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THE SUCCESSFUL APPLICATION OF THE LATEST SIEMENS VAI SINTER TECHNOLOGIES AT THE SINTER PLANT NO.1 IN DRAGON STEEL CORPORATION, TAIWAN[1]

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Abstract

The objective of this paper is to present the latest developments of Siemens VAI Sinter Technologies which were successfully applied at the Sinter Plant no. 1 at Dragon Steel Corporation in Taiwan. The Siemens VAI recently commissioned the sintering state-of-the-art plant at Dragon Steel which consists of innovative solutions and design packages to enhance sinter quality and productivity thus generating ideal blast furnace burden for optimized production.
Key words: Agglomeration; Sinter plant; Cost efficiency; Developments.

OS SUCESSOS APLICADOS DAS ÚLTIMAS TECNOLOGIAS DE SINTER DA SIEMENS VAI NA PLANTA N.1 DA DRAGON STEEL CORPORATION, TAIWAN

Resumo

O objetivo deste trabalho é apresentar os últimos desenvolvimentos da Siemens VAI na área de sinterização aplicados com sucesso na. Dragon Steel Corporation Sinterização No1, em Taiwan. As tecnologias “estado da arte” para sinterização da Siemens VAI recentemente comissionadas na Dragon Steel consistem em soluções inovadoras e pacotes de projetos que visam melhorar a qualidade do sinter e a produtividade, criando assim uma carga otimizada e ideal para os alto-fornos.
Palavra-chave: Aglomeração; Sinterização; Eficiência de custo; Desenvolvimento.

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1 INTRODUCTION

The Taiwanese steel producer Dragon Steel Corporation (DSC) awarded Siemens VAI, a member of the Siemens Group Industrial Solutions and Services, with the design and supply of a new sinter plant, a blast furnace and a slab caster. These metallurgical facilities will be part of a new iron and steel works that will be built in the harbor area of Taichung (Figure 1). Following the start-up of the works, which took place on December 2009, DSC will be able to enter the flat-steel market sector with a production capacity of 2.5 million tons of high-quality slabs per year.

DSC is a 100% subsidiary company of China Steel Corporation, the largest steel producer in Taiwan. Dragon Steel currently produces approximately 800,000 tons per year of carbon-steel grades which are cast as billets, blooms or beam blanks followed by rolling into heavy sections.

As a major supplier of metallurgical plants for more than 50 years, Siemens VAI was selected to contribute to the steel capacity expansion campaign in the flat-product steel sector. Siemens VAI headquarters in Linz, Austria was the responsible for the design and installation of the sinter plant no.1, and Siemens VAI, UK was engineer and supply the blast furnace and the 2-strand slab caster.

Figure 1: Job site for Dragon Steel integrated steel works.

This paper focuses on the sinter plant and describes the advanced technologies applied.

2 APPLIED TECHNOLOGY

2.1 Proportioning, Mixing and Granulation Technologies

For the proportioning of the raw mix, 22 sets of raw materials bins with a capacity of 380 m³ each were installed. The bins are designed to avoid “bridging” of the raw materials within the bins and to reduce the segregation of coarse and fine particles during charging and discharging. The segregation in the bins during charging and discharging occurs differently at different filling levels of the bins. The higher number of bins allows for simultaneous discharging of a single ore type from

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at least two bins with different filling levels, thus compensating the different segregation of the coarse and fine ore particles during charging and discharging.

The discharge of the raw materials with dosing weigh feeders from the different bins is controlled on the basis of the “real time dosing system”. With this control system, the desired mixture composition will conform with predetermined ratios throughout the entire operation.

The collecting belt conveyor feeds the raw materials to the Intensive Mixing and Granulation System (IMGS). In the Intensive Mixer, the materials are mixed and homogenized. In order to adjust the optimum moisture content of the sinter raw mix, water is added in order to meet the requirements for achieving high permeability on the sinter strand. For optimization of the sintering process, an even distribution of the ores, additives and fuels within the sinter raw mix is of ultimate importance. With a conventional mixing drum, a homogeneous sinter raw mix can only be achieved to a limited extent. With the smooth, even and precise discharge from the proportioning bins and a respective number of bins in combination with the Intensive Mixing and Granulation System, no blending yards are required.

