GREEN TECHNOLOGIES FOR HIGHER ENERGY EFFICIENCY IN ELECTRIC STEELMAKING[1]

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Abstract

Apart from the metallic input materials, energy is the main cost driver in electric steelmaking operation today. The increasing energy-price trend indicates that even higher prices can be expected in the future. Next to the increasing energy costs, electric steelmaker take notice that international agreements and national laws increasingly call for a reduction of pollution and CO2 emissions. This trend ask for advanced solutions to meet the environmental regulations and energy-prices of today and those in the future. A comprehensive energy management is necessary for an energy efficient steel plant operation. Recent developments on the EAF technology focuses on optimized scrap charging, preheating technology, melting, slag-free tapping and continuous power on operation during charging, tapping and taphole refilling. The solution set new benchmarks in electric steelmaking for lowering the specific energy consumption rate and related emissions to the environment. Considering the energy balance of an EAF, it becomes obvious that the lion's share of process energy losses is the hot offgas exiting the furnace. Hence, the application of efficient methods to recover this energy can make a major contribution toward improving the overall energy balance in electric steelmaking. The closer link between CCM and RM is a further trend at mini mills. Either hot charging or direct rolling leads to a high potential in energy savings. This presentation gives an overview of energy saving from scrap to final products with a visionary outlook on green technologies.

Key words: Electric steelmaking; Innovation; Mini mill; Energy efficiency.

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1 INTRODUCTION

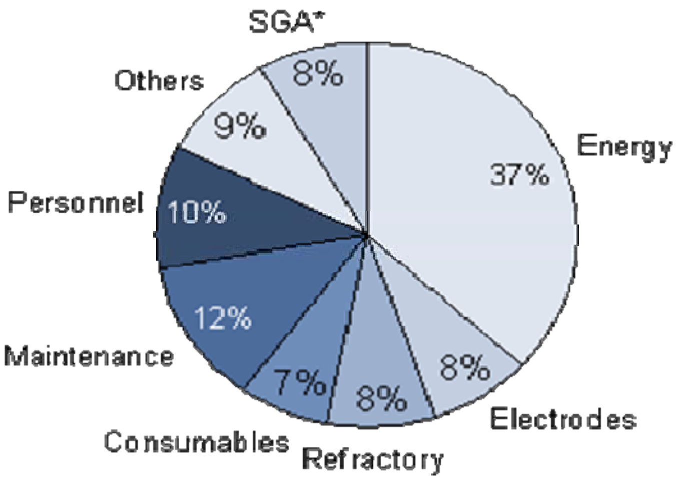
Steel is and will remain to be the predominant metal used by the industry in the coming decades. The global electric steelmaking market has been characterized by steadily increasing demands for structural steel. By 2015, annual electric steel production is expected to increase to more than 500 million metric tons and to 575 million tons by 2020.(1) This will be accompanied by continuously increasing costs for metallic input materials (scrap, direct-reduced iron/DRI, hot-briquetted iron/HBI) and energy apply highly efficient technologies to ensure the optimized use of resources. Especially the rising trend for energy prices is a risk for electric steelmaker as the energy costs are the lion's share of the operating costs of a minimill. Electric steel producers therefore need to respond to these trends by a comprehensive energy management to ensure the energy efficiency of the steel plant. Investments in new technologies and modernization of the existing minimills can reach energy savings up to 30% along the mini mill.

2 ENERGY AS MAIN CHALLENGES OF ELECTRIC STEEL PRODUCERS

One of the main challenges that must be met by the electric steel industry today and in the future are increasing energy costs and stricter environmental regulations.

