STUDY ON BOILER NOx EMISSION AND CONTROL MEASURES IN FERTILIZER INDUSTRIES

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ABSTRACT

BACKGROUND

With the increasing population food material demand increasing in the world wide while due continues production soil fertility rate decreasing, so fulfillment of people food demands we needs fertilizers to increase food production. To increase the fertilizers production industrialization needs to increase everywhere. Fertilizer industries have boilers for steam production and reformer for hydrogen generation which have also waste heat recovery boiler. In the both furnace they are using natural gas and off gases as fuel. This study is covering comparative operation strategy of different industries as well as different boilers and its effects on Nitrogen oxides generation, sampling and analysis process and control measures. Industries have different operation process and parameters for the same boilers according to their heat recovery demands and energy saving scheme. NOx basically formed by the three ways thermal fuel and prompt. Boiler's furnaces are working at high temperature which causes Nitrogen oxides formation.

METHODS

By studying of the operation manuals of all boilers and furnaces.
By studying of the old lab data records.
By studying of the DCS history trends.
By day to day data and operational monitoring.
By sampling and analysis.

RESULTS

In this study we found following factors responsible for NOx emission

1. Design of burners.
2. Operation strategy.
3. Flue gas treatment.

CONCLUSION

We can reduce formed by stacks flue gas treatment. Selective Catalytic reduction system, selective non-catalytic reduction system, flue gas recirculation and ammonia/urea injection system are used for flue gas treatment. This study said ammonia/urea are usually available in fertilizers campus for treatment process but till still not a single fertilizer production company using this treatment process for Nitrogen oxides reduction. This study covering reference study of reformer furnace which I saw poker use for fuel distribution in case of off gases it is giving surprising result in Nitrogen oxides generation. Use of poker with ultra Nitrogen oxides burner in fuel system giving only 2-3 PPM Nitrogen oxides at stacks.

KEYWORDS: Nitrogen oxides, Environment, Fertilizer, Emission, Boiler, Stack.

INTRODUCTION

Nitric oxide (NO) and nitrogen dioxide (NO2) both are referred to as nitrogen oxides (Nitrogen oxides). Combustion of fossil fuels is the dominant source of Nitrogen oxides emissions. The emissions are not dependent on the amount of nitrogen in the fuel but also on the air-fuel mixture ratio. High temperatures and oxidation-rich conditions during combustion generally favor Nitrogen oxides formation in combustion.

Nitrogen oxides having a family of seven members as NO, NO2, N2O2, N2O, N2O3, N2O4, N2O5 in which NO and NO2 known as basic pollutant. All Nitrogen oxides finally converted as NO2 in atmosphere.

Boiler Nitrogen oxides formed as:

Combustion process: Fuel + Air (O_2 + N_2) + Ignition = combustion gases (Nitrogen oxides) + heat

Ideal Natural Gas

Example of natural gas: CH_4 + O_2 + N_2 => CO_2 + H_2O + N_2 + O_2 + Heat – Above 2600 F: N_2 + O_2 + Heat => Nitrogen oxides.

