TK-CSA NEW RH INSTALLATION – MOVING TO INDUSTRY 4.0 SOLUTION*

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Abstract

The paper describes the recent new installation and start-up of the second RH (Recirculation Degasser) in Rio de Janeiro plant of thyssenkrupp CSA Siderúrgica do Atlântico. The new plant is installed as part of the existing RH, the twin solution increases the overall melt shop production in the area of quality plates especially for deep drawing grades. With this new equipment, CSA is able to increase degassed grades production with a state of art asset that has the ultimate technology in operation, safety and automation. The description of the main components parts and the operational concept gives an overview of the latest experience in RH plant engineering combined with best operational practice of world class steel producer.
Keywords: RH (Recirculation Degasser); Equipment parts, Automation; Plant Operation;.

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1 INTRODUCTION

The new RH installation is part of the 330t melt shop line of the integrated steel plant including 2 desulfurization, 2 converters, 1 AHF (aluminum heating furnace), 2 RH and 2X2 strand casters located in Rio de Janeiro, Brazil.
The new RH is completing the first project phase consisting in a single RH position. A full integrated twin solution is the final configuration of the plant. The new plant is connected to the existing parts in few core parts: the alloy bunker system, the suction line and the vacuum pump. The basic configuration requires to have fully independent plants. Production of high quality grades will increase from an average 20 to 33 heats per day (about 11,000 t of liquid steel/ day) with an annual capacity close to four million ton.
The new plant configuration gives the possibility to increase the high quality grade production, especially deep drawing grades. CSA established high quality standard for their final products. See Figure 1 3D Model of the RH plant

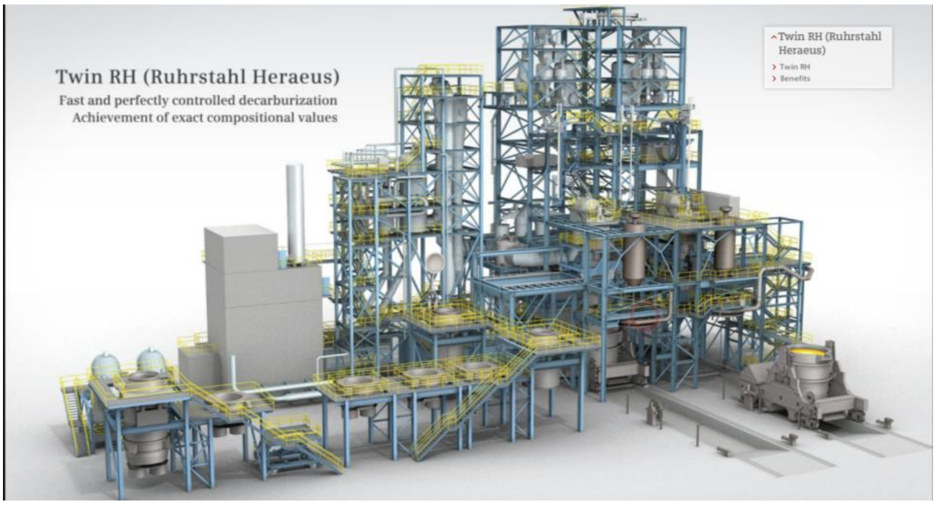

Figure 1 3D Model of the RH plant

2 EQUIPMENT MAIN PARTS

The main parts of the new RH consist of a hydraulic ladle lifting system of a capacity of five hundred ton, a fast vessel exchange design, combined oxygen lance, eight different vacuum alloy feeders, with a dedicated steam ejector vacuum pump with a capacity of 1000 kg/h at 0.67mbar.
All the equipment parts require a dedicated integration with the running plant. The erection of the plant did not require any major shut down of the existing station.