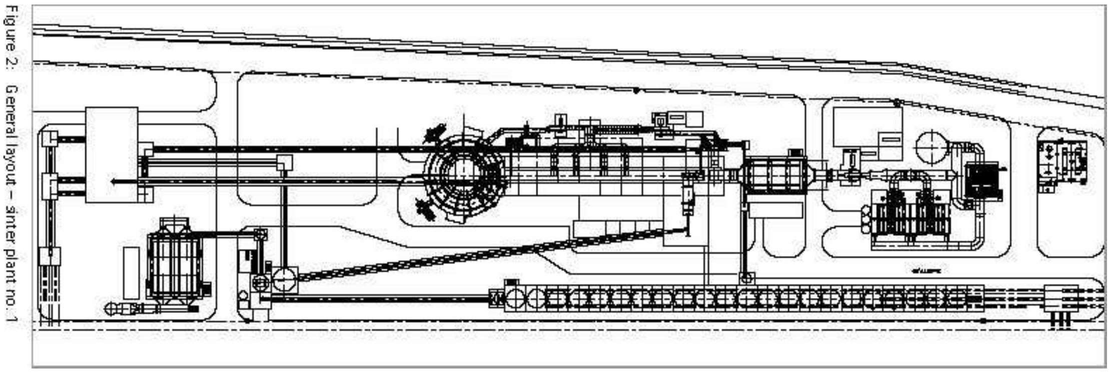

Figure 2: General Layout – sinter plant no1.

2.2 Mixing

For the primary mixing, an agitating-type Intensive Mixer will be applied. The retention time of the material in the mixer is approx. 1 minute. The inner volume of the mixer is approx. 5 m³.

When comparing the agitating-type Intensive mixer with the conventional mixing drum, the following can be stated:

1 The agitating-type intensive mixer introduces high energy with its mixing tools directly to the raw materials to be mixed, achieving an even distribution of all raw materials within the sinter raw mix and bringing iron ores and fluxes in tight contact.
2 The conventional mixing drum can only use gravity forces for distribution and mixing of the raw materials, which very much limits the mixing efficiency.
3 The homogeneity of the produced mixture is therefore substantially higher using the intensive mixer.

Figure 3: Agitating-type intensive mixer.

2.3 In-Plant Return Fines Addition

The sinter raw mix generated in the Intensive mixer is transported via a belt conveyor to the granulation drum. The in-plant return fines are charged to the sinter raw mix before the granulation drum, evenly distributed on the belt conveyor by dosing weigh feeders.

2.4 Granulation

The return fines addition takes place before the granulation drum that is installed directly above the raw material charging station. This so-called late return fines addition functions as additional nuclei for the formation of granules in the granulation drum. Here, the final moisture is also adjusted to improve the granulation effect, thus optimizing the permeability in the sinter strand. The granulated sinter raw mix is charged via an oscillating belt conveyor to the sinter machine feeding hopper. This arrangement results in the shortest transportation route from the granulation drum to the charging hopper, minimizing the disintegration of granules at transfer chutes.

2.5 Sinter Machine Design

2.5.1 Sinter Machine Charging

The sinter machine charging consists of a hearth layer charging system and a system for the granulated sinter raw mix charging – the twin-layer charging system.

2.5.1.1 Twin-Layer Charging System

Since the sinter machine shall be operated with a bed height >600 mm, the sinter raw mix charging system is of utmost importance for achieving the required uniform segregation with regard to the material grain size distribution and coke content distribution, as well as for achieving an optimum permeability in the sinter bed.

This is achieved with the twin-layer charging system with a pre-segregation in the charging hopper, whereby the coarser fraction is first charged as the bottom layer via a special charging chute system, followed by charging of the finer fraction as the top layer via a drum feeding system. The coke content in the sinter raw mix goes desirable with the finer fraction in the upper layer (Figure 4).

