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THE GALV-TWINS
THE CGL #4 AND #5 AT VOESTALPINE LINZ WORKS

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Abstract
The paper presents the technical and technological features of the two Galvanizing Lines at the voestalpine works Linz/Austria and points out the specific differences regarding the products. CGL #4 was started up in 2007 and CGL #5 in early 2010. These 2 lines, built by Andritz, have been the up-to-date final step in developing the actual capability of voestalpine to supply the market for galvanized products including AHSS, TRIP and DP within the wide range of market segments from building to automotive exposed.
Keywords: Galvanizing; Direct fired furnace; Differential rapid jet cooling; Zinc-Magnesium.

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INTRODUCTION

In June 2005, the decision to increase the production of galvanized steel strip at voestalpine Linz works was settled by signing the contract for the CGL #4. And because of the worldwide steep growth in the demand of galvanized material, the further step of even building a CGL #5 within a short period was discussed. At these days it was a rather logical idea, considering the boom in planning, erecting and operating new CGLs (Figure 1).

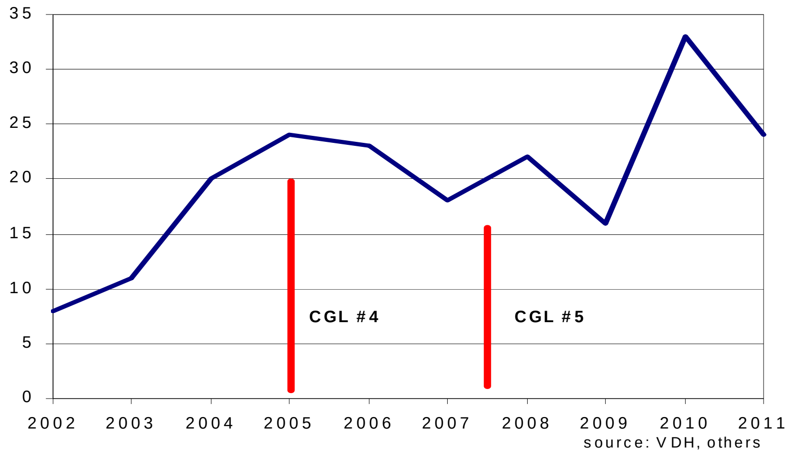

Figure 1. Number of Newly Started CGLs per Year (world wide).

Late in 2007, right after the successful build-up of production the "Twin" of CGL #4 was born. Nevertheless, the deve-lopment of the market and adaptations to voest alpine´s market strategy made some changes necessary within the original plans and the two lines became more like "brothers and sisters"(1) with only a few, but important differences.
Before 2005 voestalpine already operated three hot dip galvanizing lines at the Linz works and therefore this investment had to be embedded into the overall planning with respect to the supply from the up-stream facilities, works logistics as well as the specific emphasis of products of each line.
Before the CGL #4 was negotiated, the trial-production of high strength steel grades at the other lines had already reached a level, where the transfer of these R&D results into a new CGL was just a logical next step to supply this market segment.
This was the reason, why CGL #4 was specifically engineered to process Advanced High Strength Steel (AHSS) and as a consequence, also CGL #5 contains this ability.

LINE CONFIGURATION

The below chart (Figure 2) shows the line configurations and indicates the relationship between the two lines, which receive their feedstock from a common bay perpendicular to the line length axis.

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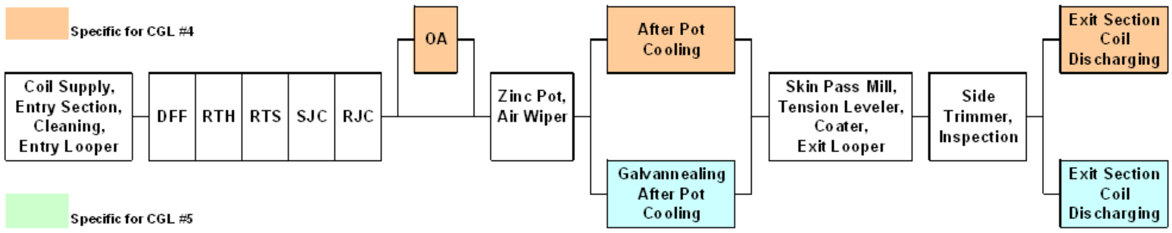

Figure 2: Process Route CGL #4 and #5.

