CO27:

DEVELOPMENT OF AN EFFICIENT

SLOP FIRED BOILER

Speaker

Rajesh Singla

ISGEC Heavy Engineering Ltd, Noida, India

At : 29th ISSCT, Chiang Mai , Thailand, 7 Dec 2016

AUTHORS

A.K. Subramanian
Head Design

Rajesh Singla
DGM, Marketing

Green Energy Boiler Division
Isgec Heavy Engineering Ltd, Noida, India

OBJECTIVE

Slop, also known as Vinasse, is an Acidic Effluent from Fermentation of Sugar Cane Molasses in Distilleries.
It is a Hazardous Waste and not suitable for Direct Disposal.

Conventional methods of disposal & their limitations

- Bio-methanation - Has Residual Liquid Discharge, Require lot of secondary treatment.
- Composting - Large area requirement, Land Pollution due to Leaching, Disposal problem during rains.
- Existing Incineration Technologies – Frequent Choking, Tube failures, Continuous operation not more than 20 – 25 days.

These do not result in "Zero Liquid Discharge".
Zero liquid discharge can be achieved through Eco –friendly Incineration Technology which is also energy efficient.

REQUIREMENT

Concentrated Slop/ Spent Wash is directly fired in the Boiler to meet Zero Liquid Discharge

A. **To Meet the Statutory Norm of Zero Discharge:**
   - By Firing Concentrated Distillery Effluent spent wash (Slop) in a boiler.

B. **Co-Product:**
   - Steam Generation to meet the process requirement of Distillery.

C. **Benefits:**
   - Power Generation to meet captive requirement.
   - Potash rich ash is saleable, generates good revenue and also eliminates disposal problem.
   - Reduction in overall production cost per liter of alcohol.

DEVELOPMENT OF AN EFFICIENT INCINERATION TECHNOLOGY NEEDS…

- In depth study of Slop and its Ash characteristics.
- Ash deformation and Fusion temperature.
- Selection of appropriate steam parameters (Pressure / Temperature Cycle).
- Option of Support Fuel(s)
- Efficient combustion system.
- Effective Air Pollution Control equipment.

TYPICAL CHARACTERISTICS OF RAW SLOP

Colour	Dark Brown
Odour	Pungent
pH	4.0 – 4.5 (Acidic)
Solids Content	9 – 12% (Weight)
Biological Oxygen Demand	45000 – 60000 PPM
Chemical Oxygen Demand	110000 – 135000 PPM

ANALYSIS OF SLOP AND COMPARISON WITH BAGASSE

ISGEC

Analysis of Slop and Comparison with Bagasse

Constituent (% Weight)	Slop (60 Brix)	Bagasse
Carbon	22.22	23.50
Hydrogen	2.15	3.25
Nitrogen	1.85	-
Oxygen	14.50	21.75
Moisture	40.00	50.00
Sulphur	0.62	-
Ash	18.66	1.50
Gross Calorific Value (Kcals / Kg) (MJ / Kg)	1800 7.5	2270 9.5

VARIATION IN CALORIFIC VALUE OF SLOP WITH CONCENTRATION

Solids Concentration (Brix) (%)	Gross Calorific Value (Kcals/Kg)
40	850
45	1200
50	1400
60	1800

