



DESIGN AND COMMISSIONING OF THE NEW STEEL PLANT OF THYSSENKRUPP¹

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Abstract

ThyssenKrupp CSA recently built a new 5 million t green field steel plant in Brazil. The presentation explains the equipment configuration, layout, and logistic concept of the steel plant, consisting of 2 converters and 2 continuous casting machines, based on the aimed product portfolio. In addition, the main challenges during cold and hot commissioning of this plant and the methodology during commissioning to ensure a safe and proper start up of the plant are being explained.

Key words: Green field steel plant; Commissioning; Layout; Equipment configuration.

PROJETO E COMISSIONAMENTO DA NOVA ACIARIA DA THYSSENKRUPP

Resumo

A ThyssenKrupp CSA construiu recentemente uma nova aciaria *green field* no Brasil. Esta apresentação explica a configuração dos equipamentos, *layout* e conceito logístico desta aciaria, que consiste em 2 convertedores e 2 máquinas de lingotamento contínuo, focados em um portfólio de produtos específico. Em adição, os principais desafios durante os comissionamentos a quente e a frio desta planta e a metodologia durante o comissionamento, para garantir a segurança operacional e *start up* adequado da planta serão explicados.

Palavras-chave: Aciaria *green field*; Comissionamento; Layout; Configuração de equipamentos.

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1 INTRODUCTION

In 2007 ThyssenKrupp started the piling activities of its new steel plant with 5.0 million t/year capacity at Sepetiba bay in Brazil. 40 months later, on September, 9th 2010 first steel was produced at ThyssenKrupp CSA. During this period, 182 km of piles have been driven, 85,000 m³ of concrete were poured, and 42,000 t of steel structure and 24,000 t of mechanical equipment were erected, as well as 3,000 t of pipes welded and 1,600 km of cables pulled (values related to steel plant only).

At the beginning of this project the equipment configuration was defined following the aimed product mix for low carbon and IF steel grades. Afterwards the general layout of this plant was defined considering the long experience of ThyssenKrupp's other steel plants and optimization aspects.

Unlike other big investments in the worldwide steel industry in the last years this plant is a complete green field plant not only allowing a high degree of freedom because of missing limiting factors such as existing infrastructure or buildings, but also for adding a various number of additional challenges to be overcome. Main challenges have been to start up the complete steel plant at once without being able to hot commission single units separately in advance and to have an operation team with different backgrounds not having worked altogether before.



Figure 1. Steel plant ThyssenKrupp CSA.

1.1 Product Mix CSA

Following ThyssenKrupp's decision to extend its production capacity and to serve the North American market, a target product mix was defined taking into consideration possible market expectations and capabilities of the existing plants). Figure 2 shows the produced product mix from startup until Nov. 2011.

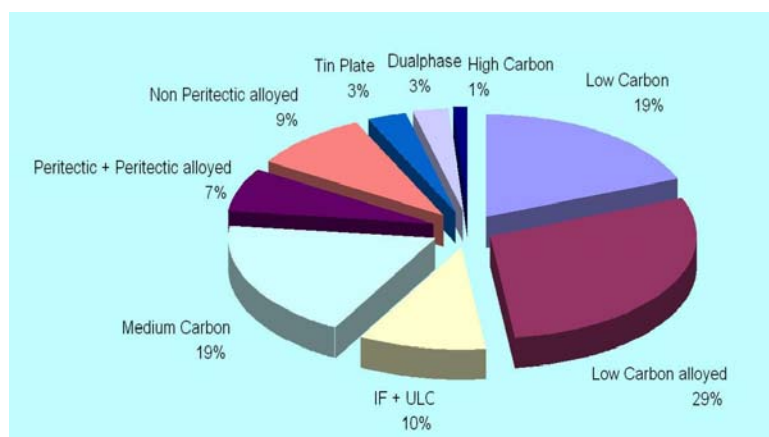


Figure 2. Product mix.



