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Assessment of Losses of Reheating Furnace in a Steel Re-Rolling Mill

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Abstract

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 a 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. For most heating equipment, a large amount of the heat supplied is wasted in the form of exhaust gases.

Keywords: Steel plant, Energy Efficiency, Furnace, Reheating Furnace, losses, SRRM.

INTRODUCTION

Reheating Furnace is an equipment to heat materials for change of shape (rolling, forging etc.) or change of properties (heat treatment). Furnaces must be designed and operated to achieve:

- A desired production rate
- Acceptable product quality (e.g. temperature uniformity in steel slabs, time at temperature in brick kilns)
- Maximum thermal efficiency
- Pollution emissions (e.g. NO_x) within acceptable or legal limits.

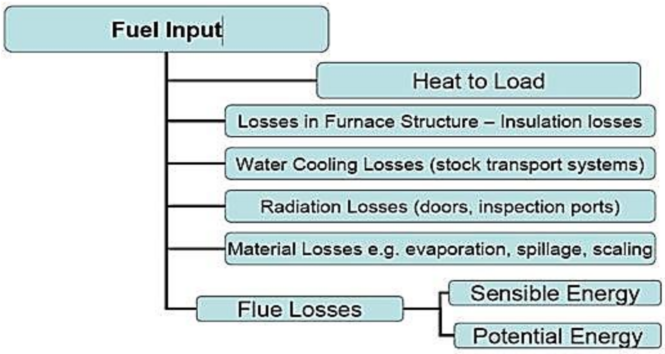

Figure 1:- Losses in furnaces

Because of their high temperature, furnaces are large users of fossil-fuel energy. The above simple diagram lists the main losses on a typical furnace. Flue gases are usually main source of wasted energy.

The present study evaluates the losses evaluation of reheating operation of steel in the reheating furnace at XYZ steel plant.

LOSSES IN FURNACE

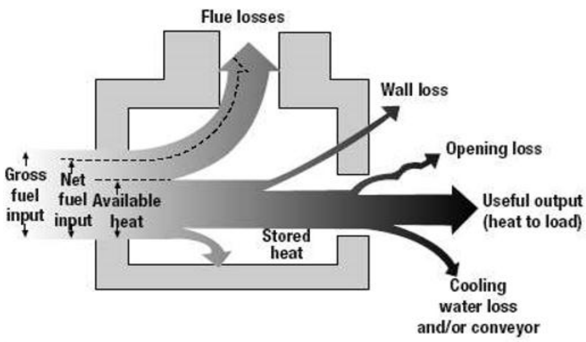

Figure 2:- losses diagram of a furnace

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A. Flue Gas Losses:

Flue gases represent the main energy loss on furnaces because of their high temperature [1]. Sensible losses as a percentage of net heat input can be estimated from the following graph for different percentage levels of excess air.

B. Wall losses

Wall or transmission losses are caused by the conduction of heat through the walls, roof, and floor of the heating device [2].

C. Cooling Media Losses

Cooling protects rolls, bearings, and doors in hot furnace environments, but at the cost of lost energy. These components and their cooling media (water, air, etc.) become the conduit for additional heat losses from the furnace [3].

D. Air infiltration

Excess air does not necessarily enter the furnace as part of the combustion air supply. It can also infiltrate from the surrounding room if there is a negative pressure in the furnace. Because of the draft effect of hot furnace stacks, negative pressures are common, and cold air slips past leaky door seals and other openings in the furnace.

E. Radiation (opening) losses

Furnaces and ovens operating at temperatures above 1,000°F might have significant radiation losses. Hot surfaces radiate energy to nearby colder surfaces, and the rate of heat transfer increases with the fourth power of the surfaces absolute temperature [4].

F. Water losses

Water flow rate, temperature difference between water in and out, etc.

G. Wall, hearth and roof losses

Outside area of furnace, thickness and thermal properties of refractory and insulation, surface

Temperature, etc.

H. Atmospheric losses

Temperature difference between in and out

Atmosphere and atmosphere flow rate.

CASE STUDY

There are total 8 furnaces installed in the plant XYZ. Out of these eight, 2 are electric arc furnace while rests are fuel fired. Furnaces installed in the plant are[5]:-

Table 1:-Furnaces installed in the Plant

Location /Furnace	Nos
Stackle Mill	2
Strip mill	1
Annealing furnace	1
Finishing furnace	1
Boggie furnaces	1

To evaluate the losses of reheating operation of steel in the reheating furnace at XYZ steel plant, we have restricted our study to Stackle mill only.

