ISGEC
JOHN THOMPSON, INDIA

High Pressure Multi Fuel Fired Boilers for Cogeneration

Development of High Pressure Boilers - Co-Generation

- **High Pressure and High Temperature Steam Cycles are Important for**
  - Increasing Cycle Efficiency of the Plant
  - Increasing Power Output from Co-Generation Plant
- **The choice of pressure and temperature levels for steam cycle depends on the following factors**
  - Fuel and Ash Properties
  - Quality of Feed Water and Water Treatment Systems available
  - Cost of Boiler and Steam Turbine System
  - Level of Confidence of Plant Operators
- **Thermodynamically the Energy Recovery from Rankine Cycle depends more on Steam Temperature**

  However, increase in Steam Temperature must be accompanied by increase in Steam Pressure to ensure optimum extraction of useful energy from the working medium

High Pressure and High Temperature Boilers - Advantages

- **Higher Power Generation Per Ton of Bagasse**
- **Higher Cycle Efficiency of Plant**
- **Saving in Bagasse, hence Extended period of Operation**
- **Lower Fuel and Steam Consumption for the same Power Output, hence Reduced Boiler Capacity**

High Pressure Boiler - Advantages

Parameters	Unit	45 Kg/cm^2 (a)		66 Kg/cm^2 (a)		87 Kg/cm^2 (a)		105 Kg/cm^2 (a) 540 ^{0}C
		440 ^{0}C	515 ^{0}C	485 ^{0}C	515 ^{0}C	515 ^{0}C	540 ^{0}C	
Feed Water temp to boiler	^{0}C	105 (without HP Heater)		150 (with 1 HP Heater)		170 (with 1 HP Heater)		220 (with 2 HP Heater)
Bagasse Quantity	TPH	43.51	46.18	41.78	42.89	41.2	42.2	38.6
Steam /Fuel ratio	-	2.29	2.16	2.39	2.33	2.42	2.36	2.59
Gross Power output	MW	24.8	28.8	26.5	28.9	28.5	29.4	29.4
Net Power Output	MW	22	25.2	23.4	25.3	25.1	25.7	25.9
Specific Steam consumption	Kg/KW-hr	4.03	3.46	3.77	3.46	3.51	3.40	3.40
Power Generation per ton of Bagasse	KW/Ton	Base	+9.5%	+11.4%	+18.3%	+21.4%	+22.3%	+33%
Heat Rate	Kcals / KW-hr	3983	3640	3579	3370	3281	3258	2980

(Calculations shown above are based on a 100 TPH Travelling Grate boiler with 69% efficiency (on GCV 2270 Kcal / Kg Basis) and Turbine exhaust at 0.1 Kg / Cm^2 (a)

Higher the Cycle Parameters – Higher the Output
More Power output with same input Quantity of Fuel

High Pressure Boiler

95 TPH, 62 Kg / sq.cm (g), 500 Deg. C
Travelling Grate Boiler,
Mid Siam Sugar Co., Thailand

High Pressure Boiler

170 TPH, 105 Kg / sq.cm (g), 540 Deg. C
Travelling Grate Boiler, Dhampur Sugar Mills, India

High Pressure Boilers - Features

- **Boilers for Co-Generation and generating power on sustainable basis must have**
  - Multi Fuel Firing Capability
  - Ability to give trouble free service throughout the year
- **The essential features of High Pressure Boilers for ensuring reliable operation on year round basis are**
  - High Uptime
  - High Efficiency
  - Low Power Consumption
  - Environment Friendly
  - Low O & M Cost

Biomass and Fossil Fuels - Multi Fuel Firing Capability


Bagasse


Paddy Stalk


Cotton Stalk


Wheat Stalk


Coffee Husk


Mustard Stalk


Poultry Litter


Sawdust


Julie Flora


Rice Husk


Lignite


Charcoal

- **Wood Chips**
- **Olive Wood Trimmings**
- **Coconut Shell**
- **Groundnut Shell**
- **Subabul Wood**
- **Red Gram Husk**
- **Bengal Gram Husk**
- **Cashewnut Shell**

