DE-FG22-94PC94122

COMBUSTION CHARACTERIZATION OF COAL FINES RECOVERED FROM THE HANDLING PLANT

DOE/PC/94122--T7

Quarterly Technical Progress Report No. 8
Report Period: July 1, 1996 to September 30, 1996

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October 1996

Work Performed Under Contract No. DE-FG22-94PC94122
For
United States, Department of Energy
Pittsburgh Energy Technology Center
Pennsylvania

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ABSTRACT

Effect of swirl settings on NOx for three firing rates were investigated. It was found that the variation of NOx concentrations with respect to the change in swirl numbers was significant. But, the variation of NOx Concentration with respect to firing rates was found to be consistent with the increase in firing rates. The flame stability was accessed by the visual observation of the flame with relation to the burner quarl.

EXECUTIVE SUMMARY

Combustion tests were conducted to determine the range of secondary air swirl required to maintain a stable combustion flame. Results obtained during the flame stability testing shows no significant effect of swirl settings on Nox, SO_2 and CO_2 for three combustion tests(834,330 Btu/hr, 669,488 Btu/hr, 508, 215 Btu/hr). At each of the two higher firing rates, combustion was relatively complete regardless of swirl settings, therefore, burner settings may be adjusted to provide a visually stable flame without concern for higher carbon in ash as a function of burner settings. The parameters affecting flame stability are mainly coal particle size, volatile matter, ash content and excess air. tests conducted at three different locations (Top, Middle, Bottom) revealed that the gaseous concentrations such as Nox, SO_2 and CO_2 were a function of residence time for each of the firing rates.

INTRODUCTION

During this reporting period (July 1 - September 30), research activities were focused on :

1. Flame stability

2. Effect of swirl settings on combustion parameters (such as NOx, SO_2 and CO_2) Work performed during this reporting period is given below with a brief discussion on flame stability.

Flame Stability

A flame is observed to be stable when it is fully contained within the burner quarl. Flame stability is assessed by the visual observation of the flame in relation to the burner quarl as a function of secondary air swirl and operating conditions. An important aspect of maintaining a stable flame is creating an internal recirculating zone within the flame which allows for greater mixing of the combustion air and fuel. This phenomena can be implemented by creating a swirl. Swirl is defined as the ratio of radial momentum to axial momentum imparted to the secondary air stream. In order to allow the proper mixing of combustion air and fuel, an internal recirculation zone is set up to cause alternate paths of radial and tangential flow. Once the swirl is applied to the combustion air, the heating rate of coal particles are increased causing an increase in the release of volatiles and char combustion.

The swirl setting when increased from a lower number to a higher number, the flame becomes more compact and intense upto a certain number which is considered to be optimum. Any further increase in the swirl number beyond the optimum level may cause the flame to be extracted into the burner region, exposing the burner components to the high intensity of heat, causing damage to the parts and possible combustion in the pipe. Secondary air allows the oxygen supply to the volatile flame, but also reduces the combustion product temperature by dilution.

When the char combustion is being fast, it offsets the cooling effect of the secondary air mixing. Therefore, it maintains the high recirculation and flame temperatures required for fast coal pyrolysis[1]. Heat losses by radiation is considered to be an important factor effecting the flame stability followed by the external recirculation of combustion products. Nitrogen oxide emissions could be effected by increasing the swirl in order to provide flame stability and higher carbon conversions. Excessive burner swirl can cause increased NOx formation, also the position of flame front plays an important factor in NOx formation[2].

Due to high flame temperatures and increased coal/air mixing, associated with increased swirl, create an ideal situation under which NOx may form. In order to keep the NOx levels lower the swirl setting is set to a lower swirl number than the optimum swirl setting.

RESULTS AND DISSCUSION

Initially, tests were conducted to determine the range of secondary air swirl required to maintain a stable combustion flame. Results obtained during the flame stability testing are given in Table 1 Appendix A.

The relative variation of NOx, SO_2 and CO_2 with respect to swirl settings for three combustion tests (834,330 Btu/hr, 669,488 Btu/hr, 508, 215 Btu/hr) with respect to swirl settings are given in Figure 1, Figure 2 and Figure 3 respectively. As seen in the Figure 1 and Figure 2 the swirl settings has no significant effect, in parts per million, for NOx and SO_2. In addition, test 2 (669,488 Btu/hr) and test 3(508, 215 Btu/hr) in Figure 3 shows no significant change in percentage of CO_2 with respect to the change in swirl number. Except in test 1, Figure 3, the swirl number 0.4 shows inconsistent value for CO_2.

