Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 8, No. 2, p. 293-297, 2016
http://www.innspub.net

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RESEARCH PAPER

OPEN ACCESS

The flame temperature effect on the reduction of environmental pollutants in a thermal power plant

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Article published on February 28, 2016

Key words: Power plant, air pollution, air temperature, pollution reduction, NOX.

Abstract

Due to the increasing development of thermal power plants with fossil fuels, Optimizing the combustion process in boilers and combustion chambers to reduce the amount of environmental pollutants is of great importance. In this paper, the effect of the temperature of the intake air into the combustion chamber and its effects on the production of nitrogen oxides and soot emissions have been studied. The results show a decrease in combustion temperature, Flame temperature is reduced and nitrogen oxides emissions are also reduced. Also in the air optimal flow obtained, due to the complete combustion of fuel and high-temperature combustion chamber, no_x was also the maximum and with the increase in air flow and temperature efficiency is reduced again. Comparison of numerical results obtained from the analysis and simulation of the current situation boiler data shows good agreement.

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Introduction

Martyr Mohammad Montazeri in Isfahan power plant due to its position near the city in terms of emissions is of particular interest. Thus this power plant trying to reduce their emissions, especially NOX. Vacuum-fired this power plant with 12 burners with gas fuel combustion are doing work.The combustion air required by the fan is blown into the furnace where the temperature of the effects on air pollution is to reduce or increase production. Analysis was performed using furnaces and power plant using the equations in this field, the effect of air temperature on emissions and its impact on the adiabatic flame temperature discussed. In previous work, Jian Ping Jing *et al.*(2011)the effect of primary air and NOx during combustion in a power plant assessed. Numerous studies around the world and various power plant in this field has been done (jing *et al.*, 2011). In research by Ming pan and *et al.*(2015) to study the use of practical methods to reduce NOX in gas fuel (pan *et al.*, 2015) and also Stupar Goran *et al.*(2015) in order to reduce NOX to review and study the impact of initiatives to reduce NOX in boiler thermal power plant have been conducted (stupar *et al.*, 2015).

The combustion air temperature

Air temperature combustion of all fuel used in combustion efficiency is considered. In other words, the temperature of combustion air can seriously affect the efficiency of the boiler.The variation in temperatures of combustion air directly on the amount of air necessary for complete combustion affects. In other words, the use of excess air as energy waste, increasing the temperature of Chimneys and reduces boiler efficiency. Lack of combustion air in the furnace to cause the incomplete combustion of fuel and produce soot. Advanced torch used to cut energy waste comes up even under 15% excess air could be necessary to continue work with high efficiency and returns. Due to changes in temperature in the combustion furnace (in different seasons of the year) alter the amount of excess air.

In Table 1, the effect of temperature changes on the amount of excess air is shown.

Table 1. The effect of temperature on the amount of excess air in the combustion furnace (karbasi *et al.*, 2005).

Most ideal situation	The effect of excess air (%)	Air temperature (F)
	25.5	40
	20.2	50
The initial set point	15	80
	9.6	100
	1.1	120

Calculate the adiabatic flame temperature

If the air-fuel combustion process is assumed to be adiabatic, In other words, the temperature of the combustion to be transferred to reaction products, the temperature of the combustion products temperature is called the theory of flame (smith,1987). Because of the change in enthalpy is independent of the process depends only on the initial and final conditions, Ignition temperature can be determined as follows:

$$\Delta H_c = \Delta H_P - \Delta H_R \quad (1)$$

In the above equation, ΔHc represents the enthalpy of combustion and ΔHR and ΔHP respectively changes in enthalpy of reactants and products are compared to a reference temperature. ΔHc is enthalpy combustion reference temperature and the reference temperature is normally 298 k(60˚F).

