Performance Analysis of Reheating Furnace on Billet Heating Production of Reinforced Iron

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Abstract. Hanil Jaya Steel company is engaged in reinforcing steel fins with various deformed and according to the Indonesian National Standard (SNI). The product produced by this company is Reinforced Iron or commonly known as Esser Concrete. One of the most important processes in the manufacturing stage of reinforcing steel is the Furnace Billet Reheating process to be processed into reinforcing steel. This study aims to analyze the performance of the reheating furnace on billet production of reinforcing iron in the Rolling Mill III area of PT. Hanil Jaya Steel. This study uses the observation method. This research results that RHF heating is carried out to change the material properties, and carry out the machining process (heat treatment). The type of furnace used at PT. Hanil Jaya Steel is a pusher type, the furnace is used to heat billets measuring 150 × 150 × 6000 mm with temperatures reaching 1100 ºC - 1250 ºC. The nominal capacity of the furnace used is 30 tons/hour. The fuel used in the reheating furnace is natural gas from PGN. The process of making reinforced concrete steel, reheating furnace process is the initial process that must be carried out to change the billet into a material that is easily shaped into reinforcing steel according to SNI standards. Heating process billet is carried out by inserting billets one by one into the RHF with a temperature of up to 1100 ºC for 2 h. With this process the billet changes, which is useful for the next process, namely the rolling process.

Keywords: Reheating Furnace · Heat treatment · Billet

1 Introduction

Reheating furnace is a machine used to heat steel to a certain temperature. This heating is done to change the material properties, and carry out the machining process (heat treatment) [1]. The steel industry is one of the largest consumers of energy resources in the world. Energy for this sector is mainly provided by fossil fuels. Therefore, optimization of processes in this sector is very important to achieve the goals related to emission and greenhouse gas reduction as well as production cost reduction. In steel mills, one of the biggest energy consumers is reheating furnaces [2]. Reheat furnaces are used to raise the temperature of the steel, most of which is introduced in the form of billets or slabs, to the desired level required to process the steel in subsequent processes such

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as milling mills. This work investigates thrust-type furnaces[3]. This type of furnace is mostly heated by some of the top fuel burners, but can also be heated by burners placed below the billet/slab. Due to the high temperature in the furnace, radiant heat transfer is the dominant heat transfer mechanism. Convection only has a greater influence on the start of the furnace. Due to the high temperature, experiments on reheating furnaces are difficult and have limited significance[4].

Hanil Jaya Steel Company is engaged in fin reinforcement steel with various deforming according to the Indonesian National Standard (SNI). The product produced by this company is Reinforcing Steel or commonly known as Esser Concrete. One of the most important processes in the manufacturing stage of reinforcing steel is the Billet Reheating Furnace process to be processed into reinforcing steel. This process is very important because it is the initial process to change the shape and structure of the billet into reinforcing steel fins. On this occasion, the author will describe how "Analysis of Reheating Furnace Performance in Billet Heating Production of Reinforcing Iron in Rolling Mill III PT. Hanil Jaya Steel Area".

2 Method

The method used in this research is the method of observation, documentation, and interviews. This research activity was carried out in the rolling mill area III, Department of Mechanics, PT. Hanil Jaya Steel whose address is at Jl. Brigadier General. Katamso, Ds. Janti, District. Waru, Sidoarjo Regency, East Java 61256. In my research as the author, I was placed and focused on the reheating furnace machine.

3 Results and Discussion

3.1 Results and Discussion

Reheating Furnace Machine is a machine used to heat steel to a certain temperature[5]. Reheating Furnaces can be divided into five zones: Non-firing, charging zone, preheating, heating and damping. Energy for heating is supplied by the tangential combustion of roof and bottom gases [6].

The fireplace or itself is moving. If the grate is stationary, meaning that the material is pushed or pulled over slips or coils, or moved through the furnace by a woven wire belt or mechanical anesthetic [7].

Reheating Furnace Pusher type as shown Fig. 1 is widely used for heating rectangular plates and billets [4]. Billets are placed close to each other without any gaps. Billets are advanced by forcibly adding more billets on the inlet side. Heating of billets only occurs from four surfaces, because billets are placed close to each other without gaps. The billet slides over the water-cooled fixed skid pipe lying along the bottom of the furnace [8].

Walking beam furnaces avoid the disadvantages inherent in Pusher-type furnaces. The billet is advanced by the movement of the moving beam and the only difference in the running combustion as shown Fig. 2 is the stock placed in the fixed furnace which is a combination of the displacement and the steady section [9].