2.1 HYDRAULIC LIFTING SYSTEM

The hydraulic station for the two RHs is combined and the force distribution to the two lifting tables is of a new design, see Figure 2 Hydraulic block distributors and ladle lifting table
The massive lifting table is capable of lifting the ladle car including the full ladle, the ladle height position is easily adjusted acting on a joystick situated in the control room. In case of any failure the system includes a back-up function able to lower the

ladle without the need of external power, accumulators or any dedicated system. In case of ladle break-out the steel flow is directed to an emergency pit located outside the lifting table area. This system gives the advantage of an open view around the ladle and vessel system with easy access to all plant parts.

Figure 2 Hydraulic block distributors and ladle lifting table

2.2 FAST VESSEL EXCHANGE

The plant layout allows a fast vessel exchange solution, complete exchange is performed in sixty minutes. Plant maintenance, access to different plant parts, plant observation during treatment are also an advantage of this solution. Alloy connection to the vessel, all media supplies to the vessel, hot off take connection are of easy access. See Figure 3 RH vessel including vessel transfer car.

Figure 3 RH vessel including vessel transfer car

All plant maintenance operations are controlled via local control boxes located outside the control room where a proper view over the moving part of the plant is guaranteed. The plant operations team have given great input to position the control units for a proper and effective concept. The control room operations are linked only to the production functions and in this case no field operations are required, this point is described later in detail in this paper.

The hot off take is a "U-design" type, easy to remove using a crane and with a well-established practice from the maintenance team. It is anyway lifted by three hydraulic cylinders and remains suspended over the vessel during the vessel travelling.
Quite a unique solution is the complete dry connection between hot off take, upper and lower part of the vessel (split vessel type). Minimum cooling water requirements, about 100 m³/h, is required for the complete plant.
Vessel refractory inspection can be easily performed during production and can be done by moving the vessel out of the treatment position.

2.3 COB COMBINED OXYGEN BLOWING LANCE

A combined oxygen and burner lance is installed capable of blowing 3,500 Nm³/h of oxygen during the treatment, for decarburization and heating purposes, and with 4.0 MW burner function for the vessel heat-up during the stand-by period. The lance design is adapted according to the maintenance experiences of the first installation, in order to avoid malfunctions. Below see Figure 4 COB Lance including top view and ignition burner flame.

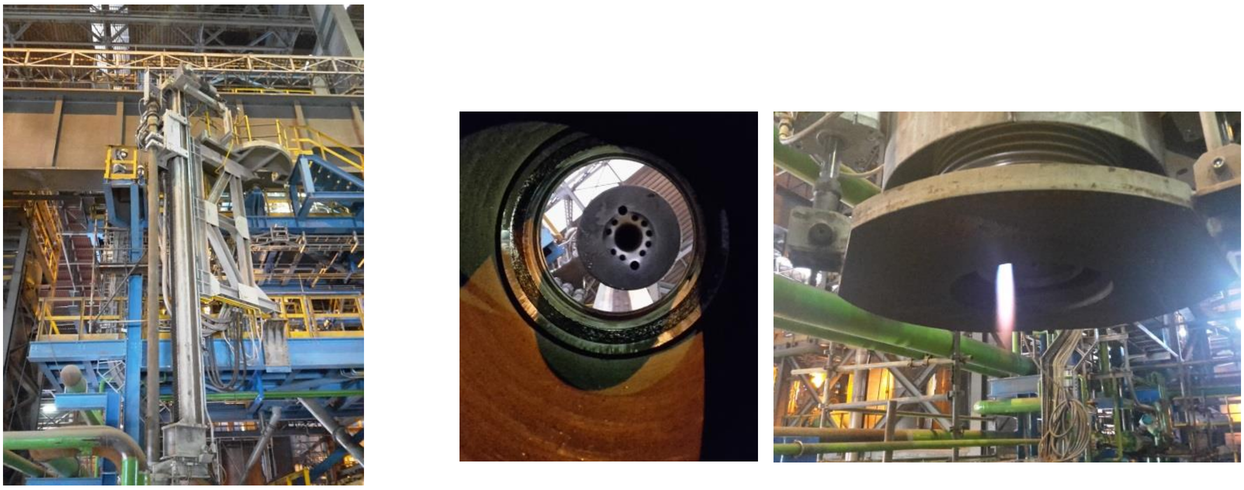

Figure 4 COB Lance including top view and ignition burner flame.

