Feature Article

Everyman's Guide to Good Boiler Combustion

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INTRODUCTION

The oil palm mill boiler has been a source of both pride and disgust in the history of the palm oil industry in Malaysia. Pride is usually restricted to the first two years of a new boiler, then slowly turning to dissent as the chimney smoke change to black colour and maintenance issues start to creep in.

After the initial euphoria, 'reality' kicks in and we naturally tend to make the following conclusions based more on our prejudices than critically analysing the problems constructively to find a solution.

- Palm oil mills have to accept the fact that their boilers cannot be compared with the power station boilers as palm oil mill boilers use oil palm biomass as the fuel, which is a poor fuel containing a high percentage of moisture that is not always consistent.
- The fluctuating quantity of the mesocarp fibre and kernel shell being fed into the boiler as fuel, will not be able to perform efficient combustion as it is difficult for the fuel mixture to acquire a reasonably acceptable fuel air mixture, unlike fuel oil or gaseous fuel for which there are special burners to ensure the necessary excess air, based on the stoichiometric ratio, for ideal combustion.
- In the event of a plant break down, when the fuel supply to the palm oil mill boiler is completely cut-off, the wet shell being fed into the boiler furnace can give rise to black stack emission, unless there is provision for its storage and conveyance to the fuel feed conveyor. In such cases, the fixed fuel-air ratio also will not be able to match the fluctuating fuel requirements.
- The fuel mixture comprising fibre and shell fed into the boiler, generally as lumps in most cases, gets deposited on the fire grates thus depriving the opportunity for it to be completely spread out in the combustion air resulting in the formation of clinkers on the fire grate.

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Despite recognising the above-mentioned 'realities' as real issues in the operation of the boilers in palm oil mills, the irony is that they are used as excuses for continuing to ignore the serious need to operate the boilers with modern control systems as shown *Figure 1*. The fact is, that the modern control systems will make a much significant difference with certain inevitable limitations compared to the thermal power stations that use homogenous fuels like fuel oil or gas fired boilers

Now let us review the typical basic control systems that a boiler should have.

FUEL FEED CONTROL BASED ON STEAM PRESSURE THROUGH A PID LOOP (Control Loop 1)

This is a brief guide line that all boiler operators should be familiar with presented in a layman's terms: The transducer in the control system senses the boiler steam pressure and compares the value with a pre-set value. If the error or the difference between the actual steam pressure and the desired set pressure is close to zero there will be no change in the control air signal transmitted to the fuel feeders.

It will remain unchanged. If the error is large, the control air signal transmitted to the fuel feeder will change proportionate to the error signal and the fuel feed rate will change accordingly either more or less so that the boiler steam pressure remains close to the set value. P of the PID controller represents the proportionate response. The integral is the error over time. If the error now is higher than the error before, the signal must be increased because the controller is not responding fast enough. If the response causes excessive hunting the Damper D is installed to dampen P&I operation for stabilising the controller but this is usually not used.

COMBUSTION AIR CONTROL (Control Loop 1)

While the fuel feed responds to the steam pressure (or steam demand), the combustion air needs to be adjusted. This is called the air/fuel ratio control. The rule is air supply should be proportionate to the fuel feed rate. Once the fuel feed rate and air supply are synchronised some of the existing woes that the millers experience in getting the boilers to operate like power station boilers will disappear. This does not discount other contributing factors that could also contribute towards black stack emission like overloading the boilers caused by slow build-up of the internal scales and external deposits of the water tubes over a period of time.

FURNACE DRAFT CONTROLLER (Control Loop 2)

The millers are requested to make use of only the Induced Draft Fan (ID Fan) to balance the furnace draft at about -0.25 inches of water. That is the purpose of having an ID Fan. It is not to work together with the force draft and secondary air fans. The ID Fan creates a natural draft whilst compensating for pressure losses due to the dust collector, pre-heat and economisers and any other pressure losing equipment you may have in the flue. We now assume we have our three

basic controls in place. Here is how it helps in our combustion:

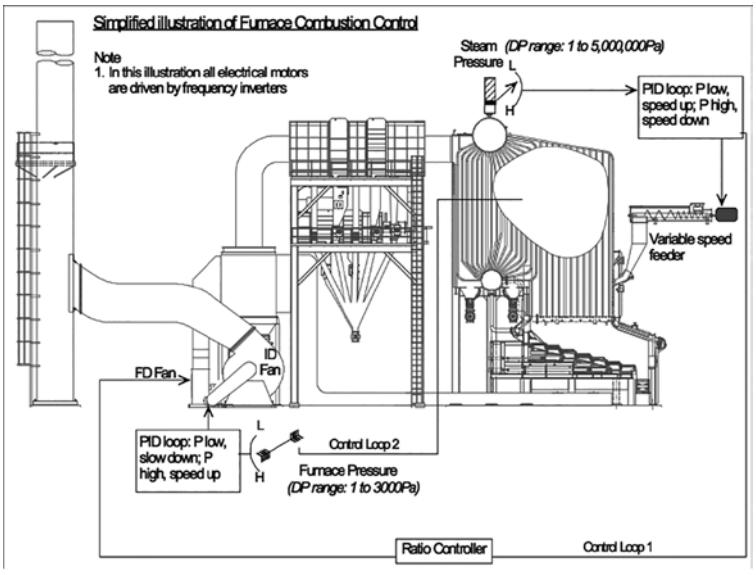
Feeding the fuel based on a PID loop should stabilise the fuel feeders to a certain speed for a certain steam flow. If this is not achieved, and the fuel feeders keep on running from zero to maximum speed during operation, we have to change the PID settings and look at the air fuel ratio. The air fuel ratio for a typical palm oil mill boiler should be around five (5 kg of air for every kg of wet fuel). This should give an excess air amount of 60% and an oxygen percentage of around 6% (volume %, wet) in the stack.

With this kind of air/fuel ratio, the furnace temperature will be high enough for stable combustion and build-up of fuel and clinker formation will be limited. It will also help in stabilising fuel feeder's PID loop.

For information, most biomass boilers are designed for 60% excess air in Malaysia, so if you are not having low oxygen values (or more than 12% CO_2 by volume, dry), you are having too much excess air.

Lastly, take some time to look at the furnace draft controller. Somehow, most men have the idea that in order to get more heat out of the boiler, they need to supply more air through it. This is not an outside fire but a combustion system. The increased air may give us a temporary illusion of more heat, but what we actually are doing is cooling down the boiler, and limiting boiler output. So next time you have your annual boiler shut-down, request your boiler service provider for an independent furnace draft controller linked to the furnace pressure sensor and ID Fan inverter or control damper.

Make sure that you have a ratio controller installed that is based on the fuel feeder speed, and if you still do not have a variable speed fuel feeder, invest in one, it's the only way forward.



Note: All electrical motors are driven by frequency inverters.
Figure 1. Simplified illustration of furnace combustion control.