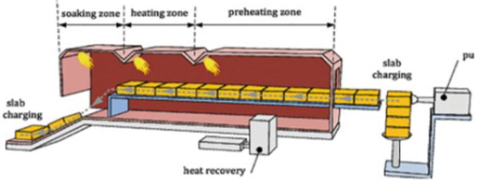

Fig. 1. Pusher Type Furnace

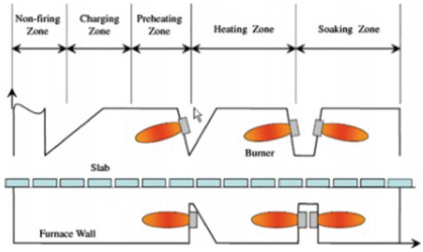

Fig. 2. Waling Beam Furnace

Fig. 3. Charging Bed

3.2 Reheating Furnace Parts

3.2.1 Charging Bed

A charging bed is a component where raw materials (billet) are placed before entering the furnace in the production process. Billets are lifted using a forklift to place on the charging bed as shown Fig. 3.

3.2.2 Main Pusher

The main pusher as shown Fig. 4 is the component used to push the billet into the reheating furnace. The billet from the charging bed shifts to the main pusher and is pushed in by the main pusher using a hydraulic working system.

Fig. 4. Main Pusher

Fig. 5. Side Pusher

3.2.3 Side Pusher

The side pusher is part of the reheating furnace which is used to push the billet out after going through the heating process to the mill line. Side pusher using a hydraulic system as shown Fig. 5.

3.2.4 Skid Rail

Skid rail/skid pipe is a reheating furnace component that is used to support billets when they are in the furnace. A skid rail is a base made of iron pipe with one side flat. The skid rail as shown Figure 6 is lined with castable, glass wool, and flint, and inside it is fed by water which serves to hold the skid rail from breaking or melting because the temperature inside the reheating furnace reaches 1100ºC.

3.2.5 Burner

The burner as shown Fig. 7 is the main component used for combustion, the burner functions to regulate the mixture of air and fuel gas continuously [10].

Fig. 6. Skid Rail

Fig. 7. Burner. Source: Personal Documentation

Fig. 8. Recuperator

3.2.6 Recuperator

Recuperator as shown Fig. 8 is a part that functions to improve efficiency in the combustion system. The recuperator's working system is to heat room temperature air (36-38 ºC) which is supplied from the blower to the burner [11].

3.2.7 Blower

The blower as shown Fig. 9 is a component that is used to suck air which will be flowed through the recuperator and be used for combustion in the reheating furnace. The blower used at PT. Hanil Jaya Steel is a centrifugal blower with a rotation speed of 250 rpm.

Fig. 9. Blower

Fig. 10. Chimney

3.2.8 Chimney

The chimney as shown Fig. 10 is a component that serves to remove smoke from the combustion process in the reheating furnace [12]. The temperature in this chimney reaches 600 °C. The chimney has another function, namely as a filter of the materials contained in the combustion smoke.

3.3 Reheating Furnace Work System

The following is the working mechanism of the billet heating process in a reheating furnace:

1) Starting from the flow of gas in the form of liquefied natural gas (LNG) with a pressure of 2 bar and a flow rate of 122 Nm^3/hour for the upper burner and a discharge of 280 Nm^3/hour for the lower burner, it is flowed from the source through a pipe with each pipe to the nozzle of each burner.
2) Air flow is supplied through the blower and heated through the recuperator before mixing with the LNG gas in the burner.
3) Gas flow and air flow mix on the burner in a ratio of 1:10.
4) In the RHF, water flows from the water treatment through pipes and is channeled into the skid rail to help cool the skid rail as a support billet in the RHF.
5) The billet journey starts from the charging bed, the billet above the charging bed is brought to the entrance of the RHF. Then the billets are pushed in by the main pusher one by one until the billets reach the final warm-up.

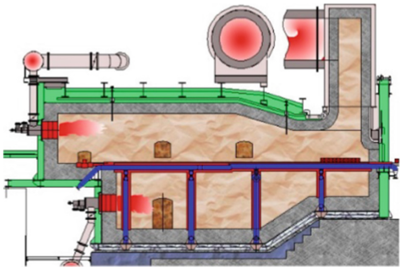

Fig. 11. Heating Zone. Source: PT. Hanil Jaya Steel

Table 1. Reheating Furnace Temperature Settings

Zones	Input	Output
Heating Zone	600 ºC	1100 ºC
Soaking Zone	1150 ºC	1250 ºC

6) The billet reheating process runs for 2 h, because the engine capacity is RHF 30 ton/hour, the capacity can accommodate 65 billets.
7) Billets that have reached the final heating are pushed out with a side pusher to the rolling process.