$$\Delta H_c = -mf \cdot NHV \quad (2)$$

In this equation mf is mass and NHV is net heating value of the fuel mixture at atmospheric pressure and a temperature of 298 k. Reactant is composed of fuel consumption and inlet air, Therefore:

$$\Delta HR = \Delta Hf + \Delta Hair \quad (3)$$

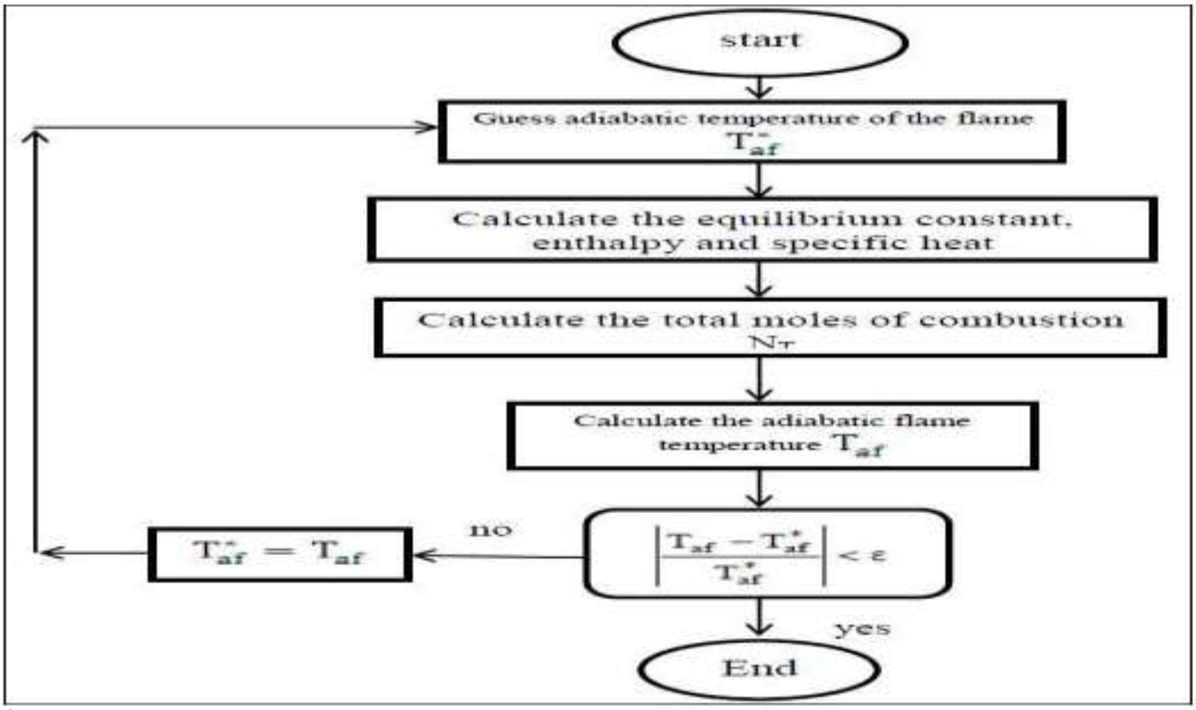

Fig. 1. Flowchart solution adiabatic flame temperature.

$$\Delta HR = \sum_i \left(n_{f,i} \int_{T_{f,i}}^{[illegible]} c_{p,j} dT \right) + n_{air} cp_{air} ([illegible] - T_{air}) \quad (4)$$

ΔHf is fuel enthalpy change and $n_{f,i}$ and $T_{f,i}$ are respectively the number of moles and the temperature of the reactant. ΔHP is calculated by the following equation:

$$\Delta HP = \sum_j \left(n_{p,j} \int_{60}^{T_{af}} c_{p,j} dT \right) \quad (5)$$

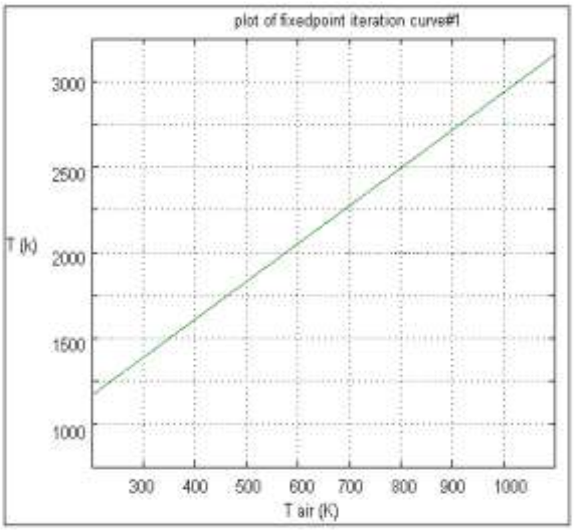

Fig 2. The effect of air temperature on the adiabatic flame temperature.

$n_{p,j}$ is the number of moles of products and T_{af} is the temperature of combustion products or flame temperature.