Figure 4 shows the effect of swirl settings on percent of carbon in ash for the three different tests. as seen in this figure, the percent of carbon content in ash at the lowest firing rate is nearly twice the carbon content of the higher firing rates.

The data for NOx, SO_2 and CO_2 at three locations (Top, Middle and Bottom) for test 1, test 2 and test 3 are given in table 2, Appendix B. The effect of firing rates on NOx, SO_2 and CO_2 at three different locations are shown in Figure 5, Figure 6 and Figure 7 respectively. As seen in these figures, as the firing rates increases the gaseous concentrations in parts per million increases. Additionally, the concentrations in parts per million increases from location bottom to location top.

CONCLUSIONS

1. Partial evaluation of flame stability analysis have been presented. At each of the two highest firing rates combustion was relatively complete regardless of swirl settings.
2. Effects of firing rates on gaseous concentration at three different locations (Top, Middle, Bottom) were evaluated. It was found that the increase in gaseous concentration is proportional to the residence time.

REFERENCES

1. Smoot D.L., and Smith P. J., "Coal Combustion and Gasification", Plenum Press, pp 430-432.
2. Beer J. M.,1985, "Coal-Water Fuel Combustion Fundamentals and Application A North American Overview," Second European Conference on Coal Liquid Mixtures, Pergamon press, pp. 381-382.

Appendix A

Table 1 Flame Stability Test Data				
CO2 %	Swirl Number	Test1	Test2	Test3
	0.55	16.5	16.8	14.9
	0.4	17.9	17.6	15.3
	0.2	16.4	17.6	15.1
NOx (ppm)	Swirl Number	Test1	Test2	Test3
	0.55	480	471	242
	0.4	452	424	243
	0.2	442	424	256
SO2 (ppm)	Swirl Number	Test1	Test2	Test3
	0.55	2895	2807	2403
	0.4	3191	2806	2665
	0.2	2943	2853	2498
C in Ash %	Swirl Number	Test1	Test2	Test3
	0.55	2.83	2.2	3.36
	0.4	1.68	1.62	3.92
	0.2	1.94	1.35	3.88