METHOD

By studying of the operation manuals of all boilers and furnaces.
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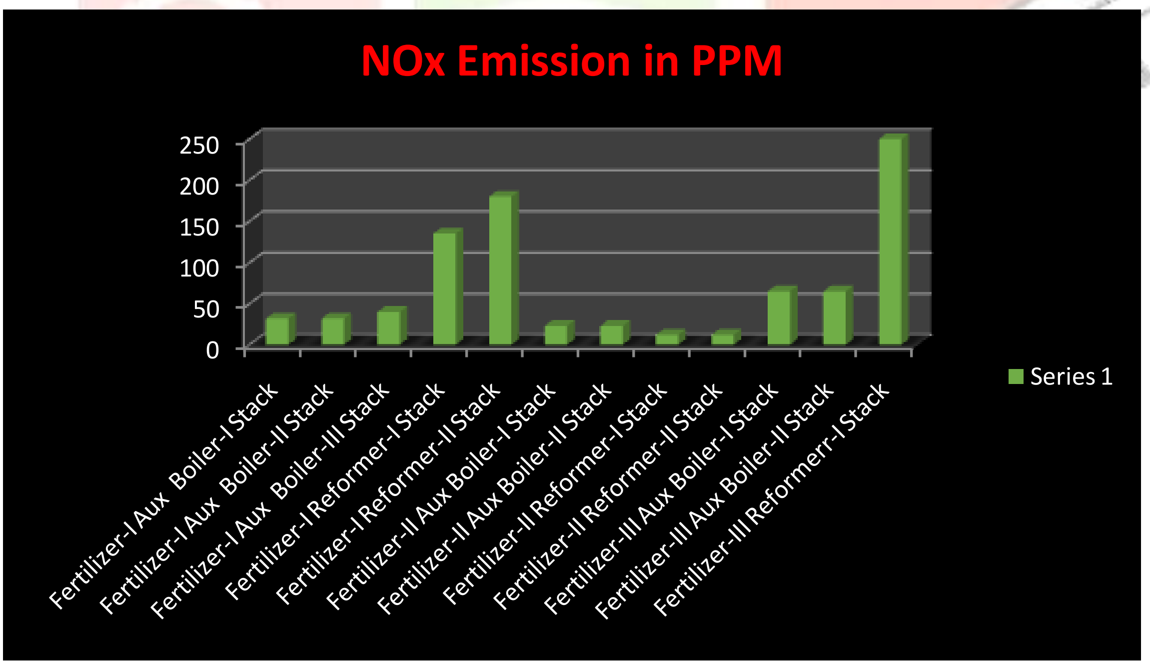
METHOD-I

Take 100ml NaOH solution in flask and pass flue gas through this solution with help of vacuum pump by rate of 0.5 LPM till 2hrs and store the sample for 24hr to ensure complete absorption. Then take 10ml of this store solution and mix with color agent then check color number at 543Hz wavelength. After finding color number multiplying by a correction factor and got Nitrogen oxides level.

METHOD-II

Take 1litter NaOH solution in flask cork tight with inert atmosphere and flush sampling line with help of vacuum pump and connect with NaOH flask without any air ingresing and fill 1 litter flue gas and store the sample for 24hr to ensure complete absorption. Then take 10ml of this store solution and mix with color agent then check color number at 543 Hz wavelength. After finding color number multiplying by a correction factor and got Nitrogen oxides level.

RESULT AND DISCUSSION



FERTILIZER PLANT-I: Fertilizer-I Aux Boiler-I & II both having 80 T/Hr capacity of steam generation by using of natural gas as fuel at 80 degree centigrade temperature and 1.5 kg/cm2 pressure to all 04 burners. Combustion air feed by blower fan at 29 C temperature and 250 MMWC pressure and flue gas exhausted at 150 C temperature by stack. Excess O_2 maintained at both boiler as 2.5%.these both boiler designed by themaax babcock Wilcox.

Fertilizer-I Aux Boiler- III having 160 T/Hr capacity of steam generation by using of natural gas as fuel at 80 degree centigrade temperature and 1.5 kg/cm2 pressure to all 04 burners. Combustion air feed by blower fan at 29 C temperature and 250 MMWC pressure and flue gas exhausted at 150 C temperature by stack. Excess O2 maintained at both boiler as 2.5%. This boiler designed by themaax babcock Wilcox.

Fertilizer-I Reformer-I is tubular reactor which is used for hydrogen generation process in bat process. It's having 320 T/Hr capacity of steam generation by flue gas heat recovery. In this furnace used natural gas with off gases as fuel at 130 C temperature and 0.50 kg/cm2 pressure to all 576 burners. Combustion air feed by blower fan at 320 C temperature and 450 MMWC pressure and flue gas exhausted by help of blower fan at 120 C temperature by stack. Excess O2 maintained at both boiler as 2.5%. This furnace designed by Haldor topso.

