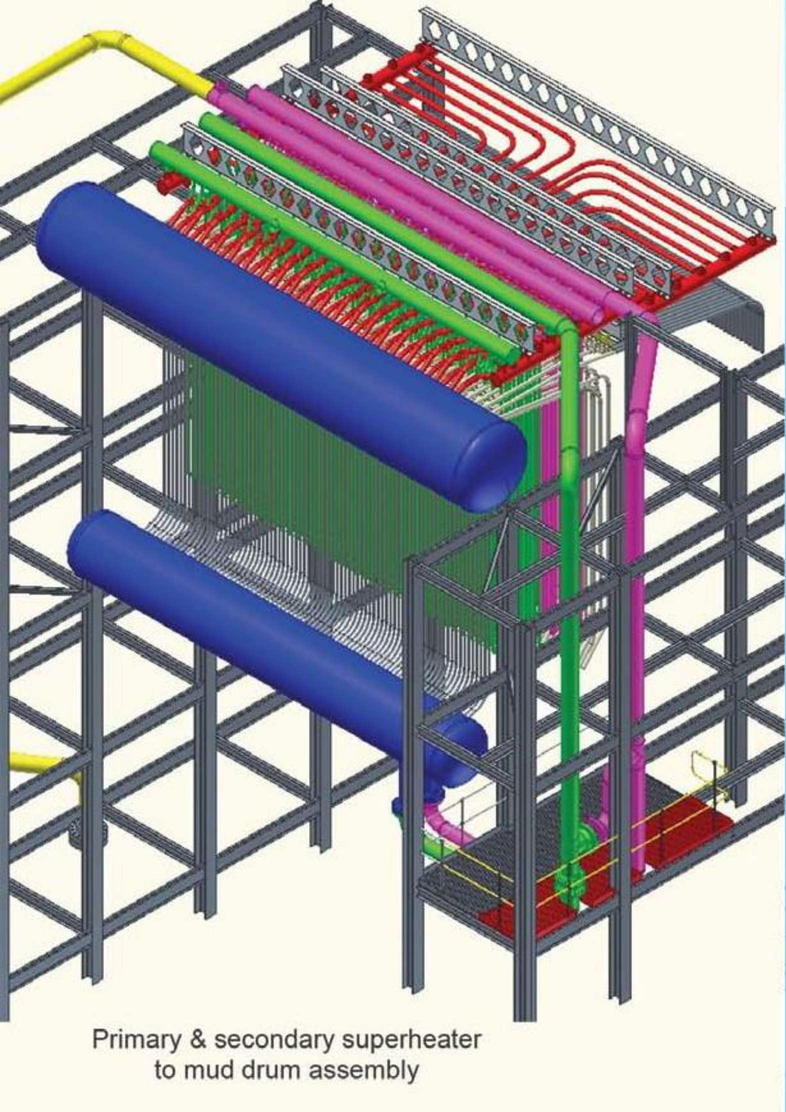
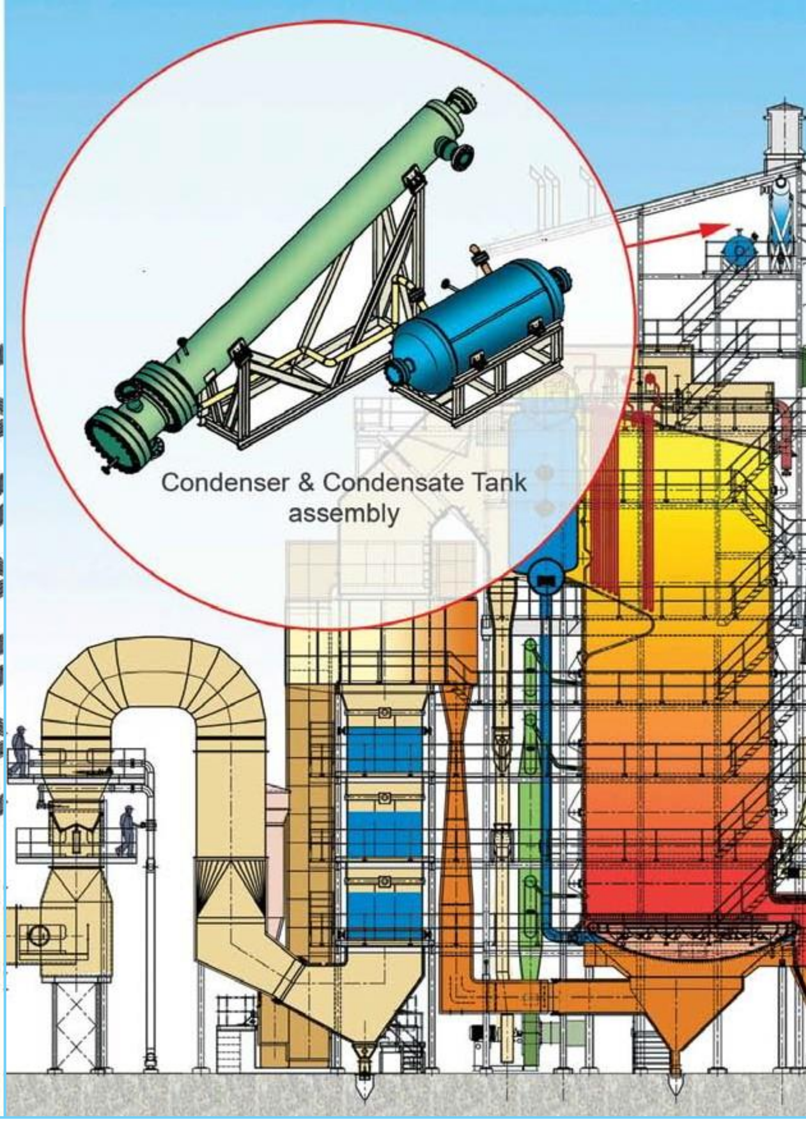