The lance is a fundamental part for the RH plant and requires reliable design in all its components like lifting and lowering mechanic, water cooling, vacuum sealing, and maintenance access in case of malfunctions. Full automatic functions are programmed in order to allow an easy start of the burner and/or a set points adjustment during the treatment.
Safety guidelines according to the latest standard norms for this kind of machine part are strictly applied and verified.

2.4 ALLOYING UNDER VACUUM

The alloy system is quite complex: four different direct feeders dose fine material directly into the vessel during the treatment that mostly contain aluminium for heating and de-oxidation purposes, cooling scrap and micro alloying materials. Two hoppers charged with different kind of alloy materials, in accordance to the steel quality requirement, can be also used under vacuum.

This configuration gives a great flexibility to the plant quality production. The RHs are able to handle easy steel grades with slight chemical analysis adjustment, giving the melt shop high flexibility in term of productivity, and at the same time can refine deep drawing grades, pipe steel and HSLA, AHSS quality etc.
A special production practice is established in order to reduce operational costs for lower value grades production in comparison to high quality grades.
The complexity of the alloy system required high efforts for the layout design and maintenance access concept. The plant extension reaches forty meter height. Weighing under vacuum, material dosing under vacuum using vibro-feeders and tube feeders, proper access to the sealed and closed parts have required detail design evaluation. The high risk of vacuum leakages has been minimized by using proper sealing and isolation valves. Instrumentations supervising the vacuum pressure and temperature in the area are installed in order to be able to isolate any malfunctions and find a prompt solution and thus avoid production disturbances.
The alloy area affects vacuum performances mostly due to the air leakages through the different system parts. A proper leakage method has to be established in order to isolate the leakage source and be able to fix it without major production disturbances.

2.5 VACUUM PUMP

Due to layout restrictions a double valve connection to the two RH vessels (with two thousand millimeter diameter pipes) is installed. The typical connection of the vacuum pump and process vessels should be movable elbow used. With the installed solution it is possible to handle two simultaneous treatments. A major checkup of the vacuum pump performances was done before start up in order to reduce the steam consumption drastically. Tuning and re-defining of the working points of the vacuum pumps led to major operational cost saving, equal to a running costs reduction of half million $/year. Performance results are shown in Figure 5 Vacuum pump performances during ULC production.
This kind of intervention was performed already on different plants proving remarkably advantageous in terms of consumption, while at the same time not affecting the pump performances.

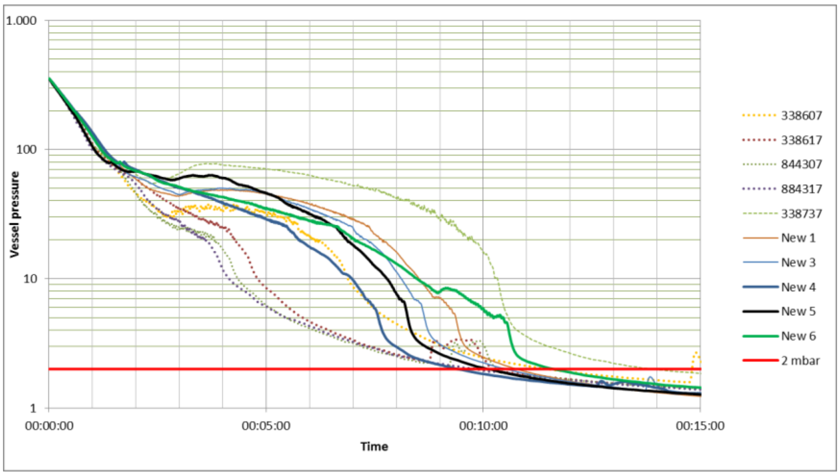

Figure 5 Vacuum pump performances during ULC production.