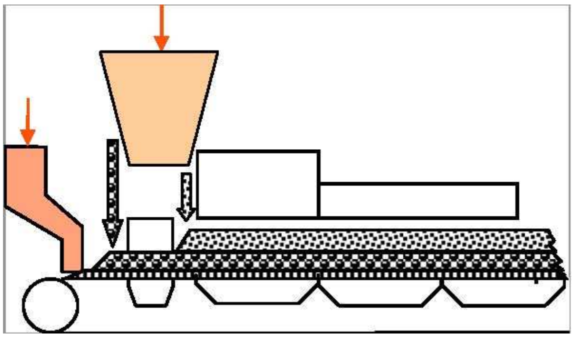

Figure 4: Principal design of twin-layer charging

The space between the charging points for the bottom layer and the top layer is used for preheating and drying the bottom layer with hot cooler off-air via a hood and a wind box. This is to avoid over-wetting of the sinter raw mix in the middle section of the sinter strand.

With the application of the Twin-Layer Charging System, mainly the following advantages will be achieved:

- High productivity
- Uniform and stable sinter quality
- Low consumption of coke and electric energy.

The advantages achieved with the IMGS will be maintained with the Twin-Layer Charging System. To protect the surrounding areas against dust, the charging system for the hearth layer is covered and connected to the plant de-dusting system.

2.5.2 Sinter Machine

The sinter machine is equipped with Siemens VAI grate wings pallet cars, where a gas-tight rim zone cover is installed between the side walls and the grate bars. This rim zone cover reduces the false air sucked trough the gap between side wall and sinter cake, which is formed by shrinking of the sinter. The pallet car bodies are designed in one piece. The sinter machine width can be extended by 0.5 m in future, reusing the single piece pallet cars (Figure 5).

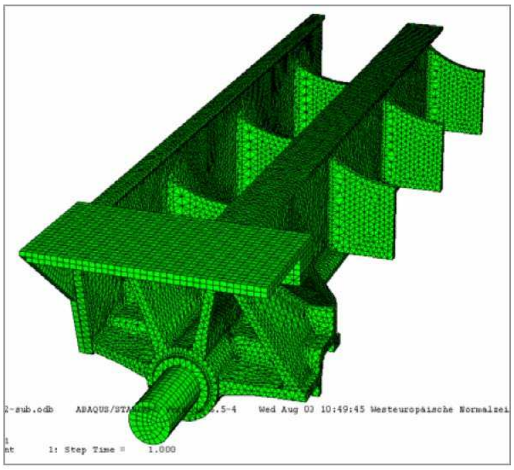

Figure 5: Finite element analysis of pallet car-body

Note: Sintering area: 248 m²; Ignition furnace: Roof burners (2 rows) – operating with CO gas; Gas main: One central gas main

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2.6 Cooler Design

The circular cooler with the specially designed cooler troughs (grate wings cooler troughs) ensures a very high utilization of the cooling air. In the first part the cooler is covered by a hood, where the hot off-air is used as combustion air for the ignition furnace and also for the selective waste gas recirculation system (Figure 6).

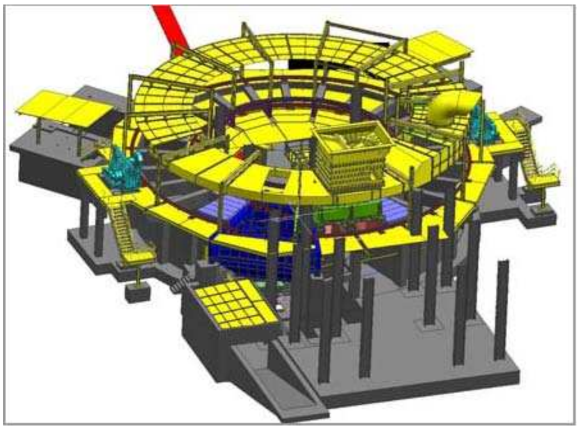

Figure 6: Cooler 3D model. The sinter plant is designed for operation without hot screening. The hot sinter will be charged directly onto the cooler via a segregation chute

