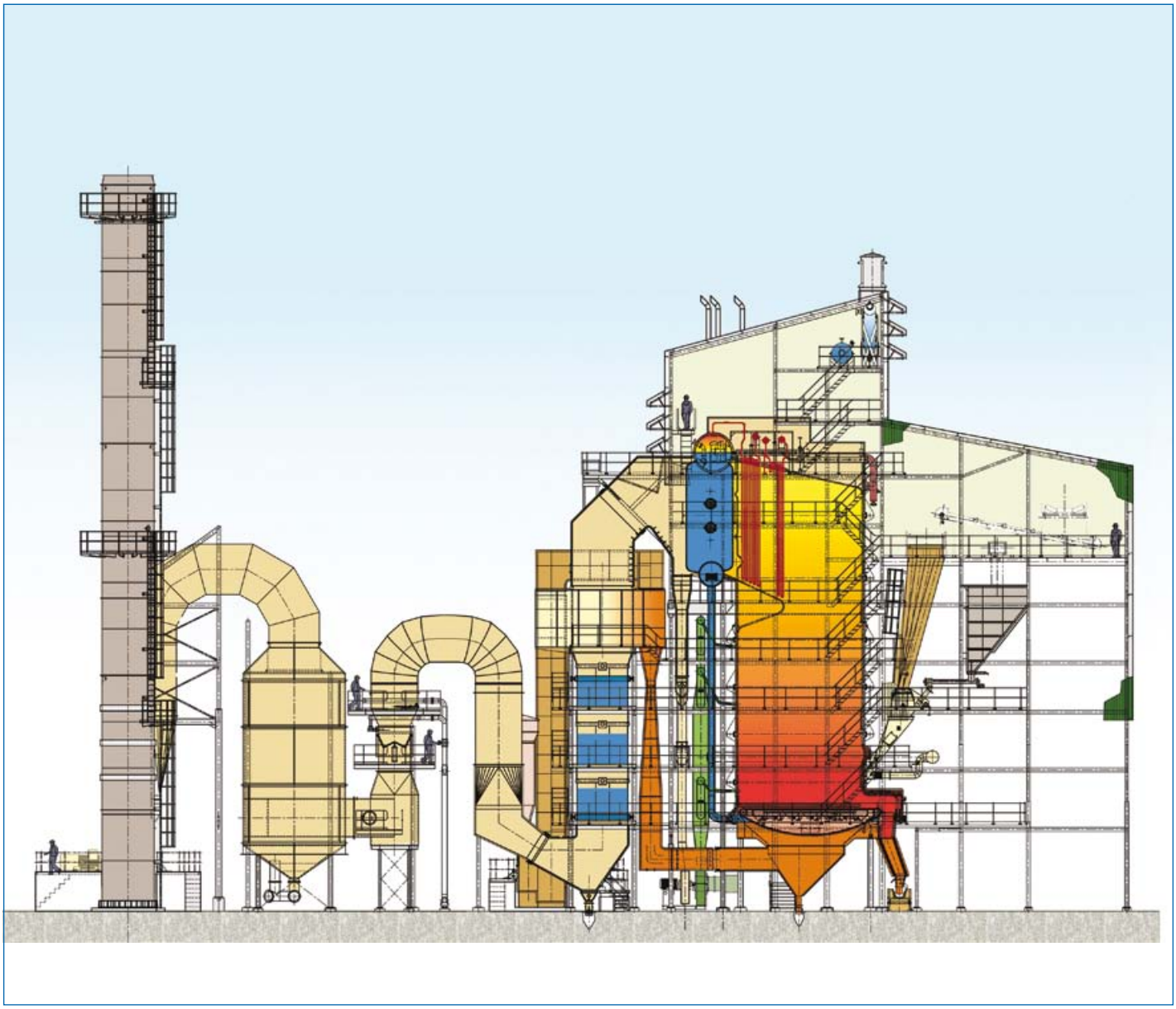

Features

- Membrane-wall combustion chamber
- Single pass mainbank
- 2-Stage controlled superheater with venturi spray attemperator
- Integral steam condenser to supply spray water
- Girth support
- Zoned CAD stoker
- Pneumatic coal & bagasse spreading
- Extended surface economiser
- Mud drum feedwater heater
- Venturi-type cyclonic wet scrubber

