CHARGE INTELLIGENT SINTER INTO YOUR BLAST FURNACE

ACHIEVE REAL COST-EFFICIENCY WITH SIEMENS VAI SINTER TECHNOLOGIES[1]

Stefan Hötzinger[2]
Edmund Fehringer[2]
Johann Reidetschläger[2]
Hans Stiasny[2]
Christoph Aichinger[2]
André Fulgencio[2]

Abstract

The objective of this paper is to present the latest developments of Siemens VAI Sinter Technologies especially concerning the cost savings potential that can be achieved in existing sinter plants and eventually in the Blast Furnace. The Siemens VAI Sinter Technologies consists of innovative solutions and design packages which enhance sinter quality and productivity thus generating ideal blast furnace burden for optimized production. An advantage of using sinter is that the blast furnace burden can be optimized by adjusting the quality and the ratio of the charged sinter in accordance with the composition and characteristics, while pellets and lump ore are normally marketed with specific chemical compositions and qualities.

Key words: Agglomeration; Sinter plant; Blast furnace burden; Sinter efficiency.

CARREGAMENTO INTELIGENTE DE SINTER EM ALTO-FORNOS

ATINJA A EFICIÊNCIA-CUSTO REAL COM AS TECNOLOGIAS SIEMENS-VAI EM SINTERIZAÇÃO

Resumo

O objetivo deste artigo é apresentar os últimos desenvolvimentos da Siemens VAI Sinter Tecnologias especialmente no que diz respeito aos potenciais economias de custo que podem ser atingidas nas sinterizações existentes e finalmente nos alto-fornos. As tecnologias da Siemens VAI consistem de soluções inovadoras e unidades de projeto que aumentam a qualidade e produtividade do sinter gerando uma carga de alto-fornos ideal para produção otimizada. A vantagem de se usar sinter em alto-fornos é que a carga dos mesmos pode ser otimizada pelo ajuste da qualidade e razão da carga de sinter de acordo com a composição e características, enquanto as pelotas e minério graúdo são normalmente marcados com composições e qualidades químicas específicas.

Palavras-chave: Aglomeração; Planta de sinter; Carga de alto-forno; Eficiência do sinter.

[1] *Technical contribution to the 39th International Meeting on Ironmaking and 10th International Symposium on Iron Ore, November 22 – 26, 2009, Ouro Preto, MG, Brazil.*

[2] *Head of technology, senior expert, Senior expert, senior expert, senior expert, vice-president, marketing manager*, *SIEMENS VAI Metals Technologies GmbH & Co.*

INTRODUCTION

Nowadays blast furnace operation at high levels of productivity and high coal-injection rates is only possible using raw materials with consistent and uniform properties. As the main component used in the blast furnace burden, the production of high-quality sinter is decisive for assuring high and stable blast-furnace productivity with a simultaneously low consumption of reductants.

The sinter plant no longer can be seen as a separate or stand alone production unit, but must be fully integrated with the blast furnace to generate the ideal burden for optimized production and cost efficiency.

The performance of a sinter plant, its productivity and energy consumption not only depends on the quality of the raw materials, but also on the design features of the installed equipment and systems, their condition and the integrated process-control systems.

What is a High Quality Sinter?

Ideal blast-furnace performance with respect to high productivity, low consumption of reducing agents and constant hot-metal quality can only be achieved employing a high-quality sinter with the following characteristics:

- Optimum grain-size distribution:
  - Grain size between approximately 5–50 mm
  - Harmonic diameter of >>10 mm
- High sinter strength:
  - Shatter Index (SI) = >92%
- High reducibility:
  - Reduction Index (RI): > 65%
  - Reduction Disintegration Index (RDI <3.15 mm): < 20%
- High porosity
- Softening temperature above approximately 1250 ℃, depending on total burden mixture
- Narrow cohesive-zone temperature
- Constant FeO content in the range of 7%
- Constant basicity B2 and B4 adapted to best suit the overall blast furnace burden