OBJECTIVES FOR THE GENERAL CGL DATA

The galvanizing lines no. 4 and no. 5 are dedicated to the production of advanced high strength steel including complex phase steel and contain all features to fulfill top surface quality requirements. The lines are able to process strip thickness between 0.4 mm and 2.0 (2.5) mm with a strip width between 750 mm and 1750 mm. The maximum speed within the treatment sections is 220 m/min, fed by the entry section speed of 300 m/min and discharged by the exit section at 350 m/min. The yearly line capacity was planned for 450000 (for #4) and 400000 (for #5) tons within 7000 operating hours, which leads to an average production of approximately 65 / 60 tons per hour.
The coil dimensions are limited to 35 tons and 2100 mm outer diameter in the entry as well as in the exit section and are supplied with 600 mm inner diameter.

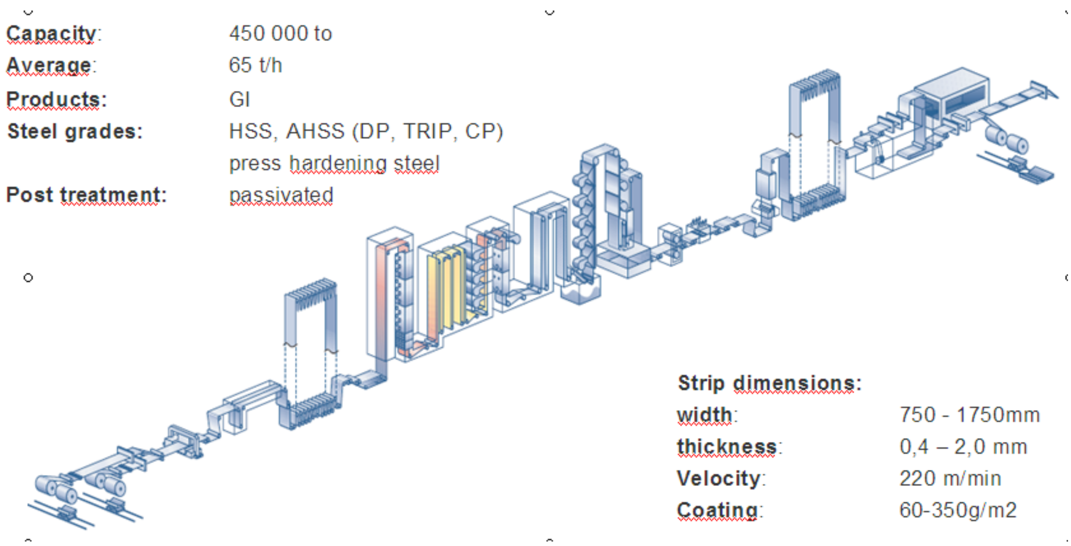

Figure 3. Layout CGL #4

The coating mass ranges from 60 g/m² up to 350 g/m² on both sides. The wide range of different steel grades produced at the CGL #4 and #5 contains CQ, IF, BH, micro-alloyed-, high strength IF, as well as, TRIP and CP steel grades, whereas CGL #5 focuses on the DP-family within the AHSS grades.

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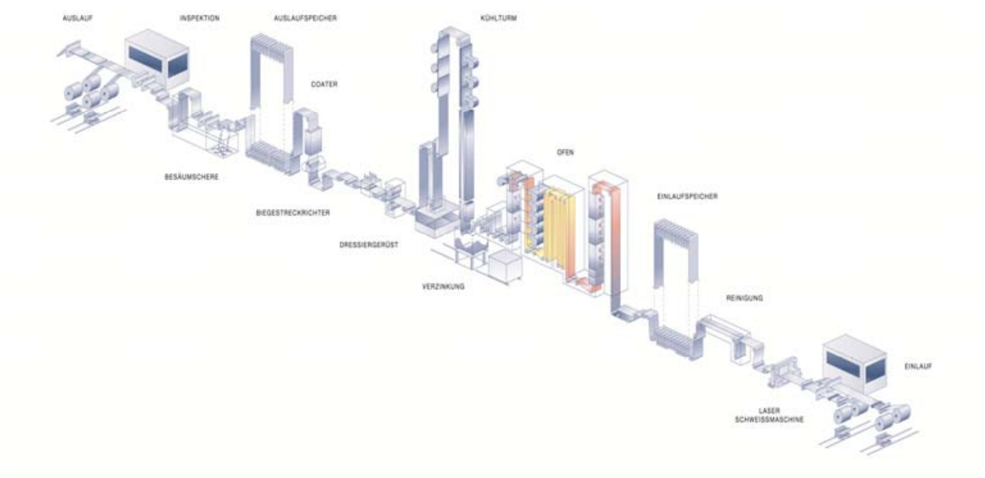

