Proceedings of the 2006 IASME/WSEAS International Conference on Energy & Environmental Systems, Chalkida, Greece, May 8-10, 2006 (pp103-109)

Study of Air Adjustment Effect in Power Plant Burners and Hazards of Its Nonadjustment

S. E. MOUSSAVI [a], A. RAFIEI [a]
E. A. SAADATI [a] AND N. FATHI [b]
[a] School of energy Eng
,Power and Water University of Technology
Shahid abbaspoor Ave
Vafadar St, Tehranpars,Tehran,
IRAN
[b] School of Mechanical Eng
Amirkabir University of Technology
P.O.BOX 15875-4413 , Hafez Ave,Tehran
IRAN

emoussavi@yahoo.com

Abstract: - This paper describes the results from a simulation of burners that have been used at thermal power plant. In. In this investigation simulation have been done by Computational Fluid Dynamic (CFD). these boilers have high heating potential and a specific complexity because of their requirements to high thermal . One of very important problems is the proper adjustment of combustion air and its distribution in different channel for entrance to the furnace. Non adjustment ratio of air entrance from different burner channels (primary, secondary , …) in some burners of this power plant resulting in unacceptable damages. Final purpose of this simulation is the effect of each adjustment on the shape and location of flame configuration and ultimately combustion state. To analysis this problem there are different practical and analytical methods, but with respect to complexity of mentioned burner, classical methods do not have potential of detailed analysis for this problem and ultimately have not capability of desirable presentation of results. Therefore, these burners are analyzed by using CFD methods. Although this problem has been solved adopting oil and natural gas fuels, but the sake of abbreviation in this paper, only the results of burner simulation in the state of the use of natural gas has been presented.
Key-Words: Boiler, Air, Combustion, CFD, Burner, Gas fuel

1 Introduction

One of the very important problems in designing and also the exploitation of power plant is the optimum designation of burners before its manufacture and doing pertinent adjustment while operating. Without doing these processes properly in steam power plant, the burners cannot provide the heating potential of the power plant, on the other hand it causes main damages in different stages of boilers. Because of this and in order to provide the best condition for burners; increase the efficiency of combustion and finally increase the efficiency of boilers in steam power plants, exploitation personnel adjust and repair burners carefully in every step of the periodical and overhauls. This affair contains different processes such as safety inspection and replacement of combustion nozzles, if necessary; and also cleaning different channels of burner from sedimentary products of combustion and ultimately adjusting different directions related to the flow of combustion air. Without careful adjustment of passing air from each channel, the combustion state, location and configuration of flame become disordered and finally we will have unacceptable damages in different parts of boilers. This paper, firstly, presents the effect of these adjustments on combustion manner and the effect of flame state on burners at Shazand thermal power plant in Arak by using CFD methods. Secondly, it presents the probable damages resulting from these disorders in system.

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2 General Introductions to Boiler Structure and the Arrangements of Burners in Boiler

At Shazand thermal power plant four water tube boilers are used in order to provide the desired superheat steam for turbines. The thermal power of each of these boilers, provided by twenty-four burners, is 325MW. The arrangement of these burners is like that of opposite burners. The main quality of these burners is that their angle cannot be changed (tilting) in order to control the temperature of reheat and superheat steam. Furthermore when the flame of each of these burners reaches the flame of the opposing burner it goes up and as a result provides the power of upper stages. In the following figure 1 we have a general view of the arrangement of burners on one side of the boiler. These burners are arranged on two front and rear sides of boiler (3rows and 4 columns).

