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Research Paper

Secondary steel mill furnace performance

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Abstract

Energy in a steel re-rolling mill is mainly consumed in furnaces. Therefore, furnace performance is very important and its contribution in the cost of product is very high. Data has been collected for two different furnaces in Stackle mill and analyzed for performance of furnace. In this paper, effect of furnace performance on secondary steel sector is analyzed. These data about performance is collected on Walking beam furnace in Stackle mill and Re-heating furnace,

Keywords: *Furnace, Efficiency, performance, steel mill, secondary steel*

1. Introduction

India is having ample steel re-rolling mills spread across the country. In today's scenario, Infrastructure growth at fast pace is need of the country and Infrastructure requires steel products in various form. Therefore, India's Secondary steel sector is very important. Approximate 3500 SRRM are running across the country and these consume good amount of energy for rising the temperature of furnace to bring the temperature to 1100 degc. Major energy consuming equipment in steel re-rolling mill is Re-Heating furnace. Data is collected at a steel mill in Haryana, India for the testing of performance of furnaces. At the time of data collection, installed capacity of this plant was 4.30 lacs metric ton and annual consumption of this steel mill is 186 GWh.

2. Energy data collection approach

The targeted data collection and energy auditing [1] is performed in following five steps

2.1. Past data & specifications / parameters

For this, mainly manual / specifications provided by original equipment manufacturer (OEM) has been referred

2.2. Instruments required

Furnace temperature is kept above 1100 deg C. Therefore, High temperature Infrared thermal scanners and imagers are used for monitoring of running parameters.

2.3. Data collection and measurements

Various temperature and heat related data has been collected and running parameters are measured for calculation of heat losses.

2.4. Data analysis & report preparation

Data is collected for two furnaces and analysed using Sankey's diagram. Detailed report is prepared for this data collected.

2.5. Final report submission

Final report with heat loss calculations is prepared and submitted. The suggestions for performance improvement also has been advised.

3. Process flow and equipment description

The process flow for thermal equipment [2] was under analysis. The list of main thermal equipment installed in this plant are:

1. Steel Melting Shop-1
2. Steel melting Shop-2
3. Furnaces
    a. Pre-heating Furnace (PHF)
    b. Walking Beam Furnace (WBF)
    c. Annealing furnace
    d. Strip mill furnace
    e. Boggie furnace
4. Finishing mill
5. Cooling Tower
6. Oxygen plant

3.1. Process Flow

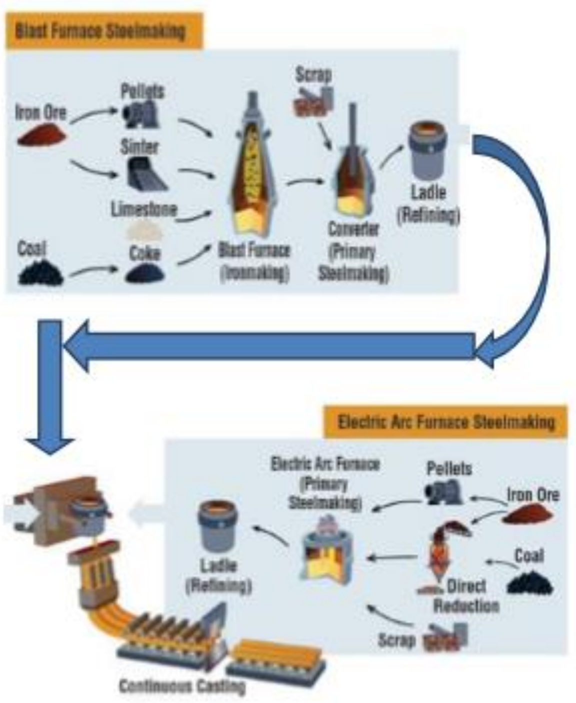

Fig. 1: Steel manufacturing process

Integrated Steel plants are firstly processing the Ore at high temperature and Blooms / Ingots are formed out of molten steel. Then it is taken to secondary steel sections for Re-shaping to desired format of product. It is known as steel re-rolling mill[3].

Furnace is equipment used to rais the temperature of steel products to 1100 – 1200 deg C. then the products are rolled to give the desired shape. There are variety of furnaces available. There are eight furnaces installed in the plant under observation. Those are:

1. Strip mill furnace - 1no.
2. Stackle mill furnace - 2 no.
3. Annealing Furnace - 1 no.
4. Finishing Furnace - 1no.
5. Boggie Furnace - 1no.