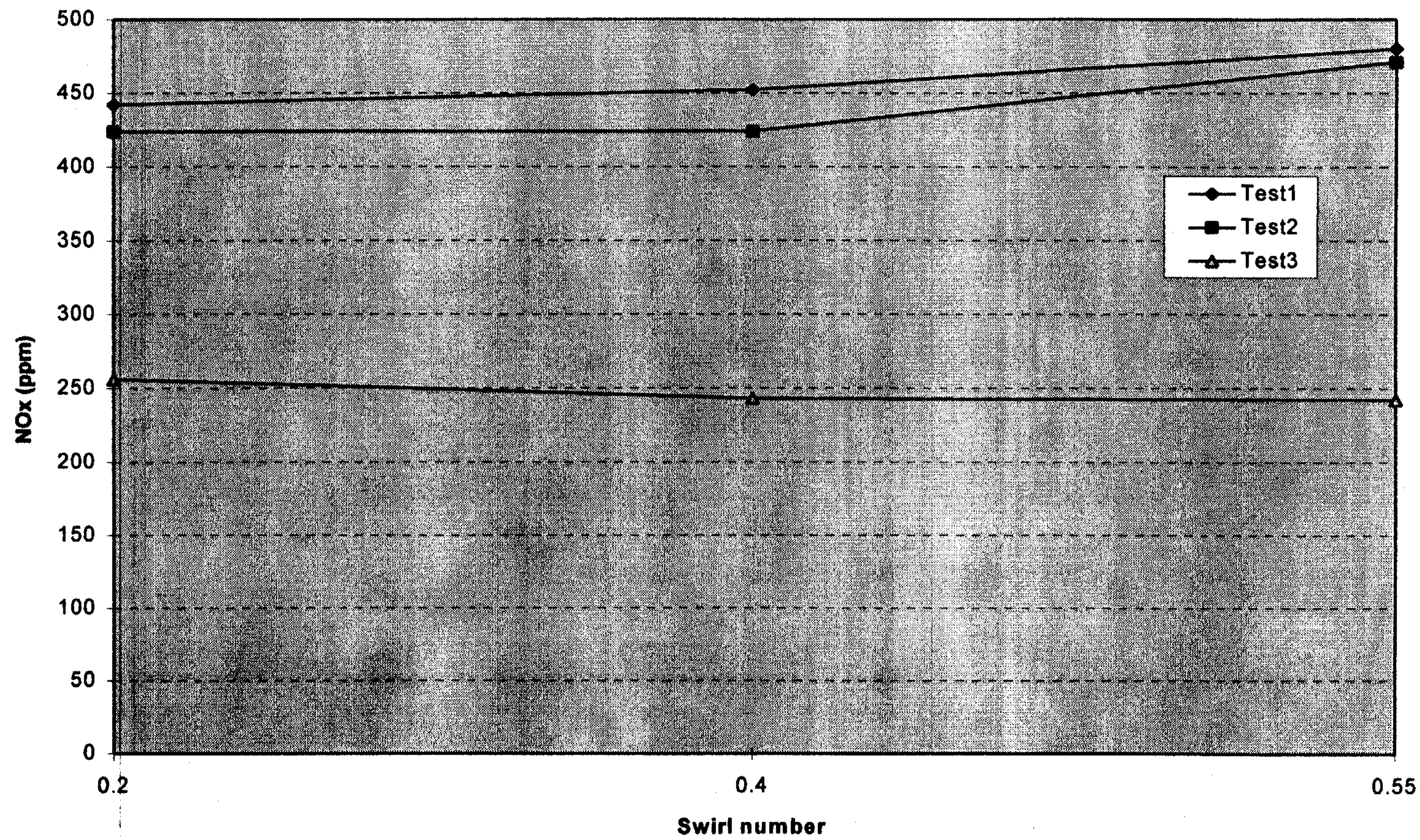

Figure 1 Effect of Swirl Setting on NOx at Three Firing Rates

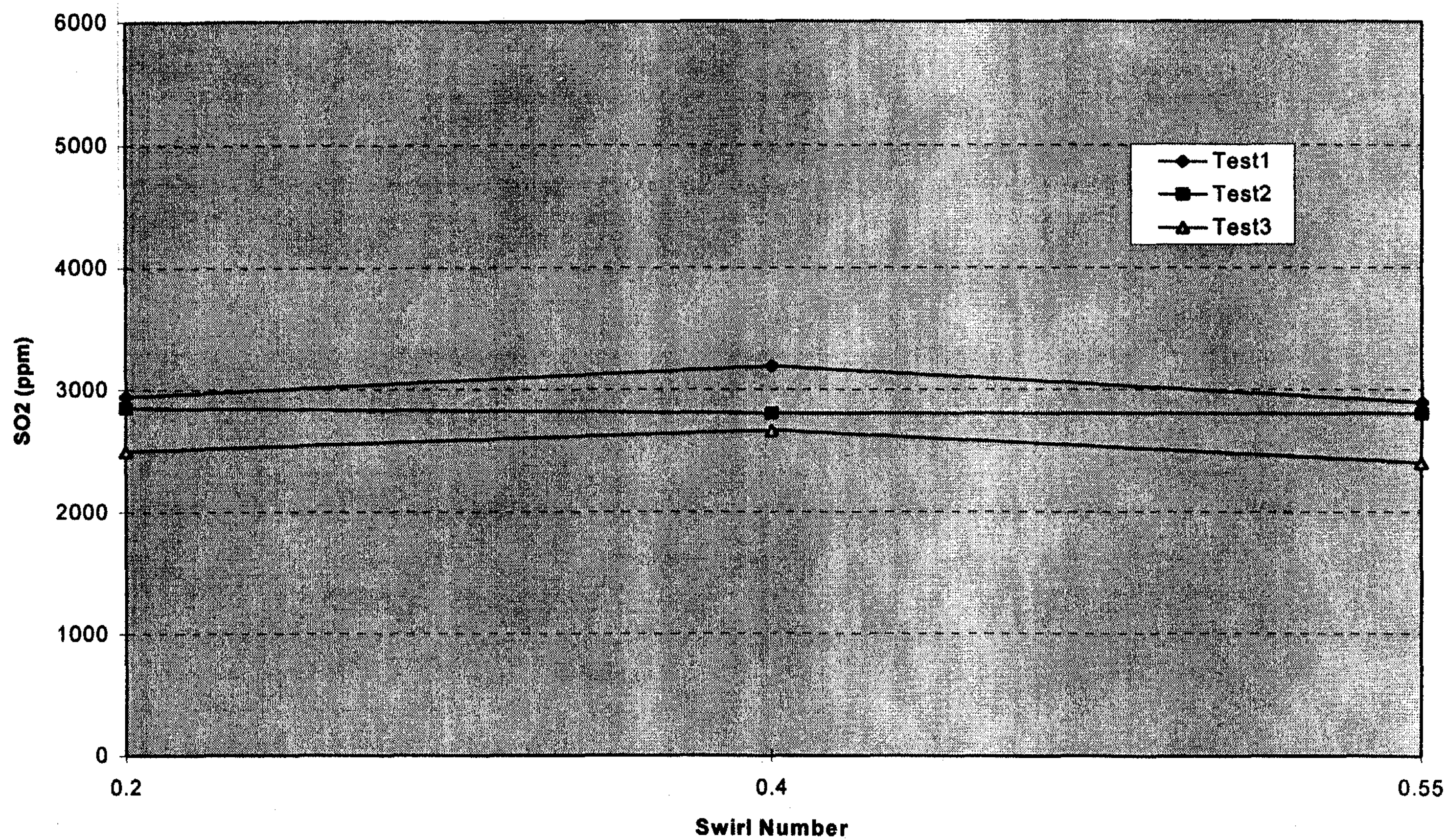

