



Technical proposal for the supply of a **MECONTROL** System

I) Boiler Optimization by Excess-Air Reduction

Most power stations control their boiler on the O₂ value at the end of the flue gas pass (behind economizer). This way to control a boiler has some substantial problems. The O₂ value is by no means representative of the total cross sectional area of the boiler and secondly the O₂ value itself does not give the boiler operator a save feedback on the total losses of the boiler.

However the O₂ value represents the largest single loss of the 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

The total energy input equals the sum of the usable energy as well as the total losses. This means that the boiler efficiency can be calculated without knowing the total amount of coal being combusted.

The boiler efficiency is affected by the grade of fuel burned, the condition of the water walls (slagging) as well as the combustion parameters mainly the excess air ratio in the boiler and the loss on ignition in the fly ash.

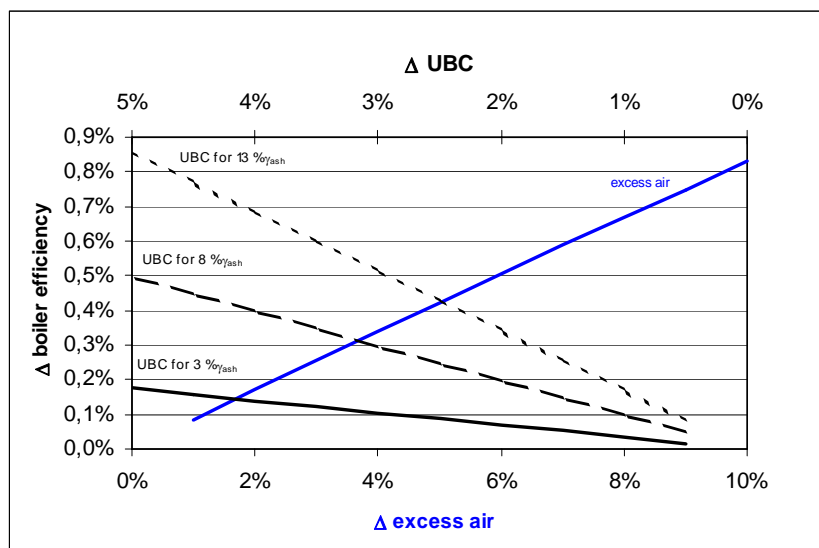
Modern boilers have an efficiency of:

$$\eta_B = 0.90 - 0.94$$

The individual sources of loss are:

Flue gas loss	< 5.0 %
Loss on ignition in the fly ash:	< 1.5%
Heat loss by convection, radiation	< 0.5 %
Loss on CO in the flue gas:	< 0.1 %
Loss of ash temperature	< 0.05 %

Generally the relationship of flue gas loss as compared to the loss in UBC can be described by the below graph for coals of different ash content ($\gamma=3\%$, $\gamma=8\%$ and $\gamma=13\%$).



It is easy to see that by lowering the excess air the boiler losses can be reduced and hence the efficiency of the unit will go up.