Stackle mill has 2 furnace, walking beam & Preheating Furnace. Fuel used for furnace is LPG & LVFO/HSD, depending upon the different grades. Detailed description of fuel, raw material specifications & Recuperator are as follows:-

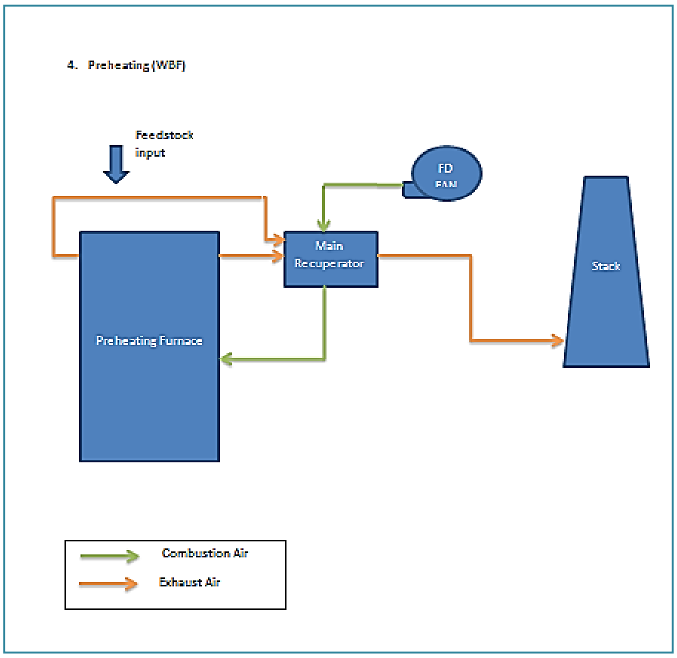

Figure 3: Block diagram of preheating furnace

Specifications

Table 2: description of furnaces of Stackle mill

S.No	Description	Unit	Flat	JBS
1	*Type of Fuel Used in Furnace*		FO	LVFO / HSD
2	*Cycle Time*			
	Productivity	MT/Hr	45	12
	Coil to Coil Gap	Min	2	6
3	*Raw Material Specification*			
	Bloom Size (T X W X L)	mm	200X200X5050	200X260X3350
	Bloom Weight	MT	1.53	1.33
	Bloom Size (T X W X L)	mm	200X260X5050	
	Bloom Weight	MT	2.00	
4	*Recuperator Data*			
	Inlet	^{0}C	550-630	630-700
	Outlet	^{0}C	180-210	200-220
	Hot Air	**^{0}C**	**280-350**	**330-400**

Furnace operating parameters are as follows:-

Table 3: furnace-operating parameters of Stackle mill

Furnace Operating parameters						
Grade	Zone Wise Temp (^{0} C)					Holding (Hrs.)
	THZ A	THZ B	BHZ	TSZ A	TSZ B	
Flat	1190-1220	1190-1220	1080-1110	1200-1220	1200-1220	3 to 5
JBS	1250-1270	1260-1280	1235-1255	1250-1270	1260-1280	8 to 9:30

Table 4: Blower details of Stackle mill

	PHF		WBF	
	Comb. Blower	**Atomiz.**	**Comb Blower**	**Atomiz.**
No Of Blower Installed	2		3	
No Of Blower Running at one time	1	Comp. air	2	Comp. air
Flow (NM3/Hr)	29000		9.86 m3/sec	
Flow in M3/Sec	7.3		9.86	
Flow in NM3/Hrs.	29000		39166	
Pressure (mmwc)	900		1000	
Motor	132 kW		132 kW	
RPM	1470		1480	

Calculations for Re-heating Furnace

In order to calculate the performance of the preheating furnace we take in to consideration the following [6][7]

Furnace Specifications

Table 4: Specifications for preheating furnace

Sr. No	Parameter	Units	Value
1	Capacity	TPH	150
2	Dimensions:		
	Length	m	15.5
	Width	m	11.9
	Height	m	2.5
3	Steel Grade		JT1250
4	Fuel Used		LDO
5	Feed-in Temperature	ºC	70
6	Feed-out Temperature	ºC	500
7	Ambient Air Temperature	ºC	38
8	Hot air Inlet Temperature	ºC	273
9	Recuperator Inlet Temperature	ºC	497
10	Flue gas outlet Temperature	ºC	340

Fuel Consumption

Fuel consumption of the Furnace was 727 kg/Hr**.**

Table 5: Fuel Consumption

Fuel Reading		
Fuel	Units	Meter Reading
LDO	Kg / hr	727

Surface Temperatures

Temperatures had been measured using IR & Thermal Imager.