Design Data		Bagasse	Coal
Evaporation	t/h	105	85
Steam Pressure - Initial	kPa	3 100	3 100
Steam Pressure - Final	kPa	4 500	4 500
Steam Temp - Initial	°C	385	385
Steam Temp - Final	°C	450	450
Feedwater Temperature	°C	112	135
Final Gas Temperature	°C	162	183
GCV Efficiency	%	69,8	84,1
NCV Efficiency	%	87,5	87,1

Fuel (As Fired)		Bagasse	Coal
Fixed Carbon	%	5,9	58,3
Moisture	%	49,6	4,9
Ash	%	4,7	11,8
Volatiles	%	39,8	25,0
Brix	%	2,1	N/A
GCV	kJ/kg	8 894	27 466
NCV	kJ/kg	7 025	26 538

CASE STUDY No.42
105 t/h Bagasse- / Coal-fired Boiler for Cogeneration

john thompson

ACTOM

JOHN THOMPSON
105 t/h Bagasse- / Coal-fired Boiler for Cogeneration

Background

In 2009, Ubombo Sugar Limited, Swaziland placed an order with John Thompson, a division of ACTOM (Pty) Ltd for the supply, delivery and erection of boiler plant, ancillary equipment and associated pipework as part of an expansion project, including cogeneration. The project incorporated a new 105 t/h boiler and a new 25 MW extraction/condensing turbo alternator (supplied by others).

The new power plant was designed to provide process steam and power to the factory and to export excess power to the national grid. It was the Client's intention to burn biomass fuel all year round. In order to provide sufficient biomass during the off-crop, the bagasse was supplemented with cane tops and trash, and a high efficiency boiler was supplied so that excess biomass could be stockpiled during the crushing season. The boiler was designed to burn coal as an auxiliary fuel, if required.

The boiler design is suitable for final operating steam conditions of 45 bar at 450 °C whilst burning bagasse, the biomass mixture and/or coal. The Client requested that the superheater be designed for initial operation at 31 bar at 385 °C to suit the existing boilers installed at the mill. A spray-type attemperator with condenser was incorporated into the boiler design to provide for turn-down to 30% and 64% during biomass and coal-firing respectively.

The Boiler

The boiler is of the single pass, panel walled girth support design.

The girth support design incorporates a combustion chamber support plane just below the mud drum level from which it expands vertically upwards and downwards. The mud drum is supported directly off the boiler steelwork and the upper combustion chamber thus expands at the same rate as the generating bank. The stoker is supported independently of the pressure part on dedicated columns at ground level. A gas tight enclosure is provided by a combination of mechanical and fabric seals at the interface of the combustion chamber and the grate.

The cane tops and trash in the biomass mixture contain alkali metal oxides, which have a propensity to cause fouling of high temperature heat transfer surfaces, especially the superheater. Consequently, the combustion chamber height was increased compared to conventional bagasse/coal-fired boilers in order to provide adequate residence time in the combustion chamber, which ensured that the gas outlet temperature was low enough to prevent fouling.

A 2m high refractory band was cast onto the combustion chamber panel walls to provide the thermal inertia required to burn biomass with a range of moisture contents. The band extends from the front of the boiler towards the rear along 2/3 of the sidewall depth. In order to prevent slagging during coal firing, castable refractory is not installed on the rearwall or rear 1/3 of the sidewall depth.

Secondary air is introduced into the furnace from the rearwall at three different levels to promote turbulence and ensure complete burnout. The "furnace nose" provides further turbulence in the upper areas of the combustion chamber.

