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EVALUATION OF HEAT INPUT, OUTPUT AND EFFICIENCY OF RADIAL TYPE BURNER IN THERMAL POWER PLANT

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Abstract
The most effective method for producing intense turbulence is by the impingement of one flame on another. This action is secured through the use of burners located in each of the four corners of the furnace. The burner nozzles are so directed that the streams of coal and air are projected along a line tangent to a small circle, lying in a horizontal plane, at the centre of the furnace. A scrubbing action is present which assures contact between the combustible and oxygen, thus promoting rapid combustion and reducing carbon loss. The experimental results of this study can be summarized as the use of tangentially fired boiler which increase splendid air-fuel mixture and pulverized coal is entrained in Primary Air (PA), and in-addition to that the Secondary Air (SA) is also projected towards the mill, finally a rotating "FIRE BALL" is formed.

The present work analysis is carried out on Tangentially Fired Boiler by considering heat input through four burners. The heat output is determined by considering various losses from the boiler that is loss due to dry gas, loss due to moisture, loss due to H_2 for combustion, heat loss due to combustile and refuse and losses due to radiation etc. In addition, heat absorbed by economizer, boilers, superheater and reheater are studied, thus finally the net heat absorbed and thermal efficiency of tangentially fired boiler are determined.

Graphs are drawn to evaluate the various effects of heat input on output parameters in the boiler. Sankey diagrams are drawn to show the performance in the boiler. The values calculated are put and shown as tables in Appendix.

Keywords: Thermal Power Plant, Tangentially Fired Boiler, Heat input through four burners and Boilers.

1. Introduction

Power generation has become a vital role in every segment of present world. To produce that much of power the tangentially fired boiler is accessible by varying the major

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influencing factors such as the inlet temperature, local heat release, practice size distribution, supply of primary and secondary air mixture. This scenario helps to increase the heat input and efficiency of the power plant. The present concept describes the operating principles and heat input procedure of corner type burners. These are also called tangential type burners because here pulverized coal and air are injected tangentially into an imaginary circle in the centre from four corners of the furnace. Tangentially firing is a method of firing a fuel to heat air in thermal power stations. The flame envelope rotates ensuring thorough mixing within the furnace, providing complete combustion and uniform heat distribution. 1.1. Tangential Fired Burners Application of burners is considered in the corners of the furnace and passage of horizontal streams of air and fuel tangent to an imaginary circle in the centre of the furnace. This results in intense turbulence and thorough mixing of fuel and air. All the fuel and air nozzles can be titled 24°. Tangentially firing can also be classified according to the mode of distribution of primary and secondary air patterns in the burners. These are described below. • Opposed tangential arrangement • Burners with side secondary air • Burners with peripheral air • Burners with sandwich air Offen and Kesserlring [1] in their paper analyzed the studies into the effects of operating conditions in a tangential fired furnace using 3d combustor model to determine temperature, velocity and thermal characteristics. They also proposed information about the Primary Air and Secondary Air inlet temperature, pressure, perfect air-fuel ratio in the combustion process. Fande and Joshi [2] in their paper studied the particle trajectories that are used to identify the causes of operational problems such as fouling on burners and temperatures achieved in various parts of boiler during the combustion process. Silva [3] worked about combustion technique can be applied for hard coal, oil, biomass, dust and natural gas in combination. The central vortex in the combustion reactor can be controlled by the burners in operation in mode enables low stoichiometry combustion to take place in furnace centre in the primary combustion zone. Piper et al. [4] have explained that to get higher combustion efficiency, the major influencing factors such as the particle size distribution, local heat release local oxygen concentration, kinetic parameters for oxidation should be considered. Lakshmi & Kishore [5] have addressed the thermal efficiency of purverised fuel boiler in a power plant to increase its heat input parameters

2. Description of Tangentially Fired Boiler

The tangentially fired boiler is based on the concept of a single flame zone within the furnace. The fuel-air mixture in a tangentially fired boiler projects from the four corners of the furnace along a line tangential to an imaginary cylinder located along the furnace centerline. When coal is used as the fuel, the coal is pulverized and entrained in primary air, and fired in suspension. As fuel and air are fed to the burners, a rotation "fire ball" is formed, which control the furnace exit gas temperature and provide steam temperature control during variation in load.