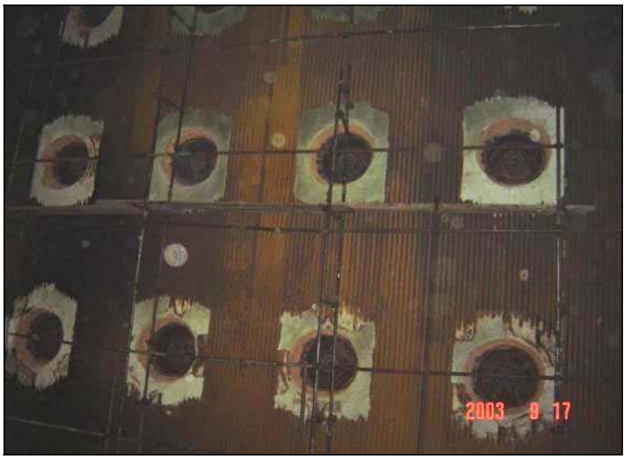


Fig.1 General Arrangement of Burners

While working in full load, twenty-three burners work and one burner remains in standby condition. Having radiated heat to water wall, the combustion products of burner are directed toward reheaters and super heaters and in different processes they provide the requisite heating potential of these sections by radiation and convection. In lower stages this power is mostly provided by radiation and in upper stages by convection. Therefore the area of section of the passing channel of boiler becomes narrow in order to increase the combustion products and consequently the coefficient of convection.

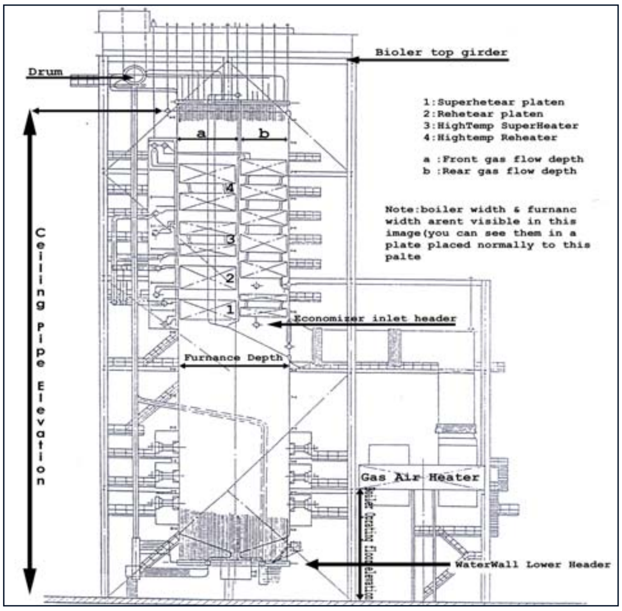


Fig.2 General View of Boiler

3 Introducing Burner and Its Different Parts

The burners used in this power plant are dual fuel (oil and natural gas) fuels in order to provide the heating potential of boiler in different loading processes. It also uses two kinds of minor gas oil and natural gas fuels in order to be used in minor warm up burners. The main container of burner is the place from which the main fuel of burner is sprinkled. Another burner, which is outside the burner structure, sprinkles minor gas oil and natural fuels into furnace. Warm up burner is very small in comparison with main burner and its usage is restricted by the exact time of boiler heating, as well as the cases in which boiler extinguishes temporarily.

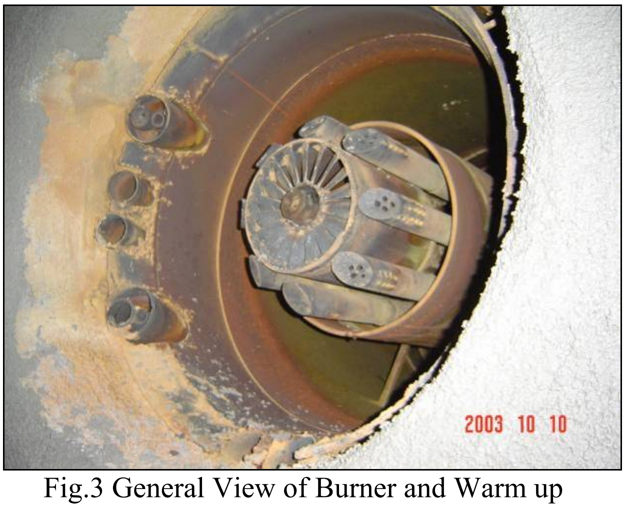
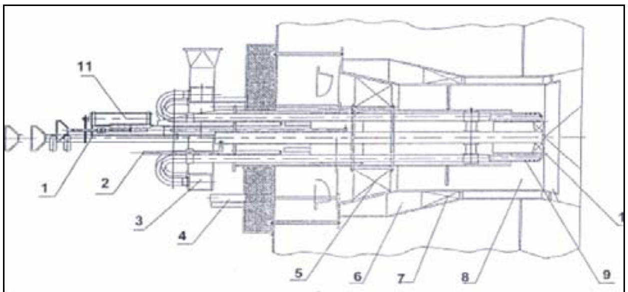