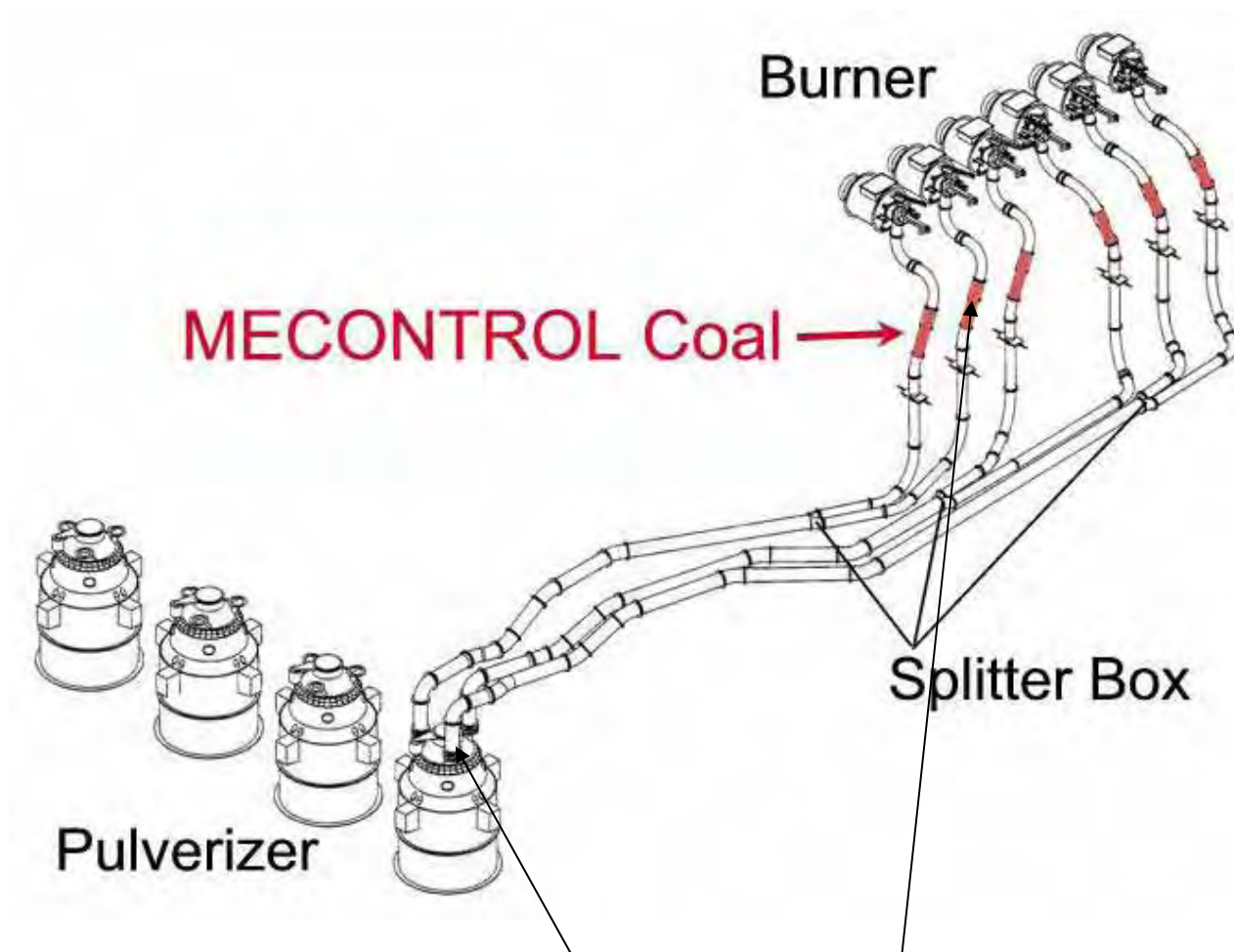
MECONTROL Coal to optimize the boiler

A key strategy is to make clearly defined changes to the individual coal pipes of the boiler and optimise the fuel distribution. By this the total excess air ratio can be reduced slightly resulting in electric power savings which will

- a) increase production
- b) reduce specific CO₂ emissions.

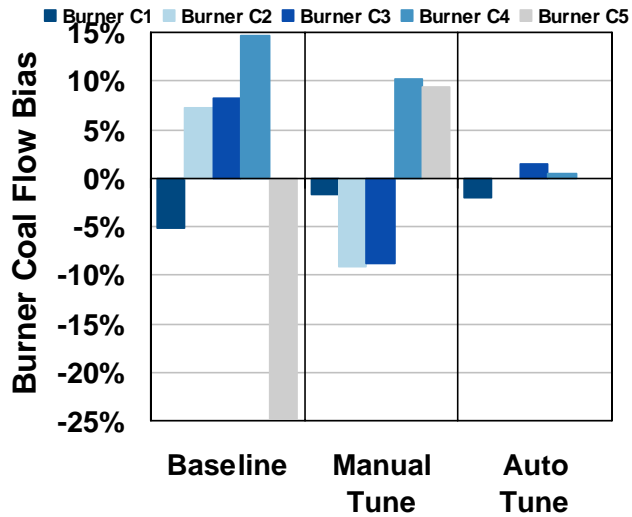
II) The Optimization technology

The MECONTROL Coal system is an on line coal flow measurement system that helps the plant to measure coal flow rates to the individual burner lines in real time.



Variable coal trimming dampers are used to control the individual fuel distribution to each burner.

By this, the coal distribution can be optimized:



Subsequently the O₂ value at the boiler outlet can be reduced slightly, which will increase boiler efficiency.

III) Example of Benefit

The Power Station has 200 MW CE type boiler. The boiler is tangentially fired and has 6 mills with 4 pipes each.

Optimization Steps:

- a) Record the coal distribution using MECONTROL Coal
- b) Adjust the coal valves in order to level out coal flow distribution
- c) Reduce the O₂ level in the boiler.

