



SIEMENS VAI LASER WELDER INDUSTRIAL RESULTS ON A LARGE RANGE OF PRODUCT*

Hervé Thomasson¹

Abstract

Siemens VAI has made an important Research & Development effort since 10 years on laser welder field. The last step of this program was in 2010, the evolution of its laser welder range by implementing the solid state technology with laser cutting and welding. Since this step, 8 welders were produced by Siemens VAI. Now after more than 1 year of industrial feedback, the results are showing a high level of performances on very demanding processing lines for a large range of products from Silicon steel to High Strength Steel with DP and TRIP grades. This laser welder concept using laser cutting and welding through solid state laser source is also proposed by Siemens VAI for pickling lines and tandem mills with significant advantages compared to standard solution.

Keywords: Laser welder; Solid state technology; Silicon steel; High strength steel.

¹ *Welder Product Manager, Siemens VAI Metals Technologies SAS, Savignaux, France*

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



1 INTRODUCTION

Siemens VAI has been a welder manufacturer for the iron and steel industry for more than 40 years. In the last few years the requirements for processing lines and for the Siroll welder product have tremendously changed with:

- The emergence of new steel grades and its constant evolution.
- The changes in the strip format range.
- The high level of performance with perfect welding quality criteria (weld robustness, over thickness...) and automatic welding quality control.

The Siemens VAI welder performance must, therefore, incorporate all of the above aspects to be able to meet the current and future requirements of the steel industry.

Therefore, Siemens VAI has developed its laser welder range with two welder types: one dedicated to light gauge (LW21L) for galvanizing lines, inspection lines, and one dedicated to heavy gauge (LW21H) for pickling lines and tandem mills.

Through continued research efforts and always willing to be ahead in terms of technology, Siemens has now reached a new step with the integration of a solid state laser source to its laser welder. This laser source replaces the CO₂ resonator and offers important benefits for steel producers. With now several industrial results on different application with this new machine concept, Siemens VAI is proposing a high performing machine with simple and easy maintenance compared to standard and classic concept.

2 REQUIREMENTS FOR WELDERS

2.1 Evolution of Steel Grade Range

Over the last years, steel grades have drastically changed. The main evolution trend concerns yield strength and elongation. New steel grades are characterized by high yield strength and a high elongation level. Steel grades are also including more and more additional elements like silicone, manganese, aluminium, bore...

With TRIP and DP steel, the lines are already processing steel grades up to 1000 / 1400 MPa and it is anticipated that they will process steel up to 2000 MPa tensile strength in the future. In addition, the new steel grades represent an ever increasing portion of the total production.

2.2 Changes in Product Format

The main evolution in terms of welder capacity is the thickness range with ever thinner gauges. The thickness range required for welders is now less than 1.00 mm thick for the pickling lines and tandem mills and less than 0.30 mm thick for galvanizing, continuous annealing or finishing lines.

2.3 High Level of Performance

Taking all the above points into consideration, the level of performance required from the welder has also been significantly improved. Availability, welding quality, weld over thickness and cycle time have reached a level never attained until now for the welder product. Besides, automatic welding quality control systems are now mandatory for the customer to avoid any human intervention and to have a clear statement of the welding quality according to customer's request.

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



3 SIROLL WELDER DEVELOPMENT PROGRAM

An extensive R&D program has been conducted by Siemens VAI in the field of welders for more than 10 years. In the 90's, the early stage of the programme was dedicated to developing a new « Flash Butt » welder concept (pickling entry section, fully continuous rolling mill ...) and a new « Mash Lap » welder concept (galvanizing line entry, continuous annealing, inspection lines ...).

The program was then pursued in 2000 with the development of the laser welding process. The first stage of development focused on light gauge (LW21L) for galvanizing lines, inspection lines... The development of the laser welder for heavy gauges (LW21H) was started in 2004 for thickness ranges from 1.00 to 7.00 mm.

Through continued research efforts and always willing to be ahead in term of technology, Siemens VAI has now reached a new step with the integration in the welder of the solid state technology for its laser source. This laser source is replacing the CO² resonator. The Solid state technology already used on other industry sectors like automotive, tailor blank welding... leads to different and significant advantages compared to the CO² solution. The Solid state technology makes it possible to transmit the beam from the laser source to the process heads (cutting and welding) through optic fibre instead of using mirrors.