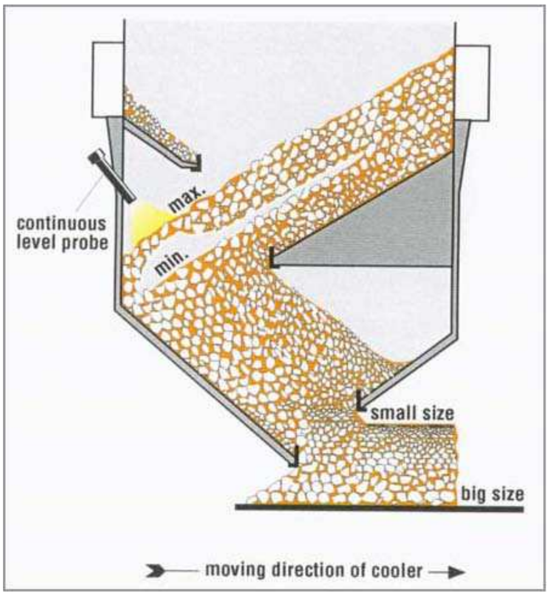

Figure 7: Principle of segregated sinter charging to the cooler

Note: Cooling area:	264 m2
Bed height:	1.5 m
Number of blowers:	2

From the cooler discharge bin, the cooled sinter is withdrawn by a speed-controlled vibrating feeder and transported via a belt conveyor to the crushing and sinter screening station.

2.7 Sinter Crushing and Screening Plant Design

The total amount of sinter is charged onto a scalping screen, where the grain size fraction 0–50 mm is screened out. The overflow 50-200 mm is charged to a roller crusher to achieve a size smaller than 50 mm.

The second screen classifies the fraction 0–10 mm, 10–20 mm and 20–50 mm. The fraction 0–10 mm goes to the return fines screen and the fraction 10–20 mm goes to the hearth layer chute. The overflow 20–50 mm goes directly to the product conveyor. The return fines screen separates the fraction 0–5 mm, which is recycled via the return fines bin to the sinter process. The overflow of this screen is transported to the sinter product conveyor.

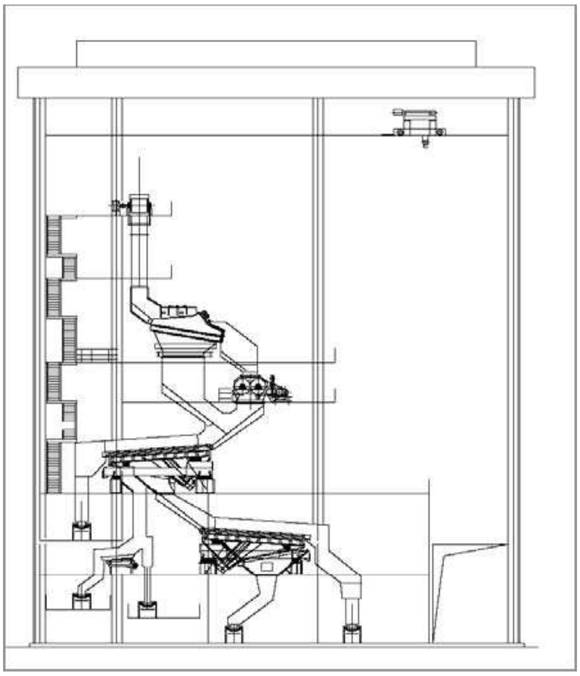

Figure 8: Cross-section of screening plant.

All the equipment for screening and crushing is located in one building (Figure 8) in order to achieve shortest possible conveyor links. For highest plant availability, the screening and crushing plant is equipped with a standby line which is located parallel to it.

2.8 Environmental Protection

Environmental protection regulations, particularly for the sinter plant, require modern and highly efficient waste-gas cleaning systems. The following maximum emission values have to be met at the sinter off-gas stack of DSC sinter plant no. 1:

Dust: < 20 mg/Nm^3 (15% O2)
Smoke: < Ringleman # 1 (or 20% opacity)
NOx: 70 ppm (15% O2)
SOx: < 50 ppm (15% O2)
Dioxin: < 0.5 ng-TEQ/Nm^3 (15% O2)

The investment and operational costs of a modern gas-cleaning system depend mainly on the waste-gas volume. Therefore, a key target is the minimization of the off gas volume of a sinter plant. A very efficient and economical solution for