Mud Drum Attemperator schematic



Spray Type Attemperator with Condenser shown

Considerations for a Mud Drum Attemperator

- Low cost
- Simple design
- Limited instrumentation
- Low maintenance cost
- No chance of steam contamination and no risk of water carry-over due to non-contact type attemperator design
- Limited pressure envelope in retrofitting situation
- Limited space in mud drum which can limit turn downs achieved

Considerations for a Spray Type Attemperator

- Higher cost
- More complex design
- Higher instrumentation requirements
- Spray water quality is very important
- Sufficient pressure differential between spray water and steam is required to achieve atomisation of spray water for optimal mixing and absorption
- Turn down achievable with a spray type attemperator is limited by the maximum recommended quantity of spray water that can be introduced which limits the spray to about 10–15% of steam flow

MUD DRUM AND SPRAY TYPE ATTEMPERATOR

Comparison for use in Dual-fired Boilers

john thompson

ACTOM

Comparison of a Mud Drum and Spray Type Attemperator for use in Dual-fired Boilers

Background

In the Southern Africa sugar industry, boilers are often designed to burn both bagasse and coal and are consequently called dual fired boilers. Bagasse has different combustion characteristics to coal. These differences affect the superheater performance and, in the case of an uncontrolled superheater, result in lower steam temperatures when burning coal compared to bagasse. Two attemperation technologies are presented and compared to show how a constant steam temperature can be achieved with a controlled superheater.

The electrical efficiency of a turbine alternator (TA) set is proportional inter alia to the steam temperature at the inlet (Energy and Environmental Analysis Inc, 2007). If steam from an uncontrolled superheater is used to drive a TA set, the variation in steam temperature will adversely affect the turbine performance. However, if a controlled superheater is used, the boiler will be able to supply steam at a constant temperature, which will allow the TA set to operate at its maximum efficiency across the range of loads.

There are generally two types of attemperators used in the SA sugar industry, namely mud drum attemperators and spray type attemperators. Both types are not always suitable for all applications and the advantages and limitations of each system are discussed below.

Mud Drum Attemperation

A mud drum attemperator is classified as a surface heat exchanger because there is an impenetrable barrier between the steam and the cooling medium. The steam is contained within tubes that are arranged in bundles and submerged in the boiler mud drum. Heat is transferred from the steam to the cooler boiler water through the tube wall. The arrangement of a typical mud drum attemperator system is shown schematically in Figure 1.

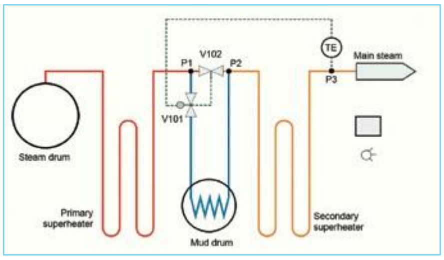


Figure 1. Mud drum attemperator system

The steam piping between the primary and secondary superheater banks (inter-stage piping) is arranged so that a portion of the steam is diverted through the heat exchanger in the mud drum, while the remainder is bypassed. The cooler steam from the heat exchanger is mixed with the bypassed steam at point P2 to give the desired steam temperature at the inlet to the secondary superheater. Valves are installed in the heat exchanger inlet line (V101) and the bypass line (V102) to control the steam flow rate through the heat exchanger.

The valves are mechanically linked and are controlled by a single signal in a master-slave arrangement. The actuator is selected to fail open so that the full steam flow is directed through the heat exchanger in the event of a signal or air failure, to protect the downstream components from overheating. The main steam temperature is the process variable for the controller.

The mud drum attemperator must be designed to have the lowest possible pressure drop. This is to ensure that the steam drum pressure does not become too high. This is very important in retrofitting of mud drum attemperators on existing boilers, as the design pressure of the drum is fixed. In a new boiler a large pressure drop over the attemperator will result in a thicker steam drum.

The design of a mud drum attemperator is a compromise between pressure drop and thermal performance. Both tend to increase with higher steam velocities in the attemperator. There are a few options to reduce the pressure drop without decreasing the thermal performance of the attemperator, for example, to increase the tube diameters in the attemperator.

A mud drum attemperator is a very simple attemperator system. It requires minimal maintenance as the only moving parts are the butterfly valves and actuator. There are only flanges on the control valves and therefore the chance of steam leaks is small. Very limited instrumentation is required for a mud drum attemperator.

In the sugar industry it is generally believed that the turn down of a mud drum attemperator is inferior to other methods of attemperation. At Illovo's Sezela Sugar Mill a mud drum attemperator was installed in boiler 4, a 31 bar, 400°C with 130tph MCR on bagasse and 104tph MCR for coal. Turn down was tested at 35% to 110% MCR on bagasse and 70% to 100% MCR for coal firing. Although the perception is that mud drum attemperators do not have sufficient turndown for coal firing, on Sezela boiler 4, the mud drum attemperator achieved good turndown and provided steady control.

Spray Type Attemperator

A spray attemperator is classified as a direct contact heat exchanger because the cooling medium is mixed with the steam. A suitable nozzle assembly is used to spray cooling water directly into the steam and thereby reduce its temperature. The arrangement of a typical spray attemperator system is shown in Figure 2.

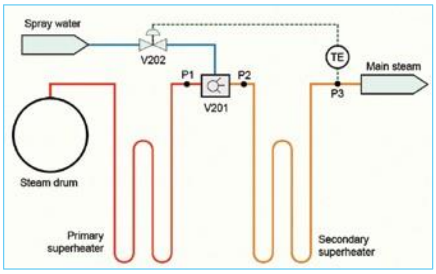


Figure 2. Spray attemperation system

The attemperator unit (V201) is installed in the inter-stage piping and connected to a spray water supply pipe. The final steam temperature is used as the process variable to the controller, which regulates the spray water flow rate to the attemperator through a control valve (V202). Although V201 and V202 are shown as discrete components in Figure 2, they are sometimes combined in a single unit.