COMBUSTION EQUIPMENT

Zoned CAD Stoker

The unit incorporates the latest generation Continuous Ash Discharge (CAD) zoned stoker in order to achieve a high combustion efficiency when burning coal. The stoker mat is made up of eight parallel strands of grate bars that are attached to pairs of chains, which in turn are driven by sprockets on the front drive shaft of the stoker. The bars are manufactured from high-grade heat resisting cast iron and are substantially ribbed to provide rigidity and also a large surface area for cooling by the undergrate air.

Undergrate zoning is incorporated to control the distribution of primary air across the length of the stoker. This consists of a series of small self-cleaning hoppers, each fitted with a damper, which is adjustable whilst the boiler is operating.

Fuel Feeders and Spreaders

Biomass is metered to the boiler through four 3-drum John Thompson fibrous fuel feeders driven by VSD drives. Coal is fed through four robust VSD-driven metering screws and discharged into the bagasse feeders.

Both fuels are conveyed into the combustion chamber through pneumatic spreaders, which incorporate trajectory control plates to distribute the fuels evenly over the surface of the stoker.

Superheater with Attemperator

In order to accommodate the stringent final steam requirement on both fuels over a wide load range, the superheater is designed as a two-stage pendant unit with an inter-stage spray attemperator.

The spray water is supplied by a condenser, which takes saturated steam from the boiler drum. This ensures that the spray water is free of solids, which would otherwise insulate the internal surfaces of the secondary superheater and also damage downstream turbine blades.

A venturi-type attemperator of Imtech-Kiekens design was selected, which allows for effective introduction of spray water into the steam flow without a large pressure differential between the water and the steam. The condenser was located at a sufficient elevation above the boiler so that the required pressure differential was provided by the static head of the spray water alone. This eliminated the need for expensive and temperamental high temperature spray water pumps.

Convection Bank

In order to avoid erosion, tubes in the single-pass generating bank are adequately pitched to ensure that gas velocities are less than 12 m/s. A collecting hopper is positioned directly behind the generating bank to collect the fly ash, grit and sand carried over from the combustion chamber. Sluicing water is introduced at the bottom of the hopper so that the collected solids can be conveyed to the ash handling plant in a slurry.

HEAT RECOVERY EQUIPMENT

Economiser

A three-bank extended surface economiser was installed to achieve the high thermal efficiency required.

In order to prevent acid dew-point corrosion in the economiser during coal firing, the tube temperatures are elevated by preheating the incoming feed water to 135 °C in a feed water heater located in the mud drum.

Airheater

The airheater is a single-bank crossflow unit designed for an outlet air temperature of 230 °C when firing biomass. The airheater is partially bypassed during coal firing to control the undergrate air temperature at 150 °C, thus preventing overheating of the grate.

ANCILLARY EQUIPMENT

Draught Plant

The forced draught fan is driven by a 160 kW VSD-controlled motor, and delivers combustion air through the airheater to the stoker plenum chamber. The secondary air fan is driven by a 90 kW motor and is controlled by an inlet damper. It supplies high-pressure air at ambient temperature to the fuel distributors and the secondary air nozzles on the rearwall.

Flue gas is exhausted from the boiler by the induced draught fan, which is direct-coupled to a 475 kW VSD-controlled motor. The impeller blades are forward-curved with radial tips, which have the self-cleaning characteristic required for biomass firing. The fan is located after the wet gas scrubber, which protects the fan from erosion.

The exhaust gases are discharged to atmosphere through a self-supporting gunnite-lined mild steel stack of 38m height.

Gas Clean Up Equipment

A venturi-type scrubber with cyclonic droplet separator of Howden design is used to remove particulates from the boiler flue gases to levels below 100 mg/Nm^3 and 120 mg/Nm^3 during biomass and coal-firing respectively.

Adequate space was allowed between the boiler heat recovery equipment and the ID fan to be able to accommodate a future ESP if improved collection efficiencies are required at a later stage.

Sootblowers

A full complement of sootblowers was supplied to clean the heat transfer equipment during operation. Six fully retractable blowers are used for the superheater, two partially retractable blowers are installed in the mainbank, and each of the three economiser banks is cleaned by a rake blower.

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