Table 6: Measured Surface Temperature

Sr. No	Surface temp	Units	Mini mum	maxi mum	Avg.
1	Right wall	degree C	75	146	105
2	Left wall	degree C	50	113	92
3	Roof	degree C	58	70	66
4	Front wall	degree C	53	162	70
5	Back Wall	degree C	152	263	202

Efficiency of Furnace

Calculated Efficiency using various formulas [8] of the furnace was 27 %**.**

Table 7: Efficiency of furnace

Parameter	Units	Value
Actual Fuel Consumption (Measured)	kg/Hr	727
Cycle time of furnace	Hr	2
C.V. of Fuel(L.D.O.)	kCal/kg	10600
Initial Temperature of Bloom	ºK	343
Final Temperature of Bloom	ºK	773
Temperature Difference	ºK	430
Cp of Bloom	kJ/kg.K	0.45
Slab quantity in furnace	Nos.	8
Net Weight of Feed stock in furnace	kg	89759
Heat output (Q)	kCal	4155112
Fuel consumption for cycle	kg	1454
heat input	kCal	15412400
Efficiency	**%**	**27%**

Radiation Losses calculation

The radiation loss can be calculated by knowing how much of heat is lost in the form of radiation [9]

Table 8: Radiation losses of Furnace

Parameter	Units	Value
Ambient temperature	ºK	313
Total Surface Area of the furnace		
Right wall	m^2	38.75
Left wall	m^2	38.75
Ceiling	m^2	184.45
Front wall	m^2	29.75
Back wall	m^2	29.75
Average wall temperature		
Right wall	ºK	378
Left wall	ºK	365
Ceiling	ºK	339
Front wall	ºK	343
Back wall	ºK	475
Emissivity of external wall surface	E	0.75
Right wall		
Losses through right wall	kCal/hr/m^2	802
Overall heat losses through the right wall	kCal/hr	31076
Left wall		
Losses through left wall	kCal/hr/m^2	606
Overall heat losses through the left wall	kCal/hr	23464
Ceiling		
Losses through Ceiling	kCal/hr	296
overall Losses through Ceiling	kCal/hr	54685
Front wall		
Losses through front wall	kCal/hr/m^2	310
Overall heat losses through front wall	kCal/hr	9216
Back wall		
Losses through back wall	kCal/hr	2783

overall Losses through back wall	kCal/hr	82806
Overall heat losses through surface	kCal/hr	201247
Energy input to furnace	kCal/hr	7706200
losses through radiation	**%**	**2.6%**

Thus, the radiation losses of the furnace was calculated as 2.6% only.

Flue gas losses

In most cases these account for the majority of the losses in the furnace [10] and it can be see below in our case too

Table 10: Radiation losses of Furnace

Parameter	Units	Value
FG Temp	ºK	833
Allowable stack Temp	ºK	473
flow rate	kg/hr.	1526
Specific Heat	kJ/kg.K	1.17
Waste Heat Potential	kCal/hr	2691199
operational hours	hr.	24
operational Days	days	320
Annual waste heat saving potential	MCal/Annum	8267364
Flue gas Losses	**%**	**35**

Flue gas losses was 35%, which was highest of all losses hence proving to be the area of major losses.

DISCUSSION

This assessment of energy found the following areas of efficiency improvement [11].

A. *Waste heat recovery*

The flue gases coming out from the reheating furnace contain substantive amount of heat energy, which can be reused.

B. *Load Preheating*

The billets are loaded in the furnace at ambient temperature, so heat is required for initial heating of that billets. The sensible heat going out of the stack along with flue gases can fulfill this heat requirement.

C. *Preheating Combustion Air*

Combustion air can be preheated in the recuperators by using heat from waste gases from the furnace. This reduces fuel consumption thus reducing the environmental impacts [12] and it also increases flame temperature and improves furnace efficiency.

D. *Proper maintenance of the furnace*

As observed at XYZ Plant there is lack of maintenance inside the furnace. At the shutdown period there are too many cracks and erosions observed on the refractory lining made by 60% alumina brick(fire clay bricks) at the inside wall of the furnace. To overcome losses due to the lack of maintenance the 90% high alumina castable can be used to fill the cracks so that heat transfer must be resisted from inside to the outside wall of the furnace.

E. *Proper utilization of Control system*

In the reheating process, furnace pressure and temperature control have significant effects on energy efficiency improvement. The negative pressure inside a reheat furnace can cause ambient air to enter into the reheat furnace, which needs extra energy to heat the leakage air to flue gas temperature. Furnace pressure controller can keep a positive pressure in the furnace chamber to reduce atmosphere losses.

CONCLUSION

The energy efficiency reported was 27 %. The flue gases loss is reported to be 35 %, which is the largest among all accounted losses during the operation.

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