Increasing boiler efficiency by UBC monitoring

The typical coal fired boiler is operated with excess air levels between 15% and 25% percent. Boiler efficiency is greatly dependent on the excess air ratio as the amount of flue gas is directly proportional to the dry gas loss of a boiler.

The efficiency of a boiler is defined as:

$$\eta_B = \frac{\dot{Q}_N}{\dot{Q}_{I,t}} = \frac{\dot{Q}_N}{\dot{Q}_N + \dot{Q}_{L,t}}$$

Indices:
N = usable energy output (steam)
I = energy input
t = total
L = Loss

Modern boilers have an efficiency of:

η_B = 0.91 – 0.94

The individual sources of loss are:

Flue gas loss	< 6.0 %
Heat loss by convection, radiation	< 0.5 %
Loss on CO in the flue gas:	< 0.1 %
Loss on ignition in the fly ash:	< 0.5%
Loss of ash temperature	< 0.05 %

The key to maximizing boiler efficiency is to determine the impact that an excess air reduction has on the unburned carbon level on the one hand and on the dry gas loss on the other hand.

The typical result of a boiler burning normal black coal is that a reduction in excess air results in a rise in unburned carbon in the fly ash. The main task in optimising coal fired boilers is to find out what the ratio between excess air reduction and carbon rise is. This ratio as well as the ash content of the coal make it possible to estimate the potential savings.

For typical applications in Germany a net efficiency gain of 0.2% up to 0.5% in operation could be achieved.

The basic concept is to use the UBC value beside the classical O_2 measurement as additional information for the potential reduction of excess air. As most European utilities have to sell their fly ash to the cement industry the upper UBC limit is 5%. However most boilers run at UBC levels of about 3%. Those power stations are direct candidates for an optimisation.

But also units that have low NOX burners and over fire air (OFA) and high UBC levels are candidates for an optimisation as each air register in the boiler has a different effect on the UBC and hence the fuel efficiency. In result a further reduction of the total excess air and hence a reduction of NOx is possible. So a better handle on UBC is also a good NOx tool.

Results:

By reducing the excess air on an 8 corner T fired unit HEW power station Wedel have reduced their excess air by 7%. The resulting efficiency gain is 0.5%. In turn the unburned carbon level rose by 2%. The coal combusted had an ash content of 3.6%. The resulting efficiency loss on ignition was 0.08%. The net efficiency gain of the unit was 0.42%.

If the coal has a higher ash content then the impact of the carbon rise on the efficiency is larger. On the other hand a coal with larger ash content is less sensitive to changes in excess air in regard to its UBC levels. I any case a trial to test the effect of air settings versus UBC levels is necessary to find out the potential efficiency increase.

Similar results have been achieved on 2 further units (EON plant Farge, BEWAG plant Reuter West), both of which have wall fired Deutsche Babcock boilers.

The savings are in the order of 100,000 up to 250,000 US$ per annum (depending on the boiler size) at a coal price of 45 US$ per metric ton.

Other applications:

Besides the quality control of the fly ash certification the on line UBC systems of PROMECON are used to control the dynamic classifier speed (i.e. the grinding process). This is especially applicable for high ash coals, which are very abrasive and cause high mill wear. For mills with static classifier the UBC monitors can also be used for the control of primary air flow through the mill in order to adjust the particle size.

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