Double regenerative burners for reheating furnaces
An innovative concept to substantially improve energy efficiency
The iron and steel industry is responsible for 30% of the industrial greenhouse gas emissions in Europe, making it the most-polluting industrial sector in terms of CO₂ emissions. A significant volume of the CO₂ emissions from integrated steel plants is related to natural gas consumption, of which about 45% is related to the fueling of reheating furnaces. Reducing this consumption is essential to positively impact the sector’s overall carbon footprint.

During thermo-reduction, which takes place throughout the transformation of iron oxides into cast iron, blast furnaces emit large volumes of a low calorific gas, named Blast Furnace Gas, (BFG), containing a high proportion of carbon monoxide. The low calorific value of this gas, that is ten times lower than that of Natural Gas (NG) for example, drastically limits its use in any industrial application. In particular, when used in the steel industry’s standard burners, BFG must be mixed with a rich gas for a very specific process/metallurgical reason: the very high flame temperatures required in the reheating furnaces cannot be reached using BFG alone. A typical composition of mixed gas used in a reheating furnace for steel stock is, expressed in calorific values, 10% BFG with 90% natural gas (NG), while it becomes 80% BFG and 20% NG when expressed in volume.

The blast furnace is the first step in producing steel from iron oxides. The purpose of a blast furnace is to chemically reduce and physically convert iron oxides into liquid iron called “hot metal”. Blast furnace equipment is in continuous evolution and today reheating furnaces process thousands of tons per day, producing huge amounts of blast furnace gas (BFG), a gas with both, a very low calorific value and flame temperature. Additionally BFG is containing considerable amounts of CO and CO₂. This, and its very low heating value of around 0.9kWh/Nm, which is not high enough for combustion, makes this gas unusable for today’s best available technology (BAT) burners.

The most common technique to valorize a part of the BFG is to use it in a mixed gas for the reheating furnaces. This implies that the calorific value of the mixed gas must be high enough to reheat the products to around 1250°C, which means that the quantity of BFG cannot be maximized. The produced excess of BFG is either sold at a low price to produce electricity or burnt by torches, and the resulting greenhouse gas is released into the atmosphere.
Lower energy consumption and decreased oxidation of steel

The development of new steel grades by steelmakers have led to a need for increasingly sophisticated process control requirements of the CMI reheating furnaces, and to improving the performance of its equipment as to combustion efficiency and product quality. The associated lower energy consumption and decreased oxidation of steel is achieved through computer simulation of gas flow, temperature calculations of heated stock, studies and evaluation of scale formation and gas analysis. Based on a combination of BAT (Best Available Technologies) and its extensive internal process know-how and experience, CMI developed a new reheating furnace concept under the name of Optimfl@me, addressing all of the above described market needs for efficiency and quality.

Today, integrated steel plants produce excess of heat that is not transformed into thermal energy, and thus still have to purchase large quantities of rich fuels, due to the low calorific value of BFG, that renders this type of gas unusable for reheating steel products at high temperatures.

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Today, integrated steel plants produce excess of heat that is not transformed into thermal energy, and thus still have to purchase large quantities of rich fuels, due to the low calorific value of Blast Furnace Gas (BFG), that renders this type of gas unusable for reheating steel products at high temperatures.
Innovative concepts for reheating furnaces

The CMI reheating furnace is designed to most effectively equalize the temperature gradient within the steel slab, bloom or billet, by optimizing the transfer of generated heat to the surface of the steel stock to be heated to a maximum. This allows for a unique temperature uniformity, while avoiding scale formation and skid marks. Besides these quality driven parameters, the latest generation of CMI’s reheating furnaces also addresses environmental and operational concerns and allows for lower fuel consumption by reducing heat losses from the furnace to the minimum, and increase availability and flexibility of operations.

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Key Figures

When compared to conventional reheating furnace designs, the Optimfl@me® global concept offers the following competitive advantages:

- A yearly gain of more than 1% of furnace investment cost
- The Optimfl@me® design results in a discharging temperature decrease of about 10°C, which remarkably improves the homogeneity of the final product.
- Lowest NOx emissions on the market
- Considerable scale reduction of around 10%
- Fuel consumption savings of up to 10%
- A yearly output increase of 0.2% (from 0.5 to 0.7%) with the same furnace capacity
Double regenerative burners, an eco-friendly solution addressing today’s market requirements

And while the new furnace concept has successfully been implemented in several revamping projects, and newly installed reheating furnaces, in many parts of the world, CMI has devoted resources to developing a new generation of burners, providing another major improvement for its steel customers. This latest innovation in the field of reheating technologies are Double Regenerative Burners (DRB), for which a patent application has been filed.

While a first trial has successfully been conducted in a plant of ArcelorMittal in Romania, using a prototype burner, it was the winning comeback to the slab reheating furnace market, where CMI won a major contract to replace two reheating furnaces with the largest furnace in Europe at ArcelorMittal’s steel complex in Ghent, that opened the path for this new innovative technology. The new ArcelorMittal hot strip mill (HSM) furnace is the first project where the innovative, patented CMI double regenerative burners (DRB) are to be installed on an industrial scale, with the aim to considerably reduce operating costs through combustion of blast furnace gas.

Besides the positive economical effect for the customer, the reduction of greenhouse gas pollution also positively affects the quality of the steelworkers’ work conditions, as well as the neighboring population’s lives.

