



## PROCESSING LINES SERVING HIGH-END STEEL PRODUCTION FOR AUTOMOTIVE PRODUCTS\*

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### Abstract

With a limited global steel production growth, automotive application market shows interesting volumes and trends especially in emerging countries. The recent period has again enabled Siemens VAI to confirm a position amongst leading suppliers of new plants serving high-end steel production in particular for unexposed and exposed automotive material. With a series of recent plant references in operation and under construction, relevant answers to such sustained level of performances are highlighted along the downstream processes. Designed for a wide range of applications, Siemens VAI processing lines includes advanced technological and state-of-the art equipment, among them, Solid state laser welder, Pickling Tunnel tanks, Skin pass mill and Tension leveller, Side trimmer with dynamic width adjustment, and new generation of Automatic surface inspection systems. With a continuous aim of driving improvements, Siemens VAI has also developed Global Quality Monitoring solutions notably through advanced software which provide just-in-time warnings and assist steel makers in the daily operation of their lines. As lifecycle partner, Siemens VAI offers solutions and services in metallurgical expertise from metallurgical modelling, through physical simulation on rolling, annealing and galvanizing processes, and enables Siemens to accompany our customers along with their project definition till fulfilment of highest market requirements.

**Keywords:** Pickling; Galvanizing; Annealing; Market trends

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\* *Technical contribution to the 51<sup>st</sup> Rolling Seminar – Processes, Rolled and Coated Products, October 28<sup>th</sup> to 31<sup>st</sup>, 2014, Foz do Iguaçu, PR, Brazil.*



## 1 INTRODUCTION

With a limited global steel production growth, automotive application market shows interesting volumes and trends especially in emerging countries. The recent period has again enabled Siemens VAI to confirm a position amongst leading suppliers of new plants serving high-end steel production for automotive sheets. With a series of recent plant references in operation and under construction, relevant answers to such sustained level of performances are highlighted along the downstream processes.

In the world of steel for automotive market, keywords are more than ever: delivering the best strip quality, processing new steel grades and operational costs cutting. To meet these challenges, Siemens VAI developed a spectrum of solutions to provide leading edge functionalities, which are driving the trends. A set of selected, but comprehensive hints are highlighted here below.

## 2 QUALITY DRIVEN TECHNOLOGIES

Amongst the pillars of global performance, product quality remains a fundamental aspect in the field of automotive, and not only for most demanding said exposed panels' materials.

- Strip shape: In the continuous trend of mechanical properties increase, flatness control remains a challenging area at various stage of strip processing. Scale breaker remains a mandatory feature to improve strip shape before high speed pickling. Besides the basic function of oxides breaking in a sufficient amount to improve acid attack, flatness management supports through uniform and homogeneous acid attack along the strip body, and minimizes risk to generate surface scratches in pickling tanks.

Strip flatness is finally mastered in exit areas of processing lines with the unrivalled Siemens technology of skin pass mill and tension leveler.

The skin pass mill (Figure 1) is also used to print the requested roughness on the strip, by transfer of the work roll roughness to the strip surface.



**Figure 1.** Siemens skin-pass mill stand

Skin pass mills are either designed dry or with wet rolling for lower rolling friction and pick-up reduction, and with high pressure cleaning system for Work Rolls and Back Up Rolls along with mill exit rinse and strip dryer to ensure the best surface quality for automotive products.

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Siemens VAI offers a full range of skin-pass mill equipment with:

- Rolling forces from 400 to 1,800 tons
- 4- or 6-high type, driven back-up rolls or work rolls
- Quick Roll change with line running
- Positive & Negative ( $\pm$ ) work roll bending for good shape control
- Constant Pass-line adjustment

The tension leveller (Figure 2) is used to correct the flatness defects by elongation/flexion. The elongation is controlled with a high accuracy, in order to not affect the roughness given by the skin pass mill. New generation of tension levellers (high tension/load, roll configuration to minimize residual stress) is now available to address upper range of AHSS grade range.



