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Energy Management of Stove in Pig-Iron Plant

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ABSTRACT: *A study was conducted in one of the pig iron plant to prime objective explore potential for energy saving. A detailed technical study on the site measurement were conducted the detailed energy & material balance of entire pig-iron production process presented in the paper. This paper describes the model- based control and estimation techniques for energy management of stove and blower house in pig-iron plant. This estimated parameter is then used by the model based controller to determine the minimum fuel required for subsequent regenerative cycle. The stove is regenerative type recuperater and uses the gas from blast furnace to stove to generate heated gas. In case of blower house the plant use the blower house building which energy consumption is very high as compare to out-put of blowing air to stove. This paper gives the energy management about the blower house and also reduces the losses in pig-iron plant. That energy management improves the production capacity.*

Keywords - *3- Phase power meter, Single phase power meter, Anemometer, Ultrasonic Non- Contact flow meter, Data control system (SCADA)*

I. INTRODUCTION

A blast furnace is used to produce molten iron oxides, coke and flux. One of the major sources of energy for this process is the sensible heat coming from the preheated air, referred to as blast air that is injected into the furnace. This air is preheated in tall, cylindrical, refractory-filled thermal regenerators called hot blast stove. Each stove goes through alternate cycles of heating and cooling referred to as 'on-gas' and 'on-blast' cycles respectively. During the on-gas cycle, the stove is heated by the combustion of fuel gas, in the combustion chamber of the stove, and then descends down through a series of hollow refractory bricks referred to as the checkers. For the on-blast cycles the flow through the stove is reversed. Blast air passes up through the checkers, where it is heated, enters the dome, and then proceeds downward into the combustion chamber before exiting the stove. The temperature of the blast air is controlled by diverting a fraction of the inlet air directly into the combustion chamber to mix with the heated air. [1]. The methodology for energy audit was followed as suggested in references [2] and [3].

II. LITERATURE SURVEY

1) James Beaumont Neilson previously foreman at Glasgow gas works invented the system of preheating the blast for a furnace. He found that by increasing the temperature to 300 degrees Fahrenheit, he could reduce the fuel consumption from 8.06 tons to 5.16 tons with further reductions with higher temperatures.[4]

2) In regenerative heat exchanger such as the Cowper (which preheats the blast furnace to this day) and in the open hearth furnace (for making steel) by the Siemens-martin process.[5]

3) Nevertheless, early hot blast stove were troublesome, as expansion and contraction were liable to cause breakages in the pipe. This was to some extent remedied by supporting the pipes on rollers. It was also necessary to devise new method of connecting the blast pipe to the tuyeres as leather could not longer be used for making the connection.[6]

III. DATA COLLECTION

1 Hot Blast Stove

The function of hot blast stove is to preheat the air before admission into the furnace through tuyere. Air is preheated to temperatures between 1,000 and 1,250^0 C in the hot blast stove. There are 3 stoves for blast furnace. Each stove consists of a combustion chamber and refractory checker brickwork. Combustion chamber lined with fire bricks and checkers are by alumina brickwork.

Fig 1. Hot Blast Stove

2 There are two cycles in the stove operation

2.1 On- Gas: Stove in heating mode.

2.2 On Blast: Stove in the blast mode.

In the first cycle the stoves are getting heated by using bf gas or coke oven gas for 35min. the flue gases (200^{0}C) will be carried out through the chimney. This stage is called 'On Gas'.

When the dome temperature reaches to the desired level (900^{0}C) the gas is stopped and cold blast that is coming from the power and blowing station is sent through the cold blast valve. This cycle is called 'On Blast'. The sensible heat that is stored the checker brickwork is carried away by the cold blast and is getting heated. Thus hot blast is produced and this blast is sent into the cold blast furnace via hot blast main, bustle pipe, compensator, tuyeres stock and to the tuyeres. 'On blast' will continue for 1-1.30 hour and will be followed by
'on gas' cycle. Thus at any point of time one or two stoves are kept 'on blast' and two stoves are 'on gas' the cycle is repeated continuously. Heated stove kept isolated, as ready for on blast cycle.

The hot blast reacts with coke and injectants, forming a cavity, called raceway in front of the tuyeres. A snort valve is located on the cold blast main, regulates the volume of blast. The steam is injected for the humidification of the blast before pre-heating in the stove. Oxygen enrichment is also done whenever necessary through the blast itself. A mixer valve regulates the hot blast temperature.[1]

3 Heat Recovery from Stack Gases in Stove

There are three number of stove, out of which 2 numbers of stoves are always on gas firing and one number of stoves is on air.