Research & development, an essential foundation for our and our customers’ competitiveness in a global economy.

Project Objectives

The project, that is co-funded by the European Union’s LIFE+ program, aims at considerably lowering CO₂ emissions (greenhouse gases) as well as at the replacement of natural gas (NG) by the less expansive blast furnace gas (BFG), with the possibility to exclusively use BFG despite its low calorific value, resulting in:

- Both, a major reduction of greenhouse gas emissions and production costs
- The reduction of the overall natural gas consumption of a rolling mill complex by 9%
- The considerable increase of BFG to feed slab reheating furnaces allows to reduce its natural gas consumption by 90%
- Abatement of cancerogenic NOx emissions in the furnace exhaust furnes below 150 mg/Nmc

Field-proven reliability with cutting-edge innovation

Regenerative burner systems are well proven in the industry. These burner systems are increasingly used for all types of furnaces in the steel industry, as they not only allow for a very low energy consumption of the furnace, but also a considerable reduction of CO₂ and NOx emissions. With the development of its innovative double regenerative burner technology, CMI helps its customers to achieve major energy savings resulting in a reduced return of investment period, particularly when installed in new furnaces.
The LIFE+ DRB project will demonstrate the efficiency of an innovative, CMI patented burner technology, in a first industrial-scale application, at the ArcelorMittal site in Ghent, Belgium, called Double Regenerative Burners (DRB).

This new technology allows the pre-heating of blast furnace gas (BFG) and air in an innovative combustion process within the burner, using a state-of-the-art fume-exhaust system that is installed inside the burner itself. This technology is to allow to reach very high temperatures of up to 1,000 degrees Celsius, both for the blast furnace gas (BFG) and the combustion air. At this temperature, BFG can be used in the furnace-reheating process without the addition of any expensive high calorie content gas, such as natural gas.

The project implies the design and installation of a pair of 7MW DRBs. And while the design has been finalized by CMI in 2015, the installation of the new burner technology on the reheating furnace for steel slabs at the ArcelorMittal integrated steel-making complex is imminent. Once this is successfully done, the DRB technology may easily be installed on all new or existing blast or reheating furnaces for steel stock.

Applying the DRB technology to all integrated steel plants operating these types of furnaces in Europe alone, potentially results in a yearly energy saving of 30,461,661 gigajoules (GJ), which translates into preventing 1,716,164 tones of carbon dioxide from being emitted into the atmosphere.

CMI’s double regenerative burners (DRB) are always working in pairs
Environmental protection and energy savings are fully compatible with increased return on investment.

**Design Key Facts**
- Double regenerative burner (DRB) technology can operate with up to 100% low calorific value BFG while respecting safety regulations, low and easy maintenance requirements and the environment.
- Possible switch from double regenerative burner mode to single regenerative burner mode, allows for the use of either BF gas only or mixed gas (BFG mixed with NG, or other gases).
- Innovative mixed media solution inside the burners:
  - Expected annual replacement rate of 5% instead of 100% for single media solutions.
- Compact burner design reduces space needed for installation.
- Easy retro-fitting on existing furnaces, also due to its reduced combustion chamber height.
- Optimized arrangement of connecting piping.
- Unit heating capacity up to 7 MW to be installed per 3 meter furnace length, while today's best available technology allows for a maximum of 4 MW.
- The DRB technology is the only solution to reach the required adiabatic flame temperature of BFG.
- New concept of fluids injection into the furnace:
  - Separate, horizontal rectangular slots for both blast furnace gas and combustion air.
  - Blast furnace gas injected into the furnace to limit the oxidation of the heated products.
  - Distinct injection speeds of 100 m/s for BFG and 70 m/s for combustion air, thus ensuring efficient combustion.
- Burner are not fixed onto the furnace structure: (estimated weight ~ 12 tons per burner).
- No special design for the furnace wall steel structure and refractory lining.
- Possibility to remove the burner when back space is available (possible installation on wheels and rails).
- Possibility to change or maintain the diffusers from outside of the furnace chamber (access between burner and furnace wall).

**Modeling, to validate the design**

CMI used its R&D facilities in a combination of laboratory-scale burner testing and Computational Fluid Dynamics (CFD) modeling to study the problem and optimize burner design and performance before starting trial tests at AM Galati, in Romania.

**Modeling and thermal calculation (Fig.1 + Fig.2)**

Modeling of fluids flows at the entry and exit of the regenerators to:
- Insure the uniform repartition of the flows in the regeneration media volume.
- Reduce the pressure losses corresponding to the speed changes (acceleration of hot fluids up to 100 m/s).
- Reduce the dead volume mainly for BFG and accordingly reduce the purging time.

Modeling of the flame inside the furnace by numeric simulation, to optimize the diffuser arrangement in order to:
- Insure flameless and complete combustion (no CO).
- Avoid impact of the flame on slabs and roof to limit oxidation and overheating.
- Determine the impact of waste gases flow from upstream heating zone.
- Determine the influence between burners side by side and top and bottom.
- Reduce the air-gas ratio (expected 10% maximum).
LIFE is the EU’s financial instrument supporting environmental, nature conservation and climate action projects throughout the EU. The general objective of LIFE is to contribute to the implementation, updating and development of EU environmental and climate policy and legislation by co-financing projects with European added value, encouraging advances in innovative technologies, aiming at a positive environmental impact.

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