



OPTI-DRIVE FULL DOCUMENT





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ACRONYMS

1. **ID** - Induced Draft
2. **FD** - Forced Draft
3. **DOL** - Direct on line
4. **VSD** - Variable speed drive
5. **PID** - Proportional integral derivative

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1. Overview

There are two methods of controlling the combustion inside the combustion chamber on a fired tube coal-fired boiler.

1. The standard method is by making use of mechanical air dampers on the ID fan and FD fan to control the combustion and furnace pressure.
2. The Opti-drive system makes use of variable speed drives on the ID fan, FD fan and stoker to control the combustion and furnace pressure.

2. Standard Method

A standard fire-tube coal-fired boiler uses DOL starters, keeping the ID fan, FD fan and stoker motors running at full speed while mechanical dampers control airflow and furnace pressure. Once the boiler reaches working pressure, the dampers close while the motors continue running, or the motors repeatedly stop and restart. Both methods waste significant energy, especially through motor start-up losses and excess steam venting.

Mechanical dampers also provide poor combustion control. For example, a small 1° change in the FD damper can result in around 10% additional excess air, making it difficult to accurately control combustion using O₂, CO₂, stack temperature and excess-air readings. As a result, the boiler cannot consistently operate at its optimum efficiency.



2.1 Feed water pump control

The standard method of maintaining the water level inside the boiler makes use of a Mobrey chamber and a mechanical magnetic switch to drive the pump's contactor on and off. This works well but there are major disadvantages to this system. The mechanical magnetic switch has a non-adjustable range of 50mm in water column height before the contact is made. This means that if the boiler is at the correct working level once the switch signals the pump to stop pumping, the water level inside the water level indicator and Mobrey chamber would have to drop by +/- 50mm before the magnetic switch contact is made to activate the pump to refill. Depending on the size of the boiler, this 50mm drop in the water column height equates to approximately 1500 litres of water that the pump needs to refill. Typically when this happens we see a pressure drop of 100kpa plus inside the steam space. This drop in boiler pressure varies depending on the feed water temperature. To regain this drop in pressure we now need to add more fuel (coal) in order to reach our pressure set point and this happens every time the pump activates to refill. This equates to high coal consumption, decreased steam output and poor boiler efficiency as well as high risk of boiler failure should the mechanical switches fail.

2.2 Disadvantages of the standard method

1. High electrical consumption
2. High coal consumption
3. Poor boiler efficiency
4. Decreased steam output as per boiler rating.
5. Regular cleaning of fire tubes
6. Poor heat transfer
7. High maintenance costs
8. High running costs overall
9. Mechanical wear and tear
10. High risk of boiler failure should the mechanical switches fail.
11. Excessive toxic emissions emitted into the atmosphere.



3. Opti-Drive Method

The Opti-drive Combustion Management System makes use of variable speed drives on the fans to control the combustion and steam output of the steam boiler extremely accurately and allows us to remove all the mechanical air dampers. This system is a fully automatic modulating system which produces steam on demand. Making use of VSDs allows us to control the combustion and flue gases with precision and accuracy ensuring that we are combusting our coal at the highest efficiency rate possible.

Unlike the standard system, the Opti-drive system allows us to configure the amount of steam output from the boiler to suit the required plant or production line steam input.

3.1 Operation of the system

Using variable-frequency drives (VFDs), the ID fan, FD fan and stoker can operate at reduced speeds such as 30–40 Hz instead of continuously running at 50 Hz. A digital PID controller and pressure transmitter accurately monitor boiler pressure and adjust the fan and stoker speeds to maintain the required pressure. For example, with a set pressure of 7 bar and a 0.5 bar differential, the system reduces the speeds when pressure reaches 7.5 bar and runs at preset idle speeds (typically ID fan 6 Hz, FD fan 5 Hz and stoker 4 Hz) until the pressure drops back to 7 bar, then increases the speeds again.

The system automatically matches the boiler firing rate to the plant's steam demand. This means only the required amount of coal is burned to produce the steam needed, resulting in significant savings in both electrical and coal consumption while maintaining efficient combustion.



3.2 Feed water pump control

The Opti-Drive system fully modulates both the fans and boiler feedwater pumps using variable-speed drives. A capacitance probe, together with a digital PID controller, continuously measures the boiler water level and automatically controls the feedwater pump. This replaces the traditional mechanical pump switch and first low-water cut-off, providing a more precise, reliable and safer method of water-level control. The operator can also adjust the desired water level directly from the control system without manually adjusting mechanical switches.