Figure 4. Layout CGL #5

ENTRY SECTION (Figure 6)

The incoming material for the CGL #4 and #5 is produced via TCM (Tandem Cold Mill) and delivered by crane to the entry coil saddles. A storage management system ensures the right coil sequence according to the level 3 production planning system.
The incoming coils are automatically de-strapped during the coil transfer before being charged to the pay-off reels of the double entry, which allow the uncoiling operation from top and bottom side.

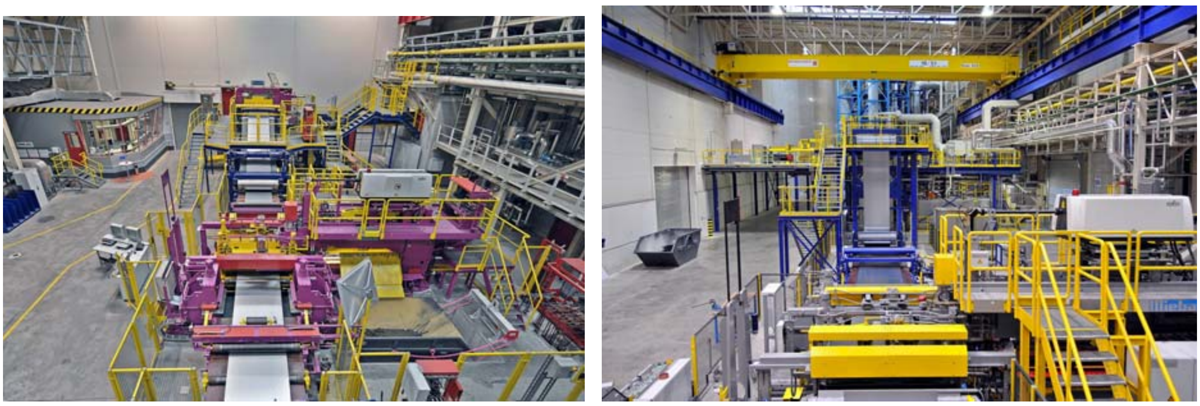

Figure 5. Entry Section of CGL #4 and CGL #5

The further processing of the strip to the laser welder is carried out fully automatically, including scrapping, strip centering and positioning at the welder.
A particularly tailored shear geometry, high precision positioning of the strip head and tail end as well as the inductive reheating device allow to reliably weld all various strip material combinations of the product mix with a thickness difference of up to 0.7 mm. Introducing the Quality Control Data System, which scans the welding process, enables a detailed rating of the weld quality. The results are displayed next to the welder.

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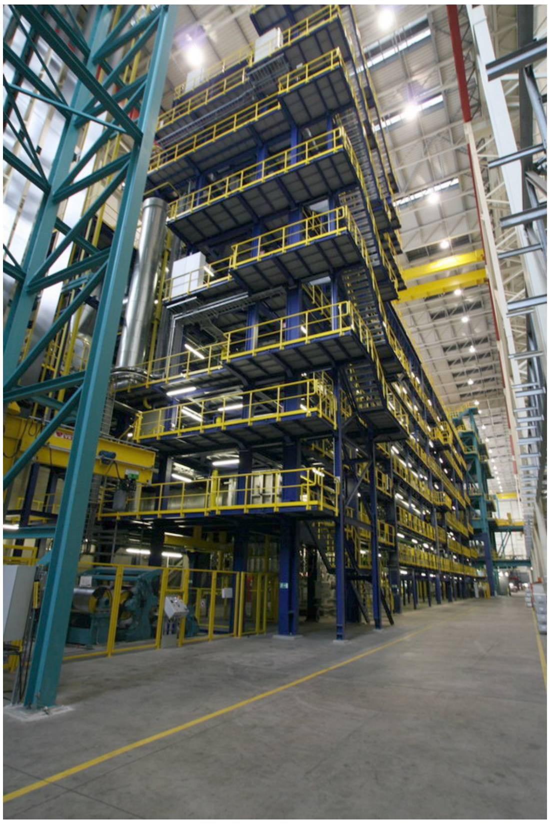
Figure 6: Furnace CGL no. 4.

