Disciplined Steps For Optimising Energy Consumption In Reheating Furnace By Hot Charging

P.K. Thakur¹, Abhijit Das², P.K. Singh³
¹,²,³RDCIS, SAIL

Abstract: Reheating furnace is used to supply input to the rolling mill called hot stock at sufficient temperature in the rolling mill. Semi-finished products from blooming-billet/slabbing mills and continuous casting shop such as slabs, blooms and billets are reheated in reheating furnace to a temperature of 1260°C to 1280°C. It uses mixed gas (coke oven gas and blast furnace gas/ BOF gas) along with hot combustion air. This results in plastic deformation in rolling mill. Reheating furnace consumes energy for reheating semi-finished products which come from stock yard. It adds to fuel cost of the industry. To reduce energy consumption, ideally the steel should undergo through a continuous process rather than a discontinuous process. For this purpose, the steel should be charged in reheating furnace at a temperature above 700°C. There is a direct link between caster and rolling mill for production. If steel is charged in the reheating furnace at the aforementioned temperature, then amount of energy is wasted in reheating decreases. This further results in energy savings of 13%. Ultimately all the above steps mentioned adds to the bottom line of the company.

I. INTRODUCTION

Steel production is a highly capital and energy intensive industry subject to intense global competition. It is vital for any steel producer to work continuously to reduce costs while at the same time responding to customers’ expectations on lower prices, shorter lead times and better quality. This research explores the opportunities for improved production and energy saving by hot charging practices. This study is based on experiences from Plate Mill of Bhilai Steel plant in Chhattisgarh, located in mid-India, where steel plates are produced.

Thermal efficiency of process heating equipment, such as furnaces, ovens, heaters, and kilns is the ratio of heat delivered to a material and heat supplied to the heating equipment. The purpose of a heating process is to introduce a certain amount of thermal energy into product, raising it to a certain temperature to prepare it for additional processing or change its properties. To carry this out, the product is heated in a furnace. This results in energy losses in different areas and forms as shown in snaky diagram figure1. Losses occur through stack roof, walls, and openings. In reheating furnace a large amount of the heat supplied is wasted in the form of exhaust gases.
Many design features affect the energy efficiency: dimensions, number of zones, wall and roof insulation, and skid design. The number of zones and the insulation between zones influence both the efficiency and the possibilities for an effective temperature control with individual zone values. Operational practices are important for the energy efficiency. Conditions may vary from mill to mill but also for the normal operation of each furnace. The ideal situation would be to run a furnace at constant nominal speed with one type of object of the same dimension. However, a number of deviations and disturbances occur these are:

- Items with different material composition, dimensionless, and charging temperatures may reside in the furnace simultaneously.
- Delays in the rolling mill may temporarily stop or slow down the transportation in the furnace
- Variations in fuel availability and composition may occur.
- Furnaces and burners are degraded by time
- Stock item heat contents are seldom known.

In general, pusher type furnace is equipped with a recuperator and skid cooling system through which steam is produced. The produced steam is used in the mill. The flue gas transfers its heat to recuperator, which is used for preheating the cold air. The efficiency for this pusher type furnace is around 46% or 59% including the steam heat.

In the modern era of fast economical growth and global competition in steel products market, it is imperative to upgrade the design of equipment and to optimize the operational parameters in steel rolling. In the reheating furnaces, the thermal efficiency and uniform heating play an important role in reduction of energy cost and minimization of metal defects. The purpose of a reheating furnace is to provide uniformly heated slabs/blooms/billets at the discharge end of the furnace before they are rolled. It is essential to improve the efficiency of furnace by saving energy and to get higher yields, less unwanted grain coarsening and more homogeneity in the products and to obtain better thermomechanical properties of the steel. It is essential to adopt the modern heating trends/parameters/control system/technology for the better management of energy in the present scenario for faster industrialization and less resources of energy as well as eco balance.

Reheating furnaces constitute an important element of the rolling mills, in which the semi-finished steel products are heated to a desired temperature for achieving the plastic properties in the products for rolling.
The basic Purposes of heating the semi-finished metal products for rolling are:
• To soften the metal suitable for rolling.
• To provide a sufficiently high initial temperature so that rolling process is completed in fully austenitic temperature region.

In order to have smooth operation of rolling mills, design features, technology and operation of reheating furnaces play important roles. The design features and operating parameters determine the quality of rolled product, yield, energy consumption, pollution and the economics of the product. In modern reheating furnaces, semi-finished products such as slabs/blooms/billets are uniformly heated to a desired temperature and have minimum skid marks. The operations of reheating furnaces are computerized control (using PLC/DCS systems along with level 2 systems) to achieve higher energy efficiencies and to have plan view rolling.

II. THE REHEATING PROCESS
Reheating is a continuous process where the stock is charged at the furnace entrance, heated, and discharged. Energy is transferred to the stock during their traverse through the furnace by means of convection and radiation from the hot burner gases and the furnace walls. Stock charging temperature may range between 700-800°C. The target temperature for reheating is governed by the demands of the rolling process. Other Important factors are:
• Expected rolling speed,
• Steel composition
• Dimension of the stock.

Quality aspects pose constraints on surface temperatures and temperature gradients. Energy has been used in the steel process stages preceding the rolling. The material may be degraded by reheating, leading to material losses, which should be noted when the furnace efficiency is calculated. The energy wasted in lost metal includes energy for iron ore refinement, reduction, and conversion. Thus the quality of the reheating is important also from an energy point a view.