2.1 Higher Energy Costs

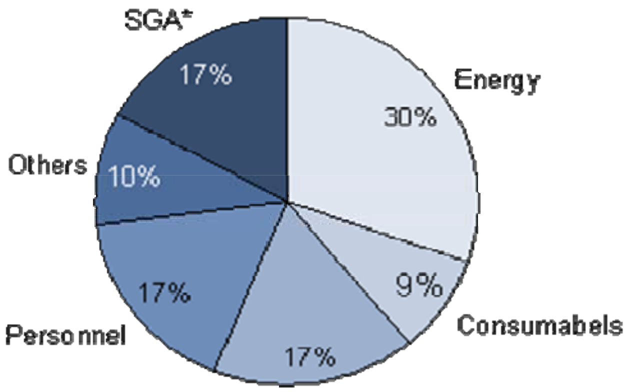
Apart from the metallic input materials, energy is the main cost driver in electric steelmaking production today (Figures 1 and 2). The increasing energy-price trend since 2004 indicates that even higher prices can be expected in the future (Figure 3). The key for reducing operating costs and ensuring high performance levels in steelmaking is to optimize plant technology and maximize plant efficiency.
Steel plant:



**Selling, General, and Administrative costs*

Figure 1. Conversion cost drivers in the electric steelmaking plant.

Rolling mill:



**Selling, General, and Administrative costs*

Figure 2. Conversion cost drivers in the rolling mill.

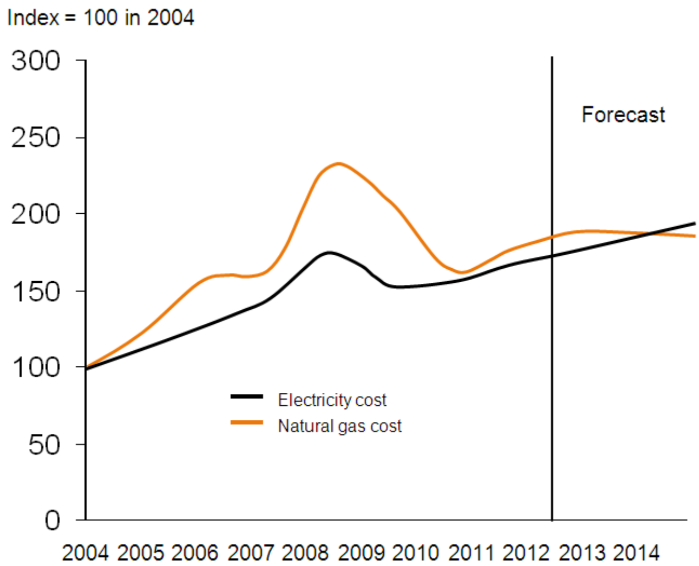


Figure 3. Development and forecast of energy costs. (Source: CRU)

2.2 Stricter Environmental Regulations

As international agreements and national laws increasingly call for a reduction of pollution and CO_2 emissions, advanced solutions must be implemented to meet the environmental regulations of today and those in the future. As a plant builder and life-cycle partner for the metals industry, Siemens Metals Technologies offers a complete suite of environmental technologies tailored to the requirements of minimills.

3 ENERGY EFFICIENCY HIGHLIGHTS

Siemens VAI visions energy savings up to 30% along the entire mini mill (Figure 4). In the following several of the most energy efficient minimill innovations from Siemens Metals Technologies are presented. The innovation and modernization portfolio show how the energy balance of a minimill plant can be improved.