Figure 2 Effect of swirl setting on SO2 at three firing rates

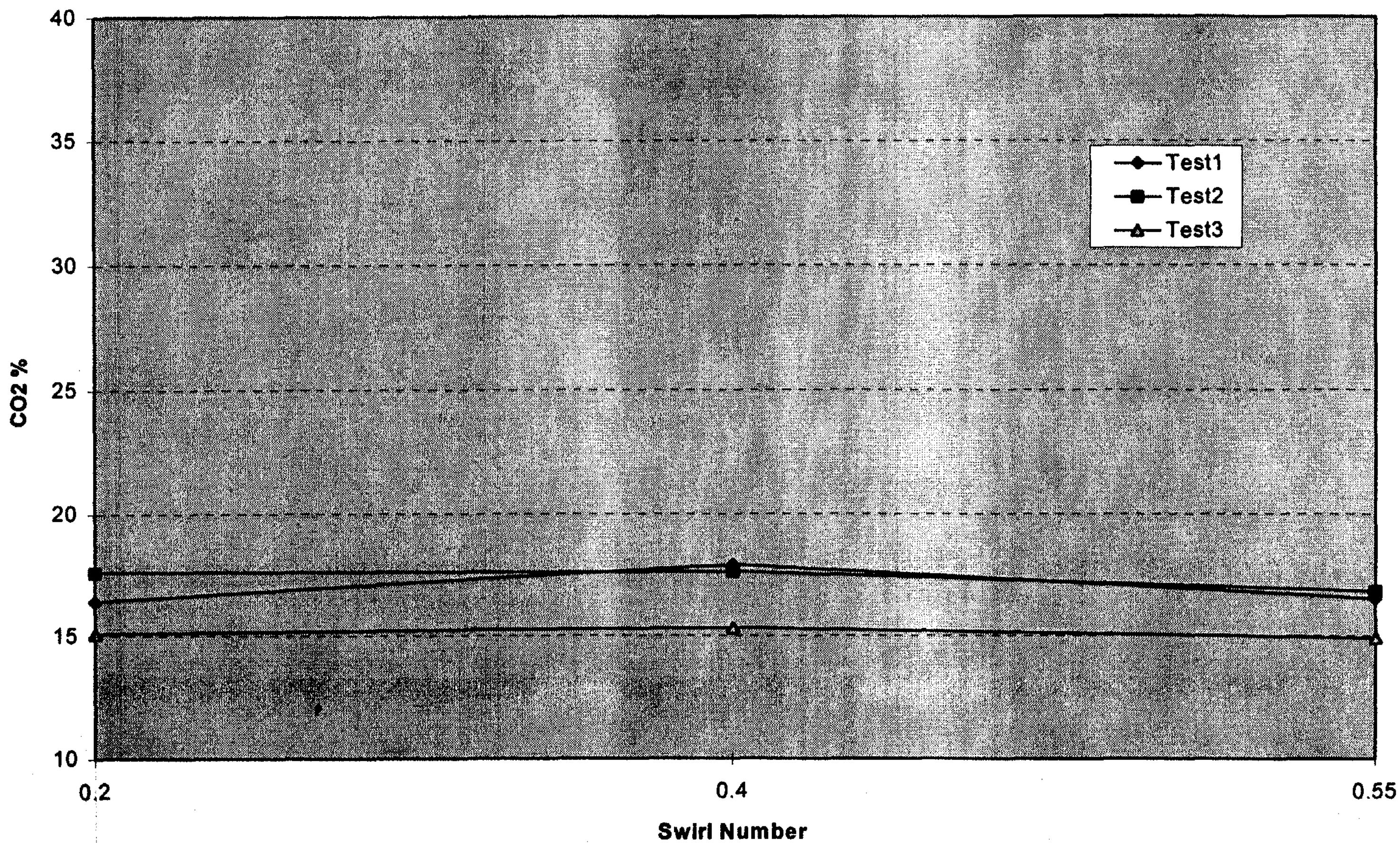

Figure 3 Effect of Swirl Setting on CO2 at Three Firing Rates.

