Galvanising lines 4 and 5 at voestalpine Linz

Two additional galvanising lines at voestalpine Linz were specifically designed for processing advanced and high-strength steel grades for a wide range of applications. Output of galvanised strip at Linz has doubled to 2Mt/y and special grades now account for more than 25% of output.

In June 2005, Andritz completed the building of continuous galvanising line (CGL) #4 at voestalpine Linz, quickly followed in 2007 by CGL #5 because of the worldwide growth in demand for galvanised material. This growth is illustrated in Figure 1 showing the number of plants built. The development of the market and adaptations to voestalpine’s market strategy made some changes necessary from the original plans, so the two lines were very similar, but with a few important differences.

Before 2005, voestalpine already operated three hot dip galvanising lines at Linz so this investment had to be consistent with the supply from the upstream facilities and works logistics as well as the specific product mix of each line. Before CGL #4, trial production of high-strength and other special steel grades on the other lines had already reached a level where the transfer of these R&D results into a new CGL was a logical next step to supply this market segment.

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.

OBJECTIVES

The galvanising lines (see Figures 3 and 4) are dedicated to the production of advanced high strength and complex phase steels and contain all the necessary features to fulfill the highest surface quality requirements. The lines are able to process strip thicknesses between 0.4mm min. and 2.0mm or 2.5mm max. for #4 and #5, respectively, with strip widths between 750mm and 1,750mm. The maximum speed within the treatment sections is 220m/min, fed by the entry section speed of 300m/min and discharged by the exit section at 350m/min. The yearly line capacity was planned for 450,000t (for #4) and 400,000t (for #5) within 7,000 operating hours, which equates to an average production of approximately 60-65t/h.

The coil dimensions are limited to 35t and 2,100mm outer diameter and are supplied with 600mm inner diameter.
The coating mass ranges from 60 to 350g/m² on both strip sides. The wide range of different steel grades on both lines contains commercial qualities (CQ), intestinal-free (IF), bake hardened (BH), microalloyed-, high strength IF, as well as transformation induced plasticity (TRIP) and complex phase (CP) steel grades, although CGL #5 focuses on the dual phase (DP) family within the AHSS grades.

ENTRY SECTION
The incoming material for both lines is produced via a Tandem Cold Mill and is 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 sides (see Figure 5). The further processing of the strip to the laser welder is carried out fully automatically, including scrapping, strip centring 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 welding of all various strip material combinations of the product mix with a
thickness difference of up to 0.7mm. The Quality Control Data System, which scans the welding process, enables a detailed rating of the weld quality, and the results are displayed next to the welder.

**CLEANING SECTION**

The cleaning sections of both lines consist of one electrolytic cleaning stage, brush section, three rinsing stages followed by wringer rolls and a dryer. The production of AHSS in particular requires efficient cleaning of both sides along the entire strip length. Due to the fact that all continuous processes within the lines 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 600m of strip.

**FURNACE SECTION**

The furnace sections each contain a directly fired entry (DFF), a heating (RTH) and soaking zone (RTS), a slow gas-jet cooling (SJC) and rapid gas-jet cooling (RJC) area followed by the equalising zone (see Figure 6). The detailed concept was installed by Andritz Selas according to the specific requirements of voestalpine and illustrates another example of success, when operating and engineering know-how are combined for a common target.

**Direct fired furnaces (DFF)**  The DFF have been designed to achieve high flexibility, higher strip temperatures than usually attained after two passes and precise atmosphere control, as well as a special focus on the homogeneity of the strip temperature (see Figure 7). DFF technology is well known for its capability to heat the strip very efficiently and to clean it in a reducing atmosphere. Direct contact between the strip surface and the hot combustion gases in a reducing atmosphere leads to a vapourisation of the oil residuals and significantly reduces iron fines. The new features, additional to 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.

The strip exits the bottom of the DFF at a temperature of 650-750°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 200-280°C.

The DFF itself consists of five zones. The upper three zones are equipped with nozzle-mix burners facing the strip, 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 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, and each has a separately controlled air-gas mixture. As a result, the stoichiometry can be adjusted very precisely over a wide control range for each sub-zone individually.

Subsequently, a temperature scanner installed in the last pre-mix zone allows 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 analyser-burner unit, where the pre-mixed gas is burnt and the waste gas is analysed (see Figure 8).

These features ensure that the preset values for the atmosphere are achieved at a precise location and at the right temperature, allowing voestalpine to control the desired surface conditioning for the relevant products. The horizontal division into sub-zones in combination with a large quantity of small cup burners allows the possibility to shut off the outer burners for narrow strip and thus increase the economic efficiency of the unit.