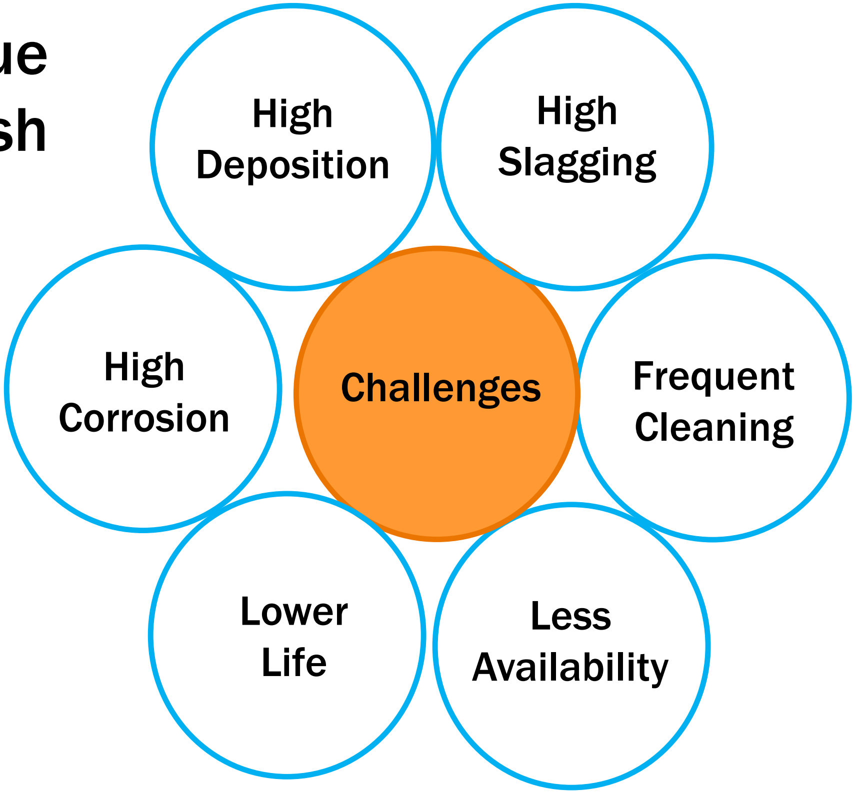
TYPICAL ANALYSIS OF SLOP ASH VS BAGASSE ASH

Constituent (% Weight)	Slop Ash	Bagasse Ash
Silica, SiO2	2.50	69.88
Iron Oxide, Fe2O3	2.00	6.49
Calcium Oxide, CaO	14.00	4.75
Magnesium Oxide, MgO	6.50	2.83
Sulphate, SO3	16.50	0.08
Phosphate, P2O5	10.00	2.01
Potassium Oxide, K2O	47.00	2.79
Sodium Oxide, Na2O3	0.50	1.22
Aluminium Oxide, Al2O3	-	9.10
Chlorides, Cl	1.00	-

Constituents which cause problems in Boiler are Alkalis (Na_2O_3+K_2O), Chlorides, Calcium Oxide & Sulphates.

CHALLENGES IN SLOP COMBUSTION

- Low Calorific Value of Slop even at 60 Brix (1800 Kcals/Kg). However it fluctuates between 45 to 60 Brix.
- Low Ash fusion temperature due to high Alkali constituents in ash (K_2O+ Na_2O).
- High Chlorides (>1%), Calcium Oxide and sulphate in ash.
- Low Silica in ash.
- Ensuring Continuous operation