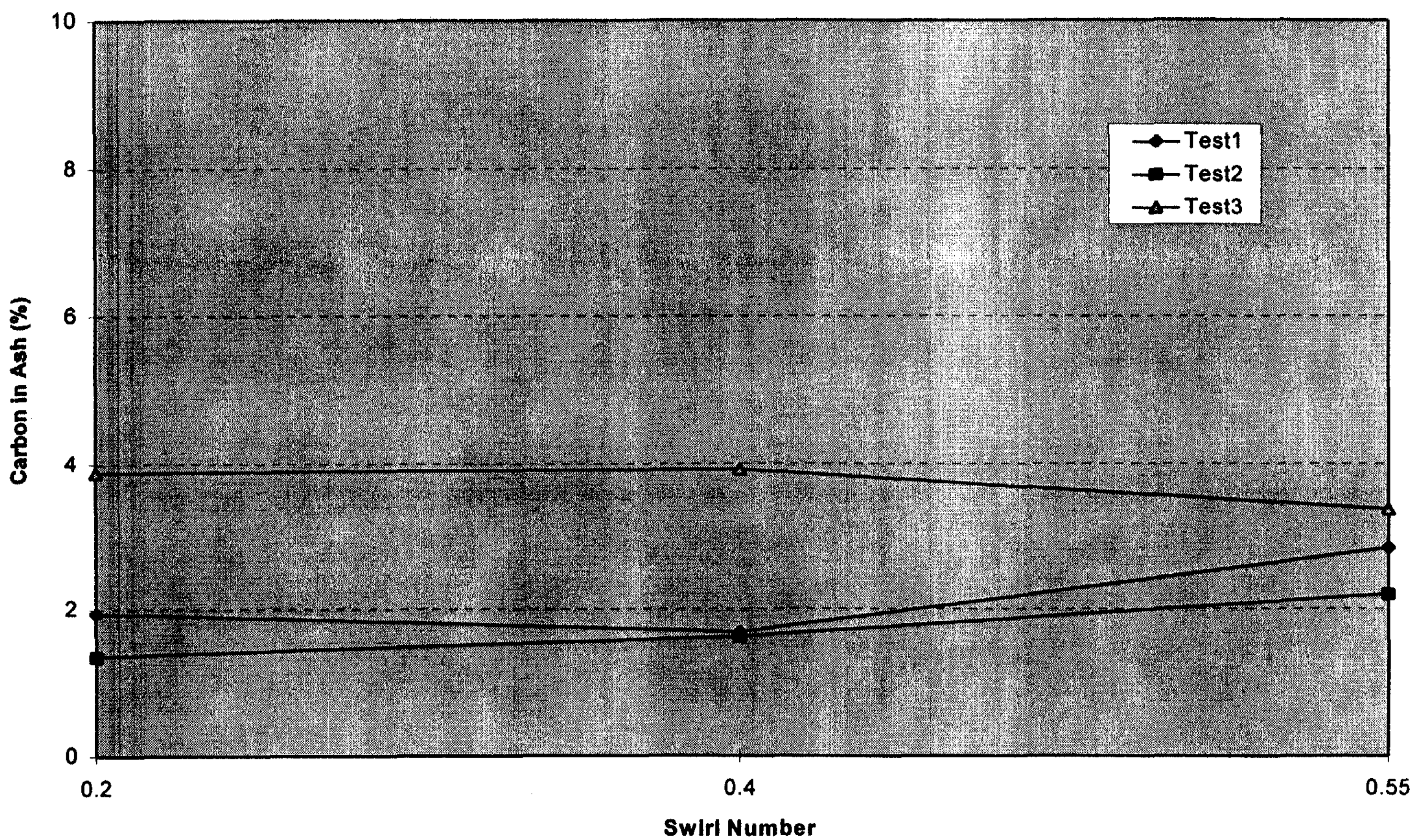

Figure 4 Effect of Varying Swirl Setting on Percentage of Carbon in Ash at Three Firing Rates