2 LAYOUT AND EQUIPMENT CONFIGURATION

2.1 Location of ThyssenKrupp CSA

The company ThyssenKrupp Companhia Siderúrgica do Atlântico (CSA) was created to execute the green field construction of an integrated steel plant for production capacity of 5.0 million t/year of carbon steel slabs per year. The site was selected because of its close proximity to rail tracks for iron ore delivery and proximity to preexisting shipping routes for the delivery of final product slabs to existing ThyssenKrupp plants in Germany and new Mobile Alabama plant. Some other locations in Brazil also fulfilling these conditions were finally disregarded because of their lower attractiveness for new employees. At project start the area was a green field in the truest sense of the word

2.2 General Layout

The complete project is a steel plant complex consisting of the following major units:

- raw material handling and storage;
- sinter plant;
- blast furnaces;
- steel melt shop (steel plant, focus of this paper);
- coke oven plant;
- power plant;
- port;
- air separation unit, and;
- supporting infrastructure.

Iron ore is supplied by rail from Brazil in the form of lump ore and pellets. Metallurgical coal is purchased and processed in the coke plant. The iron making facility consists of two identical blast furnaces designed for a burden of lump ore, pellets, sinter, coke and pulverized coal injection. Unique to this plant is that the only railroad is for the supply of Brazilian iron ore and pellets. All internal transportation is by mobile carriers including final slab delivery to the port. The plant is designed with the latest state of the art technology and environmental protection concepts meeting and exceeding Brazilian environmental standards.



Figure 3. CSA site before construction start.



2.3 Process Flow Steel Plant

Before defining the layout of the steel plant, the key input and output factors had to be qualified and quantified (Figure 4).

In order to achieve 5 million t of slab production around 5.3 million t of hot iron need to be processed resulting in 5.0 million t of hot metal after desulphurization and 5.2 million t of steel after primary metallurgy.

Unlike other steel plants these figures are based on a zero external scrap rate. Reason was the assumption that usable scrap is not available in sufficient amount and at reasonable prices in Brazil. Meanwhile this assumption has proven to be wrong, adding some flexibility for the coordination of CSA's blast furnaces and steel plant. With some further improvement 5.75 million t seem to be possible in the future.