Stackle mill is having two furnaces. Out of these two, one is walking Beam Furnace (WBF) and another one is Pre-heating furnace (PHF). The fuel in these furnaces are LPG & LVFO respectively.

Details of Stackle mill are as follows:

Table 1: Stackle mill Specifications

S. No	Description	Unit	Flat	JBS
1	Type of Fuel		FO	LVFO / HSD
2	Cycle Time			
	Productivity	T/Hr	45.0	12.0
	Cycle	Sec	120	360
3	Raw Material			
	Bloom Size (T X W X L)	Cm	2*2*50.5	2*2.6 *33.5
	Bloom Weight	Kg	1530	1330
	Bloom Size (T X W X L)	Cm	2*2.6*50.5	---
	Bloom Weight	Kg	2000	---
4	Recuperator parameters			
	Inlet	ºF	1022 - 1166	1166-1292
	Outlet	ºF	356 - 410	392 - 428
	Hot Air	ºF	536 - 662	626-752

4. Pre-heating furnace

The furnace specifications of Pre-heating furnace in Stackle mill are as follows:

Table 2: Pre-Heating Furnace Specifications

S.No	Parameter	Units	Value
1	Installed Capacity	Ton/Hr	150.00
2	Furnace Dimensions:		
	Length	Cm	15500
	Width	Cm	11900
	Height	Cm	2500
3	Steel Grade		JT1250
4	Fuel		LDO
5	Feed-in Temperature	ºF	158
6	Feed-out Temperature	ºF	932
7	Ambient Air Temperature	ºF	100
8	Hot air Inlet Temperature	ºF	523
9	Recuperator Inlet Temperature	ºF	926
10	Flue gas outlet Temperature	ºF	644

4.1. Pre-Heating Furnace Process Flow

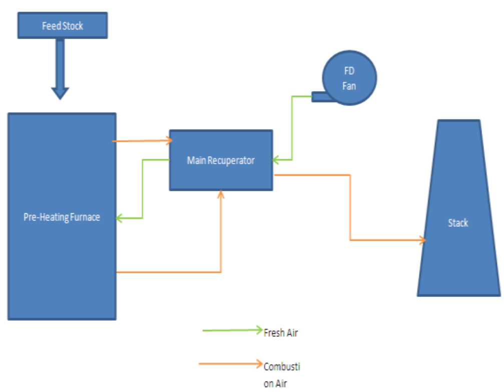

Fig. 2: Pre-Heating furnace process flow

4.2. Pre-Heating Furnace Fuel consumption

Month wise fuel consumption in the Pre-Heating

Furnace of Stackle mill is as follows:

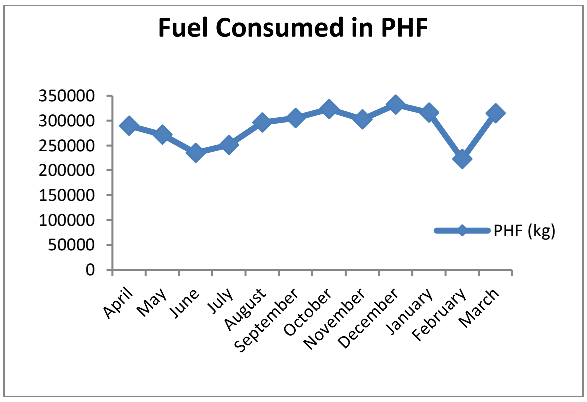

Fig. 3: Pre-Heating furnace Fuel consumption

4.3. Heat losses in Pre-Heating Furnace

Fuel Consumption = 0.727 T/Hr
Cycle time of furnace = 120 minutes
C.V. of Fuel (L.D.O.) = 10.6 MCal/kg
Heat Input = m*GCV*Cycle time
= 727*10600*2
= 15.41 G Cal
Initial Temperature of Bloom = 343 ºK
Final Temperature of Bloom = 773 ºK
Slab quantity in furnace = 8 Nos
Cp of Slab = 450 J/kgK
Net Weight of Feed stock in furnace = 160.21 Ton
Heat output (Q) = m* Cp*ΔT
= $160.21 \times 10^{3} * 450 \times 10^{-3} * (773-343)$
= 7.41 G Cal
Therefor thermal loss is:
Heat Input-Heat Output
=15.4 G Cal -7.41 G Cal
= **8.0 G Cal**

Pre-Heating Furnace Efficiency percentage
= (Heat Output/Heat Input)*100
= (7.41 /15.41) *100
= **48.08 %**

4.4. Flue gas loss saving potential

Table 3: Pre-Heating Furnace losses

Flue gas Waste Heat Potential		
Parameter	**Units**	**Value**
Flue Gas Temperature	ºC	560.0
Recommended stack Temp	ºC	200.0
Flue gas flow rate	T/hr	11.0
Specific Heat of Flue gas	kJ/kg degK	1.17
Waste Heat recovery possible	GCal/hr	19.48
operational hours	hrs	24
operational Days	days	320
Annual waste heat saving potential	**GCal/Annum**	**59838.86**

Hence, thermal energy loss of **59.8 x 10^{9} Kcal /annum** may be saved by using waste heat recovery devices. Hence, efficiency of PHF will improve accordingly [6].