Appendix B

TABLE 2 GASEOUS CONCENTRATIONS OBTAINED AT THREE LOCATIONS IN THE COMBUSTION CHAMBER

Firing Rate (Btu/hr)	NOx(Top) (ppm)	NOx(Middle) (ppm)	NOx(Bottom) (ppm)
834,330	481	468	451
669,488	379	333	317
508215	210	178	213
Firing Rate (Btu/hr)	**CO2 (Top) %**	**CO2 (Middle) %**	**CO2 (Bottom) %**
834,330	16.9	15.9	15.9
669,488	15.1	15.1	14.5
508215	15	15	14.4
Firing Rate (Btu/hr)	**SO2 (Top) (ppm)**	**SO2 (Middle) (ppm)**	**SO2 (Bottom) (ppm)**
834,330	3103	2818	2842
669,488	2863	2723	2479
508215	2864	2855	2488

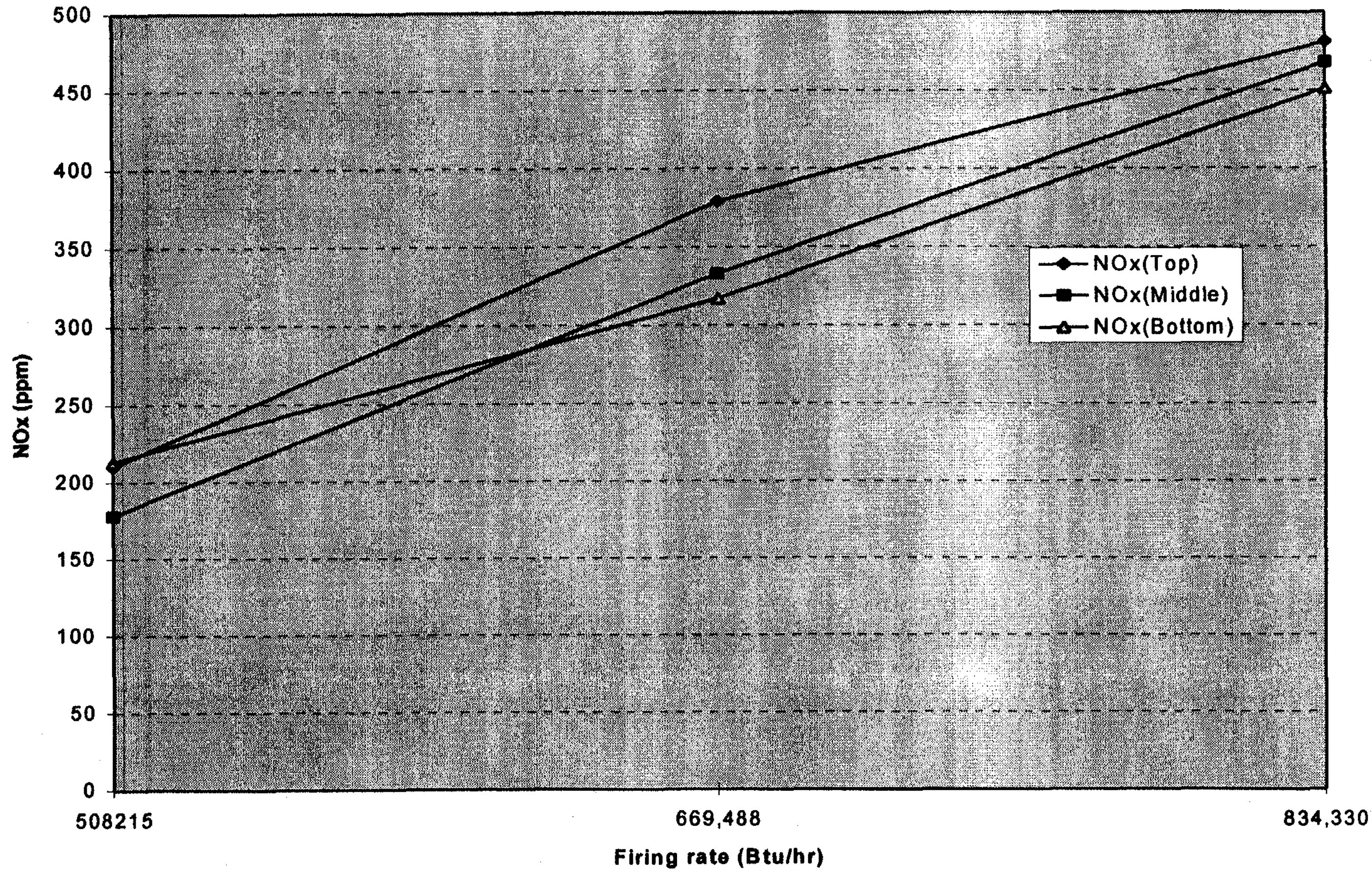

Figure 5 Effect of Firing Rate on NOx Measured at Three Locations of the Combustion Chamber

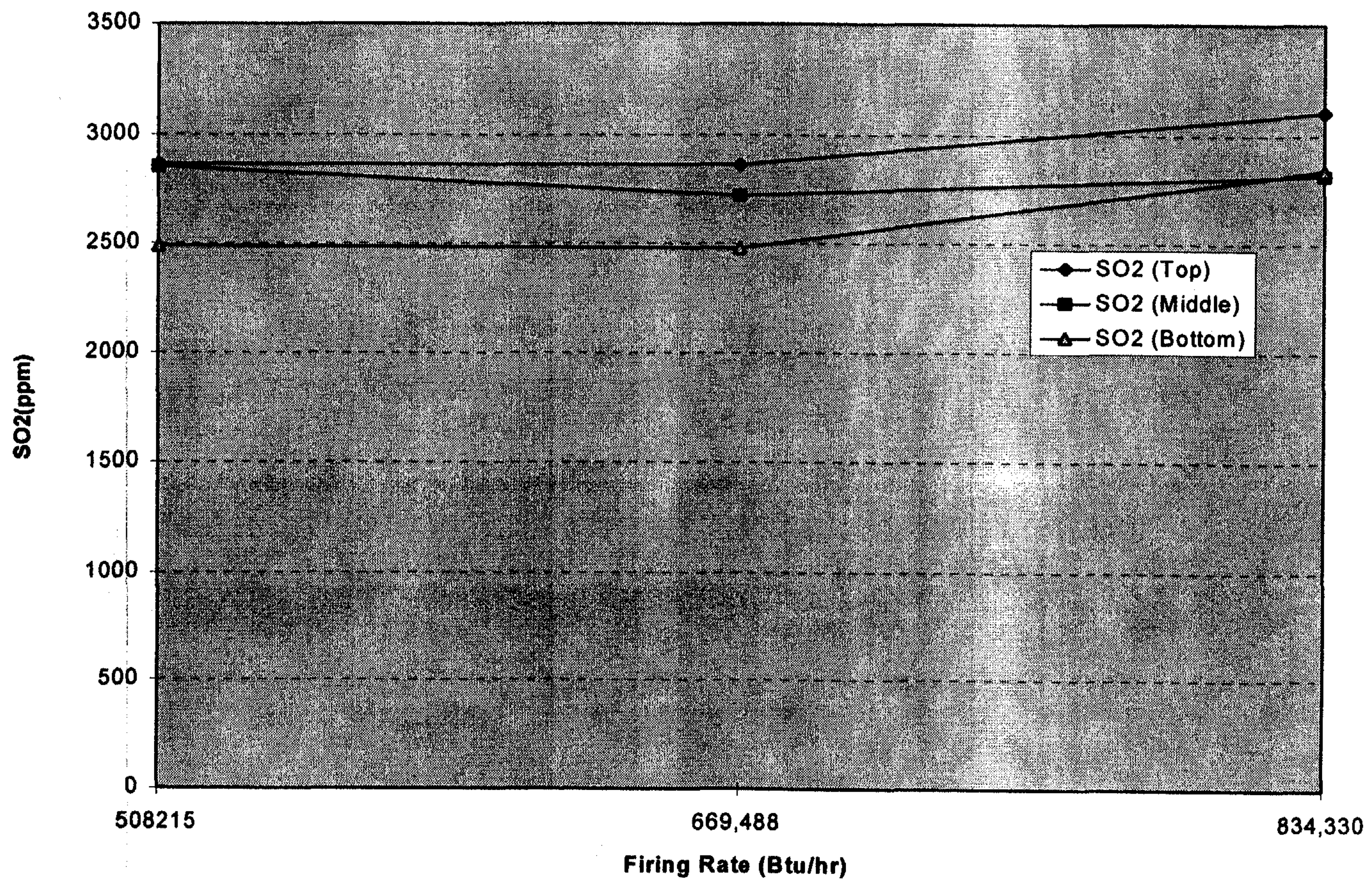

Figure 6 Effect of Firing Rate on SO2 Measured at Three Locations of the Combustion Chamber