A decisive precondition for the production of high-quality sinter is a homogeneous sinter raw mix of high permeability. All additives should be uniformly distributed throughout the mixture. A high and uniform permeability allows the bed height on the sinter machine to be increased, which accordingly lowers the fuel consumption for the sintering process. Excessively high sintering temperatures can thus be avoided, positively contributing to the sinter strength, the reducibility of the sinter and indirectly, the FeO content, among other benefits. Sinter with a FeO content of less than 7% can only be produced with a sinter-machine-bed height of higher than 600 mm.

In this context it is important to mention that the proper equipment must be installed to ensure that the fuel concentration continually decreases from the top to the bottom of the sinter raw mix layer in order to optimize burn through temperatures.

Economic Benefits due to Increased Sinter Ratio in the Blast Furnace

Investigations have shown that operating a blast furnace with higher content of sinter in its burden mixture can be considerably cheaper than with the similar operation with high usage of pellets or lump ore.

High Quality Sinter Demands High Quality Equipment and Innovative Design

In recent years a number of important developments have been made by Siemens VAI in the field of iron-ore sintering technology, which have substantially contributed to increased productivity, improved and uniform product quality, reduced energy consumption, lower operational costs and particularly, decisive environmental advantages. Furthermore, the production capacity of sinter plants could be increased substantially when the correct technologies are applied.

These benefits were primarily achieved through the application of the following technological developments and optimization packages:

- Proportioning, Mixing and Granulation Technologies for improved raw mix preparation through the implementation of the Intensive Mixing and Granulation System (IMGS)
- Sinter raw mix charging system to the sinter machine for better segregation
- New wide-body pallet car design – the Grate-Wings Pallets is an economical solution for new sinter plants and as well for increasing capacity of existing plants
- Elongation of sinter strand without change of existing waste gas system
- Advanced charging chute design which efficiently segregates the sinter particles onto the sinter cooler reducing energy consumption
- Sinter Cooler design with high cooling efficiency and waste heat recovery systems
- Selective Waste Gas Recirculation System which reduces the sinter off gas volume, CO_2 content and reduces solid fuel consumption
- Integrated automation and process optimization programs – Level 2 expert system

PROCESS DISCUSSION

Applications for Modernization and New Plants Design

The key design features and advantages of these solutions as well as examples of application results in addition to modernization solutions are discussed below. All these solutions are welcome to be implemented in the design phase of a new plant and also in existing plants.

Proportioning, Mixing and Granulation Technologies for Sinter Mix

The production of high-quality sinter depends to a high degree on the chemical composition of the raw materials, especially with respect to the gangue content (SiO_2, MgO, Al_2O_3), interstitial water and the CaO/SiO_2 ratio of the sinter raw mix.

The maximum grain size of the additives should be limited to approximately 2 mm with consideration to the targeted sinter strength, reducibility and porosity.

For the proportioning of the raw mix, specially designed raw materials bins are 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. A higher number of bins allows for simultaneous discharging of a single ore type from 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 to predetermined ratios throughout the entire operation. Usually a collecting belt conveyor feeds the raw materials to the Intensive Mixing and Granulation System.

Coke Preparation System

Coke preparation system uses roll crushers and/or rod mills and Flip-Flop Screens. The system assures defined particle size range of the crushed solid fuels.

With solid fuels crushed to the required grain size range according to their reactivity, mainly following improvements are achieved:

- lower energy consumption
- high and even sinter quality
- decreased waste gas emissions

The Intensive Mixing and Granulation System

Siemens VAI Intensive Mixing and Granulation System (IMGS) is a highly economical alternative to conventional sinter raw mix preparation systems, especially when raw materials with a high content of ultra fine materials and high moisture fluctuations have to be treated. Additional benefits are also achieved in the treatment of raw materials with a standard grain size distribution.