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Tangential firing gives a swirling action to the fuel which increases the residence time of fuel into the furnace and also increases turbulence. Thus tangential firing promotes the coal input range between 10000kg/hr and 11452 kg/hr with primary air impended to the furnace from the burner, in addition to that secondary air possess the increase of ignition in the furnace and participate in the maximization of combustion efficiency.

In the combustion process there will be release of losses such as loss due to radiation, loss due to dry gas, loss due to combustile and refuse. Finally we can obtain the total heat output of 16589.61 kJ/hr with the heat losses of 1757.01 kJ/hr for given heat input of 18085.21 kJ/hr. The overview can be governed by factors like rationalization of Combustion, rationalization of Heat input and lastly prevention of heat losses.

2.1 Analysis of Tangentially Fired Boiler and Analysis of the Problem:

From the Tangentially Fired Boiler different losses are obtained. The losses are loss due to dry gas, loss due to combustile and refuse, loss due to H_2 for combustion, and loss due to radiation. The calculations of various losses in boiler are discusses below. In addition to this heat input, heat output and efficiency in a tangentially fired boiler are also calculated.

Simple Boiler:

Total heat input or calorific value (kJ/kg) Heat absorbed by the boiler:

$$q_0 = m_a \times (h-h_f)$$

3. Evaluation Parameters of Tangentially Fired Boiler:

3.1 Input parameters of a Tangentially Fired Boiler:

Inlet primary air temperature	=	481K
Inlet Secondary air temperature	=	618 K
Primary Air	=	24.61%
Secondary Air	=	61.84%
Temperature of Pulverized Coal	=	333 K
Coal Burned	=	11452 kg/hr
Number of Mills	=	8
Output of the Mills	=	6871.2 kg/hr
Moisture Vaporized per kg fuel	=	0.051 kg/kg Pulverized Coal
Moisture Content in Pulverized coal	=	0.17

3.2 Assumptions:

Theoretical air needed	=	5.673 m^3/ kg.
Excess air Coefficient	=	2
Specific heat of air before mixing	=	1.006 kJ/kg^{o}C
Specific heat of air after mixing	=	1.173 kJ/kg^{o}C
Specific heat if pulverized coal	=	/kg^{o}C

3.3 Simple Boiler:

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Heat required to produce 4.76 kg of steam = m_a (h – hf) At 250°C, h = 1957.21 kJ/kg

hf = m cpdT

= 1 * 1.006 * (250-180)

= 71.23 kJ/kg

Total heat absorbed:

q_o = m_a * (h-hf)

= 4.76 * (1780.21 – 71.23)

= 8108.60 kJ/kg

Where,

Calorific Value or heat input = 9700.12 kJ/kg

Efficiency of Simple Boiler:

$$\eta = \frac{\text{Heat Output (or) Heat Absorbed}}{\text{Heat Input}}$$

=8108.60 / 9700.12

= 83.19%

3.4 Heat Input of Tangentially Fired Burner:

Total pulverized in primary air:

Bmf= (1 – dW) * (B_j – 0.15* Z_m* B_m)

= (1 – 0.051) * (11452 – 0.15 * 8* 6871.2)

= 3043.02 kg/hr.

Heat needed to heat pulverized coal:

Total heat input of a pulverized coal

Eq= Bmfx (q1+q2)…..**5.7**

= 3043.02*[123.56 + 470.77]

= 18085 kJ/hr

3.5 Heat output of Tangentially Fired Boiler

Corresponding enthalpies are finding with the help of feed water temperatures in Moeller chart and steam tables.