Fertilizer-I Reformer-II is tubular reactor which is used for hydrogen generation process in bat process. It's having 320 T/Hr capacity of steam generation by flue gas heat recovery. In this furnace used natural gas with off gases as fuel at 65 C temperature and 1.50 kg/cm2 pressure to all 112 main and 14 tunnel burners. Combustion air feed by blower fan at 320 C temperature and 450 MMWC pressure and flue gas exhausted by help of blower fan at 150 C temperature by stack. Excess O2 maintained at both boiler as 2.5%. This furnace designed by KBR.

FERTILIZER PLANT-II: Fertilizer-II Aux Boiler- I & II both have 150 T/Hr capacity of steam generation by using of natural gas with off gas as fuel at C temperature and 1.5 kg/cm2 pressure to all 04 burners. Combustion air feed by blower fan at 25 C temperature and 250 MMWC pressure and flue gas exhausted at 150 C temperature by stack. Excess O2 maintained at both boiler as 2.5%.These both boiler designed by Maachi Engineering.

Fertilizer-II Reformer- I & II are tubular reactor which is used for hydrogen generation process (bat process). It's having 320 T/Hr capacity of steam generation by flue gas heat recovery. In this furnace used natural gas with off gases as fuel at 45 C temperature and 1.50 kg/cm2 pressure to all 720 burners. Combustion air feed by ejector effect from ambient automatically at ambient temperature and flue gas exhausted by help of blower fan at 150 C temperature by stack. Excess O2 maintained at both boiler as 2.5%. These both furnace designed by Mishubishi heavy Industries (MHI).

FERTILIZER PLANT-III: Fertilizer-III Aux Boiler-I & II both has 80 T/Hr capacity of steam generation by using of natural gas as fuel at 80 C temperature and 1.5 kg/cm2 pressure to all 04 burners. Combustion air feed by blower fan at 29 C temperature and 250 MMWC pressure and flue gas exhausted at 150 C temperature by stack. Excess O2 maintained at both boiler as 2.5%.these both boiler designed by themaax babcock Wilcox.

Fertilizer-III Reformer-I is tubular reactor which is used for hydrogen generation process in bat process. It's having 320 T/Hr capacity of steam generation by flue gas heat recovery. In this furnace used natural gas with off gases as fuel at 45 C temperature and 0.50 kg/cm2 pressure to all 576 burners. Combustion air feed by blower fan at 375 C temperature and 450 MMWC pressure and flue gas exhausted by help of blower fan at 150 C temperature by stack. Excess O2 maintained at both boiler as 2.5%. This furnace designed by Haldor topso.

REDUCE THERMAL NITROGEN OXIDES FORMATION

ALTERING THE FUEL/AIR RATIO AND EXCESS O2

Nitrogen oxides can reduce by optimizing fuel/air ratio means O2 can we reduced up to acceptable limit while it is defined as 5-15% in theoretical calculation of combustion. But during my study I found in some furnace it's maintain as 1-3% which is giving good result in Nitrogen oxides emission and also saving overall energy in boiler.

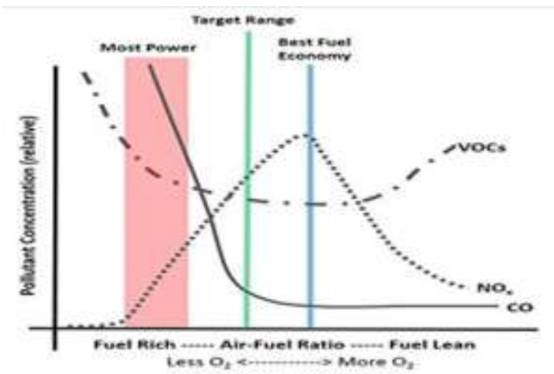


Fig: Air/Fuel Ratio Curve

IMPROVING FUEL/AIR DISTRIBUTION AND MIXING

Nitrogen oxides can reduced by proper mixing and retribution of fuel/air for this I found in my study some furnace having staged fuel burning system and some having staged air distribution system. I found in Algeria Fertilizer Project all furnaces having both systems.