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the substantial reduction of the waste gas volume is the application of Siemens VAI's "Selective Waste Gas Recirculation System." At DSC sinter plant no. 1, this system has been selected under consideration of the following conditions:

- Homogeneous sinter raw mix.
- Normal operation with bed height >600 mm.
- Sufficiently high oxygen content in the range of 17% for the gases re-circulated to the sinter machine to avoid any negative impact on the sinter plant productivity and sinter quality.
- The sinter machine pallets are designed according to Siemens VAI's technology, minimizing the false air sucked in along the rim zone areas.
- The "Selective Waste Gas Recirculation System" is designed on the basis of the following features:
- The waste gas of the 1st and 3rd sections of the sinter machine is mixed with cooler off-air and ambient air and is then re-circulated to the area above the 2nd section of the sinter machine.
- The sinter waste gas re-circulated to the surface of the sinter bed has sufficiently high oxygen content and a temperature which is well above the critical dew point.
- The recirculation hood installed above the 2nd section of the sinter machine is equipped with a special sealing system to avoid re-circulated waste gas containing carbon monoxide being able to escape into the environment.
- The temperature in the waste-gas recirculation hood is approx. 150 ℃.

2.8.1 Main Advantages of the "Selective Waste-Gas Recirculation System"

- Off-gas volume reduced by 40%
- Lower investment and operational costs for the waste-gas cleaning facilities
- Decreased coke consumption mainly due to the energy recuperation from the carbon monoxide and hydrocarbons contained in the re-circulated waste gas

2.8.2 Waste Gas Cleaning System

2.8.2.1 Bag Filter Dry Absorption Process

The waste gas that is pre-dedusted in an electrostatic precipitator will be purified in a flat-bag filter system, which reduces mainly dust, HCl, HF, SOx, heavy metals and hydro carbons through a dry absorption process to the required levels. The process is shown in Figure 9.

$2\ HCl + Ca(OH)_2 \rightarrow CaCl_2 + 2\ H_2O$

$2\ HF + Ca(OH)_2 \rightarrow CaF_2 + 2\ H_2O$

$SO2 + Ca(OH)_2. \rightarrow CaSO_3 + H_2O$

$SO3 + Ca(OH)_2 \rightarrow CaSO_4 + H_2O$

In addition to this, a part of CO_2 from combustion is converted according to

$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$

and sulphite is converted to sulphate by partial oxidation according to

$CaSO_3 + ½\ O_2 \rightarrow CaSO_4$

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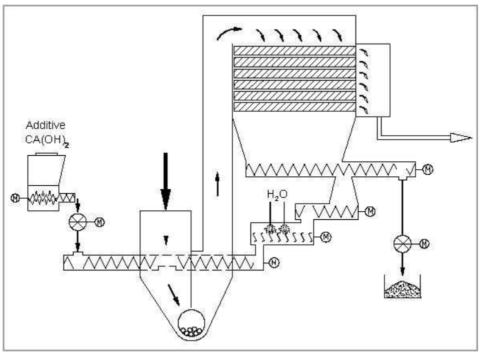

Figure 9: Dry absorption bag filter flowsheet

The process works on the following chemical and physical basis: Absorption of acid crude gas components HCl, HF and SO_2/SO_3 by means of injection of calcium hydroxide as an additive powder.

The reaction products, discharged from the system, partially contain chemically bonded water from hydration –the quantity depends on the crude gas conditions in the filter – as well as approximately 3% physically bonded water as material moisture.

The Bag Filter Dry Absorption Process includes the following process sections:

- **Additive Powder Dosage**

This deals with the continuous and controlled injection of the required additive powder $Ca(OH)_2$ and its distribution in the crude gas flow by means of an additive powder dosing device. The additive powder is injected into the crude gas flow near the conditioning rotor, located in the lower reaction chamber elbow.

The provision for the future installation of a lignite coke injection system to reduce the dioxin level in the clean gas to <0.1 ng/Nm³ is considered for the design of the bag filter system.