Constant air leakages supervision is fundamental for high production rate and especially if deep decarburization grades have to be produced. Wearing of the ejectors body are regularly inspected, cleaning of the pump is done on a regular base, suction capacity curves are as well monitored, proper test procedures are constantly improved. Pump designer and operational team are in tight contact to be able to react to any unusual behavior. Training of the maintenance and operation team remains important for reducing plant stops, fact finding strategy is fundamental for a plant part that is unique in its type in a steel plant.

3 ADVANCED PLANT SUPERVISION

Great importance was given to the plant operation concept and design efforts were invested accordingly. The overall solution was verified and shaped in accordance to the plant operators experience. A new combined control room is installed where the full plant operations are supervised. A CCTV system controls the major plant area, the system is connected to the plc where plant operations are controlled with automatic switching between the different cameras, including different zoom view, in accordance to the process active phase.
The operators are so guided through the different treatment steps. A larger area of the jumbo screen is dedicated to highlight the active phase, this large view changes with the different available view.
The control room has no direct view over the plant operations considering that after a certain time the windows view are reduced almost to zero because of glass damages or excess dirty glowing on the glass, mostly small sparks and steel splashes.

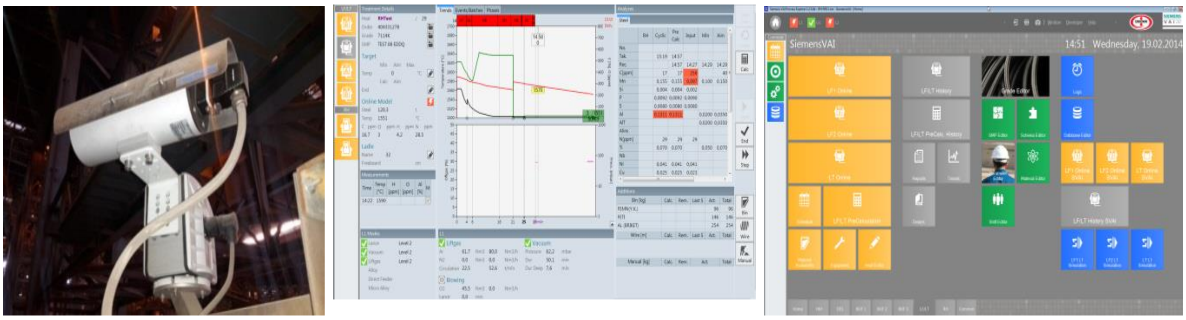

Figure 6 Camera system – Level 2 main process overview

Besides the camera control an automatic vessel immersion is also under test, the freeboard is measured automatically using a radar control and the operations are followed via camera. The operators have control over the vessel position directly in the control room using a dedicated joystick.
The process and the operations are controlled by the level 2, the operation starts in accordance to the metallurgical models calculation. The main phases of the RH treatment, degassing, decarburization, alloying and heating, are controlled and guided by the level 2. It is not the practice to run the treatment under a lower automation level. See the Figure 6 Camera system – Level 2 main process overview
Level 2 is the main screen for the operators: at both sides two HMIs supervise the machine interlocks and alarms status, on the wall in front of the operation desk four forty-two inches combined screens are the “big eye” over the plant in operation.
In order to run both plants in a single operation desk a duplication of the same layout is available next to the other. See following Figure 7 Plant operation overview

Figure 7 Plant operation overview

The level 2 models are supporting all process phases indicating the correct recipe for oxygen and aluminium additions when it is time to achieve the decarburization and the thermal balance of the treatment. The alloying model corrects the steel analysis in all different process phases. The process phases are so constructed that the operators have a consequent logic overview over the different priorities. A high accurate thermal model gives an exact temperature prediction. Offgas analyses data and process flow control give an indication of the decarburization efficiency. When the process models results are displayed then the operator has to acknowledge them in order to transfer the set parameters to the plc and to start oxygen blowing sequences, material discharging, vacuum regulation etc.