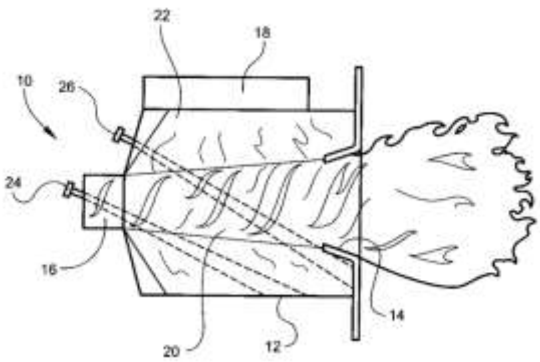


Fig: Air/fuel distribution

IMPROVING FLAME DISTRIBUTION

Nitrogen oxides emission can reduce by improving flame distribution in burner which helps to reduce hot spots in furnace; hot spots are basic cause for thermal Nitrogen oxides generation.

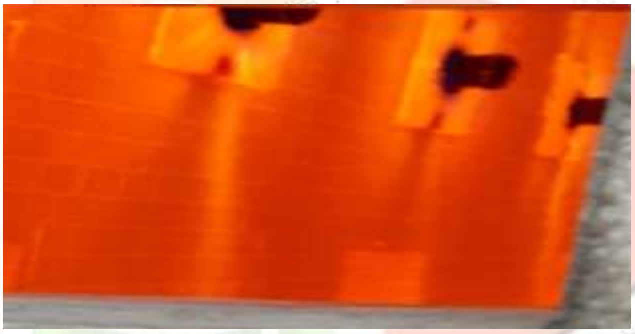


Fig: Burner flame distribution

Fig: Burner flame distribution

LOW-NITROGEN OXIDES BURNERS

This burner specially designed for low Nitrogen oxides generation approx 30 PPM

Fig: Low Nitrogen oxides burner Front

Fig: Low Nitrogen oxides burner back

ULTRA-LOW-NITROGEN OXIDES BURNERS

Ultra low Nitrogen oxides burner designed for very low Nitrogen oxides generation approx 7-15 %.

Fig: Ultra low Nitrogen oxides burner back

Fig: Ultra low Nitrogen oxides burner front

Fig: Ultra low Nitrogen oxides burner with Poker

TREAT THE BOILER EXHAUST TO REMOVE NITROGEN OXIDES

SELECTIVE CATALYTIC REDUCTION (SCR) SYSTEM

Once when Nitrogen oxides formed then we can reduce emission by treating to flue gas by selective catalyst reduction system. In the SCR we are using catalytic bed (ammonia injection for activation) in the path of flue gas before economizer. This catalyst bed adsorb Nitrogen oxides and by this way Nitrogen oxides emission in flue gas reduced.

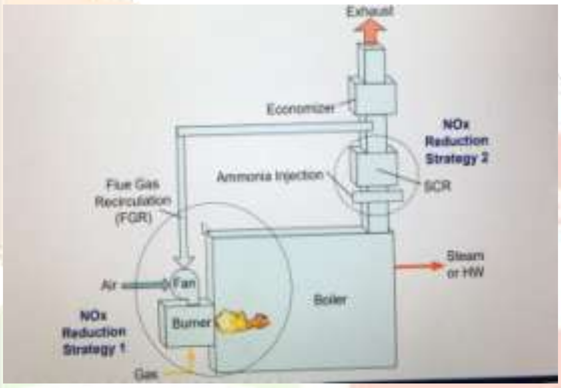


Fig: SCR

NON-CATALYTIC REDUCTION (SNCR)

To reduce Nitrogen oxides when we are using selective non catalyst reduction system then we are injecting ammonia or urea solution directly in hot flue gas which is reacted with Nitrogen oxides and reduce emission level at stack outlet.