The Intensive Mixing and Granulation System is characterized with the combination of a special designed vertical Intensive Mixer (high speed agitating mixer) – as shown at the figure 1 - and a horizontal Intensive Granulator (figure 2) installed downstream to the Intensive Mixer, preferably just before the sinter machine feeding system. In specific cases, just a single equipment for intensive mixing and granulation can be installed depending on the raw mix and operational parameters.

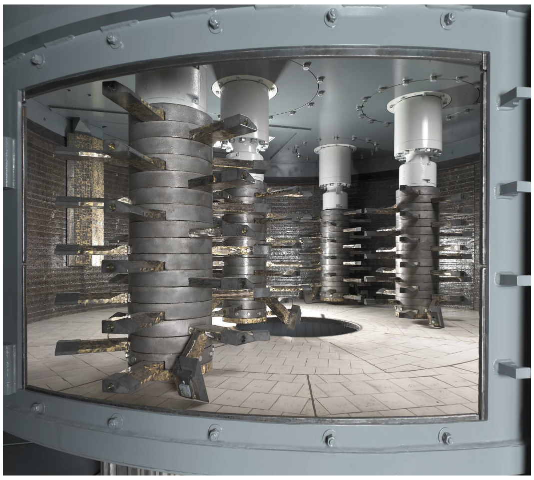


Figure 1: Eirich intensive mixer

Figure 2: Horizontal granulator

With this system 100% of the sinter raw materials are treated. 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.

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

- 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. (micro and macro mixing)
- The conventional mixing drum can only use gravity forces for distribution and mixing of the raw materials, which very much limits the mixing efficiency (only macro mixing)
- The homogeneity of the produced mixture is therefore substantially higher using the intensive mixer.

With the application of the Intensive Mixing and Granulation System mainly the following benefits can be achieved:

- Reduced space requirement
- No pre-blending (blending yards) required (only bunker blending system)
- Completely homogeneous sinter raw mix with high and even permeability
- high productivity of the sinter plant even when ores and additives with high ultra fine grain size are sintered
- Even with higher amount of iron ore concentrate (pellet feed) the productivity is maintained
- Economically reuse of revert materials, i.e. dusts, sludge, scales, and others
- High and stable sinter quality, resulting in high performance of the blast furnaces
- Lower electric energy consumption even when the sinter machine is operated with high bed height
- Lower solid fuel consumption, because of best possible fuel distribution
- Improved performance at the blast furnaces

See at Table 1 below operational results achieved with the IMGS*:

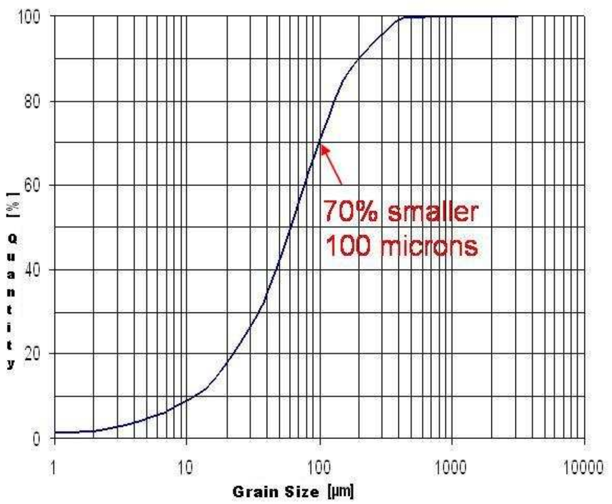
Table 1: * Results achieved in voestalpine stahl Donawitz, Austria after replacement of the existing combined mixing and rerolling drums by a single Horizontal Intensive Mixer

Plant Operational Data:	Before IMGS	After IMGS
Suction Area	120 sqm	120 sqm
Bed Height	600 mm	600 mm
Suction Pressure	140 mbar	140 mbar
Productivity	33 t/m2/24h (approx. 4.000 t sinter/day)	35 t/m2/24h (approx. 4.200 t sinter/day)

Below at figure 3 it is possible to see some pilot tests made in 2008 with a high quantity of iron ore ultra fines and the achieved results.