- **Woody Biomass**
- **Cane Top & Trash**
- **Cane Pith**
- **Other agricultural wastes, individually or in combinations**
- **Coal**
- **Supplementary Fuel - Oil, Natural Gas and Bio-Gas**

Travelling Grate Boilers - Multi Fuel Firing Capability

- **Of the several Technologies available, Travelling Grate Boilers can efficiently burn the following:**

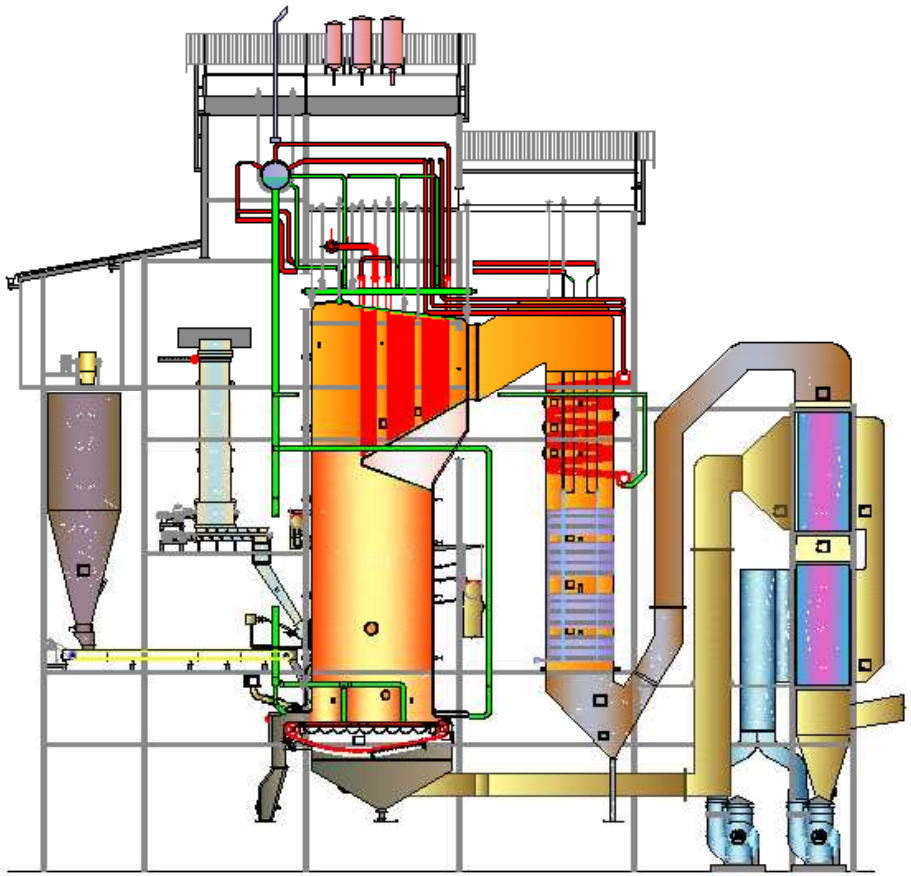
❑ Biomass Fuels:

- ➢ Bagasse
- ➢ Rice Husk
- ➢ Wood Chips
- ➢ Cotton Stalk
- ➢ Mustard Stalk
- ➢ Paddy Stalk
- ➢ Coconut Shell
- ➢ Olive Wood Trimmings
- ➢ Groundnut Shells