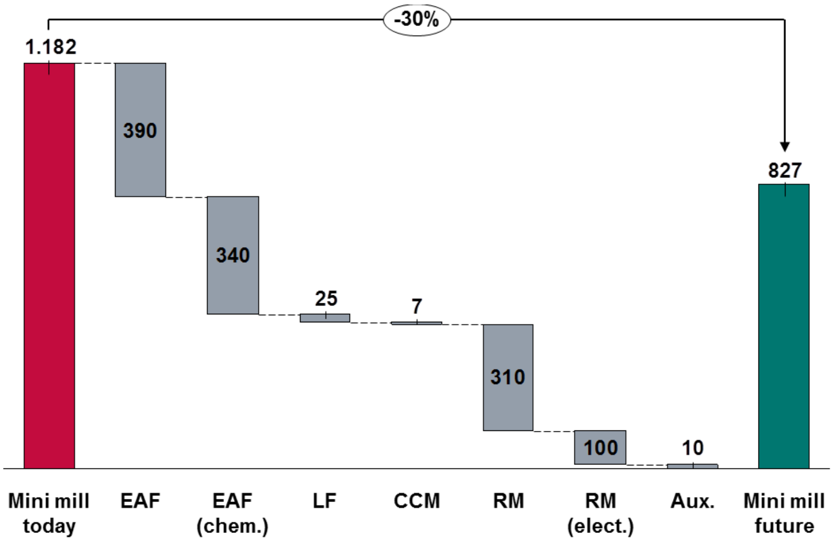


Figure 4. Energy savings up to 30% along the mini mill possible.

3.1 Scrap Preheating in a New Generation of Electric Arc Furnaces

Increasing energy costs and stricter environmental regulations lead to in higher conversion costs to produce steel. A state-of-the-art electric arc furnace must therefore fulfill the following technical and market demands:

- maximum utilization and minimum downtimes to ensure high productivity;
- high degree of automation and process control to enable reliable and consistent steel production;
- energy-efficient steelmaking operations;
- assurance of utmost personnel safety;
- low flicker effect;
- fulfillment of current and future environmental regulations.

Simetal EAF Quantum is a new shaft-type electric arc furnace from Siemens Metals Technologies that combines decades of experience in the engineering and installation of EAF plants with the know-how and experience acquired from the supply of more than 20 shaft-type furnaces. Through the utilization of the furnace offgas during the heat cycle, 100% of the scrap is preheated prior to melting. Simultaneous scrap charging and melting allow the power-on time to be maximized. These features result in considerable energy and cost savings in addition to a substantial reduction in tap-to-tap times that approach 30 minutes. Furnace practice employing a hot heel allows for flat-bath operation during the melting phase and reduces a potential flicker effect. Furthermore, the combination of the patented Fast tapping system (Furnace Advanced Slag-free Tapping), a new system for scrap-charging into the furnace shaft, a unique design of the offgas processing system and application of the latest analysis techniques sets new benchmarks in the design and performance of high-performance electric arc furnaces. An energy consumption of only 280 kWh/t of tapped steel, a productivity increase by at least 10%, and a 30% reduction in the specific electrode consumption is offered by this new furnace generation. The combination of all of these factors and other benefits leads to a total conversion cost advantage of approximately 20%. Return on investment is possible within two to four years, depending on the energy costs and production program.

The first order for a Simetal EAF Quantum furnace was placed by the Mexican steel producer Talleres y Aceros S.A. de C.V. (Tyasa) in December 2011 for the supply of a 100-ton furnace.

3.2 Continuous DRI Melting

It is now possible to continuously melt DRI (direct-reduced iron) in an electric arc furnace with the new Simetal EAF Fast DRI. A highlight of this solution is that DRI feeding and the electric power input continue uninterrupted even during tapping. Siemens Metals Technologies developed this furnace type as an advanced DRI-based EAF that is characterized by an improved shell design and liquid heel operation for accelerated DRI melting. Tapping and tap-hole refilling are performed under power-on conditions. This is made possible thanks to a completely new mode of shell movement combined with the Fast slag-free tapping system. Slag carryover is minimized thanks to the siphon-type design of the tapping channel.
Existing furnaces can be modernized with the Fast DRI system. To boost productivity even more, hot DRI from the direct-reduction plant can be charged into the FAST DRI furnace at approximately 600°C by means of a specially developed DRI plate conveyor transfer link.

3.3 Maximum Furnace Performance

The need to efficiently use EAF charge materials and energy is a key driving force behind EAF developments. The electricity over chemical energy input diagram shows potential for optimization (Figure 5). One of the latest EAF innovations from Siemens Metals Technologies to meet this challenge is the Simetal EAF HeatOpt. This solution features the continuous monitoring of the furnace offgas, the offgas flow and the slag level. Additionally, the input of natural gas, oxygen for refining and post combustion, and carbon for slag management is also carefully controlled by the system.

