To Improve the Boiler's Efficiency Using a Variety of Methods

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A B S T R A C T
When evaluating boiler efficiency using the conventional method, a complete study of the coal is required. Yet, it is hard to regularly monitor the efficiency of a boiler because it is so expensive and time-consuming. The majority of businesses can, however, operate since it is considerably simpler to perform proximate analysis on coal. The study's major goal was to evaluate how many characteristics, including return water temperature, condenser temperature, and many other parameters linked to temperature concerns, affected the boiler's performance in addition to verifying the performance claims. Monitoring boiler performance has the purpose of regulating the plant's heat rate. In this essay, the operating efficiency of a boiler is determined, and significant losses are computed

Keywords:Boiler efficiency, Supercritical technology, Reduce fuel consumption, Usage of ESP

1. Introduction

Due to their excellent fuel efficiency, diesel engines are frequently employed in transportation and power production applications. Unfortunately, due to their significant NOx and soot emissions, diesel engines can pollute the environment. As a result, a lot of effort has been put towards lowering these pollutant emissions because they have a negative impact on both the environment and human health. Several innovative compression ignition combustion techniques have been put forth in an effort to lower NOx and soot emissions in-cylinder while keeping good thermal efficiency.

Any power station's boilers are regarded as the most important component because they are where the fuel is used to generate the required amount of heat. A boiler is an enclosed vessel that offers a way to transmit the heat from combustion to turn water into steam. A boiler is a sophisticated assembly of an evaporator, reheater, super heater, economizer, air pre heater, as well as a number of auxiliary components such fans, pulverizers, and other devices[1]. The goal of the boiler performance test is to compare the boiler's actual performance and efficiency to its design values. It serves as a gauge for monitoring changes in boiler efficiency from day to day and season to season as well as advancements in energy efficiency for controlling unit heat rate:

The direct method:
Where the energy gain of the working fluid (water and steam) is compared with the energy

content of the fuel. This is also known as „input-output method" due to the fact that it needs only the useful output (steam) and the heat input (fuel) for evaluating the efficiency. This can be evaluated using the formula as follows :

Boiler Efficiency=Heat Input/Heat Output×100
Boiler Efficiency=Steam flow rate×(steam enthalpy-feed water enthalpy)

Until 2008, the total number of using industrial boilers has been amounted to 578200 units. The traditional method to test boiler efficiency is time consuming and expensive, and the test of boiler efficiency needs ultimate analysis of fuel. However, the test of the ultimate analysis of fuel is in need of long time, and its related equipment is also more expensive. Now taking coal-fired boiler for example, through the regression analysis, a new calculated

model is proposed. Ultimate analysis is replaced by proximate analysis of coal in boiler efficiency testing. This method can simplify the experimental procedure greatly. Save time and cost in the experiment.

The formation and emission of NOx have been of particular interest . In the performance of central heating systems fired by biomass and particularly wood pellets has been studied. In their study of the emissions from a domestic/small-scale 50 kWth underfeed stoker biomass pellet boiler, Liu et al. concluded that an air staging (primary and secondary air) leads to considerable NOx reductions, particularly with biomass fuels containing relatively high fuel-N content (higher than 0.46 % on mass basis). On the other hand, they highlighted the fact that the height of the secondary air inlets above the bed plays an important role on the emissions, but a trade-off between NOx emission and CO emission has to be considered. Concerning especially the NOx emission, Glarborg et al. have studied the chemical and physical processes that govern formation and destruction of nitrogen oxides in combustion of solid fuels and concluded that, although the governing mechanisms for fuel nitrogen conversion are not completely understood, in most solid fuel fired systems, oxidation of fuel-bound nitrogen constitutes the dominating source of nitrogen oxides. After an experimental investigation of the ratios H/N and O/N content of the biomass and their relation to NO fuel formation for a lot of biomass data set, Vermeulen et al. have concluded that for weight ratio H/N above 25 and ratio O/N above 140, all fuel N converts to NO. The same conclusion has been drawn by Sartor et al. in their work aimed to develop a global simulation model of the CHP plant and the attached district heating network installed on the Sart-Tilman Campus of the University of Liège.