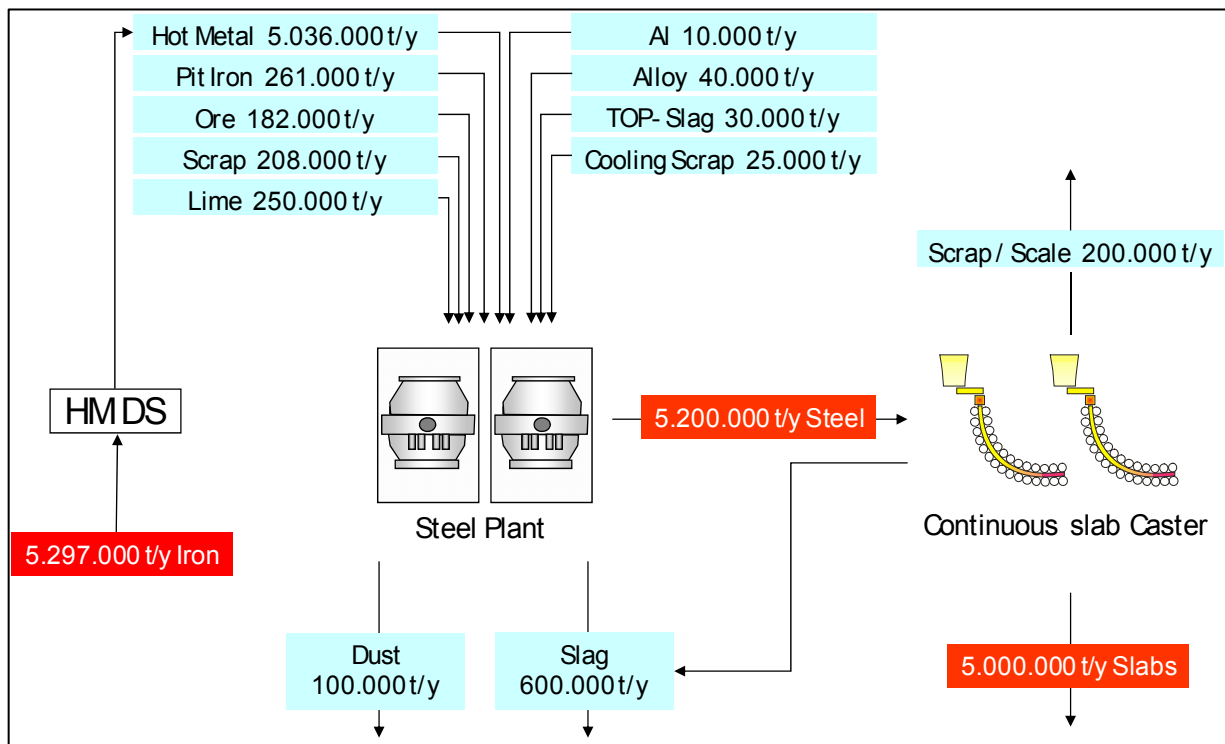


Figure 4. Process flow steel plant.

2.4 General Layout Steel Plant

The steel plant consists of hot metal desulphurization, converters, secondary metallurgy and continuous casters. As shown in Figure 6 the position of these units follows the material flow and trying to optimize the usage and number of required overhead cranes.

As a result in total 8 overhead cranes are required for the ladle handling. Three of them with the capability to lift full ladles (550 t), the others only empty ladles (180 t). The heavy load cranes have the highest load of overhead cranes ever build and used in Brazil.

One important specialty at CSA is the short distance between blast furnaces and steel plant works. Thus allowing saving torpedo cars and one handling operation and directly tapping hot iron at the blast furnaces into the hot metal charging ladles.



For this operation special transportation cars have been designed able to take the load of a full ladle of around 500 t (Figure 5). In Figure 5 you can see the ladle, the pallet and the Mover.

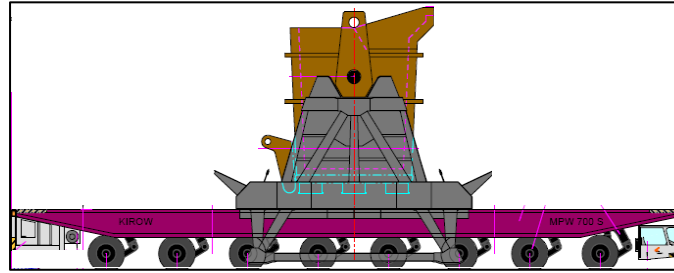


Figure 5. Hot metal transport car, pallet and ladle.

The platform of these ladle transport cars can be lifted up and down allowing more flexibility in the logistics of ladles and pallets.