These stoves are regenerative type recuperate. When the stove is under firing mode, the BF gas burns and heats the refractory inside the stove for certain time. In the next cycle, firing is stopped and fresh heated air is passed through the same stove which heats the air, which is being supplied to BF furnace. The sequence of stove being on gas firing mode and on air continues round the clock. Blast furnace gets heated air continuously all the time.

[1]

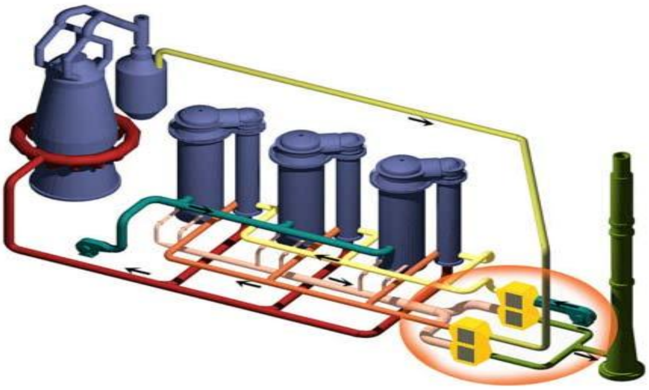

Fig 2 .Animated process diagram of stove and blast furnace

4 Observation

Stove on Gas firing mode –

1) Temperature of air being supplied for combustion of BF gas : 200^0C
2) Quantity of air being supplied for combustion of BF gas : 5,200 cum/h =6656kg/h
3) Temperature of BF gas being supplied : 200^0C
4) Quantity of gas being supplied : 7,700cum/h = 10,472kg/h

4.1 Input Material & Energy per Stove

TABLE 1: Input Material & Energy Per Stove

Material	Quantity	Temp, Entering °C	Heat in kj/h
Air For Combustion	6,656 kg/h	200	11,71,043.32
BF Gas	10,472 kg/h	45	1,19,386
Heat Generation By Combustion Of BF Gas	10,472	GCV of BF gas = 2,180.37 kj/h	2,28,32,881.7
Total	17,128 kg /h		2,41,23,311.5

4.2 Output Material & Energy

TABLE 2 : Output Material & Energy

Material	Quantity	Temp, Entering °C	Heat in kj/h
Stack Gases Leaving Stove	17,128 kg/h	370	60,82,344.22

IV. CALCULATION

1. Heat Loss from Surface:

Outer Diameter of stove : 5.5 meter Height
: 28,415 meter Surface area : 540 sq meters
Heat loss from vertical surface at 100^0C : 6283.5 kj/h sq meter
Total heat loss from surface : 6283.5 ×540 = 33, 93,090 kj/h
Heat stored in stove : Entering heat – leaving heat
: 2, 41, 23,311.5 – (60, 82,344.22 + 33, 93,090)
: 1, 46, 47,877.37 kj/h

Since two number of stove are in operation all the time, heat stored is 2, 92, 95,754.74 kj/h

2. Heat Duty To Heat The Fresh Air Supplied To Blast Furnace:

Mass of air being circulated through the stove : 32,927 kg/h
Temperature to which the air being heated : 910^0C
Heat duty to heat the air : 2, 91, 31,068.4 kj/h
On gas firing mode : 35 minute
On blast time mode : 60-70 minute

3. Heat Recovery From Stack Gases Of Stove:

Air supplied for combustion of BF gas in stove is heated to 200^0 C.
Heat duty to heat the air = 6656 × 0.24 × (200-30)
=11, 37,585 kj/hr

It was seen that temperature of stack gases leaving heat recovery unit was 200^0C. Further heat available in stack can be recovered. Heat recover with temperature drop of 100^0 C can be done.

Heat recovery potential = 17,128×0.24×100×4.189
= 17, 21,980.60 kj/h

Say 1600 Kg/h of BF gas per stove
Thus heat recovery potential for one blast furnace : 1600kg/h
Heat recovery potential for two blast furnaces : 3200kg/h of BF gas
This heat can be made available for slag dryer
Price of BF gas : Rs 500 /MT Thus annual monetary saving potential
: Rs 14, 00,000 /- Investment
: Rs 20, 00, 000 /- Simple pay back
: 18 months

V. CONCLUSION

Detailed study of pig iron plant and draft energy audit of the plant. In that plant the hot blast stove energy management and there energy consumption study. By using the hot gas we are save the electricity from the slag dryer section and utilizes the hot gases in that slag dryer.

Regenerative recuperative heat exchanger gives the beneficial process to pig iron plant. Small amount of investment gives the huge amount of energy saving in plant.

Detailed study of pig iron plant also with energy and material balance of that is done.

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