Laser welding machine of Siemens VAI proposes laser cutting operation which makes possible to have a perfect cutting operation on the whole range of steel grades and thickness and then a perfect preparation for the welding phase by laser.

4 SOLID STATE TECHNOLOGY ADVANTAGES

This new technological step gives a lot of benefits to steel producers with among others, a higher efficiency, lower consumptions, higher process speed for cutting and welding, easier maintenance with no mirror installed on the machine...

4.1 Simple Beam Path Transportation

By using optical fibre to transport the beam from the laser source to the process heads (for cutting and for welding), the customer does not have mirrors or beam switch on the machine. With this beam transportation system, the adjustment of the welder is very easy and the maintenance operations are reduced to almost nothing for the beam path. With this fiber technology, we have a "plug and play" system which avoids accurate and difficult adjustment of beam path. This is a key point for commissioning point and maintenance as it has been confirmed after commissioning and industrial feedback of last Siemens VAI projects. One fiber is connected on the cutting head and one on the welding head and both are connected on the other side to the laser source (Figure 1).

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



Figure 1: Fibers connection on welding/cutting heads and on laser source

With the length available for the fibres, it is possible to install the laser source separate from the welder. Therefore the laser source could be installed in a dedicated space or room which is not possible with CO² technology. This makes possible to have a perfect control of the laser source environment and will improve drastically the life time of the laser source.

Additionally, without laser source on the machine, the space required by the machine mainly on the motor side of the line is reduced. This point could be a key aspect in case of lines being revamped where the space is often an important issue.

4.2 Higher Efficiency and Lower Maintenance

With a higher efficiency, it makes it possible to decrease electrical consumption and sizing of other systems like the cooling unit. At a same laser power level, installed electrical powers for the chiller and laser source are reduced by 50%.

In term of maintenance, the maintenance level on the fiber system, with no overpressure system, no mirror, no check of internal part, is limited to a visual control without any dismounting operation.

For the laser source itself, the maintenance is drastically reduced compared to CO² technology with a simple yearly maintenance. At a same laser power level, the using hourly cost (including maintenance gas, electrical consumption) is 80% less for solid state technology compared to CO² technology.

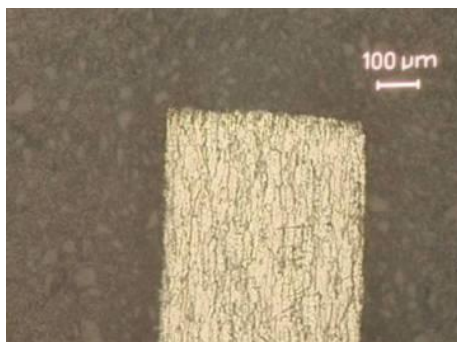
4.3 Higher Performance in Cutting and Welding

One main point for the laser welding process is the preparation of the strip. Therefore the cutting operation is a key point. With laser, the cutting quality is perfect without deformation of the strip which is with mechanical shearing. There is no limitation in term of steel strength for the cutting capacity.

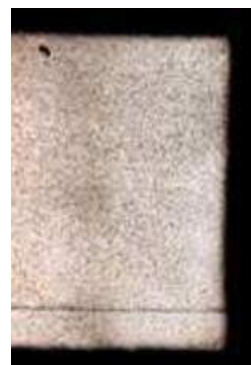
As a none-contact operation, there is no wear of the cutting tools. Therefore maintenance is almost zero compared to an heavy maintenance of mechanical shear with blade change and grinding.

Quality and reliability of cutting has been verified on the whole range of thickness for the 2 applications LW21L (CGL/CAL/RCL) and LW21H (PL/PLTCM) (see cutting quality on Figure 2).

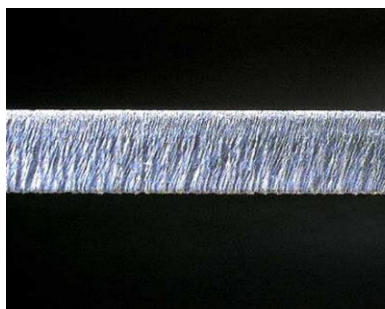
* *Technical contribution to the 51st Rolling Seminar – Processes, Rolled and Coated Products, October 28th to 31st, 2014, Foz do Iguaçu, PR, Brazil.*



0,5mm cutting edge



2mm cutting edge



2mm cutting face



6mm cutting face

Figure 2: Cutting quality

Because of the higher quality of the beam, with a same laser power installed, cutting and welding speed will be higher with a gain from 20 to 100 % depending of the thickness for cutting and from 20 to 50 % for welding. In the figures hereunder are given industrial results for cutting and welding speed in different configurations: 3,3 KW solidstate, 4KW solidstate, 3,5KW CO² (Figure 3 cutting speed comparison and Figure 4 welding speed comparison).