It is remarkable how the person in charge of plant operations can control, maintain and support the plant operators using a high level of automation essential for quality production, especially when it comes to analyzing the heats historical database.

These plant operations indicate the way to Industry 4.0 supporting the steel producers requirements: quality, flexibility and productivity by digitalization in the area of communication, computational power, internet and Cloud technologies. Smart sensors provide additional information about the process of the entire plant. Smart sensors either directly measure physical values or use existing measures to indirectly calculate additional information. Process models, digital “twins” of the plant, enable process optimization in real-time as well as offline simulation. This means perfect process guidance and full support for further process development.

Comprehensive information about the condition of the equipment and the respective processes enables predictive maintenance, which will help to avoid unplanned outages. This means improved plant availability and therefore increased plant productivity.

An important evolution is driven by the advanced communication technologies allow for information to be transported beyond conventional limitations. From the collection of sensor data in harsh environments or from mobile equipment to displaying the information on mobile devices. From the shop floor to the „manager‘s pocket“.

Below see Figure 8 Smart Work concept

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4 OPERATION CONCEPT

The production program requires high flexibility. Short casting sequences are nowadays a typical answer to the market demands, as big a stock cannot be built up. The RH has to be able to run deep vacuum and deep decarburization heat in short time, <13ppm carbon content is a typical requirement. The RH treatment becomes quite demanding in this case, temperature adjustment and oxygen support for deep decarburization is alternative required during the treatment. Operations have to run smoothly and without interruptions. Fast process phases require a high blowing rate with COB lance (almost 1 m^3/s is blown). In order to speed up the reactions no vacuum regulation is applied during this phase: the best carbon/oxygen equilibrium is found if the lowest vacuum pressure is maintained, in this case the vacuum pump is able to keep the vacuum pressure below 10 mbar. Also in this case the operational experience found a best combination between high oxygen flow rate, lance distance and efficient oxygen penetration. Not only the best process performances were found but also the vessel, and hot offtake skull formation due to steel splashes is minimized. The hot off take requires regular cleaning off line, but it is re-used for thousands heats before refractory replacement.
Materials are charged from the different vacuum bunkers for de-oxidation, for chemical heating, for cooling and alloying with short pauses in between the different batches discharge. Fine weighing, fast chemical analysis response, including sample taking, sending and analyzing, are required to satisfy the short casting sequence time that is in many cases lower than thirty five minutes. Sample taking and temperature taking are performed automatically via lance manipulators.
Besides the production of ultra-low carbon grades the RH plant is handles various series of high strength low alloy grades and pipe grades. In this case the operational practice is so well established that deep vacuum is minimized to a short degassing period. For alloying, buffering and all treatment phases where deep vacuum is not required, a higher pressure is maintained ensuring proper recirculation in the vessel, yet minimizing the costly refractory consumption and snorkel maintenance. In this area, especially for the snorkel maintenance, the skilled operation practice ensures a life of more than 120 heats. The two RHs include an automatic robot for internal and external snorkel refractory gunning; the operation runs automatically with the use of a remote controller and pre-selected gunning sequences. This operation is performed

any time if it is available after a treatment. See below Figure 9 Snorkel gunning machine in operation

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5 CONCLUSION

Expanding an existing facility requires a different design concept in order to respect the original design. Besides that the operational experience collected during the running of the first installation gives key suggestions and hints for possible improvements for a new installation. Designer and end user cooperation and team work ensure great success to the project. In secondary metallurgy the RH, the vacuum plant type, plays a major role in integrated plants still after many years of utilization. Research in terms of new solutions and the improvement of plant operations have still major potential for expansion that nowadays is guided by the plant digitalization.