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Emission reduction opportunities of Coal-Fired Steam Generator

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Abstract. Energy and its production today has become one of the most controversial topics. Power plants around the world produce energy with different sources, but so far there is no energy source that can make competition with coal for many years and for many reasons. Even though power plants with this kind of fuel have their own advantages, the biggest drawbacks are the release of hazardous and toxic substances. These emission components negatively affect the environment and for this reason in many countries of the world, are described the limits of the emitting rate. For this purpose, in this paper there will be analyzed methods which may result in the reduction of emissions and the adjustment of power plant efficiency especially in the steam generator as one of the main parts.

Keywords: Energy, Power Plants, Steam Generator, NOx emissions

1 Introduction

Coal is considered as the most widely used fuels and according to statistics it is said to be around 75% of the energy supply in many parts of the world. The work of power plants that use coal as a fuel has a deficiency and it is the emission of nitrogen oxides. As day to day, the release of such oxides is increasing, there are arising concerns about the quality of air and health in general. Since such emissions are a big concern related to many life issues, then for their reduction, a change should be made. During the combustion process, we have the desire to use the energy of the fuel to the maximum. Also by exploring for changing the operation of the combustion equipment, we must make sure that we do not increase the risk of emissions of other substances and that this modification will affect the breakdown or deterioration of the working process and flexibility. In this paper, there will be analyzed some of the methods that can be applied in order to control emissions of harmful components in accordance with established standards and rules.

2 NOx emissions and methods of its reduction in Steam Generator

NOx is produced from the reaction of nitrogen and oxygen gases in the air during combustion, especially at high temperatures [1]. This component, in addition to negative effects on health, has negative effects on ecosystems as well. Investigations on the side effects of the use of fossil fuels that accompany the release of these materials have been made years ago, when somewhere between 1990, the introduction of an emission reduction method resulted in a satisfactory reduction of NOx. So far, some proposals have been made for methods that help reduce the quantity of such components. For controlling NOx emissions, there are usually approached Combustion Control and Post- Combustion Control. Combustion controls reduce the level of NOx emissions by altering or modifying the firing conditions under which combustion is achieved [2]. Post-combustion controls reduce the level of NOx emissions by converting the NOx formed during combustion to nitrogen (N₂) gas [2] and this group includes: SNCR (selective non-Catalytic Reduction) and SCR (Selective Catalytic Reduction). In general, some of the methods that control nitrogen oxide emissions are the following:

- Burner Optimization
- Low NOx burners
- OFA(Over Fire Air)
- Flue Gas Recirculation
- Low Excess Air

Burner Optimization: The burner optimization for reducing NOx is made by making changes in operating conditions. By modifying the mills, air and fuel balance, a significant reduction in NOx emissions can be achieved.

Low NOx burners: Low-NOx burners are designed to reduce the peak flame temperature by inducing recirculation zones, staging combustion zones and reducing local oxygen concentrations.

Fig. 1. Low NOx burner [3]

OFA (Over Fire Air): OFA- over Fire Air or two stage combustion is a way of including over firing air in boilers where the air is divided into primary and secondary sections. The OFA allows to obtain an amount of combustion air from the primary combustion zone. Primary air is mixed with fuel while secondary air is introduced through the air nozzles above the combustion zone. The purpose of an OFA system is to reduce NOx emissions from the boiler by staging the combustion process. A portion of the secondary air is diverted from the burner front to a series of OFA ports that are located above the burners. As a result, the burners are fired with less than the total amount of air needed for completed combustion.

Fig. 2. OFA Scheme [2]

Flue Gas Recirculation: Flue gas recirculation is a highly efficient technique for reducing NO_x. This method has been implemented for a long time and operates according to the principle of recirculation of flue gases from the boiler exhaust duct into the main combustion chamber. The higher the heat capacity of the flue gases, the greater the reduction, a higher amount of flue gases is equal to a lower flame, a lower flame temperature is equal to less NO_x [4]. This technique is the best when it comes to manage costs and benefits. Its main advantages are: there is allowed the perfect correct flow of flue gas for any operation condition and it also can turn down with the firing rate of the burner, its cost comparing to other NO_x reduction system, is lower etc. Apart from the advantages this method has also disadvantages and one of them is the potential loss of flame stability.

Fig. 3. Flue Gas Recirculation Scheme [2]

Low Excess Air: The excess air in boilers is among the main factors of NO_x creation. Thus, low air-firing has been introduced, which reduces NO_x to a nice percentage. The NO_x creation rate typically peaks at excess oxygen levels of 5 – 7% where the combination of high combustion temperatures and the higher oxygen concentrations act together. Thus, through the LEA, the limitation of excess air entering the combustion process is made so as not to result in excessive amounts of nitrogen and oxygen entering the flame.

SNCR (Selective non-Catalytic Reduction): Is a method of reducing NO_x by incorporating substances such as ammonia or urea into the flue gas. If the temperatures are lower than the optimal ones, then the opposite occurs, there increases the NO_x emission. Temperature, residence time, type of NO_x reducing reagent, reagent injection rate, uncontrolled NO_x level, distribution of the reagent in the flue gas, and CO and O₂ concentrations all affect the reduction efficiency of the SNCR [5].

Fig. 4. SNCR [3]

SCR (Selective Catalytic Reduction): This is an advanced system for reducing NO_x through the use of a liquid (in this case) ammonia. The catalyst allows the ammonia to reduce NO_x levels at lower exhaust temperatures than selective non-catalytic reduction. The technology is that the ammonia or the appropriate nitrogen compounds which are blown into the SCR reactor reduce the NO_x to the N₂ and H₂O under the catalysis of the metal catalyst [6].

Fig. 5. SCR [3]

3 Conclusion

In this paper are shown some of the methods and technologies that have been used in recent years and which are of great importance because they help to reduce the risk of being threatened by the environment of health issues in general. Even though these methods have some drawbacks, they are efficient and through their application NO_x values can be reduced to high percentages. These methods are likely to combine among themselves and thus can achieve a reduction of up to 80%.

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