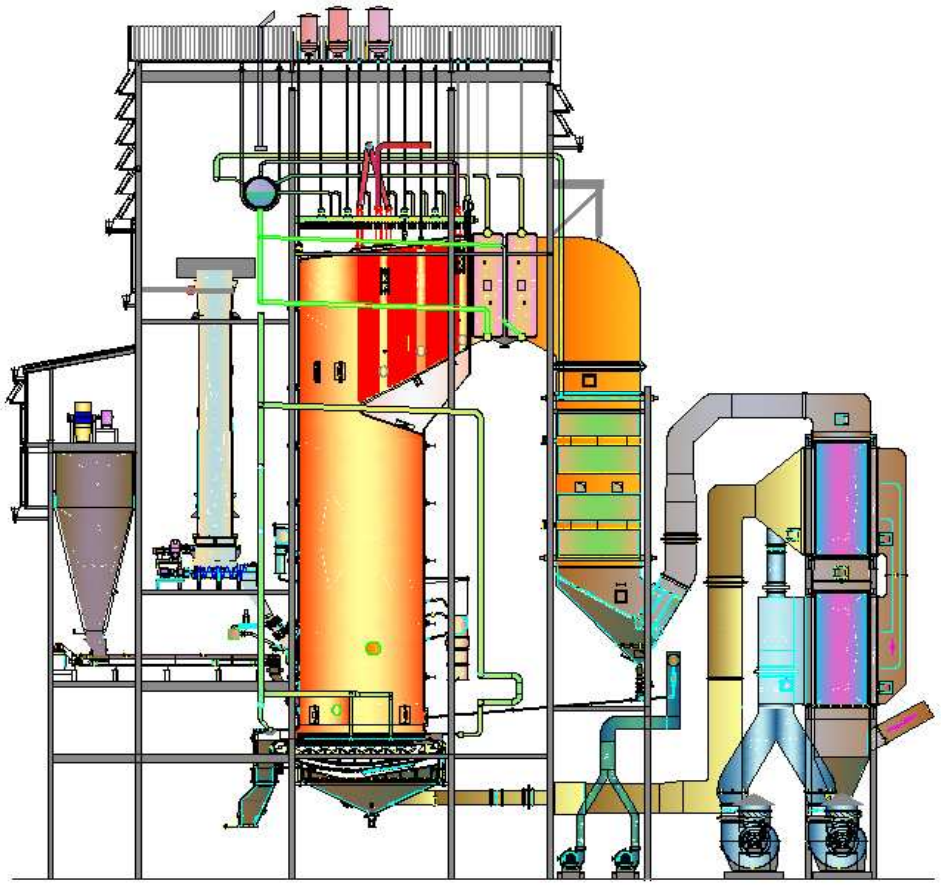
❑ Fossil Fuels:

- ➢ Coal
- ➢ Lignite
- ➢ Oil
- ➢ Gas

Single Drum Travelling Grate Boiler with Evaporator

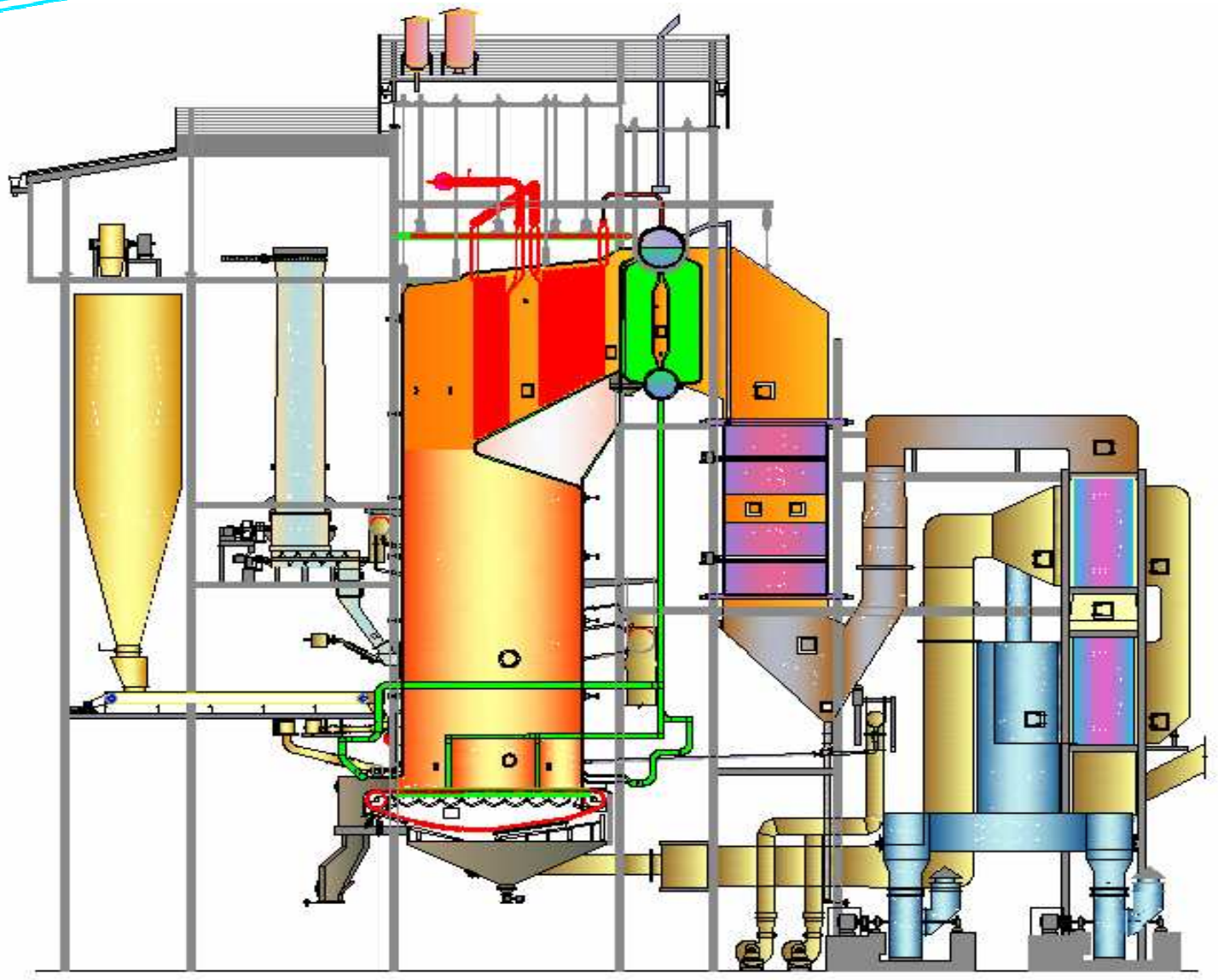


Single Drum Design Travelling Grate Boiler with Evaporator in Second Pass



Single Drum Design Travelling Grate Boiler with Modular Evaporator Bank

Bi-Drum Design Travelling Grate Boiler



Travelling Grate Boiler with Boiler Bank

High Uptime

Single Drum Design **(For Steam Pressure >87 Kg / sq.cm a)**	• **High ligament efficiency of drum (85 – 90%), hence lower drum thickness.** • **Better circulation due to non-heated down comers** • **No tube expansion**
Bi Drum Design **(For Steam Pressure <87 Kg / sq.cm a)**	• **With single pass boiler bank which eliminates eddies and minimises erosion**
Generous Grate area loading **(<2.5 M Kcals / hr - sq.m)**	• **Ensures efficient combustion of fuel**
Generous Furnace Volumetric loading **(<0.25 M Kcals / hr - cubic m)**	• **Ensures adequate residence time (2.5 to 3.0 seconds) for efficient fuel combustion** • **Reduces unburnt Carbon loss** • **Ensures optimum furnace exit flue gas temperature (<900 ^{0}C)**

