as energy-saving, eco-friendly operations. This is complemented by perfect know-how of the technologies involved in pickling, cleaning, and coating because they provide the foundation for all-inclusive strip processing systems.

Our scope of supply and services covers the complete range of electrical and automation systems tailored to the mechanical and technological aspects of strip processing lines, as well as all services from design to commissioning.
Prior to commissioning, the SMS Siemag X-Pact® automation for the hot-dip galvanizing plant was tested with our Plug & Work process. It is one of our special services that we put automation systems thoroughly through their paces in our Test Centers before commissioning at the customers’. To do this, we assemble the various components of our automation systems and test the soft- and hardware under realistic conditions, using simulation systems developed by our experts.

We call this unique service “Plug & Work”. It means we exactly simulate, test, and optimize the entire mechanical and drive technology of the plant and the product to be manufactured. “Plug & Work” cuts stoppage time during commissioning on the construction site, and also reduces the risk of production interruptions during run-up.

As part of this operation, the engineers from U.S. Steel Košice were prepared for commissioning and future maintenance work on the new plant. All this took place while our employees trained the customer’s operating personnel on the original control desks using the original software.

Plug & Work thoroughly prepares employees for commissioning.
Employees are trained on the original control desks with the original software.
TECHNICAL DATA

**STRIPE SPEED**

<table>
<thead>
<tr>
<th>Section</th>
<th>Speed</th>
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<tbody>
<tr>
<td>Entry section</td>
<td>230 m/min</td>
</tr>
<tr>
<td>Process section</td>
<td>180 m/min GI</td>
</tr>
<tr>
<td></td>
<td>140 m/min GA</td>
</tr>
<tr>
<td>Intermediate section</td>
<td>220 m/min</td>
</tr>
<tr>
<td>Exit section</td>
<td>250 m/min</td>
</tr>
<tr>
<td>Flying shear</td>
<td>40 m/min</td>
</tr>
</tbody>
</table>

**ENTRY SECTION**

- Number of coil racks: 2 x 4 (8 charging stations)
- 2 x 1 coil-lifting platforms for removal of strapping
- Payout coiler: from top

**EXIT SECTION**

- Flying crank shear
- Cut length scrap: 500 mm
- Cut length samples: 500 mm
- Strip speed max: 40 m/min
- Coiler: From top or bottom
- Number of coil racks: 4 in the adjacent hall

**STRIPE DIMENSIONS**

- Strip thickness: 0.30 – 2.00 mm
- Strip width: 800 – 1,850 mm
- Maximum coil diameter: 3200 mm²
- Roughness: 0.8 – 1.5 µm

**COIL DIMENSIONS**

- Outer diameter max: 2,300 mm
- Inner diameter max: 508 – 610 mm
- Maximum weight: 32,000 kg
- Minimum weight: 10,000 kg

**MATERIAL**

- Steel grades: CQ, DQ, DDQ, EDDQ, SEDDQ, HSS-CQ, HSS-DQ, HSS-DDQ, BH, DP
- Tensile strength (TS/Rm) max: 980 N/mm²
- Yield strength (YS/R0.2) max: 780 N/mm²
- Nominal tensile strength: 270 – 640 N/mm²
- Nominal yield strength max: 120 – 345 N/mm²

**ANNUAL CAPACITY**

- 410,000 t
### SKIN-PASS MILL

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Maximum</th>
<th>Minimum</th>
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<tbody>
<tr>
<td>Backup roll diameter</td>
<td>1,100 mm</td>
<td>1,000 mm</td>
</tr>
<tr>
<td>Work roll No. 1 diameter</td>
<td>450 mm</td>
<td>400 mm</td>
</tr>
<tr>
<td>Work roll No. 2 diameter</td>
<td>650 mm</td>
<td>600 mm</td>
</tr>
<tr>
<td>Work roll balls</td>
<td>approx. 2,100 mm</td>
<td></td>
</tr>
<tr>
<td>Positive and negative work roll bending</td>
<td>±500 kN</td>
<td></td>
</tr>
<tr>
<td>Force of roll on roll gap</td>
<td>10,000 kN</td>
<td></td>
</tr>
<tr>
<td>Cylinder force</td>
<td>11,000 kN</td>
<td></td>
</tr>
<tr>
<td>Drive motor power of the floor backup roll</td>
<td>1 x 280 kW</td>
<td></td>
</tr>
<tr>
<td>Time for changing the work rolls</td>
<td>90s for same work roll diameter, 140s for different work roll diameters (time between stop and start of the strip)</td>
<td></td>
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### DEGREE OF SKIN-PASSING/DEGREE OF LEVELLING

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Degree of Skin-passing</th>
<th>Yp Tensile Strength</th>
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<tbody>
<tr>
<td>Skin-pass mill</td>
<td>max. 2.0 % for strip 2.00 x 1,600 mm, 180 N/mm²</td>
<td></td>
</tr>
<tr>
<td>Tension leveler</td>
<td>max. 2.0 % for strip 2.00 x 1,600 mm, 180 N/mm²</td>
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### COATINGS

<table>
<thead>
<tr>
<th>Material</th>
<th>Maximum Difference of Coating per Side</th>
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<tbody>
<tr>
<td>GI material</td>
<td>40 – 225 g/m² per side</td>
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<tr>
<td>GA material</td>
<td>30 – 90 g/m² per side</td>
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<tr>
<td>Maximum difference of coating per side</td>
<td>30 – 150 g/m² per side, max. 1:3</td>
</tr>
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CONTACT PARTNERS

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