Results achieved with IMGS

Laboratory results with Russian Concentrate



	Sinter Pot	Basis for Plant
Productivity	30 – 36 t/m^2d	33 t/m^2d
TI (> 6,3 mm)	62 %	70 %
Raw mix moisture	6.5 – 8.5 %	8.0 %
Burnt lime addition	4 % of Raw Mix base (incl. RF)	< 4 %
Solid Fuel Cfix	45 kg/t Sinter	< 45 kg/t
Suction pressure	125 mbar	140 – 170 mbar

Figure 3: IMGS results with concentrate from Russia.

Charging Concept of Sinter Raw Mix to the Strand

As modern sinter machines are operated with a bed height of up to 800 mm, the raw mix charging system is of utmost importance. Controlled charging of the sinter raw mix to the sinter machine leads to the following improvements:

- High and uniform permeability of the raw-mix layer for the production of high-quality sinter at a low electric energy consumption rate
- Controlled segregation of the sinter raw mix during charging to the sinter machine to ensure the desired grain size distribution from the top to the bottom of the sinter bed

- Decreasing concentration of the fuel from the top to the bottom of the sinter bed to allow proper burn through temperature

The sinter machine charging consists of a hearth layer charging system and a system for the granulated sinter raw mix charging. For achieving the required uniform segregation with consideration to the material grain size and coke content in the sinter machine bed, as well as to maintain a high degree of permeability, the Siemens VAI Twin-Layer Charging System was developed.

The Twin-Layer Charging System

With the Siemens VAI Twin-Layer Charging System 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.

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

- Increased plant productivity, even with bed height of up to 800 mm
- Reduced specific solid-fuel consumption
- Lower specific consumption of electric energy estimated at 2%

The advantages achieved with the Intensive Mixing and Granulation System 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.

The Grate-Wings Pallet Cars Design

A modern sinter machine requires pallet cars which have to be designed to minimize false-air intake and therefore should be equipped with rim-zone covers to ensure good sinter quality also along the sidewalls.

The latest sinter machine pallet design featuring grate wings pallet cars was developed by Siemens VAI as a highly economical solution for application in new sinter plants as well as for increasing the capacity of existing sinter plants.

The pallet car body forms the upper extension of the wind boxes, allowing a very economical sizing and arrangement of the suction area. Furthermore, between the suction area and the pallet car side walls, gas-tight rim-zone covers with a width of up to approx. 300 mm of the sinter machine, are installed. 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 providing lower manufacturing costs.

With the new generation of sinter machine pallet cars, mainly the following benefits can be achieved:

- Decreased false air intake and waste gas volume
- Therefore, lower electrical energy consumption
- Sinter output increased by more than 12%

When applied to new sinter machines, the new design has the advantage that the width of the sinter building and of the sinter-machine supporting structure can be kept comparatively narrower. For example, the sinter building width as well as the sinter machine supporting structure for a new sinter machine with a pallet width of 5 m can be the same as required for a conventionally designed sinter machine with a pallet width of 4 m. With the application of this new design, the investment costs can therefore be kept lower than in the conventional design.

When existing sinter machines are upgraded with the new pallet car design, the width can be increased. Therefore, a conventional sinter machine with a width of e.g. 4.5 m can now be extended to approximately 5 m, resulting in a capacity increase of approximately 12% - as shown at the figure 4.