The spray water should contain minimal suspended or dissolved solids because these will be precipitated out of the water when it evaporates in the steam. The solids will be carried along with the steam and be deposited on the internal surfaces of the piping and superheater tubes.

A mud drum attemperator will supply steam of a very high purity because the steam does not mix with the cooling medium. With a mud drum attemperator therefore, the possibility of insulating boiler internal surfaces or damaging downstream equipment is much smaller than for a spray type.

The purity required for attemperator spray water is specified in boiler water treatment codes. Although demineralised water can be used, it usually requires further purification in a polishing plant before it can be sprayed into the steam.

High purity condensate can also be used as spray water.

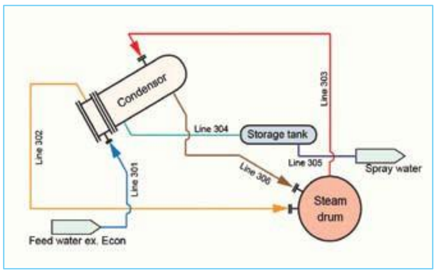


Figure 3. Integral condenser system

A dedicated condenser is usually incorporated into the boiler to generate high purity condensate with minimal risk of contamination. A typical integral condenser system is shown in Figure 3.

Conventional attemperator units typically specify a pressure difference of 650 to 900 kPa between the spray water and the steam to achieve effective atomisation. Where spray water is supplied from an external source, the spray water pumps should be able to supply spray water at the required pressure. These pumps tend to be expensive because they deliver a large head at a relatively low flow rate.

When the spray water is drawn from an integral condenser unit there is an added complication in that the temperature of the condensate is only a few degrees below the saturation temperature. Consequently, the system should be designed with care to avoid cavitation at the inlet of the spray water pumps.

Generally, John Thompson uses venturi spray attemperators because they require a much lower pressure differential between the spray water and the steam than a conventional attemperator. A 6m static head is enough to deliver the required atomisation of the condensate.

Manufacturers normally specify a minimum length of straight pipe so that the spray water can evaporate. The maximum amount of spray water that is normally used, is 11% of the total steam flow.

There are only two flanges in the steam pipework, but there are a number of flanges in the spray water pipework and therefore there is a higher risk of water leaks. More instrumentation is required than for the mud drum attemperator, especially if a condenser is used. This increases the maintenance requirements.

Turn down for a spray type attemperator is typically 40% to 110% MCR on bagasse and 87% to 110% MCR on coal. As with all attemperator systems, this is also a function of the superheater area in the boiler.

Comparison

Installing a spray type attemperator does not require any changes to the pressure part of the boiler. A mud drum attemperator however, does require work to be done on the pressure part. If a large heat exchanger is required to give the turn down required, then there are two potential disadvantages. Firstly, it will require more time to install because access is reduced. Secondly, there is inadequate clearance between the heat exchanger tubes and the internal surface of the mud drum to expand the mainbank tubes when they need to be replaced. In the case of a new boiler, the mud drum diameter can be increased to accommodate the enlarged heat exchanger. The only space requirement for a spray type attemperator is space for the integral condenser, if one is required.

The relative cost of a spray type attemperator with integral condenser excluding allowance for condenser support structure is approximately 18% higher than the standard mud drum attemperator system. The costs of retrofitting a mud drum attemperator into an existing boiler are higher than those for a new boiler due to the difficulties associated with drilling large bore holes in the mud drum for the *in situ* steam pipes.

The mud drum attemperator is less maintenance intensive than the spray type attemperators but cannot be used if a mud drum feedwater heater is installed.

Conclusions

A mud drum attemperator can supply steam of a higher purity than a spray attemperator because it is not mixed with the cooling medium.

As proven by testing Sezela's boiler 4 post retrofit of a controlled superheater with mud drum attemporator, a much larger turn down is possible with mud drum attemperators than previously thought.

A mud drum attemperator is less expensive and simpler than a comparable spray type attemperator, with reduced maintenance requirements.

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