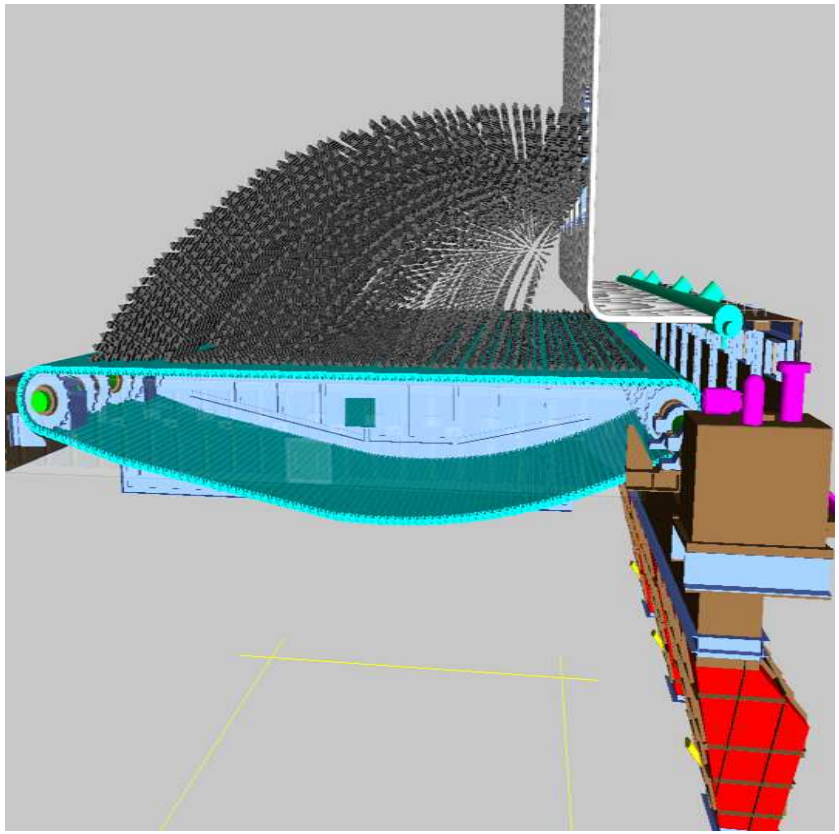
Contd…

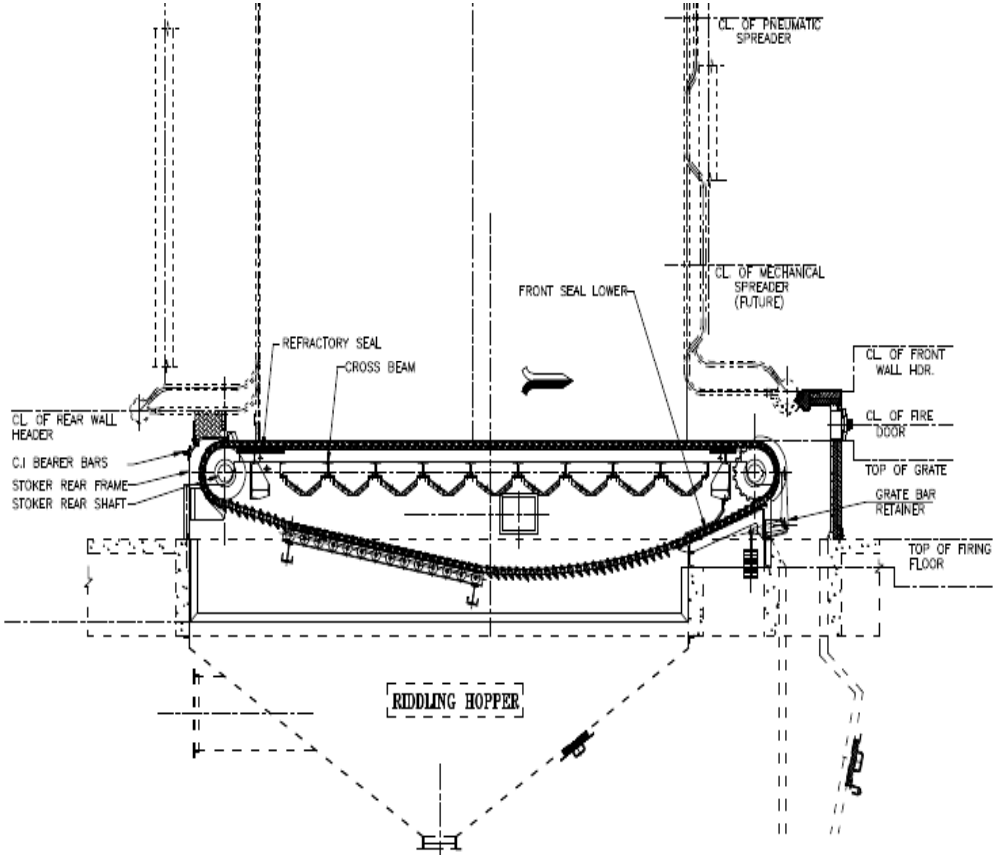
High Uptime

Water Cooled Membrane wall construction for furnace	• Minimum maintenance • High structural rigidity • Maximum absorption of heat
Convective Super heater Design (Shielded by nose)	• Lower metal temperatures • Avoids fouling
Wide Pitching for Super heater Tubes	• Avoids fouling due to Alkali ($Na_2O + K_2O$) content in ash
Double Casing for Economiser	• Protects Tube bends from erosion
Ferrules for Air heater Inlet Tubes	• Minimises Erosion
Corten Steel Material for Air heater at the cold end	• Minimises Corrosion