Extension of existing pallet cars → Active Areas Increase by + 10-12%

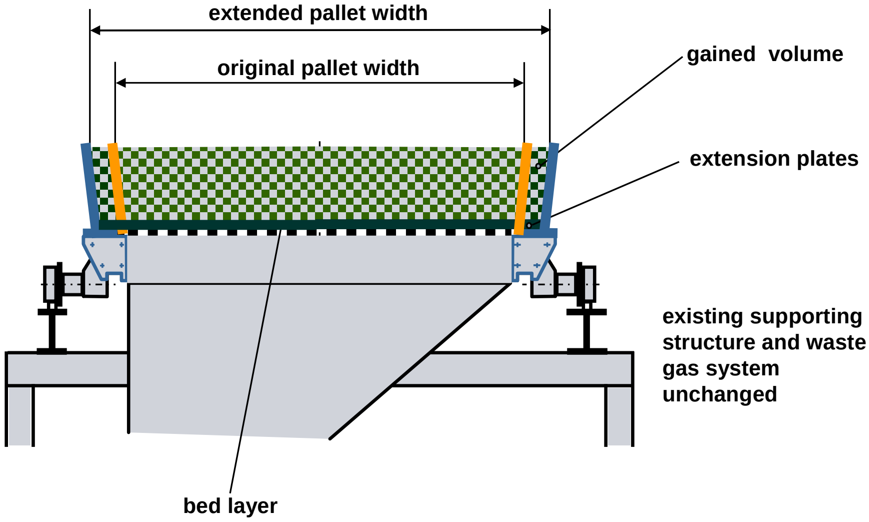


Figure 4: Pallet car extension

New Sinter Cooler Design combined with Cooler Off-air Recirculation and Energy Recovery

For cooling of the sinter a circular sinter cooler with specially designed cooler trough and pallets is applied.

The trough is designed to minimize the false air by-passing the process of sinter cooling along the side walls. For example, a cooler with a pallet width of 4 m is designed with a trough width of 4.6 m. With the specially designed sealing system the loss of cooling air is minimized.

The hot cooler off-air is recirculated to the sinter machine, being used as hot ignition air in the ignition system and as annealing air after ignition.

A main part of the warm cooler off-air is recirculated to the sinter machine where it is mixed in the Selective Waste Gas Recirculation System with the sinter waste gas recirculated to the sinter machine – as figure 5 shows.

Different waste heat recovery systems can be installed in the sinter cooler and the sensible heat of the off-air is used to generate electric energy or process steam.

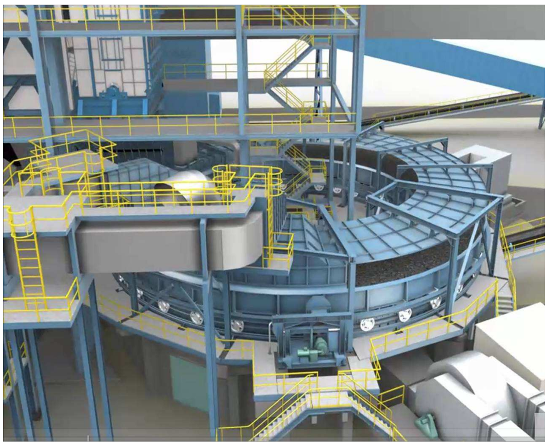


Figure 5: Advanced sinter cooler design with off-air duct for recycling

Figure 6: Installation of an extended sinter cooler

With the new designed sinter cooling system mainly the following advantages are achieved:

- Higher cooling efficiency resulting in decreased specific cooling air volume
- Decreased electric energy consumption by up to 3%
- Effective utilization of heat-recovery system in combination with off-air recycling

This means that the capacity of a conventional circular sinter cooler with a trough width of e.g. 4 m can be increased by approx. 15%, without the need to increase the cooling air volume – see figure 6.

Advanced Cooler Charging Chute Design

Siemens VAI developed a specially designed cooler charging chute to enhance the efficiency of cooling air. With this solution, an improved segregation of the sinter deposited onto the cooler is achieved in that larger particles segregate at the bottom and smaller particles at the top of the cooling bed across the cooler width. This contributes to a more homogenous permeability of the sinter bed on the cooler.