CHALLENGES OF FIRING SLOP

BEFORE

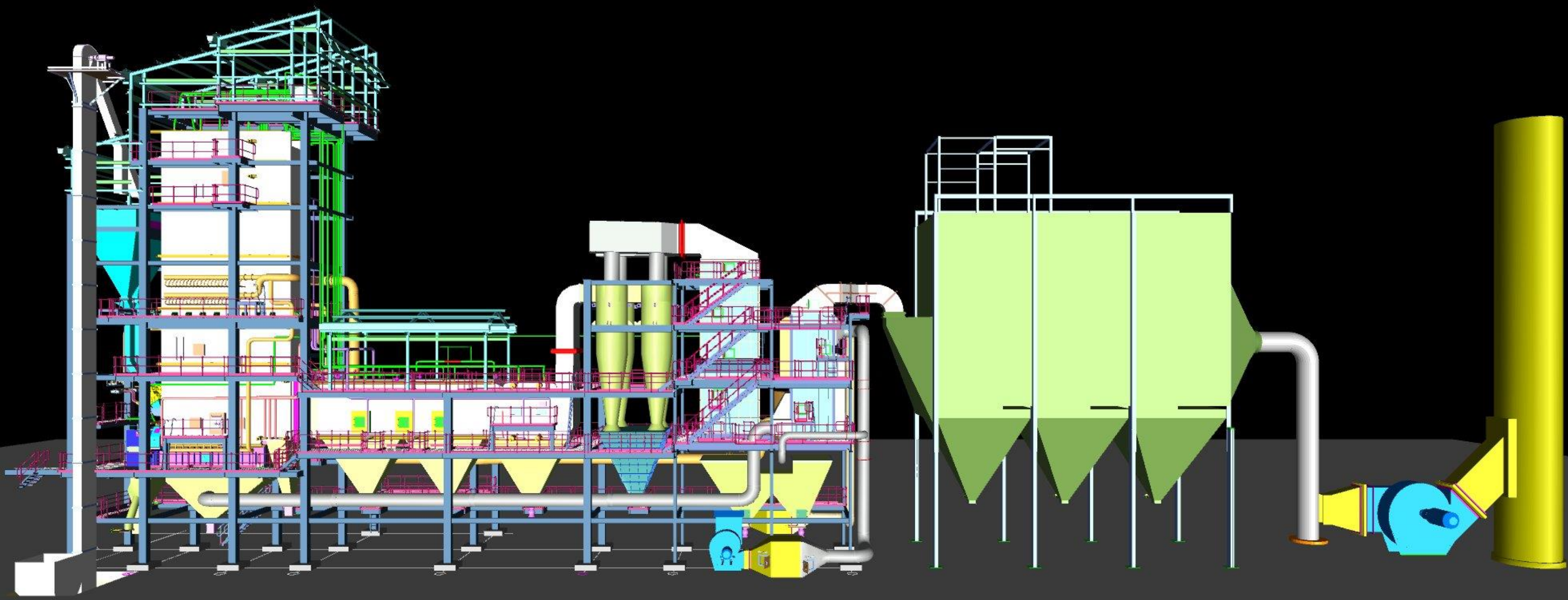
AFTER

Deposits & Fouling of Tubes

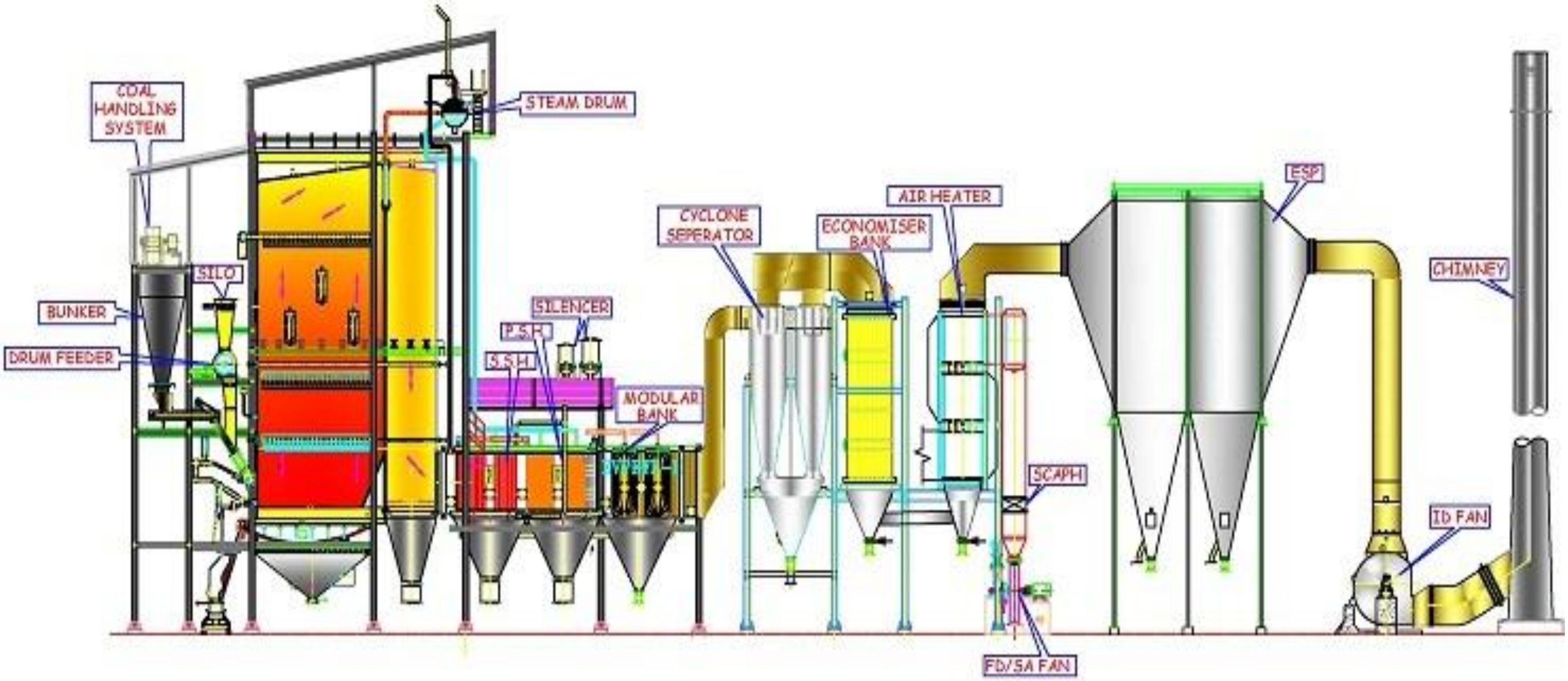
SELECTION OF SUITABLE TECHNOLOGY TO SUIT:

- Sustained Boiler operation with varying Slop concentration, also low GCV.
- Ability to fire variety of Biomass Fuels and Coal for combustion support.
- Ability to generate steam with supporting fuel in absence of Slop to keep distillery running.
- Minimum operating cost.
- Easy to operate, user friendly technology.

TYPICAL ARRANGEMENT OF BOILER IN 3D



TYPICAL ARRANGEMENT OF 2nd GENERATION BOILER



BASIC CONFIGURATION OF BOILER

- Specially designed Travelling Grate stoker heat-resistant grate bars for wide fuel flexibility.

- Grate Bars with more overlap to ensure uniform distribution of combustion air across grate.

- Continuous ash discharge from grate ensures removal of clinkers, if formed, without stopping the boiler.

BASIC CONFIGURATION OF BOILER

THREE PASS CONFIGURATION

- First and Second pass are vertical, made up of Water cooled membrane wall and do not have any heating surfaces inside.

- Third pass is Horizontal and accommodates primary and secondary super-heater, evaporator, economizer and air heater.

BASIC CONFIGURATION OF BOILER

TALL FURNACE

- To achieve high residence time of 7 to 8 Seconds to ensure efficient combustion of the slop / support fuel.
- To achieve low flue gas temperature (<600 ^{0}C) at Inlet of super-heater to avoid fouling due to alkalis in ash.
- To avoid corrosion of super-heater elements due to chlorides in ash.

BASIC CONFIGURATION OF BOILER

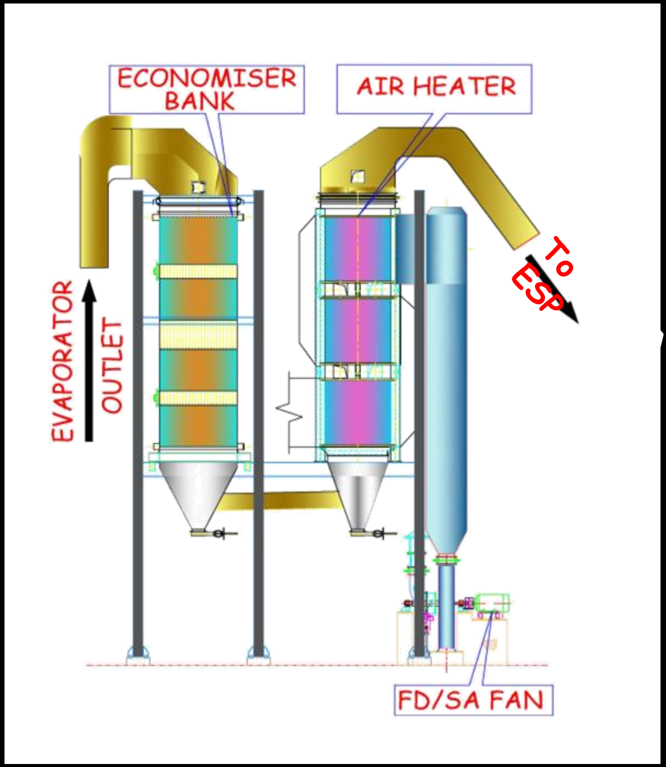
- Wide transverse pitching of super heaters, economizer and air heater to avoid fouling due to high alkalis in ash.