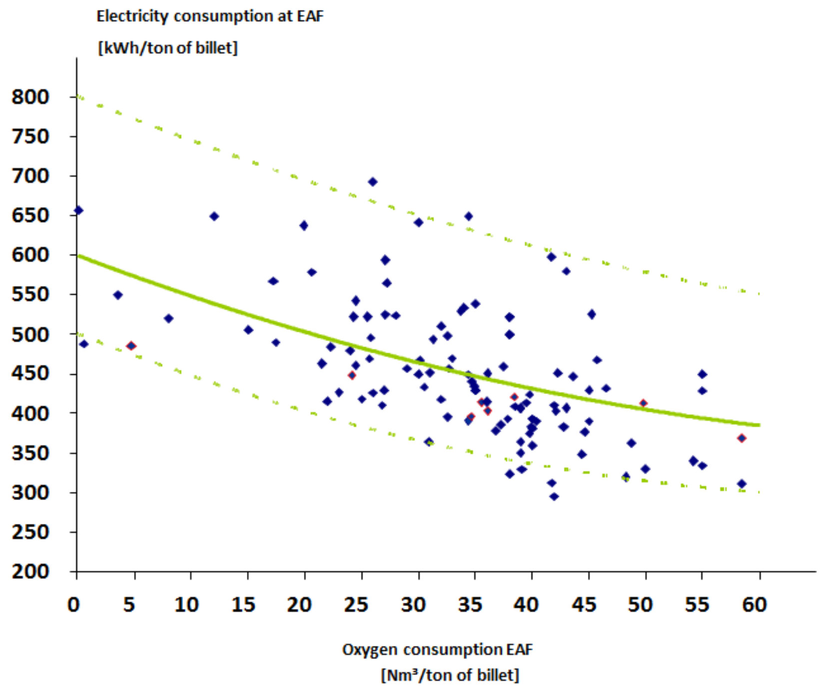


Figure 5. Simetal EAF HeatOpt: Electricity input over chemical input. (Source: Siemens VAI Database)

Simetal EAF HeatOpt is comprised of four main parts: the holistic process model (HPM) itself – a combination of algorithms and prediction strategies; the Lomas offgas analyzing system; the SAM offgas flow analyzer; and the FOX300 slag foaming indicator.

Benefits for producers include:

- productivity increase by approximately 3.6%;
- decrease in gas and O_2 consumption by approximately 15%;
- average decrease in carbon consumption by 15%;
- reduced conversion costs by roughly 2 U.S.$/ton of tapped steel;
- high process transparency through the application of graphical analyses.

3.4 Recovering the Energy of the EAF Offgas

When considering the energy balance of an EAF, it becomes obvious that the lion's share of process energy losses is the hot offgas exiting the furnace. Hence, the application of efficient methods to recover this energy can make a major contribution toward improving the overall energy balance in electric steelmaking.

In the new Heat2Power EAF energy-recovery system from Siemens Metals Technologies, the conventional water- and air-cooled offgas system in a conventional EAF is replaced with a heat-recovery steam generator (HRSG). Depending on available space, the HRSG can be installed inside or outside of the meltshop. Steam buffer storage (well known from LD/BOF-based steelmaking) or a unique high-temperature molten-salt energy-storage system ensure a constant supply of steam even during furnace charging or tapping. The steam can be directly used for many applications such as process heating, steam ejectors, district heating or seawater desalination to name just a few. Furthermore, comprehensive solutions to use the steam to drive steam turbines with outstanding efficiency were also developed. Depending on the size of the recovery system, up to 35 kWh of electrical energy per ton can be regained with these power-generation systems. A significantly reduced carbon footprint – depending on the national conversion factor per kWh – even doubles the benefit of an efficient energy-recovery system from hot EAF offgas.

3.5 Totally Optimized Steelmaking Operations

On the basis of decades of experience in the supply of complete metallurgical plants, Siemens Metals Technologies has at its disposal an unparalleled wealth of experience that extends from plant engineering, installation, start-up and commissioning to operational, metallurgical and automation expertise A specialty of the company is the integration of automation solutions within existing automation environments. A wide range of advanced process-optimization systems, the latest process models and various automation packages are available to reduce the raw material and energy consumption starting with the EAF and extending up to the secondary metallurgical facilities. Sophisticated solutions and systems for energy management, manufacturing execution, quality control and condition monitoring serve as the basis for plant-wide optimization, cost-effective operations and high-performance electric steelmaking.