The DFF is completely fibre lined, which significantly reduces the thermal inertia, allowing faster changes and higher flexibility as well as higher exit strip temperatures in comparison to the previous generations of DFF. In the 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 eight passes of the radiant tube heating (RTH) and radiant tube soaking (RTS) zones ensure that the right specific temperature vs. time curve for the different steel grades is achieved. Needless to say, 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 and rapid jet cooling (DRJC) This is situated downstream of the six-zone slow gas-jet cooler (SJC) and is based on an Andritz Selas patent (see Figure 9), and 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 700W/m²K at 5% H₂, the design is based on the optimisation of the nozzle geometry, the optimised 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 individual valves for all feeding ducts and can separate or further adjust the individual areas (see Figure 10).

The temperature scanner at the exit of the DRJC measures the temperature profile across the width to ensure temperature control over the strip width. This avoids
cooling buckles of thin strip at high cooling rates and allows compensation of inhomogeneous strip temperatures due to strip changes related to width, thickness and the preset values for the temperature gradients.

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.

**Equalising zone** To meet the product mix requirements, an optimised equalising 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 have this kind of equalising zone and the material is fed towards the snout. 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 in the annealing furnace, the strip enters the zinc pot (see Figure 11). Surprisingly, given its importance and influence on the coating result, often, this part of the galvanising line has been somewhat neglected. High strip speed (max. 220m/min installed) leads to excessive drag out of the molten alloy and consequently to 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 350t zinc pot at CGL #4 has very high power (3 x 550kW), to keep the bath temperature as constant as possible.

Due to the different target production of CGL #5 (galvannealed final product) there are two 300t hydraulically lifted zinc pots, which are shifted into operating position along the line axis, depending on the product, normal galvanised (GI) or galvanealed (GA).

To produce the best surface quality, stageless heating equipment instead of the more commonly used binary control (on/off), is used. 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 350g/m² on both sides. Because of the additional galvannealing capability of CGL #5, after pot cooling (APC) consists of an induction heated channel including 3,100kW edge heating.

**SKIN PASS MILL**

Following the APC tower, a skin pass mill is installed for surface treatment and development of mechanical properties (see Figure 12). The mill provides a rolling force of 15MN, the possibility to use two different work roll diameters of 450mm and 650mm, and is designed specifically to treat advanced high-strength steels combined with excellent elongation behaviour, by introducing different modes of control for rolling force and elongation.

As a specific feature, a traversing high-pressure cleaning device ensures the continuous generation of highest surface quality using high-pressure demineralised water (up to 200 bar) onto the work rolls and back-up rolls to keep them free of contaminating particles (see Figure 13). As a result, the surface lifetime of the rolls, particularly of the work rolls, 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.

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

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 in-line or reverse operation mode of the applicator rolls, depending on the media and the respective set-value for the coating thickness.

EXIT SECTION
The turret type side trimmers, with a scrap baller at CGL #4 and a scrap cutter at CGL #5, achieve the ordered strip width, and are located after the exit looper and in front of the inspection stands (see Figure 14).

Although use of an automatic surface inspection became state-of-the-art for the newer galvanising lines at voestalpine, ultimate inspection is carried out by specialised operators, and visual control still remains the optimum quality control system. 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 requisitioning can be preset by length, weight or coil diameter, which is achieved by the flying shear at an exit line speed of approximately 60m/min. CGL #4 operates with one tension reel, whereas CGL #5 produces smaller coils and so is equipped with two re-coilers. All are capable of 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 CE standards, allows the operators to observe and run the line with the ability to carry out necessary interactive interventions under safe conditions. For this purpose, more than 40 electrically locked doors are placed at positions through the surrounding fences where rapid manual activity might be necessary.

TIME SCHEDULE
CGL #4: After the engineering, manufacturing and erection phase of 14 months, and a cold commissioning period of three months, the first galvanised strip was produced in April 2007. Design capacity was achieved in three months and most of the intended steel grades and surface qualities optimised. Considering the economic situation in 2009, #5 was extended by only three months, but cold commissioning was kept as scheduled. A benefit of this delay was very rapid production of prime material when the line was commissioned.

SUMMARY
Andritz technology, engineering and supply combined with voestalpine experience, production know-how and the knowledge and team spirit of all engineers from research, quality, maintenance, logistics and production departments, enabled voestalpine to increase the galvanising capacity from about 1 Mt/y (CGL #1 to #3) to about 2Mt/y, with production of advanced high strength steel grades increasing from 3% in 2004 to 27% in 2010. These steels are supplied to a wide range of market segments, from building to automotive.

Arnold Kapellner is with Andritz AG, Linz, Austria. Jürgen Ziemandorff is with Andritz Selas, Ansieres, France.

CONTACT: Arnold.kapellner@andritz.com