CLEANING SECTION

The cleaning sections of both lines each consist of one electrolytic cleaning stage, brush section, three rinsing stages followed by wringer rolls and a dryer. Especially the production of AHSS requires the high ability of efficiently cleaning both, the top and bottom surfaces as uniformly as possible across the width and along the entire strip length.
Due to the fact that all continuous processes within the galvanizing line need to be operated within close tolerances of their optimum values, the entry looper is designed to allow extended validation of the entry process including – in case of doubt – a second execution of the welding operation. Thus, the entry looper contains up to 600 m of strip.

FURNACE SECTION (Figure 8)

The installed furnaces contain each a directly fired entry, the heating and soaking zone, a slow and rapid gas-jet cooling area followed by the equalizing zone. The detailed concept has been installed by Andritz Selas according to the specific requirements of voestalpine production and research departments and gives another example of success, when operating and engineering know-how are combined for a common target.

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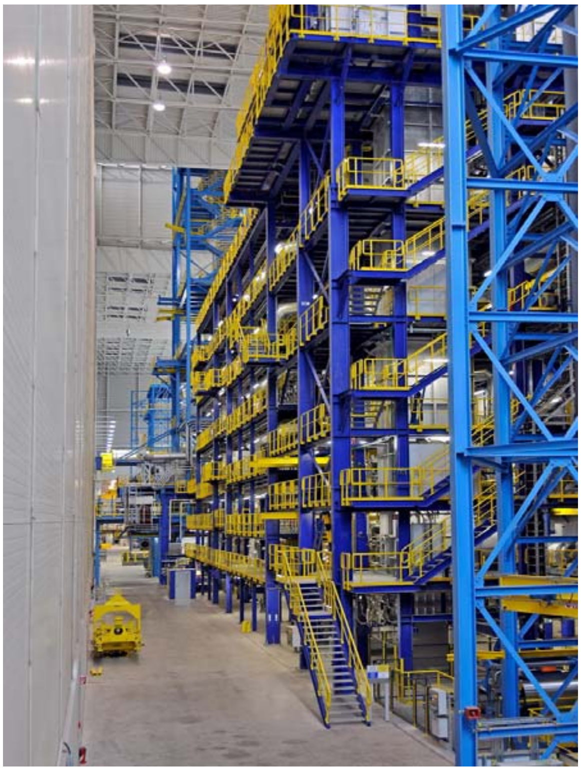

Figure 7: Furnace CGL no. 5.

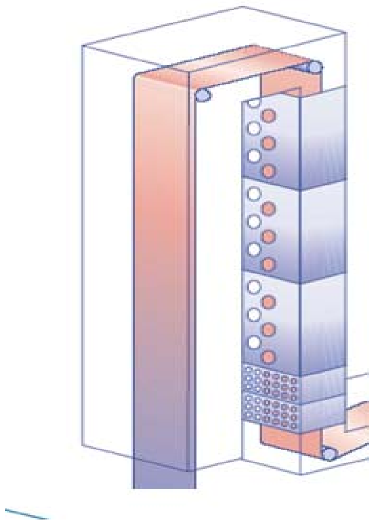

Figure 8: DFF Schematic View.

DIRECT FIRED FURNACE (DFF)

The Direct Fired Furnace has been mainly designed to achieve highest flexibility, higher strip temperatures than usually attained after two passes and a precise atmosphere control as well as a special focus on the homogeneity of the strip temperature.
The DFF technology is well known for its capability to heat the strip very efficiently and to clean the strip in a reducing atmosphere. The direct contact between the strip surface and the very hot combustion gases in a reducing atmosphere leads to a

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vaporization of the oil residuals and reduces as well as removes the iron fines to a high extent.

The new features, additional to the strip cleaning, achieve a controlled surface conditioning in a precise temperature range and at a defined location in a homogenous manner across the strip width.

By travelling from top to bottom the strip exits the DFF at a temperature of 650°C to 750°C through a sealing device, which separates the atmosphere between the radiant tube section and the DFF. The hot waste gases flow against the strip travel direction and heat the incoming strip in the vertical pre-heater to a temperature of 200°C to 280°C.