The savings will be as follows:

Optimization of excess air, LOI and NOx

Fuel: Hard coal

Power Plant: Test plant		
Specific prices		please fill out:
Fuel price per metric ton (=Mg)		€ 25
Net power issue price per kWhr		€ 0,04
Ash tipping fee (now) per Mg		€ 0
Ash tipping fee (predicted) per Mg		€ 0
Ammonia-reactant price per Mg (preselect type!)		€ 0

Operating data		please fill out:
Mean continuous load (Basis: steam production)	%	100%
Full-load (100% MCR) operating hours per year	hrs	6.000
Coal mass flow (100% load)	Mg/hr	155
Excess air ratio (100% load)	-	1,22
Gross heat input (calculated for 100 % load)	MW _{th}	541
Gross electric power output (100% load)	MW _{el}	200
Net power efficiency	%	37%
	% of gross power	
Internal power consumption (100 % load)	output	3,5%
Fly ash carbon content (100% load)	%	0,5%
Flue gas temperature downstream of air-preheater	°C	140
O ₂ operating value at NOx probe, dry flue gas	Vol.-%	6,0%
O ₂ reference value, dry flue gas	Vol.-%	6,0%
NOx emission value, STP dry, ref. O ₂	mg/m ³	800
CO ₂ emission value, STP dry, ref. O ₂	mg/m ³	250

Design fuel		please fill out:
Lower heating value, LHV	MJ/kg	12
Ash content (raw)	%	40,00%

Water content (raw)	%	10,00%
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Operating fuel (for different water- / ash-content)		please fill out:
Lower heating value, LHV (recalculated)	MJ/kg	12,54
Ash content (raw)	%	40,00%
Water content (raw)	%	8,00%

Losses (absolute, relative)		
Flue gas heat loss ($t_{\text{basis}} = 25^{\circ}\text{C}$)	$\text{kW}_{\text{thermal}}$	29.737
Ignition loss (by unburned carbon)	$\text{kW}_{\text{thermal}}$	2.845
Ignition loss (by CO)	$\text{kW}_{\text{thermisch}}$	490
Total loss (related to gross heat input)		6,1%

Goals of good combustion practice		please fill out:
Reduction of excess air	%-points	4,0%
Reduction of fly ash carbon content	%-points	0,0%
Reduction of NOx	mg/m^3	0
Reduction of CO	mg/m^3	0

Energy savings by optimization		
Δ Flue gas loss ($t_{\text{basis}} = 25^{\circ}\text{C}$)	$\text{kW}_{\text{thermal}}$	852
Δ Power consumption of combustion air- / ID-fan	$\text{kW}_{\text{thermal}}$ (recalculated)	1.823
Δ Ignition loss (by C in fly ash and CO in flue gas)	$\text{kW}_{\text{thermal}}$	0
Increase in fuel heat savings	total	0,49%

Savings		
ΔCO_2	Mg/a	5.604
Δ fuel per year	Mg/a	4.607
Savings in fuel costs per year		€115.181
<u>Alternative:</u> Increase in power production per year	kWh	5.937.290
<u>Alternative:</u> Return by Δ power production per year		€237.492
Reduction of ash tipping fee or Extra profit from ash sale per year		€0
Reduction of ammonia	Mg/a	0
Savings in ammonia costs		€0

With the above assumption the plant could each year:

- increase electricity production and earn 237 492 €
- save 5600 t of CO₂. At 10 € per ton that would equate 56 000 € per year. However the CO₂ price can be very volatile and rise significantly in the future. That would increase the payback significantly.

Part of the boiler optimization will be to monitor the CO and the UBC on a regular basis and to prevent increase of these levels.

IV) CO₂ monitoring by specific air consumption

A common way to measure the efficiency of a boiler is to account the amount of coal into boiler and the amount of electricity put out over long term. The big problem with this is that the amount of coal and especially the calorific value of the coal can not be measured more accurately than +/- 2% and that it is not constant! Hence the exact calculation of the efficiency and the reduction of CO₂ emission on a small scale (below 1%) is not provable.

The alternative proposed by PROMECON is to use the following parameters for a CO₂ balance verification:

- a) main generator electric output
- b) total fan power

O₂ Levels on the boiler outlet should be kept at a predefined set point (normal operation of a DCS O₂ controller)

The idea behind this method is that the Oxygen Levels of the air put into the boiler is very constant. So the amount of air going into the boiler less the amount of excess air (O₂ levels) is converted into CO₂ and can be calculated by using the known oxidation factor of the fuels burned.

If the O₂ level on the Boiler outlet is reduced then the ratio of fan power versus produced load is getting smaller.

This change in ratio directly represents the increase in efficiency in 2 ways:

- a) less electricity is needed to move the air through the boiler
- b) the increase in boiler efficiency will turn up on the generator shaft and slightly increase the electric power produced.

The savings in fan power as well as the increase in generator power can be measured very precisely and they can easily be multiplied with a factor to document the CO₂ savings.

Any possible losses on the steam side such as slagging, super heater spraying etc. will be accounted for because they all turn up on the generator shaft.

Also changes in heating value of the coal or the coal feed will result in the used fan power as well as in generating power on the turbine shaft.

It is important to note that this is a relative method, that needs the establishment of a base line. It is not so important what the exact efficiency of the unit is, but the changes made by the O₂ reduction are traceable by this method, even for very small changes.

By recording generator output and total fan power at constant O₂ levels on the boiler outlet. The reduction in CO₂ can be estimated and documented.