Unlike the standard Mobrey chamber and magnetic switch system, which allows the water level to fluctuate by approximately 50 mm before the pump switches on, the Opti-Drive maintains the boiler at a consistent working level. The pump adds small amounts of water continuously according to the current steam demand, preventing large changes in water level and reducing unnecessary drops in boiler pressure. This improves boiler efficiency, steam output and coal consumption, while also providing improved protection against low-water conditions.

3.3 Stack temperature

Another key feature that the Opti-drive system has to offer is exhaust gas temperature readings directly coupled to the control systems user interface. By being able to monitor the temperature of the exhaust gases we can determine the correct bed height and Stoker speed required to optimise the boiler's performance. The advantage of this is that the operator can gauge exactly what the bed height and stoker speed should be even if the consistency of coal delivered is different every time. This makes it extremely easy for the end user to operate the boiler to its ultimate performance capabilities.



3.4 Feed water temperature

Another feature that the Opti-drive system has to offer is the temperature of the feed water. As with the exhaust gas temperature, the feed water temperature can be viewed on the display screen on the control system's user interface. As with most boilers and their steam output ratings, the feed water temperature plays a major role in the boiler's efficiency. Although the feed water temperature cannot be controlled by the control panel, by knowing what the temperature of the feed water is allows us to take extra measures to ensure that the boiler is operating at its maximum efficiency.

3.5 Automatic coal feed

As mentioned previously, the Opti-drive system is a fully automatic system, this includes the coal screw or coal feed conveyor system. By making use of a highly accurate ultrasonic sensor we are able to measure the exact height of coal inside the hopper. This allows us to programme when to start filling and when to stop filling the hopper. This may not seem like a key feature where coal saving and boiler efficiency is concerned but is actually a fundamental feature that does contribute to coal saving and boiler efficiency. By ensuring that the hopper operates at the correct levels at all times, we are removing the possibility of any excess air entering the combustion chamber/furnace through the hopper. This ensures the correct air to fuel ratio at all times which in turn ensures the correct combustion. Another highlight is that this system removes the human error factor. It guarantees that the boiler always has an ample supply of fuel (coal) and does not rely on the operator to make sure the hopper is full and at the correct operating levels. In many cases the operator will forget to fill the hopper and the boiler will run out of fuel. This means a loss of steam production and will be costly to the company.



3.5 Achieving electrical savings

The standard boiler water-level system uses a Mobrey chamber and mechanical magnetic switch to switch the feedwater pump on and off. Although effective, the switch has a fixed operating range of approximately 50 mm, meaning the boiler water level must drop by around 50 mm before the pump is activated.

With the Opti-Drive system, the ID fan starts at 0 Hz and gradually ramps up to its optimum speed, typically 38–45 Hz, instead of continuously running at 50 Hz. A digital draught and PID controller also regulates the FD fan to maintain the required furnace pressure. Using a VSD therefore reduces energy consumption while maintaining or improving combustion performance.

For example, a 30 kW ID fan running continuously at 50 Hz would consume significantly more energy than the same motor controlled by a VSD. During a typical 60-minute cycle, the Opti-Drive may run the fan at full operating speed for around 40% of the time and at an idle speed of approximately 6 Hz for 60%. This can reduce consumption from around 30 kWh to approximately 18 kWh per hour, while achieving the required boiler performance. The same energy-saving principle is applied to the FD fan and stoker, further reducing overall electrical consumption.

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3.7 Achieving coal savings

Typically, from experience, the coal saving to be expected by using this system can range from 5% guaranteed to plus minus 12%. There are many factors that influence this and it is very difficult to accurately guarantee an exact expected coal saving due to these factors. This mainly depends on coal consistency and quality. However, with all the key features that the Opti-drive system has to offer we can guarantee a minimum saving of 5%. This is very rarely the case as in most projects we have achieved a 12% plus coal saving.

These savings are achieved by ensuring proper combustion throughout the firing range and by controlling the flow of gases through the boiler to allow for the best heat transfer possible. By being able to manage the combustion and all other aspects together with all the key features that the system has to offer ensures that the fuel is combusted properly to a point where it provides no more energy before exiting the boiler through the ash door. This makes the system extremely cost effective and reliable

3.8 Benefits

- Complete automatic control.
- Significant fuel cost saving (Typically anything from 5% - 12% fuel saving can be achieved).
- Significant electrical power saving. (Typically anything from 30% - 60% can be achieved)
- Modulating pumps. (Typically anything from 2% - 5% saving can be achieved)
- Constant steam pressure.
- Increased combustion throughout the firing range.
- Increased boiler efficiency.
- Increased steam output.
- Fewer toxic emissions emitted into the atmosphere creating a better carbon footprint.
- Less maintenance and cleaning of fire tubes.
- Cleaner and better working environment.
- Longer life expectancy of all moving parts.
- Reduced human error.