The above integral can be defined by using Cp or using the amount of Cp related to any of the components of the calculation. The latter method is more suitable in computer calculation. For example ΔHP can be obtained by the following equation:

$$\Delta H_p = A(T_{af} - 60) + B/2(T^2_{af} - 60^2) + C/3(T^3_{af} - 60^3) + D/4(T^4_{af}) \quad (6)$$

$$A = \sum_j n_{p,j} \quad (7)$$

Similar relationship for B, C and D can be written. Since the specific heat of combustion products is dependent on the flame temperature, flame temperature calculation is done by trial and error. Thus, at a temperature guessed and the specific heat of the product at this temperature can be calculated. Then the equation is rewritten and for the solution of Newton's method is used:

$$\Delta H = \Delta Hc - \Delta HP + \Delta HR \quad (8)$$

If T_{af}^* be guessed at, at New T_{af} with the following equation to be determined:

$$T_{af} = T^*_{af} - \frac{\Delta H(T^*_{af})}{\Delta \acute{H^\circ}\ (T^*_{af})}$$

(9)

For the solution converges, the following conditions must be met (ε is accepted error):

$$\left|\frac{T_{af} - T^*_{af}}{T^*_{af}}\right| < \varepsilon \qquad (10)$$

Fig is a flowchart resolution:

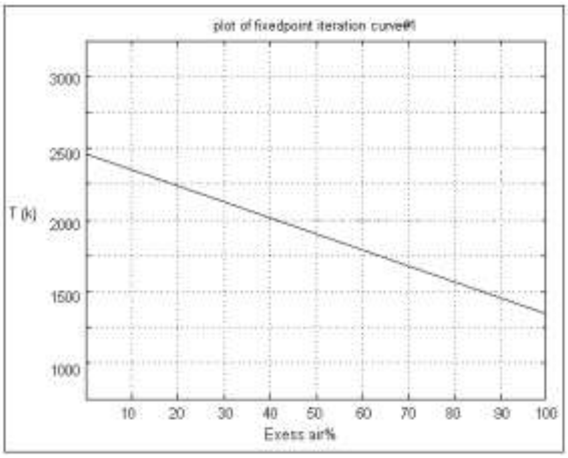

Fig. 3. the effects of excess air on adiabatic flame temperature.

The effect of temperature on the emission of pollutants

To optimize the combustion process and reduce emissions in flue gas can be used in two parameters: air temperature and the amount of excess air and by changing these parameters and to evaluate the results of these changes are best combustion conditions for emission reduction achieved.

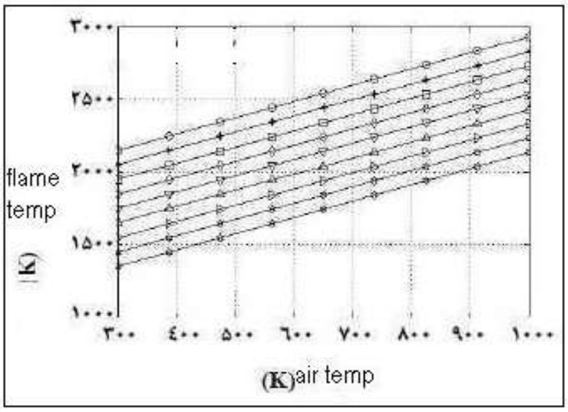

Fig. 4. The effect of rising temperatures on the adiabatic flame temperature(omidkhah and nadaf, 2006).

The combination of combustion gases before using the relationship of flame temperature was calculated. The equation parameters air temperature (4) and the excess air at equations (4 and 5) in a non-linear equations can be seen. When solving this equation, we can change the temperature and the percentage of excess air repeatedly and the results of these changes can be seen. After the calculation of the above equation, the curves that show the effects of temperature and excess air pollutants is to be drawn. To help these curves can be formed objective function to optimize operations.

By solving these equations Figure 2 and 3 is obtained:

Conclusion

As can be seen if inlet air temperature is much less adiabatic flame temperature is also lower and also reduced the amount of nox. Also compared with the results and draw diagrams similar results have been obtained in other papers. Adiabatic flame temperature has come down to below 1800 ° F can significantly reduce the amount of NOx. To reduce the adiabatic flame temperature, use lower temperature in the combustion chamber. Even a slight reduction in temperature can have large effects in reducing emissions. The power plant studied by reducing the inlet air into the combustion chamber temperature of 12 ° C The production nox was low amount of 140ppm.

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