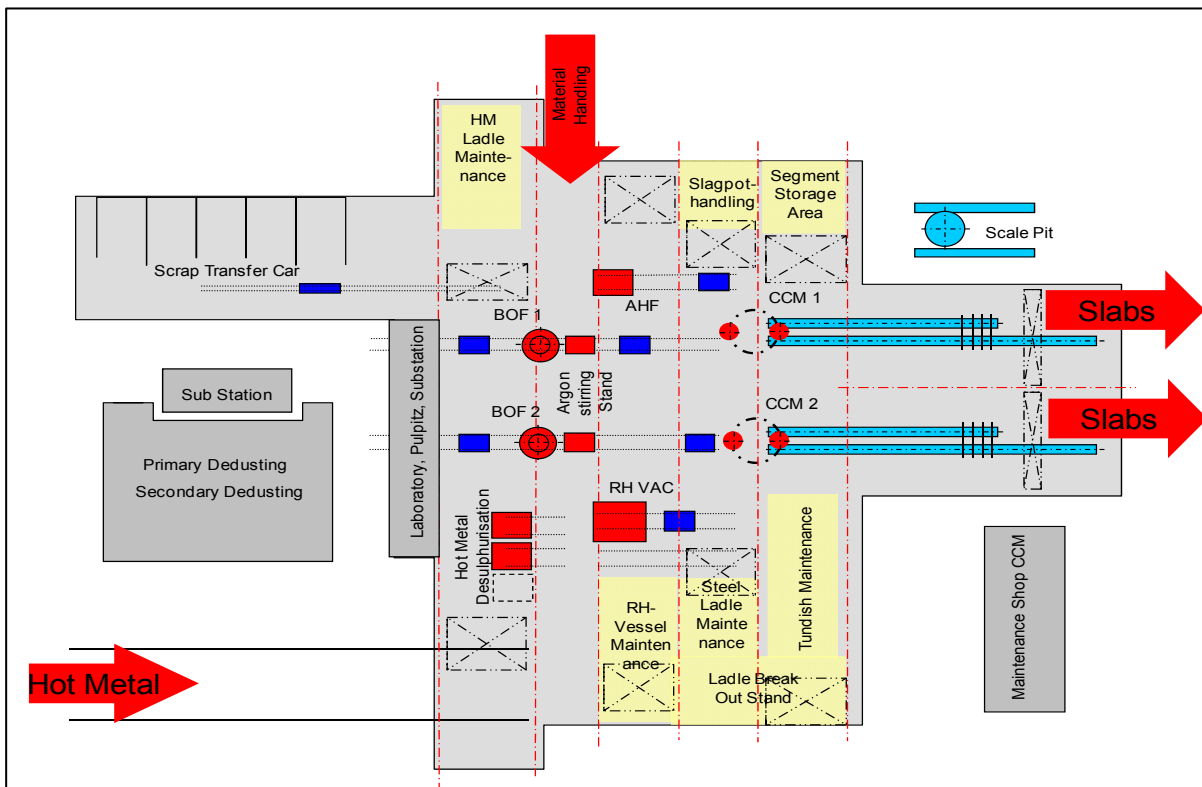


Figure 6. General layout steel plant.

2.5 Hot Metal Desulphurization

The steel plant has two hot metal desulphurization stands in order to desulphurize 100% of received hot metal. The desulphurization agents are lime, calcium carbide and magnesium. The final sulphur content can be as low as 10 ppm with treatment times of 15 minutes to 30 minutes.

The treatment takes place in the hot iron ladles and is based on the dip-lance method. With this method the desulphurization reagent is brought into the melt via a lance with the help of a pneumatic conveying system. This ensures an optimum distribution of the desulphurization reagent in the melt and thus a high accuracy of the required degree of desulphurization as well as economic viability.



The retention time of the reagent in the melt considerably influences the success of the treatment, i.e. the deeper the reagent is blown through the dip lance into the bath, the longer is the retention time of the reagent in the melt and the better the result of the treatment.

Besides the longer retention time of the reagent in the melt it also ensures a better thorough mixing of the melt due to rising bubbles.⁽¹⁾

2.6 Converter

The two converters are handling heat sizes up to 340 tons with a tap to tap time of 39 minutes to 44 minutes. The converter vessels have argon stirring and removable bottoms. The steel shop is supplied with flux handling and ferroalloy handling system. The steel shop incorporates primacy off gas cooling system and evaporation cooling for steam production and a primary dedusting system with BOF gas recovery.

All supporting equipment, e.g. oxygen and off gas system, is designed for possible parallel operation. Two water cooled lances (one operating and one standby) are provided for each converter.

The converter operation is optimized by means of a level II process automation system based upon sub lance equipment and offgas analysis for end point control. At the process equipment state of the art technologies like Lomas gas analyzing system or pneumatic slag stopper for slag free tapping but also new developments like the liquirob for sublance can be found. The liquirob is the first application of industrial robots for manipulation of sublance sensors and follows the success of robot technology at other areas of metallurgy (EAF, CCM, lab, etc.)

The converters are located at a centre line distance of approximately 40 meters where there is visual contact to the common central control room.

The transportation of liquid steel and slag is realized by transfer cars running on the same rail underneath the converter. The slag pots are transported by a slag pot carriers to the slag pit.