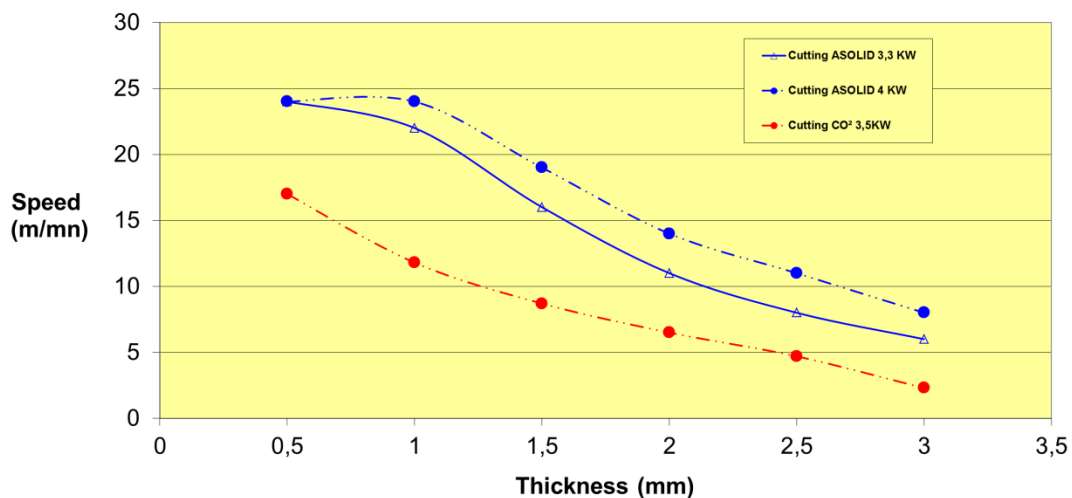


Figure 3: Cutting speed

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

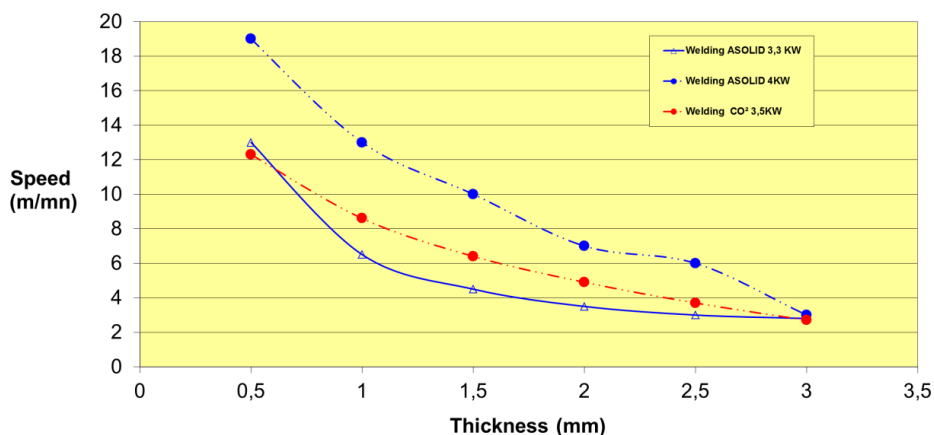


Figure 4: Welding speed

Laser cutting (non-contact process) is eliminating wear of cutting tools and achieves a perfect strip preparation without strip deformation for the welding operation (cutting, welding phase in Figure 5).



Figure 5: Cutting and welding phase

5 WELDING RESULTS

Welding quality has been verified on a wide range of product for:

- carbon steel to High Strength Steel (CQ, DQ to TRIP, DP)
- silicon steel (oriented and none-oriented grain up to 3,5% silicone content)
- stainless steel (different qualities)

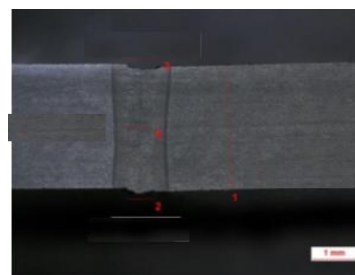
Different test are performed to qualify the welding parameter like stamping test (ball test), tensile test (for HSS), macro or micrograph (Figure 6).