- Efficient and reliable on-load cleaning system using soot blowers for heat transfer surfaces.

- Air heater designed for airflow through tubes and flue gas flow outside to eliminate choking of tubes

BASIC CONFIGURATION OF BOILER

- Cold end block of air heater is provided with corten steel tubes to minimize corrosion.
- Vertical arrangement of economizer and air heater reduces dust load and ensures efficient cleaning with soot blowers.
- Use of secondary air nozzles at strategic locations to provide turbulence for good combustion



BASIC CONFIGURATION OF BOILER

- Specially designed Slop nozzles with ball and socket arrangement for tilting, at strategic locations on Furnace Water wall to ensure efficient combustion.

- High pressure Slop pumps for proper atomization

BASIC CONFIGURATION OF BOILER

Specially designed air pollution control equipment –

- Combination of Pre-Dust Collector and Electrostatic Precipitator.
- Higher Spacing between Electrodes of ESP
- Special Type TR Set Controllers of ESP.
- Shorter Length of Electrodes for Effective rapping in ESP.

INSTALLATION :
BALRAMPUR CHINI MILLS, INDIA

40 TPH, 45 Kg/cm^2, 400 Deg C, Slop with Bagasse as support fuel

BRIEF REPORT

ISGEC

BALRAMPUR CHINI MILLS LIMITED (Operated continuously for more than 95 days; Total – 282 days till date)				
Site : BALRAMPUR, U.P, INDIA		**Commissioned** – November' 2015		
SITE PARAMETERS	UNIT	DESIGNED	ACHIEVED	
Steam flow at MCR	TPH	40	39 – 42	
Steam pressure at MSSV Outlet	kg/cm^2	45	43 – 45	
Steam temperature at MSSV Outlet	°C	400	395 – 402	
Feed water temp. at economizer Inlet	°C	140	130 – 140	
Fuel Fired (Slop + Bagasse)	MCR	100%	100%	
Fuel Parameters			Avg.	TPD
Slop quantity fired (55 – 60 Brix)	TPH	13.00	13.00	300 – 370
Bagasse fired	TPH		7.00	170 – 200
Power Consumption for Auxiliaries	KW	600	418	
Dust concentration at the ESP outlet	mg/nm^3	Less than 50	15 – 42	

HIGHLIGHTS :
BALRAMPUR CHINI BOILER

- Successfully operating with Bagasse as support fuel
- Boiler operated for more than 90 days continuously
- 50+ days of Continuous operation 4 times since commissioning
- Firing 13 – 16 TPH Slop continuously.
- Bagasse moisture variation 35% – 58%.
- Negotiating wide variation in Slop Brix.
- Meeting SPM emission level as per pollution norms (less than 50mg/nm^3) with ESP.
- Additional revenue by selling Potash rich ash.
- Generating continuous 5.0 MW of power.

INSTALLATION :
INDRESHWAR SUGARS, INDIA

23.5 TPH, 40 Kg/cm^2, 400 Deg C

Slop with Bagasse as supporting fuel

BRIEF REPORT

INDRESHWAR SUGAR MILLS			
Site : BARSHI, MAHARASHTRA	Commissioned – March' 2016		
Parameters	UNIT	Design	Achieved
Steam flow at MCR	TPH	23.5	18 – 22
Steam pressure at MSSV Outlet	$kg/cm^2(g)$	40	40
Steam temperature at MSSV Outlet	°C	400	390 – 400
Feed water temp. at economizer Inlet	°C	145	135 – 142
Main Fuel/s – Slop + Bagasse – Bagasse	MCR	100%	100%
Slop quantity to be fired (55 – 65 Brix)	TPH	7.5	4.5 – 6.2
Slop GCV (at 55 Brix)	Kcal/kg	1750	–
Dust concentration at the ESP outlet	mg/Nm^3	50	34