The DFF itself consists of five zones. The upper 3 zones are equipped with nozzle-mix burners facing the strip and ensuring a very high heat transfer between the burner flame - which is kept in the burner blocks - and the strip.

Premix-burners are operated within the two last zones, where air and gas are mixed well before the burner nozzle.

This accurately adjusted mixture is supplied to a multitude of small burners which are located in a panel facing the strip.

These panels are divided into sub-zones, which correspond to four width ranges. Each of the sub-zone has a separately controlled air-gas mixture. As a result of this, the stoichiometry can be adjusted for each sub-zone individually in a very precise way over a wide control range.

Subsequently a temperature scanner is installed to the last pre-mix zone, allowing the control of a very homogeneous temperature profile across the width and along the strip.

In addition, the air-gas ratio per sub-zone is constantly verified via an analyzer burner unit, where the pre-mixed gas is burnt and the waste gas is frequently analyzed (Figure 9).

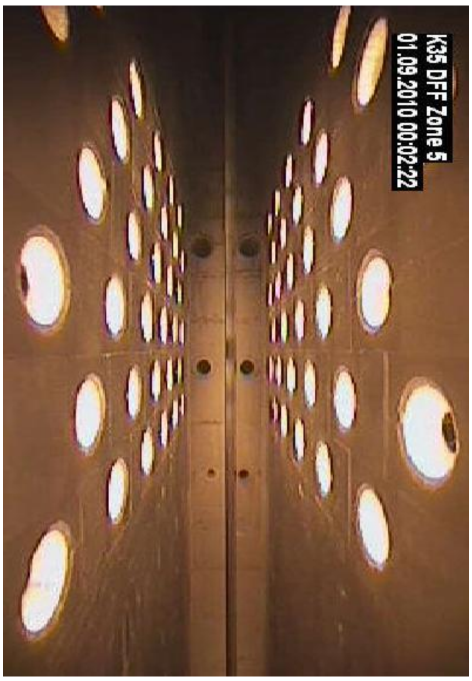

Figure 9: View into pre-mix Zone.

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Figure 10: DFF Waste Gas Analyzer Station.

These features ensure that the preset values for the atmosphere are achieved at a precise location at the right temperature, allowing voestalpine to control the desired surface conditioning for the relevant products.
The horizontal division into subzones in combination with a large quantity of small cup burners allows to shut off the outer burners for narrow strip and thus increasing the economical efficiency of the DFF.
The DFF is completely fiber lined which reduces the thermal inertia drastically. This allows faster changes and higher flexibility as well as higher DFF exit strip temperatures in comparison to the previous generations of DFF. In case of a strip stop, the DFF will be rapidly quenched and the strip temperature remains within a reasonable range.

HEATING- AND SOAKING ZONES

The 8 passes of the heating and soaking zones ensure to achieve the right specific temperature vs. time curve for all different kinds of steel grades. Needless to say, that the acceptable deviation from the temperature set values shows a very narrow tolerance, measured and controlled by additional temperature scanners. Especially, considering the influence from the previous production steps, this is imperative for the production of uniform mechanical properties along the strip length.

DIFFERENTIAL RAPID JET COOLING (DRJC)

Downstream of the 6 zones of Slow Gas Jet Cooler the Differential Rapid Jet Cooler has been implemented, which is based on an Andritz Selas Patent.
This technology allows a controllable temperature profile along the strip width at highest cooling rates which is essential for the production of HSS and AHSS grades.
To achieve a heat transfer coefficient above 700 W/m2 °K at 5% $H_{2,}$ the design is based on the optimisation of the nozzle geometry, the optimized flow conditions of the cooling gas - by avoiding any disturbing lateral flows - and on movable nozzle boxes, to control the distance between nozzle and strip surface during operation.
The different cooling modules are fed by three blowers. Whereas normally one blower feeds one module over the whole width, this patented design is based on a distribution of the cooling gas flow in a vertical manner: one blower feeds all modules in the centre. A second blower feeds the areas next to the centre and the third blower feeds the outer column of all modules.