With this especial design the main benefits achieved are:

- Improved cooling efficiency
- Increased cooling bed permeability
- Less spillage in the charging area

The Selective Waste Gas Recirculation System for Sinter Off-Gas

Environmental protection regulations, particularly for sinter plants, require modern and highly efficient waste gas cleaning systems. The investment and operational costs of a modern gas-cleaning system depend mainly on the waste gas volume. Siemens VAI has developed and implemented new technologies which enable environmental emissions in sinter production to be reduced to previously unattained levels.

Therefore, a key target is the minimization of the waste gas volume of a sinter plant. A very efficient and economical solution for the substantial reduction of the waste gas volume is the application of Siemens VAI's Selective Waste Gas Recirculation System.

Selective Sinter Waste Gas and Cooler Off -Air Recycling

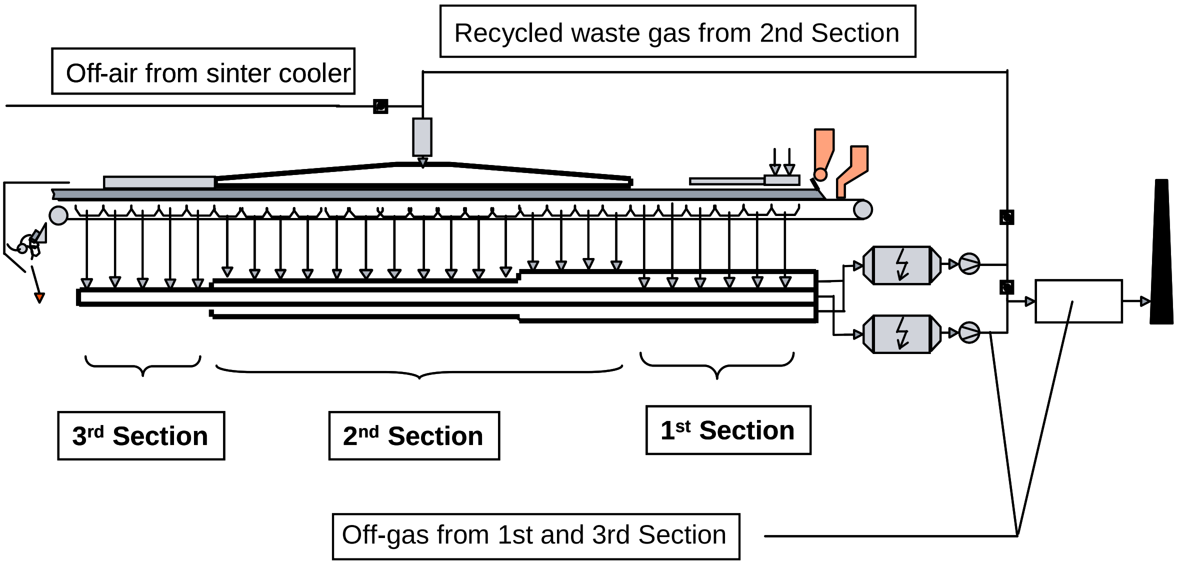


Figure 7: Schematic representation of system

With this system the waste gas of selected wind-boxes of the sinter machine is mixed with cooler off-air and/or ambient air and is recirculated back to the sinter strand, as seen in the figure 7.

The Selective Waste Gas Recirculation has been developed primarily to keep the off-gas volume the same and increasing the sintering capacity and decreasing the emissions. Specific investment costs are minimized and additional equipment for gas cleaning facilities shall be optimized in investment and operation costs. Other waste gas recirculation technologies would lead to a higher off-gas amount with all the consequences.

The typical benefits of this system are:

- Decrease of waste gas volume up to 40%
- Proven reduction in the solid fuel consumption by up to 10%
- Decreased investment and operational costs for waste gas cleaning plant
- Full productivity using same raw mix
- Lower CO_2 emissions by up to 10%
- Lower specific emissions of SOx, NOx, PCDD/PCDF and heavy metals

Operational Results Achieved with the Selective Waste-Gas Recycling:

Below it presented the average results achieved with the Selective Waste Gas Recirculation System and modernization project at voestalpine Stahl Linz/Austria in 2005, also known as EPOSint.