Gas of the converters is collected in the primary dedusting system consisting of a one line boiler, cooling spray system and electrostatic precipitator (Figure 7). From there it is sent to a gas holder for further use of its chemical energy-content.

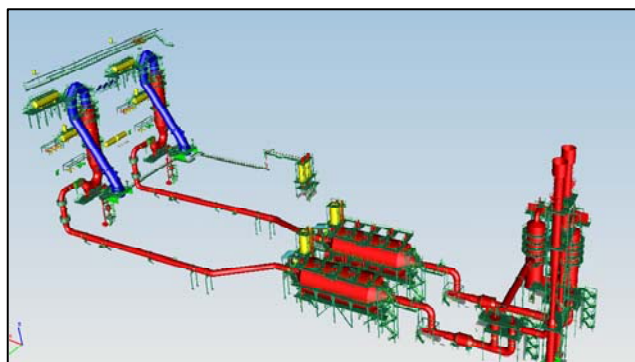


Figure 7. Overview Primary Dedusting.⁽²⁾

After charging the hot metal into the converter the ladles are being sent back to the blast furnace for another cycle. The ladle maintenance takes place in the hot metal ladle maintenance area (Figure 8).

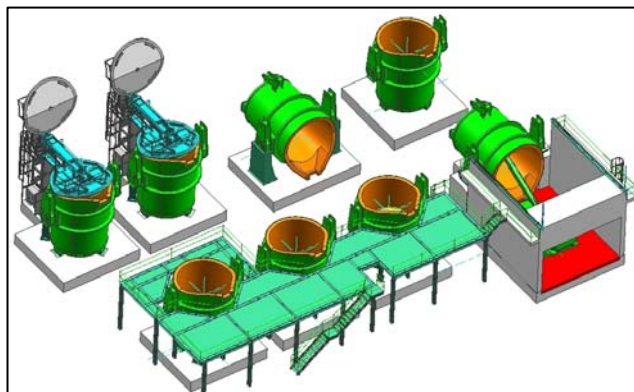


Figure 8. Hot metal maintenance area.⁽²⁾

2.7 Secondary Metallurgy

Secondary metallurgy consists of ladle treatment stands, RH vacuum degasser and an AHF (Aluminium Heating Furnace) plant. Future expansion plans allow for a second RH vacuum degasser.

Each ladle treatment stand is in line with one BOF and consists of two argon lances, material addition system and facilities for measurement and sampling.

RH vacuum degassing is designed to achieve a final carbon and hydrogen content of ≤ 15 ppm and $\leq 2,5$ ppm respectively. Treatment time is 15 minutes to 30 minutes depending on final steel specification.

After placing the ladle into the steel transfer car, it is being moved underneath the RH vessel. The steam injector pump is started up against the closed vacuum valve, and the lifting gas tuyeres on the upper snorkel of the RH vessel are switched from nitrogen to argon. The ladle is lifted with a hydraulic device until the snorkels are submerged into the steel bath. The vacuum valve is opened, with the result that the pressure in the RH vessel falls and the liquid steel raises into the vessel. Once the necessary pressure level has been attained, the appropriate metallurgical steps are carried out, including the addition of the necessary alloying agents.

The multifunctional lance can be used for decarburize or alternatively aluminum heating during the treatment.⁽²⁾

The RH is also equipped with 4 direct feeders for instant addition of aluminum, scrap and micro alloy during vacuum and 2 vacuum hoppers for further alloy addition during treatment.

The AHF plant is an immersive bell type with a maximum heating rate of 8°C per minute, two wire feeders with 4 wires per feeder and argon purging lance without bottom stirring.

The steel treatment takes place in the ladle according to the temperature and the actual steel composition. The heating unit mainly consists of a refractory lined heating bell which can be lowered into the molten steel by means of the lifting device. On top of this heating cover, a consumable refractory coated lance for oxygen blowing is installed. The alloy system, consisting of 18 daily storage bins, is shared between the RH vacuum degassing and AHF plant.