**Figure 2.** Siemens tension leveller with cassette quick exchange device

Advantages of Siemens tension leveller:

- Well proven and standardized technology
- Low operating cost (automatic operation, cassette quick-change device, automatic control of work rolls intermeshes)
- Efficiency (improved flatness, especially on strips with high yield strength; possibility of 2 sets of two leveling units in operation; possibility of running one leveling unit while the second unit is under maintenance)

Clean surface from pickling process: Management of pickling process section is done in fully automatic mode and is based on the FAPLAC APM+ physical setup model which determines all relevant process parameters (acid temperature, acid flow ...) taking into account the strip speed, acid and iron concentrations, strip tension, Hot Strip Mill coiling temperature...

Siemens developed in recent years Pickling Tunnel tanks (Figure 3). This design enables higher pickling efficiency and allows higher pickling speed with uniform reaction due to high turbulences generated through combination of below features:

- Spray headers installed at the entry and exit side of each tank. It built up also a hydrodynamic sealing between the pickling tanks and the wringer roll tanks and keep the pickling liquor above the pass-line of the steel strip.
- Lateral injectors arranged perpendicular each pickling tank and allow achieving a better pickling efficiency especially at the strip edges.
- Tank bottom and immersion covers build up a tunnel shape where the strip is guided through.

The acid level in the tank can be automatically adjusted allowing the strip to run at very low speed without any over-pickling. Such possibility is very interesting for the

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coupled line as this allows larger mill downtimes (roll change ...) without stopping the process section and then to maintain high surface quality.

On pickle coils production, the strip in the tanks never touches any fixed part, avoiding risk of scratches.

The very compact design of Tunnel Pickling tanks permits reduction of the fume exhaust flow rate decreasing the energy consumption and fume scrubber size.

The rinsing unit which is cascade type and includes a high pressure last rinsing ramp allows perfect strip cleanliness and minimizes the water consumption.

Such overall pickling process section is a must have solution to combine highest productivity, reliability of large production needs and high quality surface strip (perfect cleanness, no scratch, no stain). And this fit today with the most stringent requirements up to automotive exposed parts.



**Figure 3.** Polypropylene pickling tanks

- Strip surface cleanliness in Annealing and Galvanizing lines: Removal of cold rolling oil and iron fines from the strip surface by a strip cleaning section, prior to enter into the furnace, is essential for best product quality, particularly if an all-radiant tube annealing furnace is installed in the line. Strip cleaning is also recommended for the highest quality products even if a non-oxidizing, direct fired furnace is installed.

Surface quality required by automotive market usually drives decision for vertical accumulators including protecting covers to prevent ingress of elements in the area. Furnaces are also preferably designed vertical for similar reasons (along with specific constraints coming from strip behaviour at high temperature).

Furnace control and Zinc Coating is at the heart of surface quality stakes for an automotive CGL; this requires specific pre-oxidizing furnace section for the higher grades with higher content in Silicon and Manganese, and adapted atmosphere control.

Galvanizing pot area is the critical process area of the line, both bottlenecking the production and dictating the most frequent line stoppages. To obtain a repeatable, uniform, defect-free coating remains a high end task of automotive lines especially for exposed material.

This goes through maintaining the coating metal melt at the right temperature, composition and level so as to keep the dross management under control.

Generally used for aluminium base melt or galvannealing coating, pre-melting pots are principally used to melt the metal needed to replenish the main coating pot, easing control and stability of composition and temperature in the main pot. One of the key advantages of such pots is to limit dross formation in main pot, and is a preferable feature of automotive-driven lines

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To remove the generated drosses, automatic (skimming robot) or semi-automatic (mechanical manipulator assisting operators) devices can be installed to eliminate a demanding, hazardous manual operation, and ensure sustained coating conditions.

### 3 GLOBAL QUALITY MONITORING

At all critical stages of steel production, Siemens VAI is able to offer the relevant monitoring systems. Getting the final required global quality for steel production is the result of a succession of process steps all along a defined metallurgical route (from meltshop, through the Hot Strip Mill, the pickling line, cold rolling mill and up to the processing lines), that have individually a high influence on the final product quality. Focusing on the final processes is necessary but not sufficient, and this is in particular valid for high end automotive market.

Amongst required monitoring systems:

- SIAS® automatic surface inspection system, with “high-sensitivity” linescan “both sides / full length” inspection, benefiting from a powerful 3rd generation LED illumination system for high defect/non defect detection ratio.
- PropertyMon system (Figure 4) for non-destructive, real-time and in-line measurement of strip material properties, such as tensile strength and yield strength across the entire length of the steel strip.
- Various gauges and sensors (roughness, width, thickness, flatness...), used for process close loop optimization or product quality tracking.