3.6 High-Speed Long-Product Casting

Producers today are increasingly demanding long-product casters capable of achieving high speed/high-output rates simultaneously with high product quality. (This is also true for the casting of rebars, which has normally been deemed as “low quality” products up until now.) Siemens Metals Technologies has developed a high-speed billet caster that is able to satisfy both of these requirements. The caster is capable of attaining casting speeds that can exceed 6 m/min for a typical billet format of 130 mm x 130 mm. A number of technical features makes this possible. Shrouded casting with slide gate control is applied. The well-proven Simetal DynaFlex Hydraulic Oscillator with leaf spring guidance allows the mold-oscillation parameters to be adjusted online as the basis for ensuring the correct lubrication of the cast product and to prevent unwanted vibrations of mechanical components. The patented Simetal Diamold solution features a specially shaped mold tube profile and extended foot roller support to accelerate billet strand-shell solidification as required for high-speed casting.

Improvements of the secondary cooling system provide the ideal billet cooling conditions required after the mold exit to ensure the correct billet surface temperature and strand solidification pattern. This, in combination with the application of a new billet strand-guiding system inside the cooling chamber minimizes billet quality defects.

3.7 Endless Production of Long Products Directly from Liquid Steel

WinLink® is of the new innovative technology from Siemens Metals Technologies for the endless production of long products from liquid steel. A billet caster is directly linked to the rolling mill for the processing of liquid steel to rebars or other long products in a continuous, uninterrupted production line. Through the direct linking of a high-speed billet caster with a rolling mill in a highly compact production facility, producers benefit from low investment expenditures (Capex), reduced conversion costs (Opex), significantly lower energy savings, reduced CO_2 emissions and the highly profitable production of long products and a fast payback period.

Installation of WinLink in a scrap-based minimill configuration is ideal for production capacities between 300,000 t/a and 400,000 t/a of finished bars comprising standard carbon-steel grades used primarily in the construction industry and for infrastructure applications. In comparison with conventional minimill plant configurations, a WinLink-based minimill offers a number of advantages as follows:

- lower investment costs thanks to the highly compact line arrangement, less civil works and decreased infrastructure expenditures;
- reduction of operating costs by up to $40/t of rolled steel depending on unit costs;
- higher product yield due to long uninterrupted casting and rolling sequences;
- reduced energy consumption thanks to direct charging of cast billets into rolling mill;
- lower personnel requirements;
- 24-hour continuous and smooth mill operation;
- production of finished rolled products from scrap in less than 2 hours.

3.8 Hot Charging to Rolling Mill

Hot charging refers to the practice of handling the billet directly from the end of the continuous caster run out table to the rolling mill furnace without intermediate storage. Modern steel plants are now designed with a direct roller table connecting the caster discharging roller table or the cooling bed to the charging grid of the reheating furnace. Billets which can´t be charged directly to the furnace can be covered with a heating box to reduce cooling of the billet.
The layout and equipment of the billet yard, which is the link between the steel plant and the rolling mill offers a valuable approach to reduce energy consumption. The higher the billet temperature when charged to the reheating furnace, the greater is the energy savings. Cooling of the billet follows an exponential function, which means that especially at the time immediately after casting every minute of handling time saved between the continuous caster and the reheating furnace is important in minimizing energy losses. Hot charging leads up to 200 kWh/t energy reduction (Figure 6). Besides the significant energy savings, an increase in reheating furnace productivity is the main incentive for hot charging. The main challenge for hot charging is the production planning, billet tracking and synchronizing the meltshop with the rolling mill.

