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Design and Constructional Changes in Boiler Chimney to Enhance Boiler Efficiency

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Abstract- The heat lost in boilers is through many ways such as discharge of hot combustion gases to the atmosphere through chimneys, discharge of hot waste water, and heat transfer from hot surfaces. This study is regarding the changes in design of the boiler chimney to reduce the fouling creation in chimney. In this research, an initial design of chimney for 15 TPH boiler, 16 bar pressure is considered. The design had a problem, in that designed chimney, maximum amount of carbon particles i.e. fouling is formed. This study is based on the work undertaken to redesign the flue gas duct in chimney to reduce the formation of fouling which affect the efficiency of the boiler. This system was specifically designed for boiler chimney. In the completion of the design, the flappers are provided in the flue gas duct. The attempt of this research is to reduce the cross section area in that particular segment to increase the flow of flue gases.

Keywords- fouling, particulate filter, particulate matter, degasification

1 INTRODUCTION

The heat lost in boilers is through many ways such as discharge of hot combustion gases to the atmosphere through chimneys, discharge of hot waste water, and heat transfer from hot surfaces. This research is about redesigning of the boiler chimney to reduce the fouling creation in chimney. In this research, an initial design of chimney for 15 TPH boiler, 16 bar pressure is considered. In this design the main problem is the amount of carbon particles formed i.e. fouling is maximum. Fouling is atopic of interest in almost all heat production systems. A noticeable fall in thermal efficiency can be caused by accumulated fouled matter, especially in those surfaces where heat exchange takes place.

In the particular case of heat production systems (furnaces, boilers), fouling or slagging problems are of interest, especially in those surfaces where heat exchange takes place. There, the sum of the accumulated fouled matter creates an insulating layer (low thermal conductivity) that reduces the global heat transfer coefficient to the working/heating fluid. As a consequence, the thermal efficiency will fall, leading to an increase in exploitation costs and pollutant emissions. In some cases, this gas-side fouling is accompanied by corrosion, or even erosion, by the impact of particulate matter (PM).

2 PROBLEM STATEMENT

Due to emerging technologies in boiler industry there emerges a need to manufacture efficient boilers. For efficient working of boiler it is necessary to considerdifferent parameters in it. The performance of boiler gets affected by different heat loss occurring in the boiler. The problem enquired with many industries is that un-burnt flue gases get accumulated on the inner surface of chimney and this forms a layer of gases on inner surface, this phenomena is called as fouling. Due to fouling in chimney surface its heat transfer rate decreases and thus the efficiency of boiler gets affected. So to overcome this type of problem we need to make a provision to recover heat lost through flue gases exhaust at the chimney stage taking a keen consideration of the effect of fouling. This fouling effect is reduced by increasing the velocity of the flue gases. So we need to make a provision for increasing the velocity of flue gases.

3 LITERATURE REVIEW

S. Chapela, J. Porteiro*, M. Garabatos, D. Pati~no, M.A. Gomez, J.L. Míguez[1] This paper shows the study about Biomass which has the advantage of being easily used in existing installations with non-renewable solid fuels, either as a final fuel or as a transition fuel. However, biomass use presents serious operational problems, such as slagging and fouling, which have slowed its development.

Jinqing Wang *, Yichao Yuan, Zuohe Chi, Guangxue Zhang[2] This paper concludedthe theory to address the fouling problem in boilers fired with high-sodium coal (HSC), a composite ceramic coating was developed using the slurry method and applied on 15CrMo steel. The fouling and thermal shock resistance was found excellent. After five fouling cycles, the uncoated steel had a surface fouling rate of 21.9%, compared to 0% for the coated steel. However, remarkable anti-fouling results were achieved when the composite ceramic coating was applied in an industrial boiler fired with a HSC blend.

CaiYongtiea, Yang Wenminga *, ZhengZhimina, XuMingchena, SiahKengBoonb, PrabakaranSubbaiahb[3] studied on modeling of ash deposition in biomass boilers. The ash deposition process in biomass boilers can induce many ash-related problems. It will reduce the heat transfer in the furnace walls and convective pass tubes and decrease the boiler efficiency and capacity. Previous review work and experience about the ash deposition process was almost focusing on coal-fired utility boiler, providing an extensive summary of knowledge and current developments about ash deposition processes, but few was concentrating on the biomass fuel-derived boiler. Numeral empirical and traditional methods, such as ash fusibility, ash viscosity, and slagging and fouling indices, which are based on the temperature and chemical composition, cannot fully predict the complicated ash deposition process.