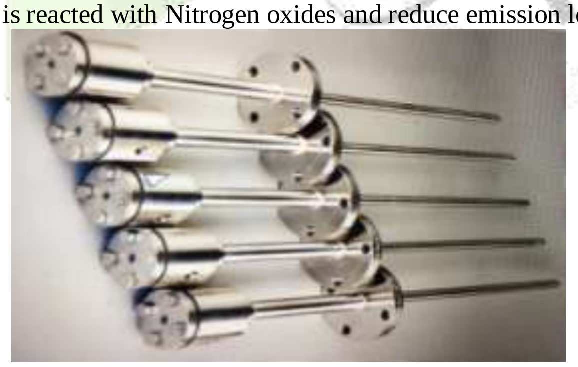


Fig: Injection gun

FLUE GAS RECIRCULATION (FGR)

In flue gas recirculation system we are using a part of flue gas as combustion air by help of combustion air blower.

Fig: FGR

CONCLUSION & RECOMMENDATIONS

The analysis of emission and control statistics of the review period concluded that Nitrogen oxides emission levels are reducing due to the implementation below recommendation and safety performance of the organization.

CONCLUSION

Boiler Nitrogen oxides emission is a very serious problem of India and it is very interesting to study. I had study here many boilers of India and also some boilers out of India and found big difference between them. It is very surprising for me here in India industries start using online analyzers since some years only. I did here a reference study on reformer stack where also installed west heat recovery boiler and found there too much high Nitrogen oxides emission in some industries. In this study covered about general about Nitrogen oxides and Nitrogen oxides family, environmental impact of Nitrogen oxides, sampling process and analysis and result and discussion. Here also discussed about available control measures and possible scopes.

RECOMMENDATIONS

Based on the detailed study and project work the following recommendations are suggested for improving the Control the Nitrogen oxides emission in fertilizers industries.

1. Ultra low Nitrogen oxides burner should be mandatory.

2. Operation strategy should be uniform which support to low Nitrogen oxides generation.

3. Ammonia injection in flue gas because they have ammonia in the same campus.

4. Flue gas recirculation system should be installed.

DECLARATIONS

ETHICS APPROVAL AND CONSENT TO PARTICIPATE:

"Not applicable"

CONSENT FOR PUBLICATION:

"Not applicable"

AVAILABILITY OF DATA AND SUPPORTING MATERIALS SECTION:

"Please contact author for data requests."

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AUTHORS' CONTRIBUTIONS:

Vinay Prakash Tyagi did site study and data collection with lab analysis.

Dr. Nihal Anwar Siddiqui conceived of the study, and participated in its coordination and guide to draft the manuscript.

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LIST OF ABBREVIATIONS

NOx	:	Nitrogen oxides.
NO	:	Nitric oxide.
NO2	:	Nitrogen dioxide.
N2O	:	Nitrous oxide.
N2O2	:	Dinitrogen dioxide.
N2O3	:	Dinitrogen trioxide.
N2O4	:	Dinitrogen tetroxide.
N2O5	:	Dinitrogen pentaoxide.
PPM	:	Part per million.
Hz	:	Hertz.
O2	:	Oxygen.
N2	:	Nitrogen.
CO2	:	Carbon dioxide.
NaOH	:	Sodium hydroxide.
Aux	:	Auxiliary.
MMWC	:	Millimeter water column.
Kg/cm2	:	Kilogram per centimeter square.
T/Hr	:	Ton per hours.
KBR	:	Kellogg Brown and Root.
MHI	:	Mitsubishi heavy industries.
SCR	:	Selective catalytic reduction.
SNCR	:	Selective non-catalytic reduction.
FGR	:	Flue gas recirculation.

FIGURES IN MS:

1. "NOx EMISSION DATA"
2. "RESULTS GRAPHICS"

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