Heat absorbed in Economiser per 4.76 kg of feed water:

h_e = m x C_p x(t0-ti)………**5.8**

= 4.76 * 4.18 * (119.89-30.56)

= 1757.48 kJ/hr Heat absorbed in boiler per 4.76 kg of feed water: At 208°C (or) 481 K hf = 970.12 kJ / kg°Chfg = 1957.7 kJ / kg°C

h_b = (hf + xhfg) - h_e ……**5.9**

= [2849.51 – 369.22] x 4.76

= 11806.23 kJ/hr

Heat absorbed in Superheater per 4.76 kg of feed water:

3.6 Heat losses in Tangentially Fired Boiler

Heat loss due to dry gas:

qdg = dry gas (kJ/kg) as fired fuel xCp(tgi-tge)

= 11.6 * 1.063 (170-88)

= 950.90 kJ/kg.

Heat loss due to moisture:

$$q_m = \frac{\text{moisture}(\%)\ \text{x}\ (h_L - h_C)}{100}$$

3.7 Efficiency

Total heat input of Tangentially Fired Boiler:

Σq= 18085.21 kJ / hr

Total heat output of Tangentially Fired Boiler:

4. Results and Discussion

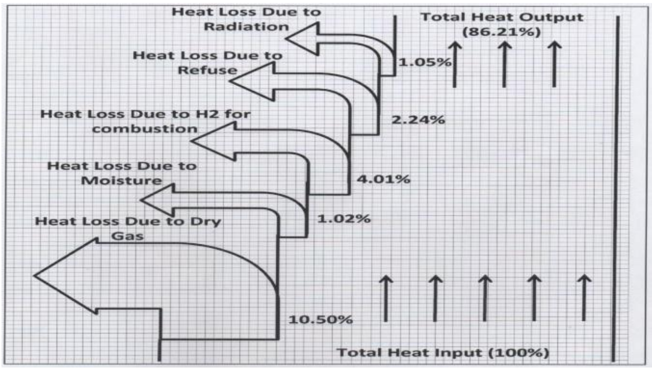

Fig. 1 Sankey Diagram for Variation of Total Heat Input to Heat Output and Heat Losses at 10000 kg/hr Coal Input

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The above fig.1 shows the variation of total heat input in tangential boiler. Temperature increases more in tangentially fired boiler compared to simple boiler. Variation of Coal input at 10000 kg/hr expels 1789.26 kJ/hr heat losses and 8526.45 kJ/hr heat is absorbed.

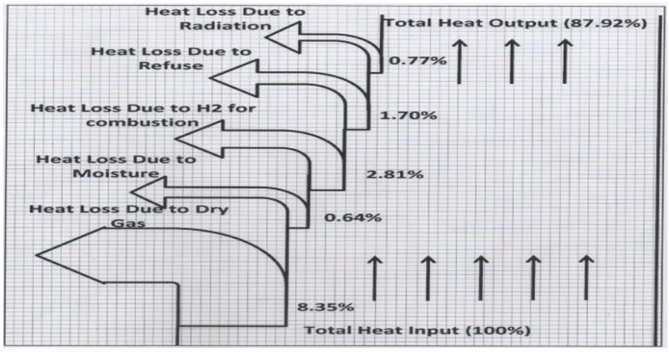


Fig. 2 Sankey Diagram for Variation of Total Heat Input to Heat Output and Heat Losses at 10500 kg/hr Coal Input.

The above fig. 2 shows the variation of total heat input in tangential boiler. Temperature increases more in tangentially fired boiler compared to simple boiler. Variation of Coal input at 10500 kg/hr expels 1689.21 kJ/hr heat losses and 10465.18 kJ/hr heat is absorbed.