4.5. Sankey's diagram of Flue gas

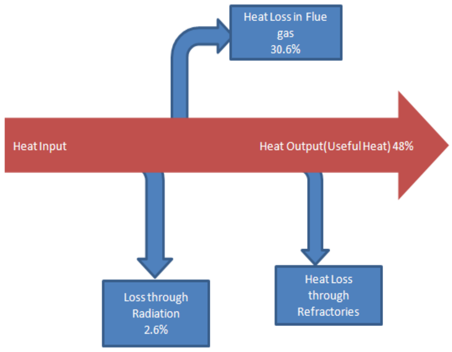

Fig. 4: Pre-Heating furnace Sankey's diagram

5. Walking Beam Furnace

5.1. Walking Beam Furnace Process Flow

The schematic process flow diagram of a typical walking beam furnace [4] is

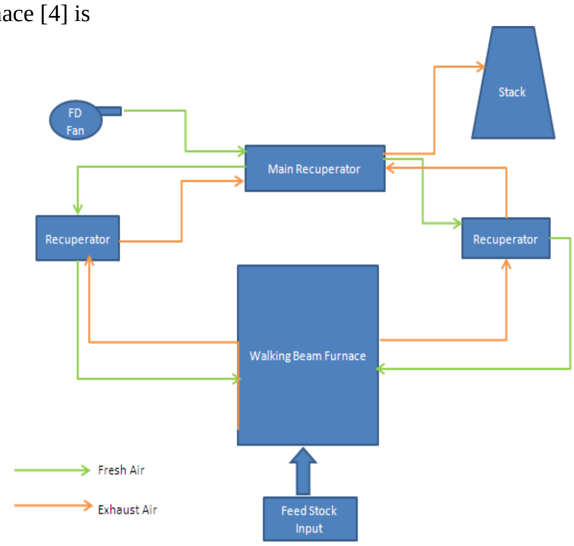

Fig. 5: Walking Beam furnace process flow

5.2. Walking Beam Furnace Fuel consumption

Month wise fuel consumption in the Walking Beam Furnace of Stackle mill is as follows:

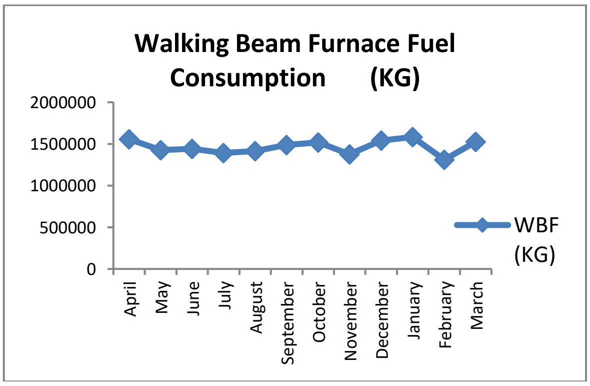

Fig. 6: Walking Beam furnace Fuel consumption

The burner specifications in this Stackle mill are:

Table 4: Stackle mill burner specifications

Area		Location	No of Burner Installed	Burner Model No
STACKEL MILL	*PHF*	*Side Wall*	3 + 3	1201-100
	WBF	*Heat Zone*	10 + 8	1201-250
		Soaking Zone	10 + 7	1202-200

5.3. Heat losses in Walking Beam Furnace

No process is 100% perfect; some losses are certain in the process [6]. The heat loss of walking beam furnace are:

Fuel Consumption = 1054.00 Nm^3/Hr
Cycle time of furnace = 210 minutes
C.V. of Fuel (L.P.G.) = 25.77 MCal/Nm^3
Heat input = m*GCV
= 1054.00 * 25.77 * 210
= 95.08 G Cal