Contd…

Continuous Ash Discharge Travelling Grate Stoker





RUGGED, EFFICIENT & EASY TO MAINTAIN

High Uptime

All Pressure Part Tubes of Seamless Construction	• Eliminates Leakages • Higher Life
Travelling Grate Bars of Spheroidal Graphite Iron Metallurgy	• Resistance to Wear and Tear at Elevated Temperatures • High Durability
Use of SA 213 T91 Material for Final Elements of Secondary Super heater	• High Creep Resistance • High Fatigue Resistance • High Corrosion Resistance
Optimum Steam side Pressure drop in Super heater Circuit	• Ensures proper Steam distribution and Cooling of Super heater Coils
Optimum Flue Gas Velocity Levels in Pressure Parts	• Minimises Erosion due to Ash Particles

Contd…

Efficient drum Internals (Cyclone Separators, Demisters)	• **Ensures High Steam Purity at all loads**
Pre dust Collector at the upstream of Electrostatic Precipitator	• **Reduces Particulate loading on ESP and ID Fans** • **Reduces Unburnt carryover to ESP, Eliminating Fire Hazards**
Higher frame size for Motors with VFD	• **Minimises Heat Losses**

High Efficiency

Tall Furnace	• **Provides High Residence time, hence lower unburnt carbon loss**
Over fire Air with High Pressure Secondary Air with Staggered Arrangement of Nozzles	• **Proper Turbulence for Efficient Combustion** • **Better Air Penetration across furnace cross section. The above ensures lower unburnt carbon loss**
Use of Refractory band inside the Furnace	• **Sustains combustion of High Moisture Fuels**
Soot Blower in Superheater and Economiser	• **For Efficient on-load cleaning thereby Keeping Heating Surfaces Clean for Proper Heat Transfer**

Contd…

High Efficiency

Optimum Excess Air Level	• **Reduces Dry Gas Loss**
Use of High Pressure Feed Water Heaters	• **Fuel Economy**
Grit Refiring	• **Reduces Unburnt Carbon loss**

Low Power Consumption

Optimum Flue Gas Velocities across Pressure Parts	• **Low draft loss, hence Low Power Consumption in ID Fans**
Variable Frequency Drives for Fans, Pumps, Feeders	• **Low Auxiliary Power Consumption**

Environment Friendly

Electrostatic Precipitators	• **To limit particulate emission up to 50 mg / Nm^3**
Silencers for Safety Valves, Start Up Vent, FD Fan and SA Fan	• **To meet noise levels as per OSHA norms**
Dense phase Fly Ash handling system	• **Closed System, avoids dust nuisance**

Low O & M Cost

Automated Operation with DCS	• Less Manpower • Accurate Controls
On line Steam and Water Analyser System	• Ensures Strict Control of Water Chemistry
On line Vibration Monitoring System for Critical Rotating Equipment	• Preventive Maintenance • Avoids Failures
Seamless Steel Tubes for Boiler Pressure Parts	• Eliminates Tube Leakages • Higher Life
Alloy Steel Tubes for Super heaters	• Resistance to Corrosion, Fatigue and Creep
Corten Steel Tubes for Cold end of Air heater	• Prevents Corrosion

Contd…

Low O & M Cost

Low O & M Cost

Wear Liners for ID Fan Blades	• **Resistance to Erosion**
Soot Blowers (Long Retractable and Rotary) at Strategic Locations	• **Avoids deposition and Fouling in Pressure Parts**
Air heater Air bypass Arrangement	• **Avoids Cold end Corrosion during Boiler Start-up, Part load operation and during Low Ambient Air Temperature**
Stoker Shaft with Self Lubricated Graphite Bearings	• **Maintenance Free** • **High Reliability**