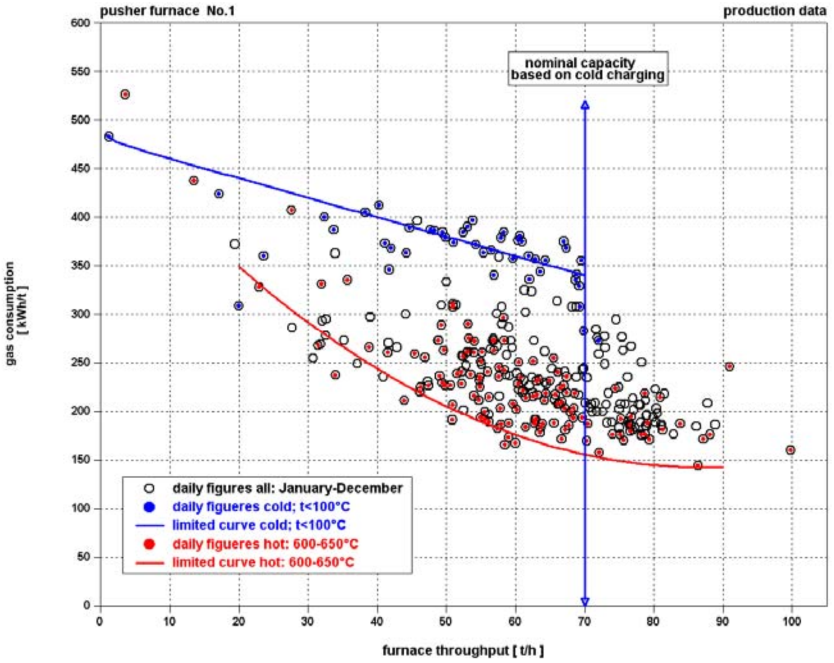


Figure 6. Hot charging leads up to 200 kWh/t energy reduction. (Source: GEVA Process Technology GmbH)

4 ENERGY OPTIMIZATION STUDY

A comprehensive energy management is necessary to ensure energy efficient steel plant operation. The energy optimization of Siemens Metals Technologies includes three stages: energy check, energy improvement study and energy realization concept.

Within the first stage the energy status of the plant will be analyzed and saving potentials identified accordingly. Than the energy improvement study will evaluate detailed investigation of energy saving potential based on individual plant configuration. Customized evaluation of potential actions to improve energy efficiency is one main outcome at that stage. Finally the energy realization concept will elaborate detailed technical concepts including implementation steps for improvement projects.
Different software's support the energy optimization and shows the specific kWh per ton savings along the different mini mill technologies.

4.1 Simetal EMS

This advanced energy management system provides the transparency required to reveal the actual energy consumption within a steelworks. Highly efficient and flexible functions for recording consumption data, energy planning and allocation, CO_2 monitoring and the generation of energy balances can be easily integrated into existing automation systems. Simetal EMS is a modularly configurable and scalable set of combinable functions suitable for different automation levels and production units. The first order for Simetal EMS was received from Taiyuan Iron and Steel (Group) Co., Ltd., China
Main benefits

- significant energy savings resulting from highest transparency of energy demand, costs and consumption per cost center;
- improved cost control through automated reporting with informative displays and key performance indicators (KPIs);
- optimization of the energy consumption within a steelworks, thereby avoiding peak network loads and unnecessary flare losses for major energy cost savings;
- reliable prediction of energy demand on the basis of mathematical simulations and computational models.

5 CONCLUDING REMARKS

To stay competitive it is crucial for steelmaker to operate the minimill plant energy efficient. The potential of a minimill plant for energy savings is enormous but unfortunately not sustainably pushed in many cases. Existing plants show considerable differences in energy intensities. Key elements of energy savings along the mini mill can be found at the preheating of scrap at the EAF, energy recovery of the EAF offgas and the avoidance of cool down processes. The closer link between CCM and RM is a further trend at mini mills. Either hot charging or direct rolling leads to a high potential in energy savings.
Attention for green technologies for higher energy efficiency must be aware on all hierarchical levels within the steel plant.

REFERENCE

1 SBB Forecaster Crude Steel Databook, September 2011.