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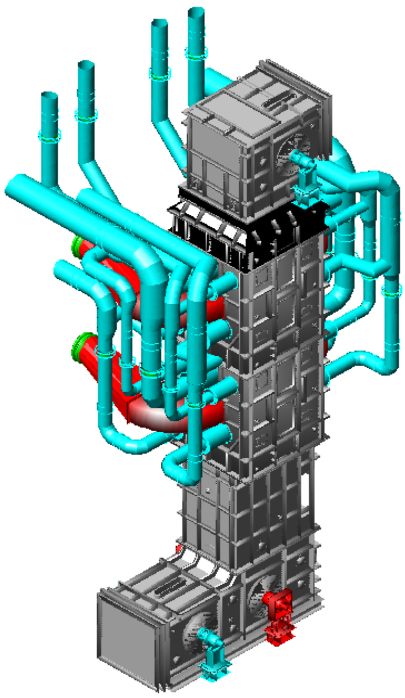

Figure 11: 3D-model of the differential rapid jet cooler.

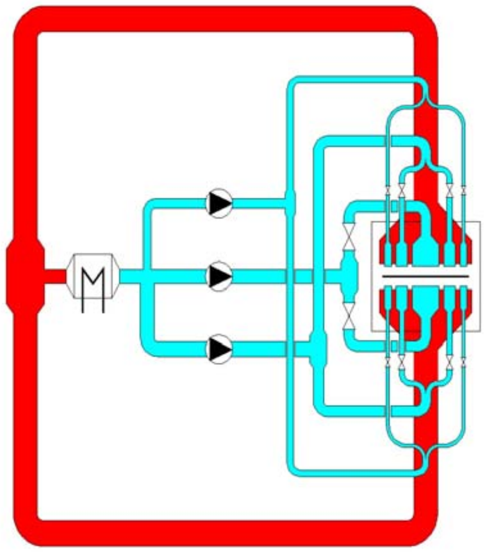

Figure 12: Schematic Flow Diagram of DRJC.

Individual valves for all feeding ducts can separate or further adjust the individual areas.

The temperature scanner at the exit of the DRJC measures the temperature profile across the width. In this way a perfect temperature control over the strip width is performed.

This firstly avoids cooling buckles at thin strips at high cooling rates. Secondly it allows voestalpine to compensate inhomogeneous strip temperatures due to strip changes related to width, thickness and the preset values for the temperature gradients.

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The DRJC can be operated in different control modes. If no special cooling rate is required the normal control mode will allow maximum capacity for a given exit strip temperature.
If a special cooling rate is required, the control mode changes and the cooling rate becomes the leading set point. Therefore the distance of the nozzle to the strip can be varied, too.

EQUALIZING ZONE

In context with the specific alloy concept of voestalpine an optimized equalizing zone (4 passes) is integrated within the overall furnace layout in CGL #4, which enables the production of all kinds of TRIP and CP-steel grades. CGL #5 does not show this kind of equalizing zone and the material is fed towards the snout.
Another two-dimensional temperature information derived by a scanner inside the snout provides the possibility to adjust the strip temperature over the strip width within very narrow tolerances.

ZINC POT AND WIPING SYSTEM

After heat treatment and surface conditioning within the annealing furnace, the strip passes the zinc pot. Often, this part of the galvanizing line has not been taken care of according to its importance and influence on the coating result.
High strip speed (max. 220 m/min installed) leads to excessive drag out of the molten alloy and consequently to a fast charging of additional zinc. As a result of experience gained from the other lines operated at voestalpine, the size and the geometry of the pot play an important role. Considering this, heating equipment for the 350 to zinc pot at CGL #4 is installed with very high power (3 x 550 kW), to keep the bath temperature as constant as possible. Due to the different target production of the CGL #5 (additionally galvannealed final product) there are two hydraulically lifted zinc pots with 300 to, which are shifted into operating position along the line axis, depending on the product (GI or GA).
Stageless heating equipment instead of common used binary control (on/off) for best surface qualities is necessary.

Figure 13: Zinc coating area.

The state of the art air knife equipment on top of three submerged rolls allows the use of air as well as nitrogen for adjustment of the coating thickness, which may be set between 60 and 350 g/m² (both sides).
Because of the additional galvannealing capability of the CGL #5 the APC (After Pot Cooling) consists of an induction heated channel including edge heating of total 3100 kW with an electrically heated soaking part.

SKIN PASS MILL

Subsequently to the APC-tower the facility for the treatment of the surface as well as the mechanical properties is located.
The skin pass mill, equipped with a sufficient rolling force of 15 MN and the possibility to use two different work roll diameters of 450 mm and 650 mm, is prepared to treat especially the advanced high strength steel. The trend for even higher yield strength combined with excellent elongation behaviour has been considered by introducing different modes of control for rolling force and elongation degree.