2.8 Continuous Casting

The two continuous casting machines are identical, each with 2 strands, with vertical bending technology and air mist cooling (Figure 9). The metallurgical length is



29.8 m. Slab thickness is 255 mm, width range is 800 mm to 2,000 mm and length range for the slabs is 6,000 mm to 12,000 mm.

Current design foresees the possibility for the installation of 2 more segments per strand, allowing to increase the casting speed from actual 1.20 m/min to 1.4 m/min and therefore capacity increase to around 5.8 million t/year.

Both continuous casters have a joint central control room, which also serves to control the torch-cutting machines, marking, deburring and stamping devices.

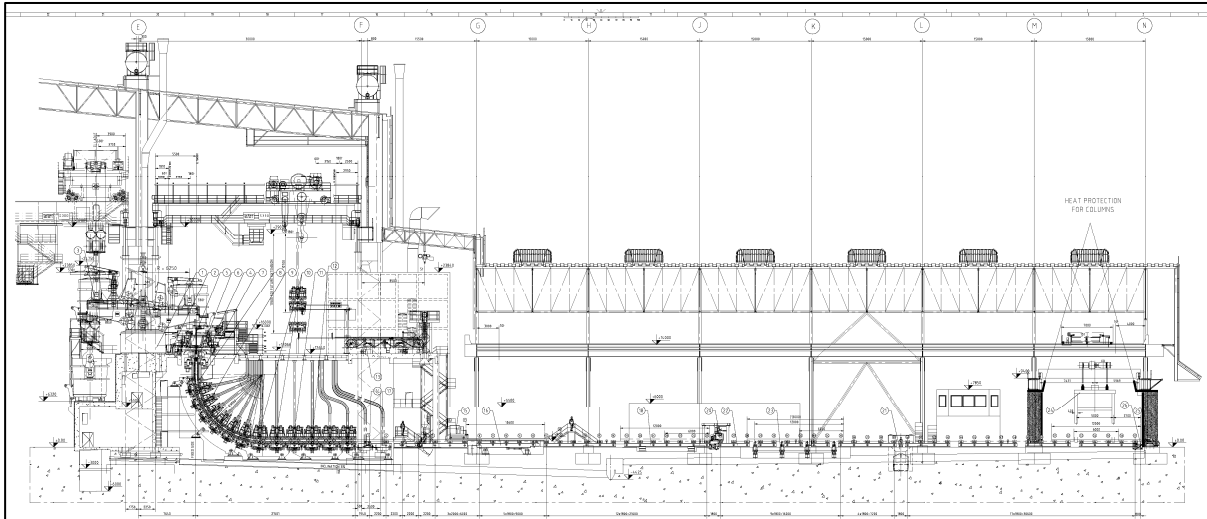


Figure 9. Side view continuous caster.⁽²⁾

2.9 Hot Commissioning

Although all plant units were cold tested in the last three months before the first hot slab date, nobody could predict the behavior of all single elements under hot conditions.

A perfect preparation with on- and offsite training, transfer of existing work instructions from the German plants and assistance by some of the most experienced Brazilian, Austrian and German specialists were some of the reasons for the smooth start up.

The different metallurgical facilities of the steel plant form a single consistent unit. A production of 3.3 mil tons of slabs, until November 2011, has proven the successful design and start up of the whole plant.



Figure 10. First slab at ThyssenKrupp CSA.



3 CONCLUSION

To define the equipment configuration and layout of a green field steel plant it is essential not only to define the target quantity but also the envisioned target product portfolio. A smooth hot commissioning can be achieved even in a Greenfield plant with quite inexperienced personnel when operational teams are trained sufficiently proper planning works are executed thoroughly and when operational and contractor's team are working closely together.

The moment of first slab production (Figure 10) proved impressively, that 182 km of piles, 85,000 m³ of concrete, 42,000 t of steel structure, 24,000 t of mechanical equipment, 3,000 t of pipes, and 1,600 km of cables are not only pure numbers of relatively simple materials, but that these pieces can form something really big continuously creating value and allowing employees to work safely and proudly in a positive corporate culture and rewarding work environment.

Acknowledgments

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