Feed Water Quality Management In High Pressure Boilers

- To Eliminate Corrosion
- To Avoid Scaling
- To Control Steam Quality
- On-line Monitoring of Condensate and Boiler Feed Water Quality using SWAS
- Fully Automatic DM / RO Plant for achieving the Recommended Feed Water Quality

Recommended Feed Water Quality

Parameters	Unit	45 kg/sq.cm (a)	66 kg/sq.cm (a)	87 kg/sq.cm (a)	105 kg/sq.cm (a)
pH		8.8 – 9.2	8.8 – 9.2	8.8 – 9.2	8.8 – 9.2
Hardness	ppm	Nil	Nil	Nil	Nil
Specific Electrical Conductivity after Cation Exchanger	µs / cm	2.0	0.5	0.5	0.3
Dissolved Oxygen	ppm	0.20	0.007	0.007	0.005
Total dissolved solids	ppm	1.0	0.25	0.25	0.15
Silica	ppm	1.0	0.02	0.02	0.02
Total iron	ppm	0.05	0.01	0.01	0.005
Total Copper	ppm	0.01	0.01	0.01	0.005

Recommended Boiler Water Quality

Parameters	Unit	45 kg/sq.cm (a)	66 kg/sq.cm (a)	87 kg/sq.cm (a)	105 kg/sq.cm (a)
pH		9.8 – 10.2	9.0 – 10.0	9.0 – 10.0	9.0 – 10.0
Total Dissolved Solid	ppm	150	100	100	100
Specific Electrical Conductivity	µs / cm	300	200	200	200
Silica	ppm	10	5 *	2.5 *	1.5 *
Residual Phosphate	ppm	15 – 25	5 – 20	5 – 20	5 – 20

** To be controlled based on drum operating pressure so as to maintain silica less than 0.02 ppm in the steam leaving the boiler drum.*

Prevention of Cold End Corrosion

- **Use of Drum Coil Heaters for Minimising Cold end Corrosion in Economiser due to Sulphur in Fuel**

- **Use of Steam Coil Air Preheater and Airheater Air by pass Arrangement for Minimising Cold end Corrosion in Air heater during Start up and Low Ambient Temperature**

Design Features of High Pressure Bagasse Fired Boilers

Design Fuel : 100% Bagasse, 77% Rice Husk , 70% Indian Coal	
Net Steaming capacity at MCR (Kg/hr) for Bagasse	1,70,000
Main Steam Pressure/Temperature at MSSV outlet	105 Kg / sq.cm (g) / 540 Deg C
Peak capacity of Boiler (Kg/hr.)	1,87,000
Duration of peak capacity / Shift	30 minutes
Steam temperature control range	60 – 100%
Boiler design pressure	124 Kg / sq.cm (g)
Feed water temperature at De-aerator outlet and Economizer inlet	130 / 220 Deg C
De-aerator operating pressure	1.75 Kg / sq.cm (g)
Gas temperature leaving air heater.	150 Deg C
Dust content in flue gases leaving the dust collection system	150 mg / N.cu.m
Dissolved oxygen in feed water (max.)	0.007 ppm

Boiler Performance

PARAMETERS	UNIT	87 Kg/sq.cm (a), 515 Deg C		105 kg/sq.cm (a), 540 Deg C	
		Design Values	Achieved Values	Design Values	Achieved Values
PLANT		NIZAM DECCAN SUGARS, INDIA		DHAMPUR SUGARS, INDIA	
Steam flow at Main steam stop valve	Tph	110	110	170	171.4
Steam temperature at Main steam stop valve	Deg.C	515 ± 5	515	540 ± 5	540
Steam pressure at Main steam stop valve	Kg / sq. cm (a)	87	87.2	105	105.4
Feed water temperature at Economiser inlet	Deg.C	170	168	220	218
Back end temperature	Deg.C	150	148	150	146
Boiler Efficiency on GCV basis	%	71.5	72.7	71.1	71.4
Auxiliary power consumption	KW	1096	1025	1912	1754
Particulate Emission at ESP outlet	mg / N.cu.m	115	115	150	150
Noise level of rotating equipment at 1 meter distance	dB	85	< 85	85	< 85

Thanks