The Indirect method:

Where the efficiency is the difference between the losses and the energy input. The efficiency can be measured easily by measuring all the losses occurring in the boilers using the principles to be described. The efficiency can be arrived at, by subtracting the various heat losses from 100. An important advantage of this method is that the errors in measurement do not make significant change in efficiency. [2] Efficiency=100- (L1+L2+L3+L4+L5+L6+L7+L8) Where,

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L1-Loss due to dry flue gas (sensible heat) L2- Loss due to hydrogen in fuel (H2) L3- Loss due to moisture in fuel (H2O) L4- Loss due to moisture in air (H2O) L5- Loss due to carbon monoxide (CO) L6- Loss due to surface radiation, convection and unaccounted L7- Loss due to Unburnt in fly ash (Carbon) L8- Loss due to Unburnt in bottom ash (Carbon)

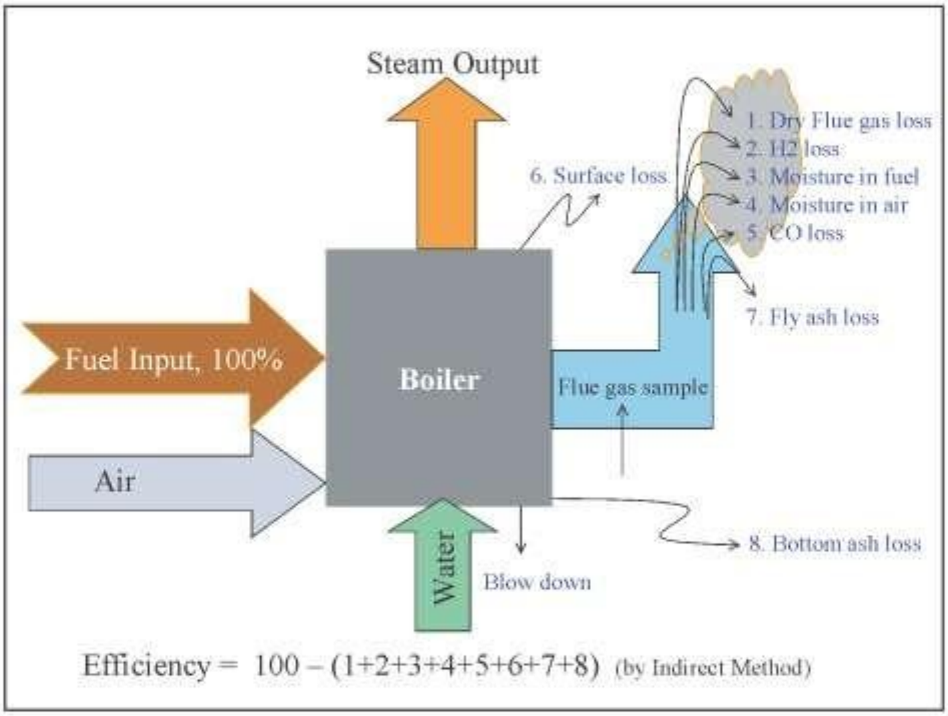

Fig.1 Fuel calculation after combustion of coal

2. Techniques to check the performance of Boiler

The following parameters need to be measured, as applicable for the computation of boiler efficiency and performance. [2, 3]

a) Flue gas analysis

- Percentage of CO2 or O2 in flue gas
- Percentage of CO in flue gas
- Flue gas temperature

b) Flow measurement

- Steam

- Fuel
- Feed water
- Condensate water
- Combustion Air

c) Temperature measurement

- Steam
- Feed water
- Condensate return
- Flue gas

d) Pressure measurement

- Steam
- Flue gas
- Combustion Air

e) Ultimate analysis for H2, O2, C, S, moisture and ash content

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3. Heat loss due to Incomplete Combustion

If V is the volume of dry gas, and CO , 2 H , m n C H is CO content volume percentage of dry gas, H content volume percentage of dry gas, and m n C H content volume percentage of dry gas. As the content of 2 H and m n C H in dry gas is extremely low and in order to calculate easily, Assuming incomplete combustion gas is onlyCO.

the 1980s as a result of renewed interest in renewable energy sources for reducing greenhouse gas (GHG) emissions, and alleviating the depletion of fossil fuel reserves. Biodiesel is defined as mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats and alcohol with or without a catalyst . Compared to diesel fuel, biodiesel produces no sulphur, no net carbon dioxide, less carbon monoxide, particulate matters, smoke a nd hydrocarbons emission and more oxygen. More free oxygen leads to the complete combustion and reduced emission

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4. Effect of Combustion

Preliminary tests have been performed to investigate the effect of the cycling frequency of the burner and the burner load. For 3 different output powers of the boiler (around 8, 6 and 4 kW), those tests have shown that the levels of NOx and CO emission decrease if the OFF period of the burner is decreased. The lowest emissions where obtained with the OFF period being completely suppressed. That is why all the tests whose results are discussed hereafter have been performed the burner working in continuous regime thanks to the new electric motor installed on the boiler to drive the endless screw that push the wood pellets in the combustion chamber. The same mass flow rate of the wood pellets has been adjusted (4.9 10 -4 kg/s) and thus the same heat input (8.68 kW on the lower heating value basis). Notice also that with the NO2 to NO converter, the NO2 measurements were of the same order of magnitude as the accuracy of the NO analyser (3 ppmv). Fig. 2 shows the evolutions of CO2, CO and NO during a test performed to investigate the effect of the excess air [8]. Despite the change made on the pellets feeding system to make it continuous (contrary to the original equipment), fluctuations on the measurements remain. That explains why a post-processing treatment of the measured data was required before calculating the mean values and their standard deviations on a stabilized period. That post-processing of all the measured variables has been performed by means of the Chauvenet criterion suggested in the Ashrae guideline and all the calculations have been performed in EES environment The great fluctuations observed on the CO emission with a continuous feeding of the pellets may be explained by the fact that the wood pellets combustion process is a complex one by nature.