**Figure 4.** Bottom face mounting PropertyMon system

To deal with this flood of data and assist steel makers in the daily operation of such a processing line, Siemens VAI developed Siroll TCOptimizer® (Figure 5), an unique and advanced software for just-in-time warnings including a computing intelligence highlighting relevant events without overwhelming users by gigabytes of data. It is designed to be a central expert system which collects data and signals from all parts of the production chain, embeds Business Rule Management System (BRMS) based upon simple logical expressions and decision trees to allow non IT-specialists to handle the incoming signals and to manage the generated relevant-only manufacturing events and just-in-time warnings.

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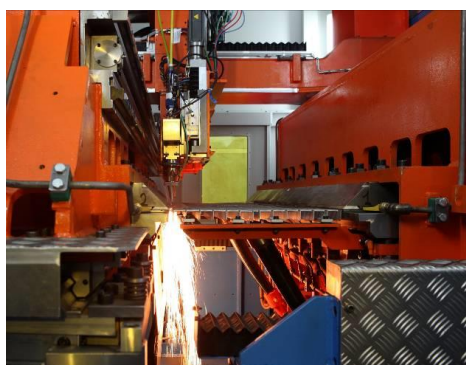
**Figure 5.** Siroll TCOptimizer solution

#### 4 NEW GENERATION OF KEY PROCESS EQUIPMENT

Sustaining high strip quality levels imposes to manage stable and reliable processes. In such approach, key process equipment now features adapted functionalities:

- Strip welding is the key element enabling a continuous production mode, and is therefore at the cornerstone of stable process ensuring the best quality all along the production. Laser welding joint brings high level of quality and reliability those prevent line speed slowdown, strip tension release in the scale breaker area, mill rolling force release, or more severe issue like a strip break.

Siemens latest laser technology makes welding possible for every kind of incoming automotive steel. A breakthrough has been pioneered by Siemens VAI with a full laser cut and weld solution (Figure 6). Already fully proven on CAL and CGL, this technology is now available on PLTCM or CPL (up to 6,5 mm). The fiber-based solid state laser technology is used on all solutions and enables new horizons in terms of material weld ability, cutting precision for better global cycle time.

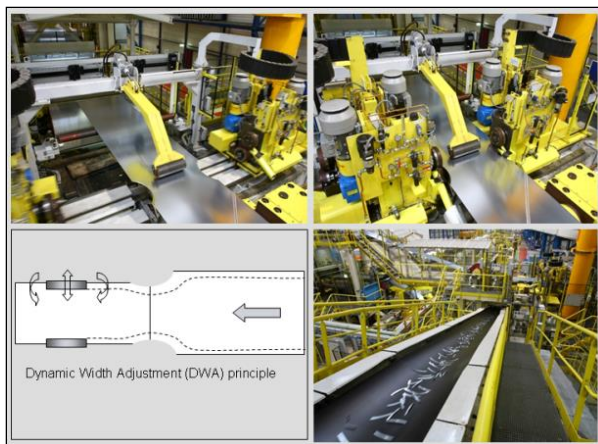


**Figure 6.** Solid state Laser welding head

Pre-heating, post annealing, weld quality control are additional features permitting to achieve the near-zero weld break ratio required by a modern line.

- No more line stoppage at side trimmer section improves strip transitions (avoiding roll marking) and/or productivity gains by avoiding notching. With Dynamic Width Adjustment, the side trimmer (Figure 7) no longer stops during a strip width change. The knife rotates accurately under the cutting axis along the width change without unlocking the heads. This offers a number of advantages such as reduced risk of jamming (as trimmed edge is never lost), and minimized cycle time.