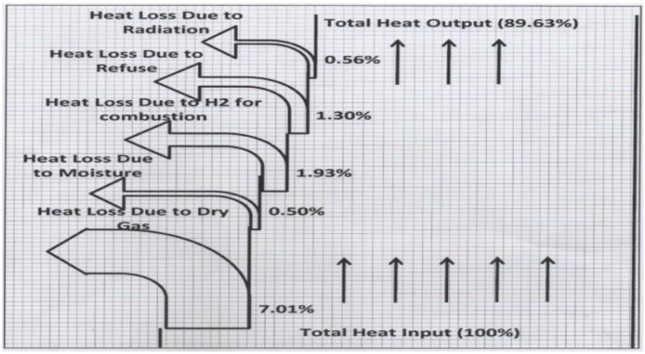


Fig. 3 Sankey Diagram for Variation of Total Heat Input to Heat Output and Heat Losses at 11000 kg/hr Coal Input

The above fig. 3 shows the variation of total heat input in tangential boiler. Temperature increases more in tangentially fired boiler compared to simple boiler. Variation of Coal input at 11000 kg/hr expels 1572.61 kJ/hr heat losses and 13056.12 kJ/hr heat is absorbed.

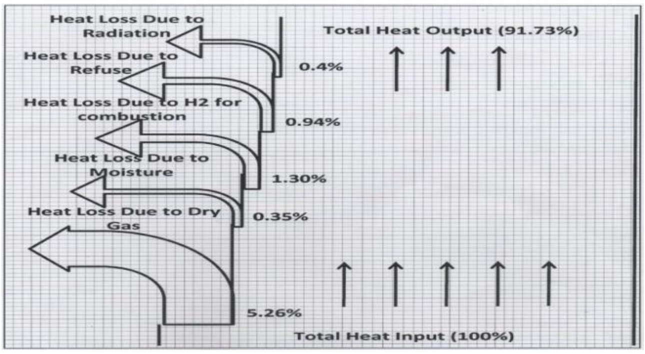
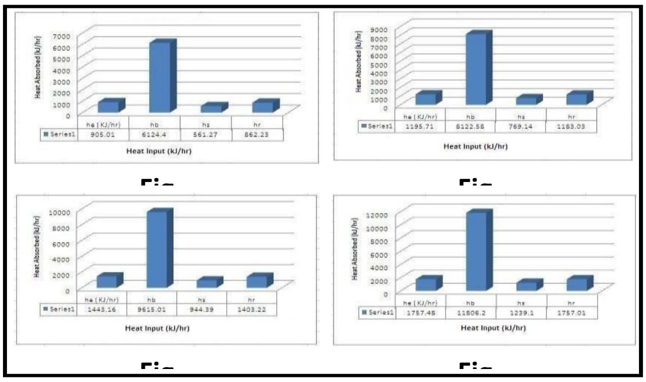


Fig. 4 Sankey Diagram for Variation of Total Heat Input to Heat Output and Heat Losses at 11452 kg/hr Coal Input

The above fig. 4 shows the variation of total heat input in tangential boiler. Temperature increases more in tangentially fired boiler compared to simple boiler. Variation of Coal input at 11452 kg/hr expels 1496.21 kJ/hr heat losses and 16589.61 kJ/hr heat is absorbed.



The above Fig.6 shows the variation of heat absorbed by the economizer, boiler, super heater and reheated with respect to Heat Input supplied by the Tangentially Fired Burner respectively.

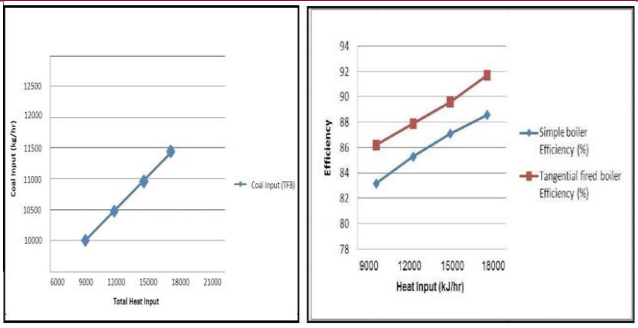


Fig. 7 Variation of Coal Input (kg/hr) with Total Heat Input in a Tangentially Fired Boiler and Variation of Efficiency (η) with total Heat Input (Σq)

The above fig. 7 gives a variation of Coal input (kg/hr) with Total Heat Input. It is observed that when Coal input increases, total heat input of Tangentially Fired Boiler also increases. The variation of Efficiency (η) with total Heat supplied (Σq). It is observed that when Heat supplied to the Tangentially Fired Boiler, its efficiency increases more than the Simple Boiler.