Reheating furnace at PT. Hanil Jaya Steel consists of two heating zones:

1) Heating Zone
   The heating zone as shown Figure Figure 11 is the preheating zone where new billets enter RHF [13]. This zone is used to help heat the billet so it doesn't take too long in the heating process.
2) Soaking Zone
   The soaking zone is the final heating zone where the billet distance is close to the burner so that the billet temperature will rise until it reaches the set temperature, which is in the range of 1150º - 1200ºC as shown Table 1 [14].

Arrangements by the operator are carried out in the reheating furnace control room. If the temperature exceeds the set point limit, the alarm will sound [15].

Example of set point temperature in reheating furnace:

3.4 Trouble and Maintenance on Reheating Furnace

3.4.1 Material is not Fully Cooked

Immature billet material is billet material that comes out of the reheating furnace and has not reached the ideal temperature set to enter the first roll stand, this material cannot be forwarded to the rolling process and must be separated to avoid damage to the standing

Fig. 12. Skid Rail Pipe

roll and minimize workplace accidents. The following are the causes of the material not being perfectly cooked:

a. There was a problem in the mill line area so the RHF room temperature was lowered for the problem-solving process in the mill line area.
b. The billet has passed through the flame from the burner so that the billet does not receive heat from the burner.

The following maintenance is carried out in the reheating furnace area:

1) Checking the skid rail in the RHF room.

The skid rail is a very vital component in the reheating process, the skid rail serves to support the billet when it is in the RHF room. Skid rail checks are carried out every time the production process stops.

2) Replacement of refractory masonry in skid rails and RHF rooms.
   Refractory stone as shown Fig. 13 is a heat retaining insulator on the skid rail as shown Fig. 12, its function is to keep the pipe from being heated so that the pipe is maintained and able to support the billet.

3) Castable replacement on skid rail lining.
   Castable as shown Fig. 14 is a component such as liquid cement whose function is almost the same as flint, which is to withstand heat radiation.

4) Cleaning the remaining combustion residue in the RHF room.
   This process is carried out to clean the dirt and debris from the combustion and debris from the skid rail repairs and the installation of flint.

Fig. 13. Refractory Stone

Fig. 14. Castable

3.5 Furnace Efficiency Calculation

Furnace efficiency can be determined using the direct method of measurement, i.e. measuring the amount of heat absorbed by the stock and dividing it by the total amount of fuel used as shown in Eq. (1).

$$Furnace\ eff. = \frac{Tot.\ Energy\ Output}{Tot.\ Energy\ Input} \times 100\% \tag{1}$$

To find out the amount of energy transferred to the stock can use the following Eq. (2):

$$Q = m \times Cp \times (T2 - T1) \tag{2}$$

Information:
Q = Hot quantity in stock (kKal).
m = Stock weight in (kg).
Cp = Average stock type heat (kKal/kg°C).
T1 = Initial Temperature (°C).
T2 = Final Temperature (°C).

3.6 Types of Heat Loss in the Furnace

To achieve good furnace efficiency, we need to know about the heat loss that occurs, the following are the types of heat loss in the furnace:

1) Loss of exhaust gas
   The flue gas loss is part of the heat in the combustion gases inside the furnace. This loss is also known as waste gas loss or flue gas loss to the chimney.
2) Loss due to hydrogen content
   This heat loss is caused by the formation of water content in combustion.
3) Lost through the entrance and exit of the RHF
   The process of opening and closing the furnace door results in the release of heat radiation in the furnace.
4) Heat loss from the furnace wall
   This heat loss is caused by the furnace lining walls which are not able to withstand radiation, thus emitting heat out.
5) Loss from incomplete combustion
   Incomplete combustion causes heat to be lost because unburned fuel or particles absorb heat.
6) Heat loss from the cooling medium
   The water cooling medium is used to keep the skid rail from breaking or burning, this cooling medium also absorbs heat.

4 Conclusion

Based on research that has been done at PT. Hanil Jaya Steel it can be concluded that in the process of making reinforcing steel, the reheating furnace is the initial process that must be carried out to change the billet structure into a material that is easily shaped into reinforcing steel according to SNI standards. The billet heating process is carried out by inserting the billets one by one into the RHF with a temperature of up to 1100ºC for 2 h. With this process the billet structure changes, it is useful for the next process, namely the roll process.

Authors' Contributions. AFS contributed writing, IMA correcting and SS editing.

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