Figure 14: Skin Pass Mill CGL #4.

As a specific feature, the traversing high pressure cleaning device, ensures the continuous generation of highest surface quality. By means of “shooting” demineralised water onto the roll surfaces with a pressure of up to 200 bar, the work rolls as well as the back-up rolls are kept free from contaminating particles. As a result, the surface life time of the rolls, particularly of the work rolls, with respect to contamination, is extended.
The additional introduction of a vacuum device, directly positioned at the nozzle header keeps the area around the mill free from the mist, which is created by the high impact force of the water jet.
The cleaning water as well as the wet skin passing effluent are discharged to the water treatment plant.

Figure 15: High pressure cleaning.

Another special feature within CGL #4 is located after the tension leveller, which is placed downstream of the intermediate bridle roll unit: the Inline Measurement System (IMPOC). This highly sophisticated unit has been developed by voestalpine to measure the mechanical properties of the finally conditioned strip. It supports the quality management implemented at this plant by recording this quality parameter along the entire strip length and enables the production of material with narrow tolerated properties.

POST TREATMENT

The final stage of surface treatment takes place at the vertical coater, situated before the exit looper. The ability to apply three different types of passivation components (all chromium-free) to the strip is carried out either in inline or reverse operation mode of the applicator rolls, depending on the media and the respective set-value for the coating thickness.

Figure 16: Vertical inspection stand.

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EXIT SECTION

The turret type side trimmer with scrap baller at CGL #4 and scrap cutter at CGL #5 finally serves for the achievement of the ordered strip width. It is located after the exit looper and in front of the inspection stand.
Although the use of an automatic surface inspection became state of the art for the newer galvanizing lines at voestalpine, the ultimate inspection is carried out by specialized operators, and visual control still remains the optimum quality control.
A moveable electrostatic oiler is installed next to the exit pulpit. The choice of the oil type as well as starting and termination of the oiling process is fully integrated into the line automation.
Coil commissioning can be preset by length, weight or coil diameter which is achieved by the flying shear at an exit line speed of approximately 60 m/min.

Figure 16: Exit Section CGL #4.

The CGL #4 operates with only one tension reel whereas the CGL #5 needs to produce smaller coils and therefore is equipped with 2 recoilers, all allow to choose winding from top or from bottom. The final discharging of the marked coils is carried out by a coil car and subsequent walking beam conveyor to the exit storage area.

OPERATIONAL SAFETY

Last but not least, the safety equipment, which has been designed according to the CE Standards, allows the operators to observe and run the line with an adequate possibility of carrying out necessary interactive interventions under safe conditions. For this purpose, more than 40 electrically locked doors through the surrounding fences are placed at positions, where a quick manual activity might be necessary.

TIME SCHEDULE

CGL #4: After the engineering, manufacturing and erection phase of 14 months the functional tests started a sequence of already proven steps in implementing such a line, which contained a period of three months “cold commissioning”, followed by the first galvanized strip in April 2007. This increased quantity and quality of the coils within 3 months to the calculated amount of monthly output of galvanized material.
Even in this period of time, most of the intended steel grades and surface qualities had been optimized, too. Considering the economical situation in 2009 it was quite natural to lower the pressure of starting the production in time and the erection /

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commissioning phase was extended by 3 months. Nevertheless, the 3 months sequence of cold run was kept as scheduled.
The benefit from such a schedule clearly can be explained by the steep increase of prime production after the first coated strip with a very limited amount of line stops due to strip transport and operational errors.

PRODUCT MIX OF CONTINUOUS GALVANIZING LINES (2004/2010)

Through the extension of the production by CGL #4 and subsequently CGL #5 the yearly galvanizing capacity of voestalpine increased from about 1,0 mio. tons (CGL #1 to #3) to about 2 mio. tons. The amount of Advanced High Strength steel grades grew from 3 % in 2004 to 27% percent in 2010.(2)
During this time period, voestalpine also increased the amount of production with best surface quality.

SUMMARY

Andritz technology, engineering and supply combined with voestalpine experience, production know–how, the knowledge and team spirit of all engineers from research-, quality-, maintenance, logistic and production departments, enabled voestalpine to produce today a wide range of products including advanced high strength steel qualities as well as EDDQ steel grades continuously in large quantities with best mechanical- and surface quality.

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