Reference Data	Before	After
Sinter Strand Speed (m/min)	1.6 – 1.7	2.2 – 2.4
Sinter production (t/24h)	6,350	(8,300) - 8,500
Productivity ($t/m^2/24h$)	37.6	(36.6) - 38.3
Coke breeze (kg/t sinter)	45	41
Ignition gas (MJ/t sinter)	50	40
Electrical power (kWh/t sinter)	40	40
Dust emissions (mg/Nm^3 // g/tSint)	46 // 104	38 // 66
SO_2 emissions (mg/Nm^3 // g/tSint)	420 // 952	390 // 677
NO_x emissions (mg/Nm^3 // g/tSint)	240 // 544	240 // 416
HF emissions (mg/Nm^3 // g/tSint)	1.0 // 2.3	0.6 // 1.0
Sinter size fraction (4–10 mm) in %	32–34	33–36
Tumbling Index (ISO + 6.3 mm) %	78–82	79–82
RDI < 3.15 mm in %	18–20	19–20
Reducibility R/dt(40)	0.9–1.0	0.95–1.05
FeO (%)	6-8	7-8.5

The Selective Waste Gas Recirculation System can be installed in existing or in green field plants as 100 % add on or fully integrated. Combined with the SIMETAL^{CIS} MEROS® process is the best available technology for sinter waste gas treatment.

Residuals Utilization at Sinter Plants

Siemens VAI approach considers increasing the input of recycling materials into sinter plants as a proven economically route for in-plant by-products of integrated steel works.
Resulting effects on sinter quality, emissions and gas cleaning facilities are in consideration too. Emission limits of the sinter waste gas and quality parameters of the produced sinter are the two most important limiting factors. The overall requirement of improvements in productivity and production of good quality sinter are to be considered and therefore every case has to be investigated.

Usually the benefits of such a procedure are:

- Waste materials are normally rich in iron, flux and fuel value
- Savings in disposal cost are possible
- Savings due to replacement of raw materials
- Lower investment costs by using the existing sinter plant

Sinter VAiron - Integrated automation and process optimization systems

Combined with Siemens VAI’s Sinter Technologies as described above, the advanced process models and the closed-loop expert systems are applied:

- All steps of the sintering process, starting with raw material storage systems and ending with the sinter charged to the blast furnaces including the sampling system are controlled based on a future-oriented strategy
- Built-in maintenance diagnostic systems
- Comprehensive data logging

With the application of Siemens VAI Sinter VAiron the following results and advantages can be achieved:

- Completely integrated solution for the entire sintering process
- Low fuel consumption and reduction of coke rate
- Increased productivity
- Improved sinter quality based on standardized and stabilized sintering operations
- Closed-loop Sinter Expert System

CONCLUSIONS

With these trend-setting developments introduced by Siemens VAI in the field of iron ore agglomeration technology, previously unattained levels, especially in respect to plant productivity, sinter quality, energy consumption and environment protection, as well as in respect to investment and operation costs, are achieved.

Furthermore, when consider the Selective Waste-gas Recirculation System of hot waste-gas from the sinter plant mixed with hot air from the sinter cooler, fuel savings up to 10% coke breeze per ton of sinter was achieved. Up to 40% of the waste-gas was kept in the sinter process meaning a significant reduction at the gas cleaning facilities.

With a vast range of sinter expert services and solutions, Siemens VAI can recommend several cost-efficient improvements for existing plants by executing a quick assessment of the sinter plant.

Acknowledments

We would like to acknowledge voestalpine Stahl Linz and Donawitz, Austria for being the reference plants to this paper as well the team which was involved in these successful projects.