- **Particle Re-circulation**

The particles separated in the filter are multiply recirculated to the flue gas flow upstream of the conditioning rotor. Absorption of pollutants in the crude gas stream is enabled by a new additive powder (e.g., $Ca(OH)_2$, etc.) and conditioned recycled particles in the reaction chamber.

- **Particle and Gaseous Pollutant Components Separation from Crude Gas**

The particle separation takes place on the filtration elements of the bag filter system. The particle layer forming on the filtration elements contains sorption additives and is some millimeters thick. It retains the solid and gaseous pollutants.

- **Handling the Filtered Components**

The separated components are discharged at regular intervals from the different sections of the bag filter. A small portion of the polluted filtered components is discharged from the system for further treatment. The major portion is reconditioned and, together with fresh additives, is added to the crude gas.

2.8.2.2 De-NOx Plant

SCR (Selective Catalytic Reduction) is recognized worldwide as the most effective NOx (nitrogen oxides) removal process to meet low threshold values. The principle of SCR NOx removal systems is to reduce NOx in the waste gas to nitrogen and water, using ammonia (NH_3) as a reducing agent.

The Catalytic NOx and dioxin removal system converts NOx according to the

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same principle as the SCR process and simultaneously decomposes dioxin into carbon dioxide, water and hydrogen chloride in the catalyst beds of the SCR system. Please refer to Figure 10 for the NOx/DXN removal process reactions.

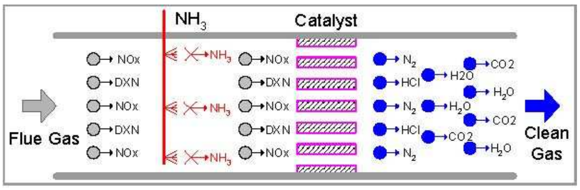

Figure 10: Principle of NO_x/DXN removal process

The fundamental reactions are:

- NOx reduction using ammonia
  $4\ NO + 4\ NH_3 + O_2 \rightarrow 4\ N_2 + 6\ H_2O$
  $NO + NO_2 + 2\ NH_3 \rightarrow 2\ N_2 + 3\ H_2O$
  $6\ NO_2 + 8\ NH_3 \rightarrow 7\ N_2 + 12\ H_2O$
- Dioxin-oxidation DXN → CO2 + H_2O + HCl

A corresponding quantity of ammonia is injected into the waste gas. More than 99% of the ammonia reacts when in contact with NOx on catalyst active surfaces.

A typical flow sheet applied for the waste-gas cleaning at DSC sinter plant no. 1 is illustrated below. SOx is to be removed by the flue gas desulphurization system (FGD – Bag Filter Dry Absorption Process), which is located right after the existing Electrostatic Precipitator (ESP). One dual functional reactor is installed downstream of the duct burners, where fuel gas is burned in order to increase the temperature of the waste gas to 280 ℃ for the operation of the catalytic NOx and dioxin removal. After passing through the reactor, the high-temperature waste-gas flows into a Gas/ Gas Heater (GGH) in order to transfer its heat to the waste-gas downstream of the FGD and booster fan. The booster fan compensates the pressure loss caused by the new flue gas cleaning system.

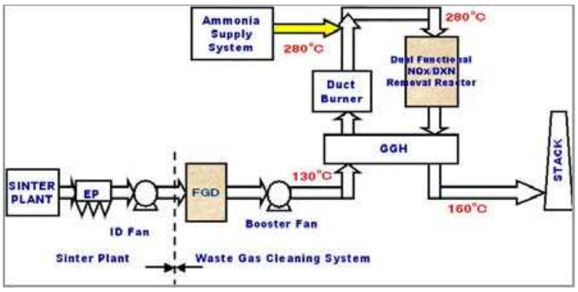

Figure 11: Flow sheet waste gas cleaning

3 CONCLUSION

With the Siemens VAI design, especially with respect to raw mix preparation, sinter machine charging, pallet cars, sinter cooler and waste gas treatment for the DSC sinter plant no. 1, a new milestone was achieved in operation figures and environmental conditions within the sinter technology. In particular, the selective waste-gas recirculation system allows operating the waste gas cleaning facilities (DeSOx, DeNox, DeDioxin) with a minimum off-gas volume, thereby resulting in low operation costs.