Pusher type furnace is perfect, in terms of energy use and flow management, for preheating and homogenizing milled slabs prior to hot rolling. This type of furnace has five heating zones, fired by mixed gas of c/v 2400kcal and dual fired facility also there. Their manually/semiautomatic operation, electronic functional interfacing with the hot rolling practices , and minimized energy consumption confirm the benefits of technology.

III. PRESENT TECHNOLOGY
Slabs produced by the continuous casting machine (CCM) are sent to reheating furnace and then they are transferred to the rolling mill bay. This continuation realize energy saving by transporting slabs from CCM to reheating furnace for charging, during this slabs are still at a high temperature condition (as-hot). Hot charging is a method in which the hot slab (slab still in high temperature condition) is first charged into a reheating furnace, heated, and then transported to the rolling mill.

The conventional process requires a large amount of energy because the slab is temporarily cool end, inspected for flaws and defects, conditioned, and then reheated in a heating furnace. In contrast, in hot charging, the hot slab is transported as hot to the rolling mill via the heating furnace, without passing through the cooling process. In conventional process the fuel consumption was in the range of 550 Mkal/T produced steel, while using hot charging the current fuel consumption reduced around (15%). At present Fuel unit consumption in current heating furnaces is approximately 468Mkal/t-steel. The saving in term of fuel consumption is possible because too much heating is not
necessary, as the slabs are in the hot conditions. This method became possible as a result of the development of techniques such as

- Preventing temperature drop in slabs in the continuous casting machine,
- Heat control techniques,
- Perfect casting technology by new Caster Machine No #6

However, in adopting this technology, the location where the existing CCM and rolling mill are installed in the same line and the distance between these two plants become a problem. This is because slabs are temporarily cooled and then reheated in a heating furnace in the majority of steel mills, and in many cases, the layout was designed assuming rolling of these slabs. As a result, linkage between the continuous caster and rolling mill is difficult.

<table>
<thead>
<tr>
<th>Conventional Charging</th>
<th>Hot charging</th>
</tr>
</thead>
<tbody>
<tr>
<td>From Continuous Casting Machine No. 1,2,3</td>
<td>From Continuous Casting Machine No.6</td>
</tr>
<tr>
<td>Shear, cooling, inspection, scrafing, stacking</td>
<td>Shear, then feed to plate mill roll table in the same line</td>
</tr>
<tr>
<td>Identification</td>
<td>Identification</td>
</tr>
<tr>
<td>Weighing</td>
<td>Weighing</td>
</tr>
<tr>
<td>Reheating furnace</td>
<td>Reheating furnace</td>
</tr>
<tr>
<td>Descaling</td>
<td>Descaling</td>
</tr>
<tr>
<td>Rolling process</td>
<td>Rolling process</td>
</tr>
</tbody>
</table>

The flow of hot charging and conventional charging to plate mill

**Features of pusher type reheating furnace of plate mill, BSP**

**Furnace:**
- Single or dual row charging, depending on slab size
- Flexible charging of differently sized slabs
- High convection technology for fast heating and cooling
- Highly efficient metallic-recuperative
- Temperature control based on metal temperature and numeric model data
- Heating and cooling without off-temperature currents by uniform introduction of heat flows into the recalculating furnace atmosphere
- Long-life low-friction skid systems ensuring a reliable and smooth slab transport

**Charging:**
- Manually centering tables
- Slab buffers
- Cross-transfer car for charging multiple furnaces operating in a parallel layout
- Single- and dual-row
- Pusher devices

**Discharging:**
- Extractor systems
- Cross-transfer car for unloading multiple furnaces operating in a parallel layout
- Down ender for placing slabs on the rolling mill feed table
IV. RESULTS & DISCUSSIONS
This table shows the continual improvements in the mill performance in the form of yield improvement, reduction in mill defects as well as fuel consumption by the hot charging practice.

Benefits achieved by hot charging in Pusher type reheating furnace
Three years data regarding hot charging of slabs in reheating furnaces of plate mill is as below

<table>
<thead>
<tr>
<th>Year</th>
<th>Total rolled tonnage of plate mill</th>
<th>Total Rolled Tonnage of hot charging</th>
<th>Percentage of hot charging</th>
<th>Sp. Fuel Cons Mkcal/T</th>
<th>Improvement in yield</th>
<th>Reduction in Mill Defect</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-13</td>
<td>1286824</td>
<td>413714</td>
<td>32.15</td>
<td>517</td>
<td>91.08</td>
<td>0.28</td>
</tr>
<tr>
<td>2013-14</td>
<td>1398562</td>
<td>529498</td>
<td>37.86</td>
<td>487</td>
<td>91.42</td>
<td>0.28</td>
</tr>
<tr>
<td>2014-15 up to Jan</td>
<td>1184687</td>
<td>455512</td>
<td>38.45</td>
<td>470</td>
<td>91.56</td>
<td>0.26</td>
</tr>
</tbody>
</table>

V. CONCLUSION
Today, sustained efforts for fuel reduction has become a standard method to achieve flexibility in production and saving money by hot charging. However, it appears that the steel industry has been lagging in this regard. This may be due to lack of understanding of the fundamental role of practices for sustained reduction in energy consumption. For better utilisation of this practice, production planning requirements for the continuous casting and hot rolling processes is prime requirement. The other important criteria are relations between mill scheduling, process flexibility, lead-times and work in process.

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