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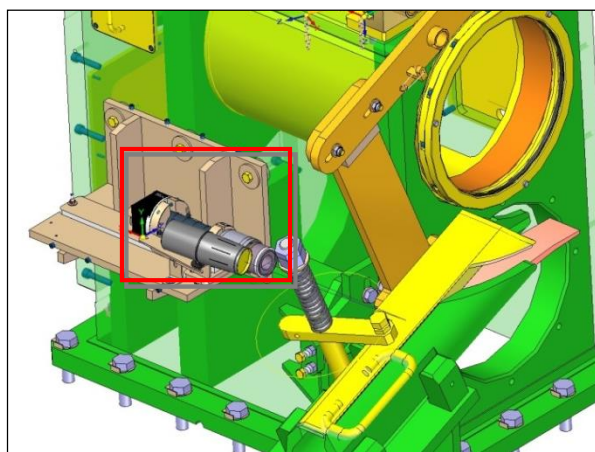


**Figure 7.** Siemens side-trimmer and Dynamic Width Adjustment (DWA) concept

Equipment condition monitoring on such key process machine is crucial for preventing unplanned downtimes and unintentional impacts on product quality. Siemens offers today an innovative condition monitoring system which detects deviations from the normal state in good time to plan the corrective maintenance measures by integrating information from several automation levels.

- On laser welder
  - Supervision of selected equipment (e.g. cutting & welding heads, planishing roll ...)
  - Monitoring of performance (clamp and welding carriage positioning)
  - Consumption monitoring (electricity and gas)
- On side trimmer
  - Width adjustment servomotors positioning
  - Gap/Lap adjustment servomotors positioning
  - Turret rotation servomotors positioning

As a perfect complementary feature, Siroll EdgeMon cameras (Figure 8) continuously analyze the shape of the strip edges after trimming so as to monitor knives quality and lifecycle.



**Figure 8.** EdgeMon camera on exit side of side trimmer head

## 5 LIFECYCLE PARTNERSHIPS FOR NEXT GENERATION OF STEEL GRADES

Improvement of steel performances, such as Advanced High Strength Steel (AHSS) with their evolved chemical composition, brought the necessity to revise the entire

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value chain. As a matter of example, recent processing lines contracted by Siemens are designed to process grades up to DP1200. Beside the necessity to define specific plant parameter and machine sizing, this new generation of materials features specific aspects to be addressed : precisely monitored upstream processes, furnace control with pre-oxidation stages, rapid cooling system ( $>100^{\circ}\text{C/s/mm}$ ) which heavily impact the end product quality.

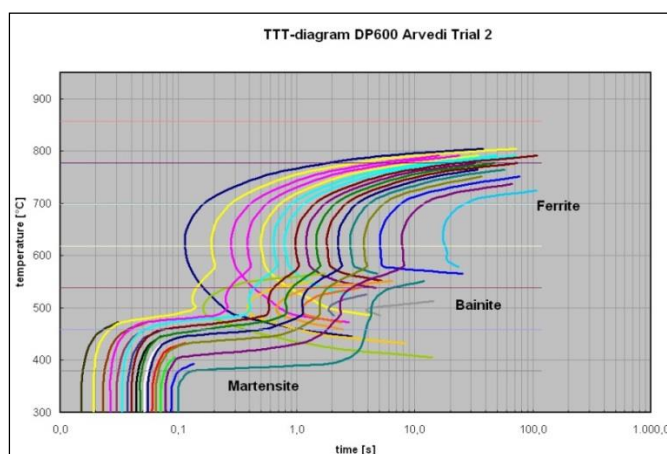
Automotive market is still clearly a trend maker in the development of new steel grades. In such environment, Siemens offers a spectrum of solutions and services to the market, in particular in the field of metallurgical know-how support and grade development, amongst these:

- Mobile SIAS® automatic surface inspection system for specific test campaigns.
- Development of tools such as physical simulators for annealing and galvanizing processes



**Figure 9.** Siroll Annealing simulator

- Metallurgical simulation tools/models and services from in-house experts workforce.



**Figure 10.** Metallurgical curves simulation

- In-house coil-to-coil versatile rolling mill / levelling unit facility

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**Figure 11.** Pilot test bench in rolling mill mode

## 4 CONCLUSION

The present article introduced the main solutions used to maximize the capacity and performance of our processing lines. Siemens VAI lines stand out for their state-of-the-art achievements and their advanced technologies which enable customers to meet the latest market requirements and future trends.

Such combinations of in-house capabilities for equipment supplier, development support along with usual core expertise competences in plant making, establishes Siemens VAI as a key lifecycle partner for the automotive steel industry.

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