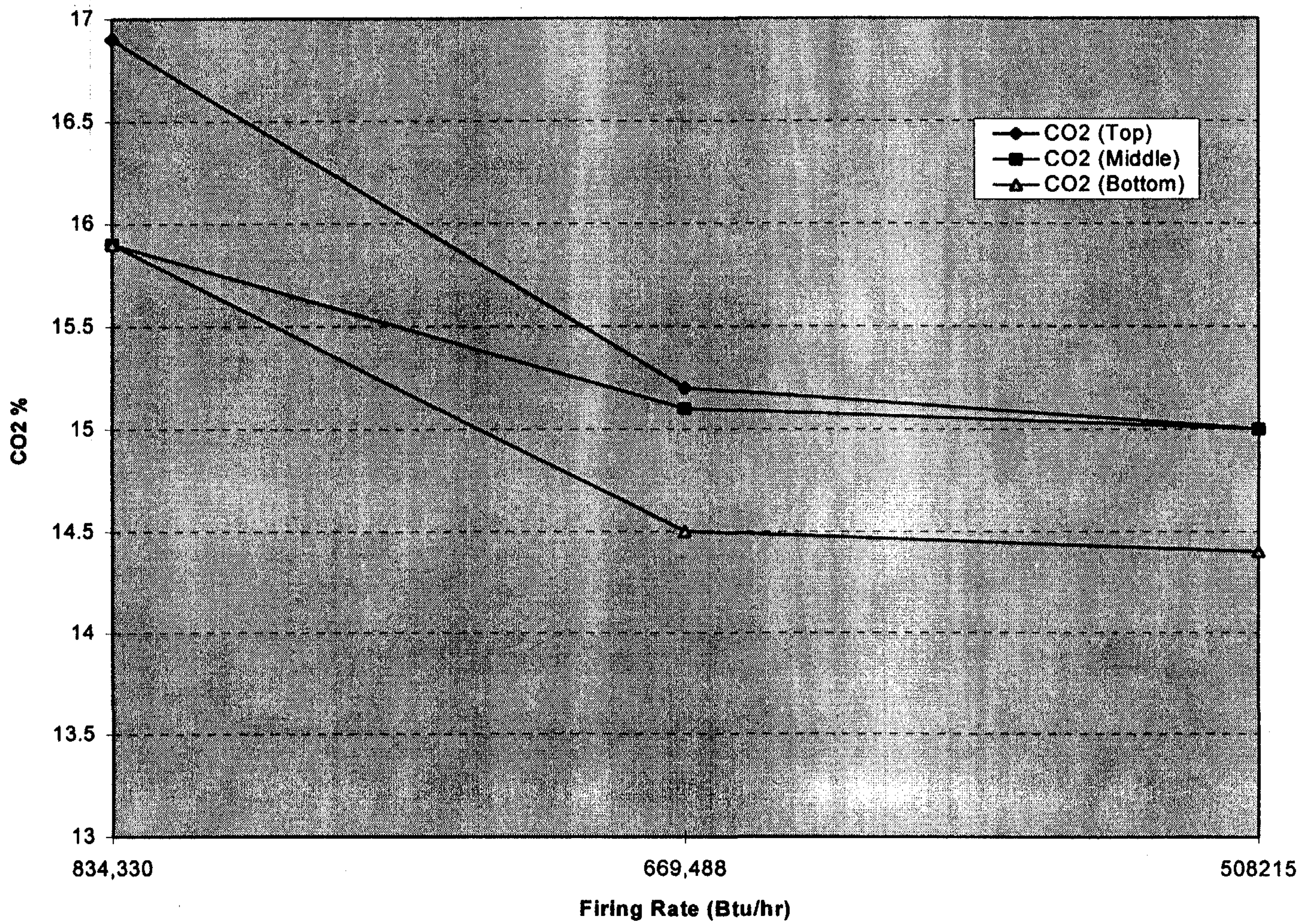

Figure 7 Effect of Firing Rate on CO2 Measured at Three Locations of the Combustion Chamber