5. Conclusions:

The following conclusions are arrived from the performance analysis of a Tangentially Fired Boiler in Thermal Power Plant.

1) In Tangential Boiler the Coal Input at 10,000 kg/hr absorbs 8526.45 kJ/hr. While coal input at 11452 kg/hr absorbs 16589.61 kJ/hr, which shows an increase of 48.68%
2) The heat absorbed in simple boiler at 9700.12 kJ/hr heat input is 8108.60 kJ/hr, while 16589.61 kJ/hr heat is absorbed at heat input of 18085.21 kJ/hr in a tangential boiler, thus shows an increase of48.21%.
3) The efficiency of simple boiler is 83.19% to an increase of 91.73% in a tangentially fired boiler, this shows an increase of 8.54%.
4) Finally the input parameters of tangentially fired boiler such as coal input, inlet temperature, excess amount of primary air and secondary air expels the output parameters of net heat output and thermal efficiency respectively.

6. Future Scope of Work

The work is carried out for tangentially fired boiler in thermal power plant using the burners and the amount of excess air. The work can be extended by:

1. Providing Co-generation for improving the work output, thereby efficiency of plant will be increased.
2. Increasing the number of nozzles in the burners will participate in the maximization of heat input.

References

1. G.R. Offen, J.P.Kesserburg, K. Lee G. Poe., control of particulate matter from Tangential fired burners, Environmental protection agency, Reduction of Co2 Emissions, North Carolina, pp.7-1 to 7-27,2015

2. Mr.AshishFande and P.V.Joshi, Practical boiler operation in the Power Plant, Applied Science and Engineering, 4th Edition, PHI Learning Private Limited, PartIV, PP-101-126, 2015.

3. CristiansV.da Silva, Study the analysis of tangentially fired burners, Reduction of Co2 emissions controlled by the burners, consolidated Edison Company of New York,

Vol.4; No.5 PP 157-261, 2004.

4. B.F.Piper, KVB, in C., New York State Energy Research and Development Authority, Combustion of Bituminous Coal in Pulverized State and liquids in tangential fired boiler, Vol.43, No.16, pp.1012-10 22, 2000.

5. Infante Ferreira, Carlos.A, Applied thermal Engineering, Utility of tangential boilers, their Design construction and Management, New Age publishers, Vol.IV.

6. Haiying Qi, Bo Zhao, Ken Gregory, Experimental investigation on gas flow in a model of tangentially fired boiler, A Options for limiting Carbondioxide Vol.18, pp. 14-17, 2006.

7. Su Cheng-dong, Tang Xu, W.T. Reid, Research on emission characteristics on axial compression, Internal deposits of Tangential boilders, 38(AO I):12-18, pp.44-52, 2013.

8. Y.K. Rao, P. Chattopadhyay, Stoichiometri and Thermodynamic processes, Operation in tangentially fired boiler, M.C.Graw Hill Education, Pvt. Limited, 3rd, Edition, pp.119-127, 2013.

9. C.S.Rao, Environmental pollution and control Engineering, New Age international publishers, 2nd Edition, pp.137-156, 2007.

10. Louis Jestin, Cenkefa, PrabirBasu, Boilers and burners, its Design and theory, Mechanical Engineering Series, Spring Publishers, 1st Edition, Vol.III, pp.112122, 2001.

11. R.K.Rajput, Thermal Engineering, 8th Edition, Lakshmi Publications Pvt. Ltd. pp.592-608, 2010.

12. Thomosshakre, Mahallawy. Conventional fossil fuel Power Plant during combustion process in tangentially firing system, International Journal Engineering, Vol.3, pp.101-116, Feb. 2015.