Initial Temperature of Slab = 1009 ºC
Final Temperature of Slab = 1543 ºC
Slab quantity in furnace = 14 Nos
Cp of Slab = 450 J/kg deg K
Net Weight of Feed stock in furnace = 248.15 Ton
Heat output (Q) = m* Cp*ΔT
= $248.15*450x10^{-3}*(1543-1009)$
= 14.26 G Cal

Therefore, the total difference in heat input and output is the loss and the quantity of loss =

Heat Input-Heat Output
= 95.08 G Cal -14.26 G Cal
= **80.82 G Cal**

This is the heat loss due to Flue gas. The efficiency of furnace is

Efficiency % = (Heat Output/Heat Input)*100
= (14.26 / 95.08)*100
= **14.97 %.**

The efficiency of this furnace is very low. These losses may be reduced by recovering the heat from flue gas [7]. Therefore, the waste heat recovery techniques [6] should be applied to the system so that the heat loss in flue gas is reduced and efficiency of furnace is improved [8].

5.4. Radiation losses in Walking Beam Furnace

Table 5: Radiation losses in Walking Beam Furnace

Surface Radiation Losses Of WBF		
Parameter	**Units**	**Value**
Ambient temperature	ºC	40
Total Surface Area		
Right wall	Cm^2	776400
Left wall	Cm^2	776400
Ceiling	Cm^2	1659200
Charging door	Cm^2	120000
Discharging door	Cm^2	120000
Average skin temperature		
Right wall	ºC	175
Left wall	ºC	150
Ceiling	ºC	215
Charging door	ºC	182
Discharging door	ºC	245
emissivity of external wall surface	E	0.75
Right wall Losses		
Heat losses through the right wall	G Cal/hr	0.165793
Left wall Losses		
Heat losses through the left wall	G Cal/hr	0.124551
Ceiling Losses		
Heat Losses through Ceiling	G Cal/hr	0.581814
Charging door Losses		
Heat losses through charging door	G Cal/hr	0.027549
Dis-Charging door losses		
Heat Losses through discharging door	G Cal/hr	0.047884
Overall heat losses through surface	**G Cal/hr**	**0.947592**
Energy input to furnace	**G Cal/hr**	**27.166850**
% losses through radiation	**%**	**3.48%**

Radiation losses through surface of furnace are only 3.48%. Still these may be reduced by proper insulation of furnace. This may require replacement of refractory or insulation.

5.5. Flue gas waste heat recovery in this Furnace

The furnace efficiency comes out as 14.97% only. Major heat loss in furnace is through Flue gas loss [9]. This may be recovered through appropriate recuperator and other waste heat recovery equipment [10].

Table 6: Waste Heat Recovery potential of flue gas

Flue gas Waste Heat Potential		
Parameter	**Units**	**Value**
Flue Gas Temperature	ºC	461
Recommended Temp	ºC	200
Flue gas flow rate	T/hr	36
Specific Heat	kJ/kg deg K	1.17
Waste Heat Potential	G Cal/hr	46.20
operational hours per day	Hrs.	24
operational Days	days	320
Waste heat saving potential per annum	**G Cal/Annum**	**141945.8**

5.6. Sankey's diagram for walking beam furnace

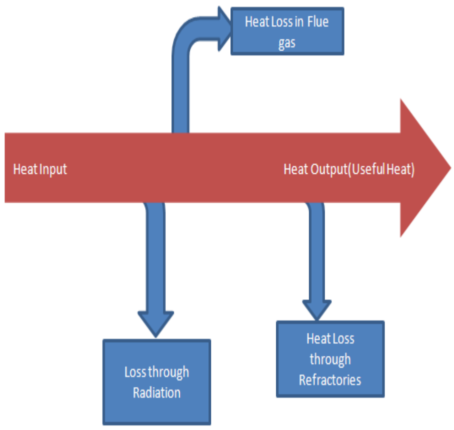

Fig. 7: Sankey's chart Walking Beam furnace

6. Conclusion

After The analysis of the Stackle mill, we observed that the efficiency of the walking Beam furnace installed in the plant is very low (15% only). The reason for low efficiency is mainly excessive

flue gas losses. In addition to this, there are radiation losses 9Surface heat losses) are approx. 3.5%. The energy saving potential from flue gases of this furnace is 1, 41,945 G Cal per annum.
The efficiency of Pre-Heating furnace is 48%. While still there is a thermal loss saving potential of 59,838 G Cal per annum.
Installation of appropriate waste heat recovery devices [11] for recovery of heat is strongly recommended and can improve the efficiency of furnaces. Similar energy conservation measures [12] may be deployed to other furnaces across the steel Re-rolling mill sector.

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