INSTALLATION : DALMIA SUGARS, INDIA

18 TPH, 45 Kg/cm^{2}g, 400ºC

Slop with Imported Coal as supporting fuel

BRIEF REPORT

DALMIA SUGARS LIMITED (Operated continuously for more than 65 days)				
Site : KOLHAPUR, MAHARASHTRA		Commissioned – November' 2015		
SITE PARAMETERS	UNIT	DESIGNED	ACHIEVED	
Steam flow at MCR	TPH	18	14 – 16.5	
Steam pressure at MSSV Outlet	$kg/cm^2(g)$	45	42 – 45	
Steam temperature at MSSV Outlet	°C	400	380 – 400	
Feed water temp. at economizer Inlet	°C	140	120 – 140	
Fuel Fired –Slop + Coal	MCR	100%	100%	
Fuel Parameters			Avg.	TPD
Slop quantity fired (52 – 62 Brix)	TPH	5.50	5.50	125 – 145
Coal fired	TPH	–	1.50	33 – 43
Dust concentration at the ESP outlet	mg/nm^3	Less than 50	25 – 40	

HIGHLIGHTS :
DALMIA BOILER

- Operating with **high moisture** (30% – 40%) Imported coal as support fuel
- Boiler crossed 65+ days continuous operation
- Firing 5.5 TPH Slop continuously
- Negotiating wide variation of Slop Brix
- ESP working extremely well to maintain SPM level with in limits
- Potash Rich ash is another source of revenue
- Generating 1.6 MW power to meet captive requirement

INSTALLATION :

MADHUCON SUGAR & POWER, INDIA

24 TPH, 45 Kg/cm^2(a), 390 °C

Slop with Coal as supporting fuel

BRIEF REPORT

ISGEC

MADHUCON SUGAR & POWER LIMITED			
Site : TELANGANA	Commissioned – January' 2016		
Parameters	Unit	Design	Operated
Steam flow at MCR	TPH	21	17 – 21
Steam pressure at MSSV Outlet	$kg/cm^2(a)$	45	45
Steam temperature at MSSV Outlet	°C	390	385 – 392
Feed water temp. at economizer Inlet	°C	150	150
Main Fuel/s – Slop + Bagasse – 100% Bagasse	MCR	100%	–
– Slop + Coal (Indian / Imported) – 100% Coal (Indian / Imported)	MCR	100%	100%
Slop quantity to be fired (55 – 65 Brix)	TPH	6.5	7.0 – 8.0
Slop GCV (at 55 Brix)	Kcal/kg	1750	–
SPM at the Bag Filter outlet	mg/Nm^3	50	29 – 42

HIGHLIGHTS :
MADHUCON BOILER

- Operating with high moisture (30% – 40%) Imported coal as support fuel
- Boiler crossed 50+ days continuous operation 3 times since commissioning
- Firing 7 – 8 TPH Slop continuously
- Negotiating wide variation of Slop Brix.
- Selling Potash Rich to fertilizer plant.
- Continuous power generation of 1.8 – 2.2 MW

TYPICAL CONFIGURATION : BOILER / SLOP / POWER GENERATION

Distillery Size	Boiler Size	Slop Quantity (55 – 60 Brix)	Power Generation
30 KLPD	12 TPH	3.5 TPH	1.0 MW
45 KLPD	18 TPH	5.6 TPH	1.6 MW
60 KLPD	23 TPH	7.5 TPH	2.2 MW
100 KLPD	34 TPH	12.5 TPH	3.2 MW
160 KLPD	40 TPH	15 TPH	4.0 MW

OBSERVATIONS

- Slop Fired Boilers with bagasse or coal as support fuel have been operating satisfactorily with continuous operation more than 90 days

- All parameters such as Steam temp / pressure, flue gas temp entering super-heaters / leaving Air heater and stack emission levels are stable during the entire period of continuous operation.

- 100% Steam Generation with support fuel in absence of Slop to operate the distillery un-interrupted.

- With Soot blowers in operation (4 to 5 times per day) all heating surfaces are observed clean.

CONCLUSION

The slop fired incineration boiler is best solution to achieve zero liquid discharge with following advantages :

- Steam and power for in house consumption.
- Travelling Grate furnace for wide flexibility of secondary fuels like Bagasse, Rice husk, Wood Chips, Coals etc.
- Low maintenance technology with high availability.
- Minimum auxiliary steam & power consumption.
- Fully Automated, Eco – friendly, User – Friendly and energy efficient technology.


Thank You