David Patiño *, Bárbara Crespo, JacoboPorteiro, Jose L. Míguez [4} performed experimental analysis of fouling rates in two small-scale domestic boilers. In this research, two domestic-scale commercial pellet boilers were studied (24kW water-tube boiler-stove and a 60kW fire-tube boiler). Average fouling rates (FR) of 7–12g/m^2h in the water-tube boiler-stove and 3–5g/m^2h in the fire-tube boiler were measured. In addition, measurements of the particulate matter (PM) concentration and flue gas composition were made during the tests. PM values of 110–280mg/Nm3 were measured for the water-tube boiler and 13–135mg/Nm3 for the fire-tube boiler.

SeungHeeEuh, SagarKafle , Yun Sung Choi, Jae-Heun Oh, Dae Hyun Kim*[5] studied on the effect of tar fouled on thermal efficiency of a wood pellet boiler. This study presents CFD (Computation Fluid Dynamics) simulation of thermal behaviour of the boiler and analysis of the thermal efficiency affected by tar fouling on the heating surface of the combustion chamber. To investigate the effect of tar fouling on thermal efficiency, the experiments were performed by combusting the 1st and the 3rd grade wood pellets, and compared with the simulations. By about 1 mm tar fouling in heating surface of the boiler the thermal efficiency dropped by 7.26% and 9.19% in the 1^{st} and the 3rd grade wood pellets, respectively.

Shiping Zhang*, GuoqingShen, Liansuo An, YuguangNiu, Genshan Jiang[6] explained monitoring the real-time pollution status of the ash fouling produced by power station boiler furnaces and properly using the soot blower system of the boiler can significantly improve the safety and efficiency of such coal-fired boilers. This article examined the application of acoustic pyrometry close to the water-cooling wall by monitoring the flue gas temperature.

4 TECHNICAL DEPTH AND STUDY

INDUSTRIAL WASTE HEAT

This is heat lost in industries through ways such as discharge of hot combustion gases to the atmosphere through chimneys, discharge of hot waste water, heat transfer from hot surfaces. This energy loss can be recovered through heat exchangers and be put to other use such as preheating other industrial fluids such as water or air. This project focuses on recovering heat that is lost through boiler chimney flue gas.

The advantages of heat recovery include:

i)Increasing the energy efficiency of the boiler.

ii) Decreasing thermal and air pollution dramatically.

CHIMNEY

A chimney is architectural ventilation structure made of masonry, clay or metal that isolates hot toxic exhaust gases or smoke produced by boiler, stove, furnace, etc. Chimneys are typically vertical to ensure that the gases flow smoothly, drawing air into the combustion. The space inside the chimney is called the flue. Chimneys are adjacent to large industrial refineries, fossil fuel combustion facilities.

The height of the chimney influences its ability to transfer flue gases to external environment via stack effect. Additionally, the dispersion of pollutants at higher altitudes can reduce their impact on the immediate surroundings. The dispersion of pollutants over a greater area can reduce their concentrations and facilitate compliance with regulatory limits.

A chimney pot is placed on top of the chimney to expand the length of the chimney inexpensively and to improve the chimneys draft. A chimney with more than one pot on it indicates that multiple fire places on different flows share the chimney. A chimney damper is a metal plate that can be positioned to close off the chimney when not in use and prevent outside air from entering the interior space and can be opened to permit hot gases to exhaust when fire is burning.

5 FOULING

Fouling is the accumulation of unwanted material on solid surfaces to the detriment of function. The fouling materials can consist of either living organisms (bio-fouling) or a non-living substance (inorganic or organic). Fouling is usually distinguished from other surface-growth phenomena, in that it occurs on a surface of a component, system or plant performing a defined and useful function, and that the fouling process impedes or interferes with this function.

Fouling phenomena are common and diverse, ranging from fouling of ship hulls, natural surfaces in the marine environment (marine fouling), fouling of heat-transfer components through ingredients contained in the cooling water or gases, and even the development of plaque or calculus on teeth, or deposits on solar panels on Mars, among other examples. This article is primarily devoted to the fouling of industrial heat exchangers, although the same theory is generally applicable to other varieties of fouling. In the cooling technology and other technical fields, a distinction is made between macro fouling and micro fouling. Of the two, micro fouling is the one which is usually more difficult to prevent and therefore more important.

TYPES OF FOULING

A.Macro-Fouling

Macro fouling is caused by coarse matter of either biological or inorganic origin, for example industrially produced refuse. Such matter enters into the cooling water circuit through the cooling water pumps from sources like the open sea, rivers or lakes. In closed circuits, like cooling towers, the ingress of macro fouling into the cooling tower basin is possible through open canals or by the wind. Sometimes, parts of the cooling tower internals detach themselves and are carried into the cooling water circuit. Such substances can foul the surfaces of heat exchangers and may cause deterioration of the relevant heat transfer coefficient. They may also create flow blockages, redistribute the flow inside the components, or cause fretting damage.

B. Micro-Fouling

Scaling or precipitation fouling, as crystallization of solidsalts, oxides and hydroxides from water solutions, as an example, carbonate or atomic number 20 sulfate; Particulate fouling, i.e., accumulation of particles, generally mixture particles, on a surface; Corrosion fouling, i.e., unchanged growth of corrosion deposits, as an example, iron ore on steel surfaces; reaction fouling, as an example, decomposition or chemical change of organic matter on heating surfaces; curing fouling - one part of the flowing fluid with a high-melting purpose freeze onto a sub-cooled surface; Bio-fouling, like settlements of bacterium and algae; Composite fouling, whereby fouling involves quite one foulant or fouling mechanism.

C. Precipitation Fouling

Scaling or precipitation fouling involves crystallization of solid salts, oxides, and hydroxides from solutions. These are most often water solutions, but non-aqueous precipitation fouling is also known. Precipitation fouling is a very common problem in boilers and heat exchangers operating with hard water and often results in limescale.Through changes in temperature, or solvent evaporation or degasification, the concentration of salts may exceed the saturation, leading to a precipitation of solids (usually crystals).

- Calcium carbonate (calcite, aragonite usually at t > ~50 °C);
- Calcium sulphate (anhydrite, hemihydrate, gypsum);
- Calcium oxalate (e.g. beerstone);
- Barium sulphate (barite).

6DESIGN AGAINST FOULING

We considered the various effects of fouling on the system and its performance, and the rate of deposition of the unwanted material i.e. fouled material on the inner walls of the chimney was in large amount, so we made changes in the previous construction of chimney and designed the flappers by various calculations to install it in the chimney.

Reasons for introduction of flappers:-

1. Increase in the velocity of the flue gases.
2. Reduction in deposition of fouling elements on the inner surface of the chimney.
3. Increase in the heat transfer rate of the system.
4. Reduction of fouling factor.

While doing this, we've ensured that there are sufficient provisions which will meet the process specification up-to shut down for cleaning.

EXISTING SYSTEM PARAMETERS

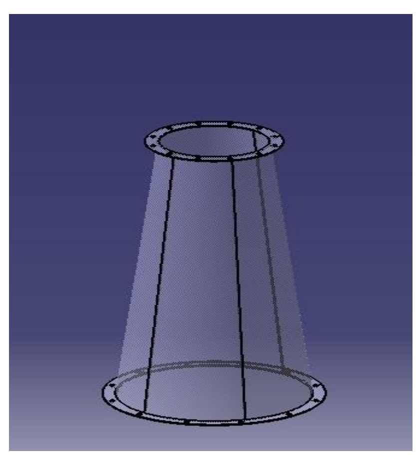

Fig 1:- CAD model of chimney

Parameters

9 CONCLUSION

The study of actual plant presented here is well suited for furthering the goal of more efficient energy resource use, locating the areas of energy wastage, cause and true magnitude of waste to be determined. Such information can be used in the design of new chimneys and for increasing the efficiency of existing systems. These detailed analyses provide a powerful and systematic tool for identifying all sources of problems and for optimizing the design of Boiler Chimney. This methodology can be used for future works as an exploratory approach for improving the cost effectiveness of the Boilers and unit costs of products, not only in Energy Intensive Industries but also to the Thermal power plants.

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