Ball test



Tensile test



Micrograph

Figure 6: Welding results

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



The use of annealing (pre and post annealing is possible on the machines) has to be verified depending on the steel grade and its use is based on the strength level and carbon equivalent level.

The annealing treatment is performed through inductive device and through industrial feedbacks, the annealing treatment is necessary for high carbon equivalent level and is systematic to achieve good results in the line for the weld joint. In the Figure 7 hereunder you have an illustration of the effect of the annealing treatment on the High strength steel on the hardness level (Hv) around the weld at different temperatures (700°C and 900°C).

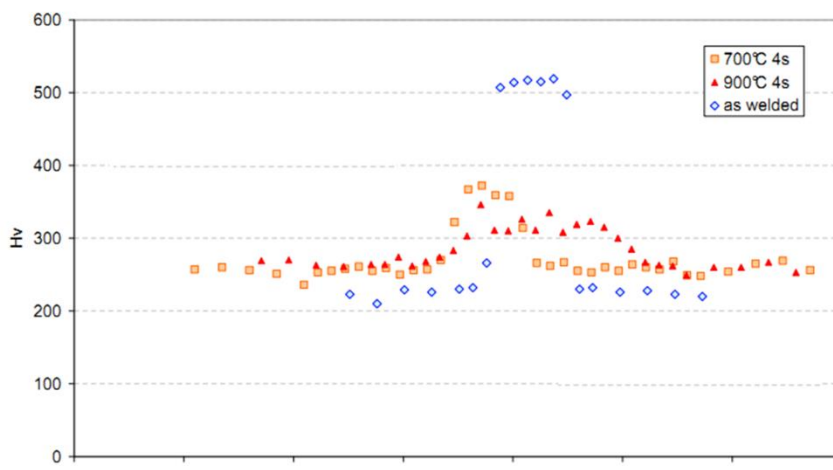


Figure 7: Cutting and welding phase

In order to support efficiently the operation and maintenance team, a qualification system of the weld is installed. It is based on welding quality control using CCD camera (Figure 8). The goal is to assist the operator for the weld qualification to avoid human wrong decision.

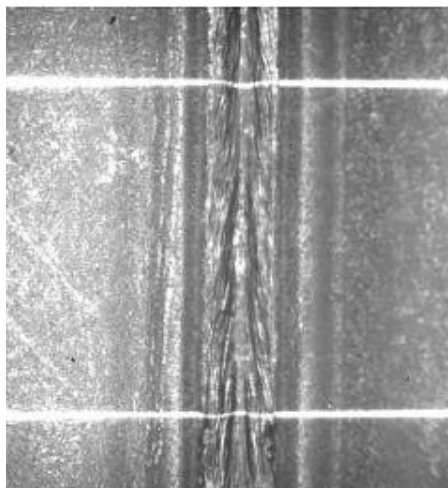


Figure 8: Welding qualification system

6 CONCLUSION

Based on the experience and knowhow of Siemens VAI as a product and line supplier, Siemens policy is to be able to propose to its customer's different products, from more conventional machines to advanced technology like laser. An important part of this approach is the permanent and intensive Research and Development

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

LAMINAÇÃO Rolling

51º SEMINÁRIO DE LAMINAÇÃO - PROCESSOS E PRODUTOS
LAMINADOS E REVESTIDOS - INTERNACIONAL
51º ROLLING SEMINAR - PROCESSES, ROLLED AND COATED
PRODUCTS - INTERNATIONAL



effort with the goal to always propose better solutions to our customers.

When thinking about better solutions, with its field experience and industrial feedback, Siemens is always thinking of different aspects from installation, return on investment (ROI), consumption, maintenance to service support and last evolution of our laser welders is fully adhering to this policy with higher efficiency and performance level, easier installation, reduced maintenance. And with a lower investment level, this new laser welder evolution represents important gains for the customer.

But of course, this is not an end and Siemens will pursue its goal of always proposing better products and better solutions for its customers to support them for new challenges.

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