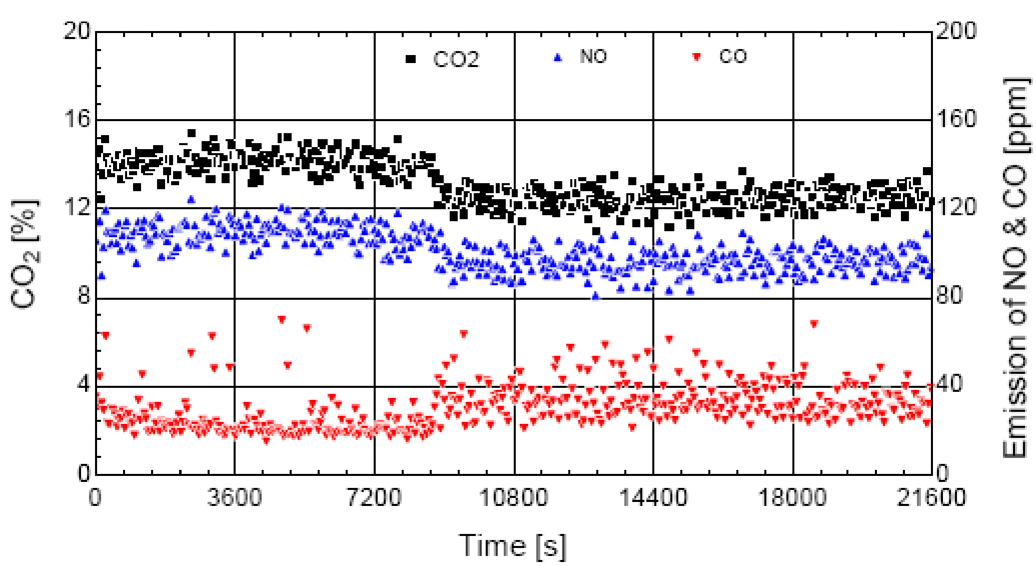

Figure 2. The flue gas dew point temperature versus the air-fuel equivalence ratio [8]

5. Outcome

The above calculation shows the various losses in boiler. The major heat losses in boiler occur due to dry heat gas loss (6.166), wet flue gas loss (10.603), and combustible loss (0.532). To find causes of above losses in boiler and recommendation to reduce the causes of degradation of boiler performance are given by fault tree analysis (FTA). The heat rate fault tree is used to identify areas in the plant where heat rate degradation may be occurring without conducting expensive tests. The fault tree is structured to provide a process by which decisions can be determined that narrow down the causes of the problem based on available information.

maximum condensation rate (33.7 %) was obtained for the test characterized by the lowest excess air (0.294) and a water return temperature of 39.6 °C. In Fig. 4, the emissions for that test were 113 and 64 mg/Nm3 for NOx and CO respectively. Except that test, the actual condensation rate lies below 10 % for all the tests performed. That is a value which is expected in practice. A condensation rate of 100 % will never occurs; i t requires an infinite heat transfer area in the boiler (or an infinite residence time of the flue gas in the boiler).

6. Conclusion

The tested boiler, according to the manufacturer, satisfies the requirements of the European standard and even better those of the Blue Angel Label, but the recommended value for the adjustment of the excess air (1.2) can be decreased to a value of about 0.4 without producing an excessive amount of CO. On the other hand, the boiler might operate more effectively if the burner's ON phase's cycle frequency is doubled, and even more effectively if the OFF period is completely eliminated. A thermal efficiency of nearly 95% was recorded with NOx and CO emissions well below the Blue Angel Label, the most stringent criterion in Europe, for a working regime between 40 °C and 60 °C and an overall excess air of about 0.4.

The heat rate of a thermal power plant is directly impacted by boiler efficiency. From calculation it is found that 1% decrease in boiler efficiency increases the heat rate by 1%. Heat rate rises as boiler efficiency falls, hence boiler performance must be increased to get desired heat rate. By cutting back on various losses and regulating stack temperature, boiler efficiency is approved.The comparison reveals that the relative mistakes are less than 5%, and there aren't any glaring differences in the outcomes between this method and the national standards. Calculations based on coal's proximate analysis can reduce the need for costly laboratory equipment and mass testing. The conclusion indicates that it is practical to determine boiler efficiency or pinpoint operational issues in order to alter combustion.

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