Fig.3 General View of Burner and Warm up Burner

The simulated burner is the section placed in main container of burner and sprinkles main fuel and combustion air into furnace. The heavy mazut by mazut gun in the center of the burner and the natural gas fuel by eight lateral gas nozzles are directed into combustion room. Fuel sprinkling system has been equipped with swirl pressure atomizer and with aid of evaporator.
Natural gas fuel does not an injection fuel system. It enters the main header of gas behind the burner and from there enters eight straight pipes directly. Therefore natural gas fuel without any main changes and via channels of gas entrance is directed into power plant and in ambient temperature is directed into the furnace where it compounds with combustion air. The requisite air for combustion is directed into furnace by two main channels and one minor channel. Between 15 to 20 percent of the whole amount of combustion air by primary air channel; between 70 to 80 percent of air by secondary air channel and less than 5 percent of the air by stepped air channel are directed into combustion room. The primary air enters from central part of burner and the distance between gas nozzles. The secondary air is out of the whole container of nozzles while stepped air channel is out of the burner structure in a farther distance from the center of the burner.



1-oil gun 2-cooling air 3-gas distribution 4-the secondary air cyclone control device 5-the secondary air cyclone 6-the stepped air pipe 7-the stepped air cyclone 8-the secondary air pipe 9-gas gun 10- flame stabilizer 11-actuator

Fig.4 Structure of Burner and Air Channels

Stabilizer is improvised on entrance channel of primary air . Stabilizer provides swirl on primary air and consequently makes fuel and air compound better with opposite burner.
Along the secondary air channel some curtains are improvised in order to provide swirl on secondary air. The swirl causes the exertion of centrifugal force on the main combustion air secondary air) and ultimately it causes the flame to spread (the expansion of flame in a radial elongation). In this way the formation of concentrated and too hot flame in one region and consequently the formation of poisoning gases (of Nox family) are prevented.

4 Theoretical and Practical Equations of Combustion

Because of the important role of combustion chemical reaction in this simulation, first we take a look on dominant reactions of combustion and present the existing compounds in natural gas of “national gas grid of Iran”
According to the results of experiment tried on channel of gas entering at Shanzand power plant, the compounds of this fuel are as follows:

	component	results
1	N2	5.0 %
2	CO2	0.2 %
3	C1	88.0 %
4	C2	4.5%
5	C3	1.48%
6	IC4	0.24%
7	NC4	0.35%
8	IC5	0.11%
9	NC5	0.07%
10	C5	0.05%
Total		100%

Table 1 chemical composition of natural gas inters to power plant

By omitting those compounds with very low mass percent and ineffective for combustion it is possible to write the theoretical equations for natural gas combustion with the air of requisite theory.

$$(1)\ CH_{3.813} + (1+\frac{3.813}{4})(O_2 + 3.76N_2) \rightarrow$$
$$CO_2 + \frac{3.813}{2}H_2O + 3.76(1+\frac{3.813}{4})N_2$$

But practically, the fuel and air do not compound with each other completely. Therefore in order to provide the combustion air and perform the optimum combustion and complete consumption of fuel, excess air is necessary. With the assumption of 8 percent for excess air, requisite in the combustion of natural gas, the following equations for practical combustion in furnace can be written: