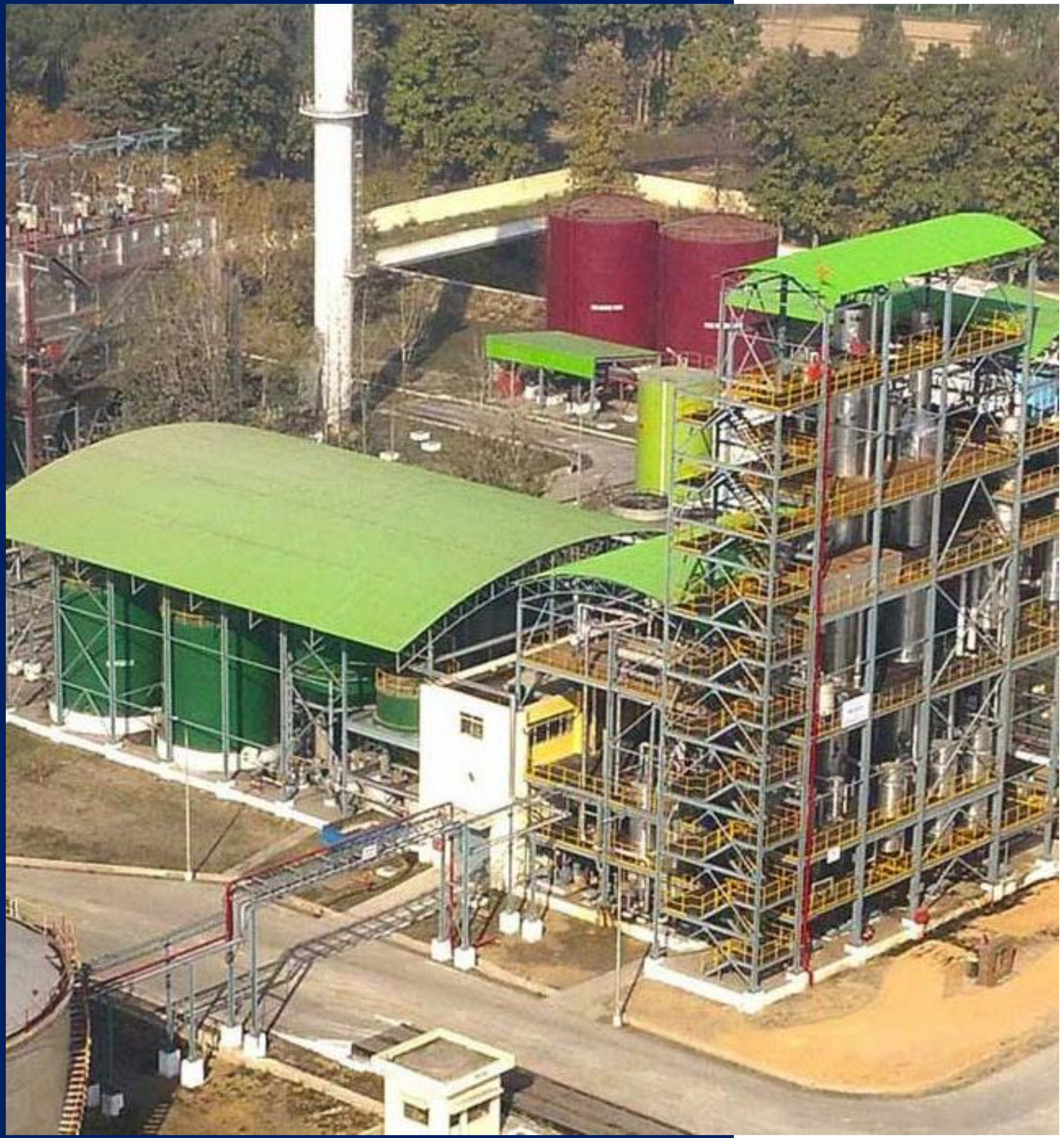


MODULATION IN INCINERATION BOILER DESIGN WITH CHANGING SCENARIO OF ETHANOL PRODUCTION

ISGEC HEAVY ENGINEERING LIMITED, INDIA

Presented by: Arun Tewari

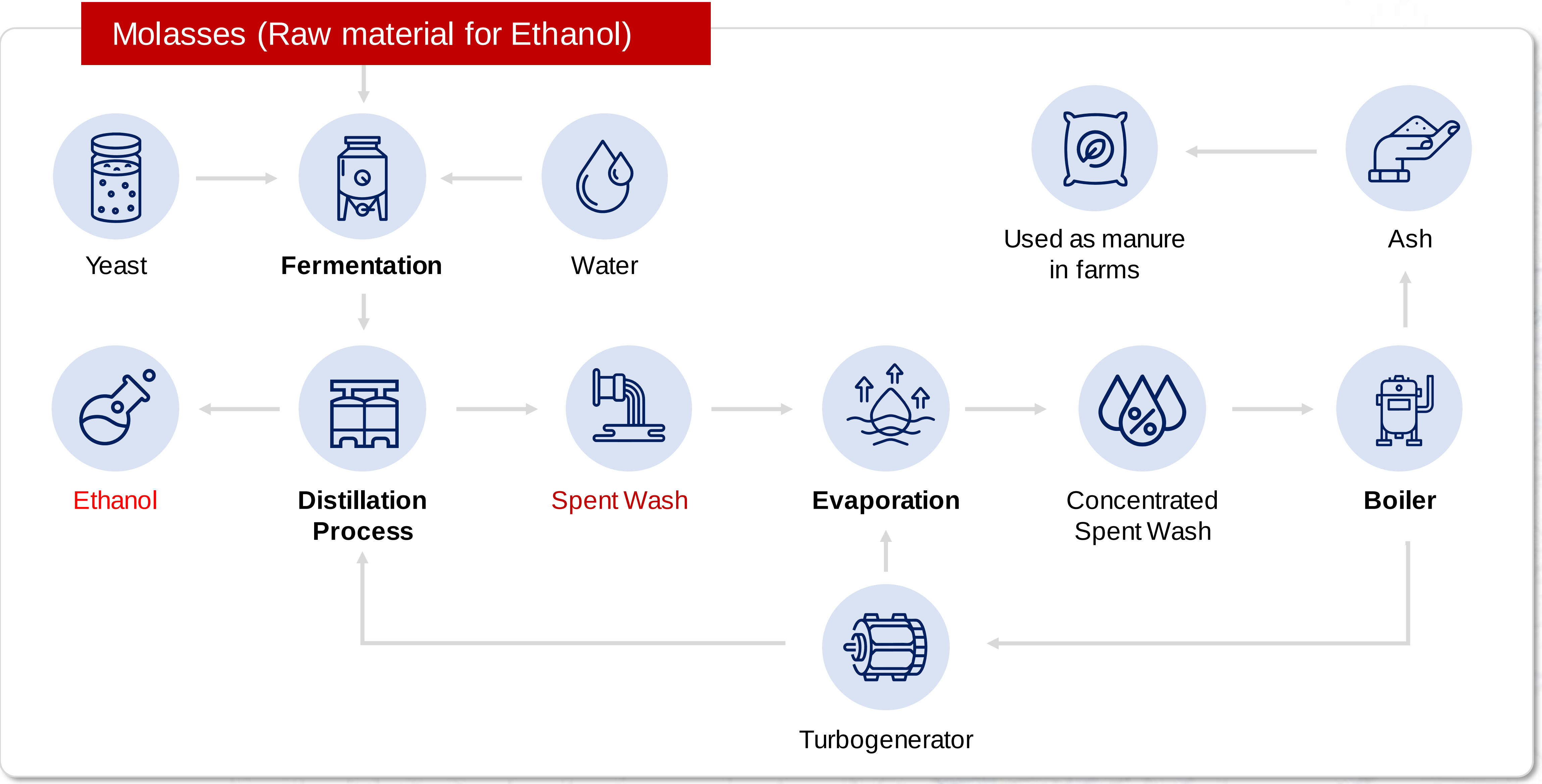
ETHANOL : A BIO FUEL

E20 Fuel

20 percent
blend of ethanol

80 percent of
fossil-based fuel

DISTILLERY PROCESS



Effluent from Distillery

VINASSE

- Concentrated Spent Wash
- SLOP
- Vinasse

INTRODUCTION

Typical characteristics and effects of Vinasse

Characteristic	Value	Effect
pH	4 - 4.5	Acidic, Corrodes the surroundings and contaminates the soil.
BOD	10,000 - 60,000 mg/kg	Will pollute rivers and ground water.
COD	110,000 - 135,000 mg/kg	Water will become unfit for human consumption and for general use.
High moisture and solid content	9 - 20% w/w depending on plant configuration	Difficult to handle and store. Requires large area to store and then removal of settled solids and its disposal is of concern.
Odour	Pungent	Unbearable

FEED STOCK FOR DISTILLERY

C Heavy Molasses → B Heavy Molasses → Syrup

Fuel	Inlet Brix(%)	Water Mixing	Outlet Brix (%) after MEE	SLOP Generation for 100KL PD Distillery
Syrup	4 to 6	No Addition	60	3 - 5
B - Heavy Molasses	10 to 12	5 to 6 times	60	11 - 13
C - Heavy Molasses	16 to 18	10 to 12 times	60	18 - 20

VINASSE GENERATION BASED ON INLET FEED STOCK

ISGEC

Vinasse Quantity Generated at 60 Brix@20Deg C

SYRUP
0.09X

B HEAVY
0.57X

C HEAVY
X

Comparison of various feed stocks and Vinasse generation 100 KLD Ethanol productions (by process calculations)

Molasses Grade	%TFS content in feedstock	%TFS content in cane	Ethanol produced L/t per tonne of cane	Sugar produced kg per tonne of cane	Vinasse production at inlet TPH @ 17 % solids	Vinasse fired in boiler TPH @ 60 % solids
Syrup	10	14	84	0	5.1	1.4
B heavy	50	7.25	21.75	95	32.1	9.1
C heavy	40	4.5	1o.8	115	56.5	16

VINASSE PROPERTIES OF DIFFERENT FEED STOCK (1/3)

Proximate analysis

	Unit	Syrup	B Heavy	C Heavy
Moisture (Total)	%	53.15	48.60	48.40
Ash	%	7.24	11.26	16.47
Volatile Matter	%	22.82	33.49	34.52
Fixed Carbon	%	16.79	6.65	5.94
Gross Calorific Value (GCV)	kcal/kg	1751	1746	1770
Chlorine content in fuel	%	1.28	0.79	0.91
Density	kg/L	1.27	1.25	1.28

Source : Reports from Spectro Lab

VINASSE PROPERTIES OF DIFFERENT FEED STOCK (2/3)

Ultimate analysis

	Unit	Syrup	B Heavy	C Heavy
Carbon	%	16.24	17.84	18.32
Hydrogen	%	4.05	3.09	2.28
Nitrogen	%	0.82	0.92	0.58
Sulphur	%	4.06	0.90	0.48
Ash	%	7.24	11.26	16.47
Moisture	%	53.15	48.60	48.40
Oxygen	%	14.20	17.39	13.47

Source : Reports from Spectro Lab

VINASSE PROPERTIES OF DIFFERENT FEED STOCK (3/3)

ISGEC

Ash properties

	Unit	Syrup	B Heavy	C Heavy
Silica	%	8.67	4.51	2.56
Alumina	%	2.24	2.73	0.42
Iron oxide	%	1.74	0.88	2.12
Calcium oxide	%	10.40	18.73	14.40
Magnesium oxide	%	5.88	12.82	6.25
Potassium oxide	%	32.00	37.01	48.50
Sodium oxide	%	0.58	1.05	0.45
Phosphate	%	8.86	1.55	9.80
Chloride	%	0.83	6.70	0.96
Sulphate	%	16.24	13.90	16.20

Source : Reports from Spectro Lab

WASTE/EFFLUENT OF PLANTS

Effluents	Generation m3/hour	CharacterstICKS
RO reject	4-6	Na+ Ca High TDS water
Mill house effluent	2 - 3	High impurities Clay, fuel fibers. Brine solution
Boiling house effluent	2 - 4	High impurities Clay, fuel fibers, Sulphur mixed water
Drain pit MEE, Boiler	2 - 5	High impurities Clay, fuel fibers
CIP cleaning drain chemicals	20 – 30 In Batch mode	HNO3. HCL, NAOH chemicals solution

Above data for 100 KLPD distillery

With Zero Liquid discharge concept in Plants, effluents generated are also mixed in Vinasse at MEE Tanks

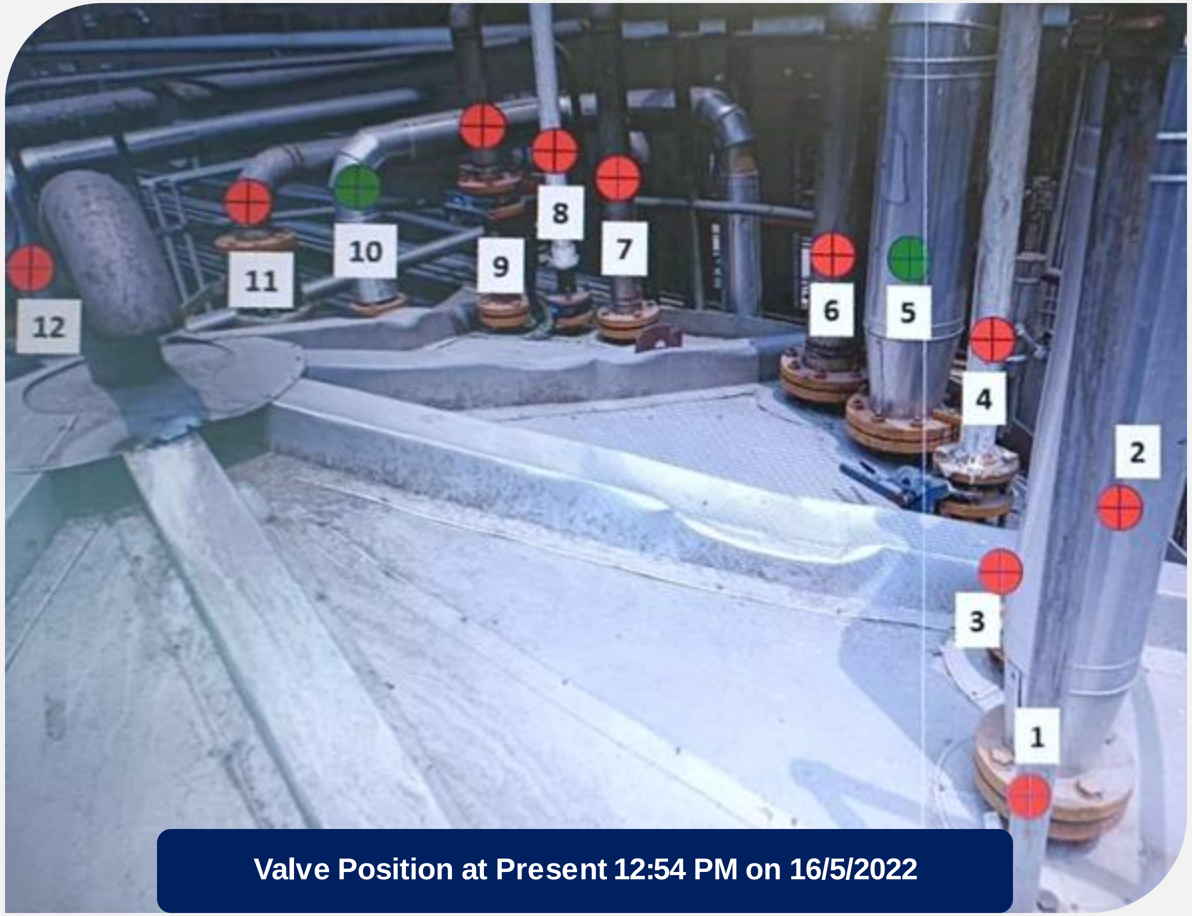
MULTIPLE EFFECT EVAPORATOR VINASSE GENERATION

All Effluents & Vinasse Passed through the MEE.

60%

Water present in Vinasse and Effluent is evaporated in MEE using LP steam to make final Vinasse 60% Brix

1	From Old Sugar RO reject
2	From Evaporator body recirculation (in case brix low)
3	From Evaporator CIP
4	Raw Water Line
5	From Distillery
6	From Lagoon
7	From MEE pit
8	From RO Reject
9	From Pits of distillery
10	From MEE Pump recirculation
11	From Evap body Drain
12	From Condensate of body (if color comes)



Valve Position at Present 12:54 PM on 16/5/2022

CHALLENGES IN FIRING SLOP

Combustion

Low Calorific Value of Slop even at 60 Brix (1750 Kcals/Kg). However it fluctuates between 55 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

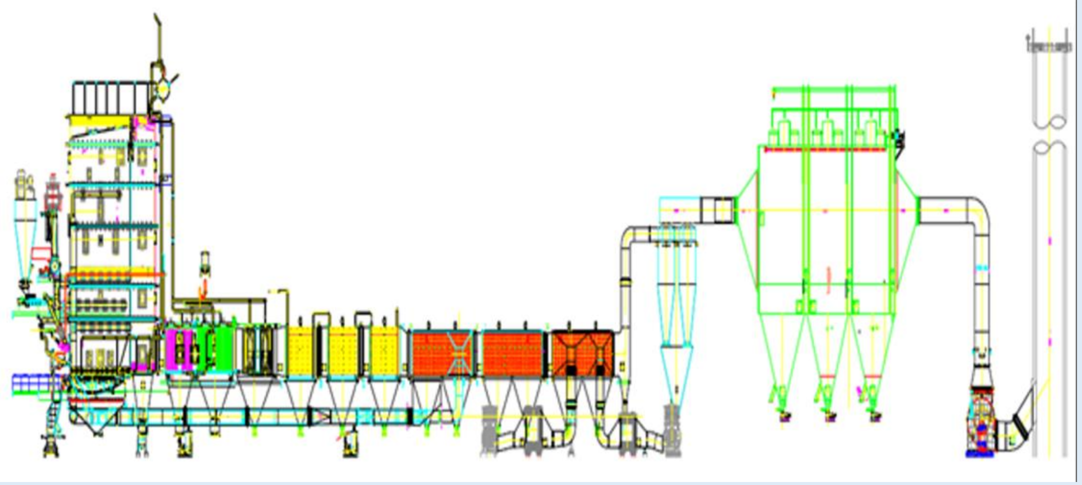
- High Deposition
- High Corrosion
- High Slagging
- Lower Life
- Less Availability
- Frequent Cleaning

INCINERATION BOILERS

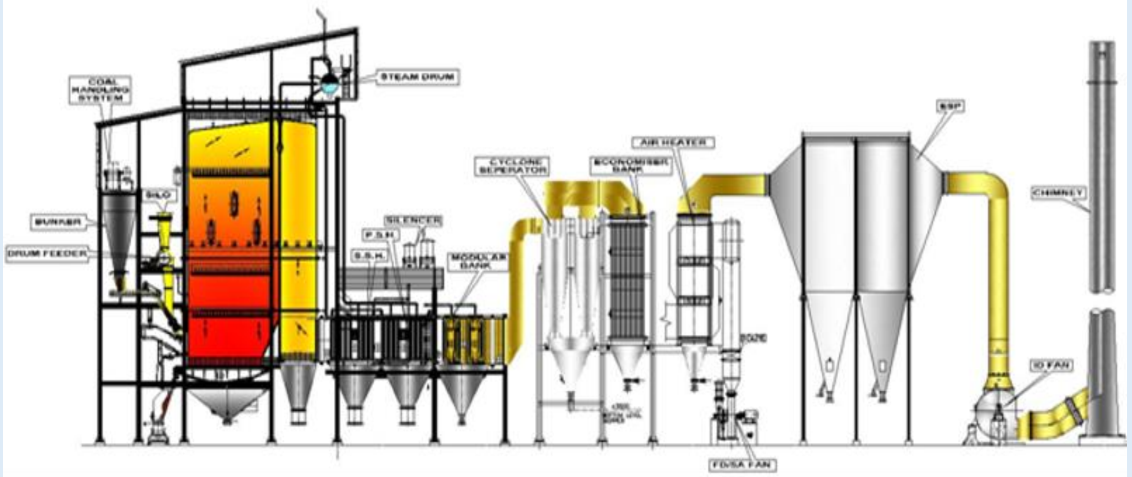
In India, when the concept of a incineration boiler was introduced in distilleries, they were operating mostly on C heavy molasses feed stock.

The incineration boiler was designed by ISGEC (In-house) with the quantity and quality of vinasse produced from these distilleries and all the auxiliaries were sized with the proportion of vinasse and support fuel.

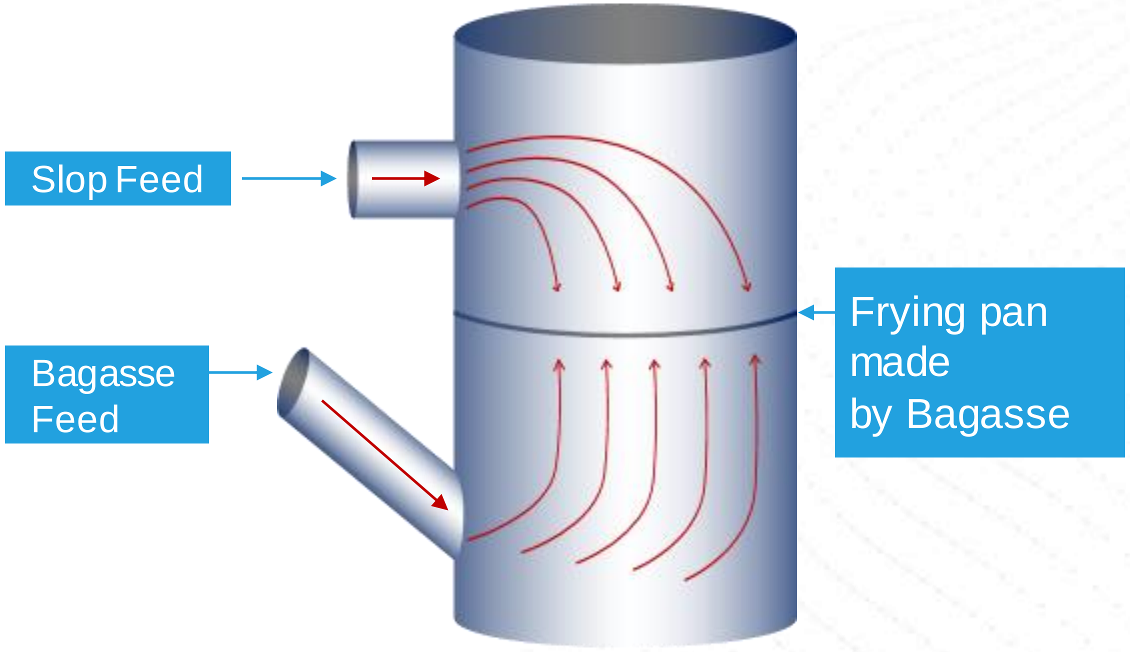
1st Generation : Horizontal layout with MDC before ESP

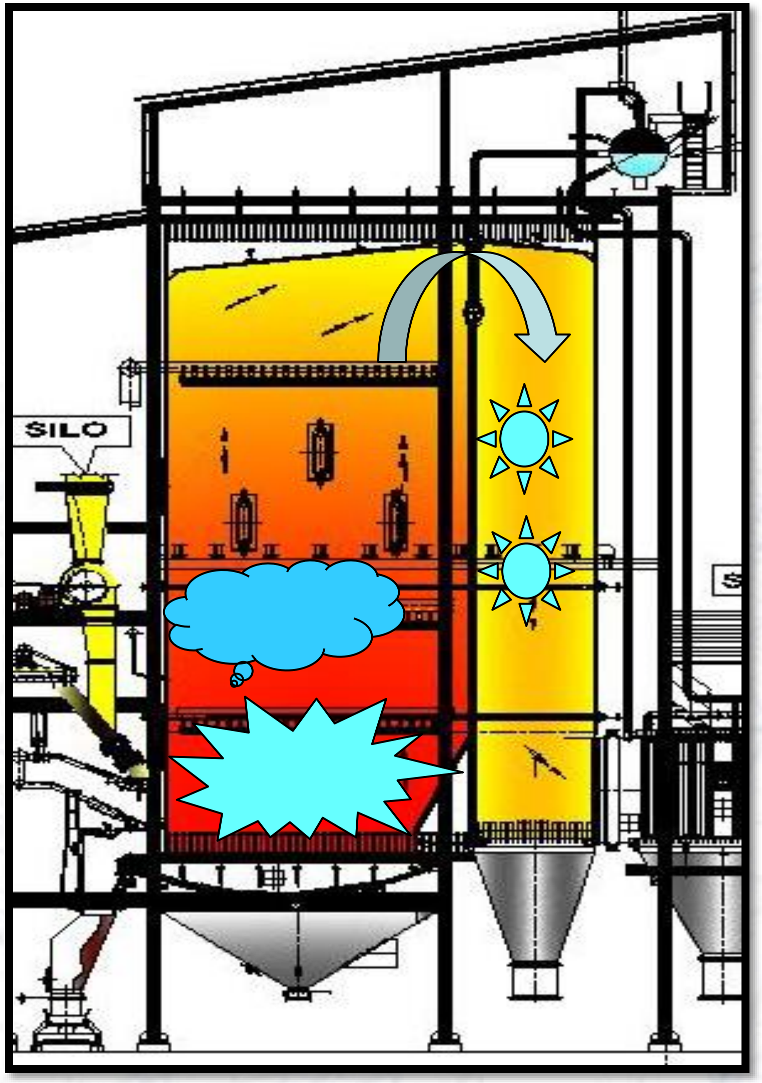


2nd Generation - Vertical layout and MDC before Economiser



DUAL SUPPORT FUEL FIRING CONCEPT



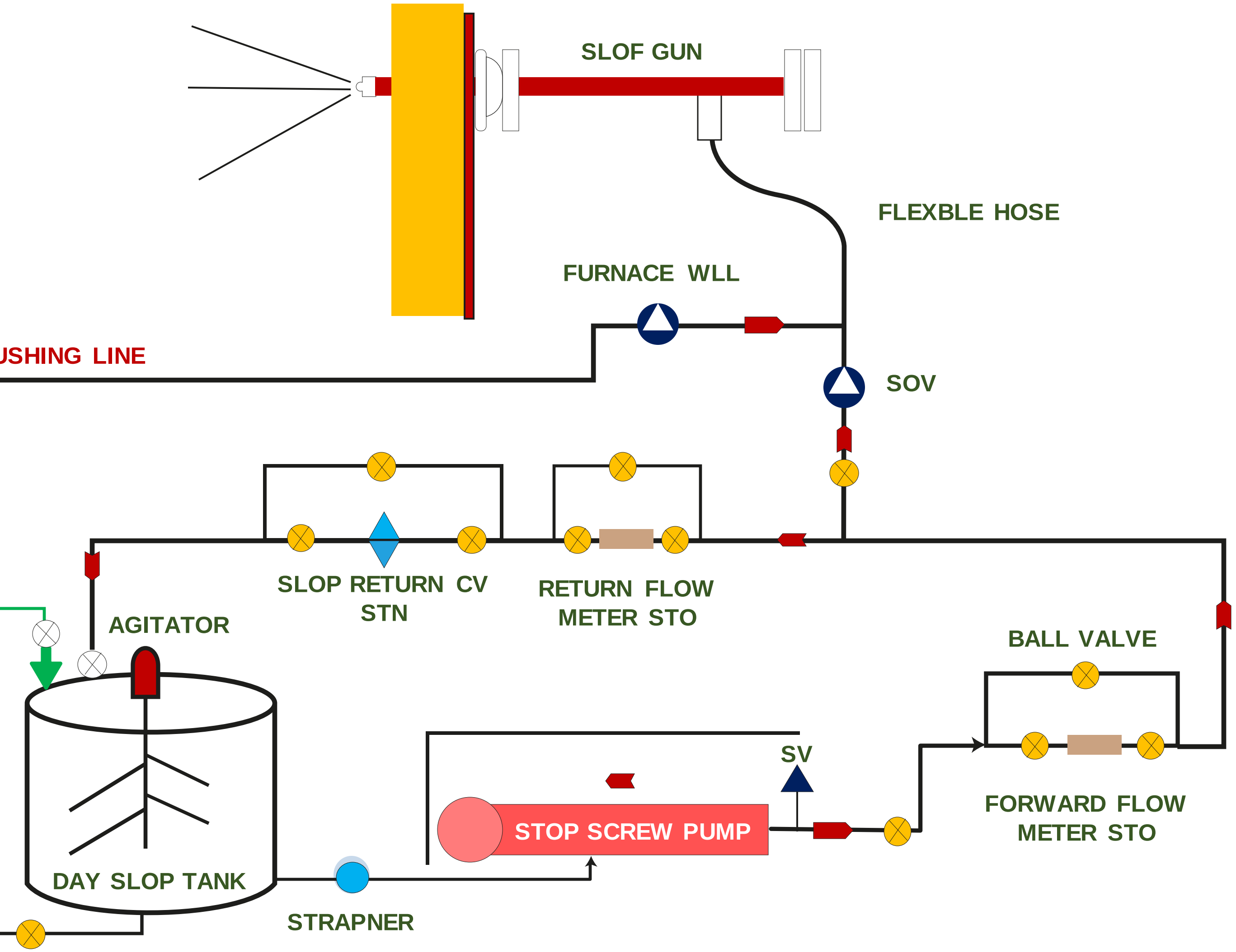


1^{st} Pass temperature : 700-740 Deg C

2^{nd} pass exit temperature : < 560 Deg C

SLOP FIRING SYSTEM

Pressure Atomized



CHANGES IN DESIGN BASED ON OPERATING FEED BACK

Aspects	Field Observation	Modulation in design
Design of First pass and Second pass furnace	First pass temperature requires 700 to 725°C to burn vinasse effectively. Second pass exit temperature restricted to below ash deformation temperature.	Balance in heating surface area provided in first and second pass.
Design of Superheaters	Low steam temperature in initial days of operation. Issues in steam temperature control.	Balance the heating surface areas in primary and secondary. superheater coils and their pitch
Design of Deaerator	Boiler was designed with Feed water economiser inlet temperatures were limited to 120Deg C as enough steam was not available for Deaerator.	Necessary changes in HMBD to meet efficiency parameter. Deaerator outlet temperature achieved 150°C.
Design of Air Heaters	High sulphur and chlorine content in slop restricts APH outlet flue gas temperature to above 190°C to avoid dew point corrosion.	Necessary changes done in air heater cold air bank design. Temperature lowered to 180°C to make boiler efficient.
Design of Hoppers	Ash choking in MS hopper with refractory lining restricts free flow of ash in hoppers.	Hoppers were made with stainless steel.
Arrangement of evaporator heating surfaces	Evaporator installed downstream of superheaters is inefficient.	Evaporators installation before super heaters to make boiler efficient.
Design of Economiser	Choking and low heat transfer in economiser	Necessary changes done in design to reduce choking and increase heat transfer.

CHANGES IN DESIGN BASED ON OPERATING FEED BACK

Aspects	Field Observation	Modulation in design
Design of online cleaning system (Soot blowers)	Boiler availability compromised if any zone systems break down.	Design support provided to vendor. Changes done to reduce maintenance and improve reliability.
Design of ash evacuation system	Boiler availability compromised if online cleaning system to any zone breaks down.	Design support provided to vendor. Changes done to reduce maintenance and improve reliability.
Design of Vinasse Nozzles	Fixed nozzle spreading not proper	Design changes done in Vinasse nozzles and gun improve efficient spraying and boiler availability.
Vinasse atomization	Low pressure atomization cause slippage of slop on grate.	Efficient high pressure atomized nozzle developed.
Steam Coils Air Pre-heater (SCAPH)	Low air temperature causes corrosion of air heater tubes.	Design changes done to improve heat recovery through SCAPH to increase air heater tube life and combustion.

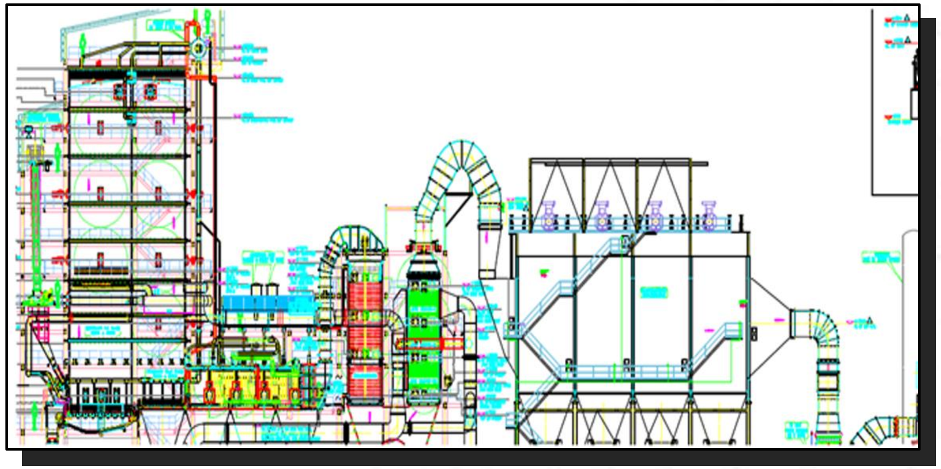
LATEST DESIGN OF INCINERATION BOILERS

ISGEC

Initially, the incineration boilers faced serious problems in terms of availability (20 – 30 days max).

Isgec has adopted changes in the design of the incineration boilers based on the feedback of operators of these boilers.

Since there has been change in the properties of vinasse owing to various feeds stocks, the boiler design was modulated / fine tunes over the years.



Current Design (5^{th} Generation) of boilers

Features of the 5^{th} Generation incineration boiler :

- Adjusting the heating surface area for the furnace first and second pass.
- Location of placing vinasse firing nozzles and secondary air.
- Adequate wall blowers in furnace first pass and second pass and their usage.
- Pitching of secondary and primary super heater to have the optimum velocity.
- Approach profile of gas entering in super heater sections.
- Stainless steel hoppers for high temperature zone with adequate vibrators and mouth opening.
- Highly reliable long retractable soot blower in super heater section.

LAYOUT CHANGES OVER THE YEARS AND GAIN

ISGEC

Layout	Space requirement	Boiler efficiency%	Auxiliary power consumption	Boiler availability (No of days)
Horizontal with MDC	More	56-58	100%	30
Vertical with MDC	Less	61-62	95%	60
Vertical with PDC	Lesser	64-65	80%	120
Addition of heating surface area in second pass furnace	Lesser	66-68	79%	180

CASE STUDY

ISGEC

Operating experience of Dalmia Sugar & Industries Limited – Nigohi

The 60 KLPD distillery (later expanded to 120 KLPD) located at Dalmia Sugar in Nigohi, (U.P) has used all three feedstock of C heavy, B heavy and syrup in the operation of their incineration boiler.

Boiler Parameter & Rating

Main steam pressure at MSSV outlet	Main steam flow rate	Feed water inlet temperature at economiser inlet	Main steam temperature at secondary super heater outlet	Designed slop fired in boiler at 60% solids	Designed air heater outlet flue gas temperature
45 $kg/cm^2(g)$	22 TPH	150°C	400±5°C	6.5 TPH	190°C

BOILER OPERATION ACHIEVED PARAMETER

Boiler parameter	Units	Syrup	B Heavy	C Heavy
Steam flow at MCR (gross)	TPH	24	24	22
Steam pressure at Main steam stop valve outlet	$kg/cm^2(g)$	44	44	44
Slop flow	TPH	3	5	8
Feed water temperature at economiser inlet	°C	136	140	140
Flue gas temperature at furnace	°C	724	680	708
Flue gas temperature at secondary superheater inlet	°C	628	590	610
Flue gas temperature at economiser inlet	°C	400	386	397
Flue gas temperature at air heater outlet	°C	196	199	218
Boiler auxiliary power consumption	kW	416	403	310
Main steam temperature at MSSV outlet	°C	400	401	402
Oxygen	%	8	5	4
Air temperature at air heater Inlet	°C	140	100	35
Attemperator flow to control steam temperature	TPH	0	1-2	3-4

OUTPUTS ACHIEVED ON VARIOUS GRADE OFVINASSE

Operational parameter	Units	Syrup	B Heavy	C Heavy
Fuel ratio for boiler on weight basis	%	8% slop + 92% bagasse	52% slop + 48% bagasse	77% slop + 23% bagasse
Slop generation	TPH	3	5	8
Unburnt carbon % in fly ash (Spectro analytical lab)	%	10	4	6
Unburnt carbon % in front ash (Spectro analytical lab)	%	1	5	8
Steam to Mix Fuel ratio (steam generated (Ton)Per ton of fuel (Slop+ Bagasse fuel mixture)		2.13	1.87	1.65
Steam consumption per KL of ethanol production	Ton/kL	3.40	3.80	3.96
Boiler availability	days	No need to stop boiler for cleaning	140 – 190 days	60 –90 days
Boiler efficiency	%	66.10	65.50	63.20

EXPERIENCE..

Operation of Dalmia Nigohi boiler has demonstrated the practical aspects of operating vinasse fired boilers for extended periods with good efficiency and extended availability, thus proving the design of incineration boiler a success with vinasse from different feed stock.

Practical findings in Boiler operation

With Syrup – High_furnace temperature controlled by online wall steam cleaning. Fermented Sugar % to be checked.

With B heavy molasses – High furnace temperature controlled by online wall steam cleaning

With C heavy molasses – Furnace temperature well in design limits; Boiler availability was good. Ash handling is key.

Achievement in ZLD (Zero Liquid Discharge)

Efforts should be taken to feed consistent quality of input to MEE Tank

This can be achieved by taking all the effluents first to Lagoon or pits and a constant homogeneous mixture of effluent should be fed to MEE Tank

RO Reject water shall be utilized maximum in ash handling system

INCINERATION BOILERS EXPERIENCE

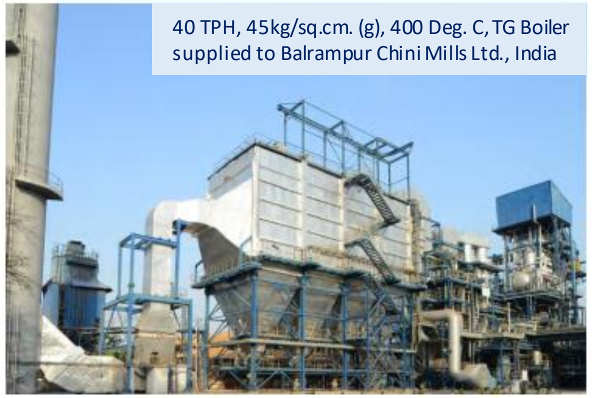
ISGEC

Dalmia – Nigohi- Succefully worked On slop from all thre feed stocks

BCML – Maizapur- Exclusively designed for syrup based Vinasse. In peration since last 65 days

OTHER INCINERATION BOILERS EXPERIENCE

ISGEC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12.5 TPH, 45kg/sq.cm. (g), 410 Deg. C, TG Boiler supplied to the Kisan Sahkari Chini mills Ltd., Sneh Road, India


80 TPH, 45kg/sq.cm. (g), 400 Deg.c, TG Boiler supplied to DSCL Sugars, Ajbapur, India


60 TPH at Bajaj Group


47 TPH at Dwarikeshdham

Isgec Incineration boilers crossing

125 PLUS

Days of uninterrupted operation


55 TPH at Sai Priya


45 TPH at Dwarikesh Bundaki


44TPH at Dhampur Asmoli

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Days of uninterrupted operation

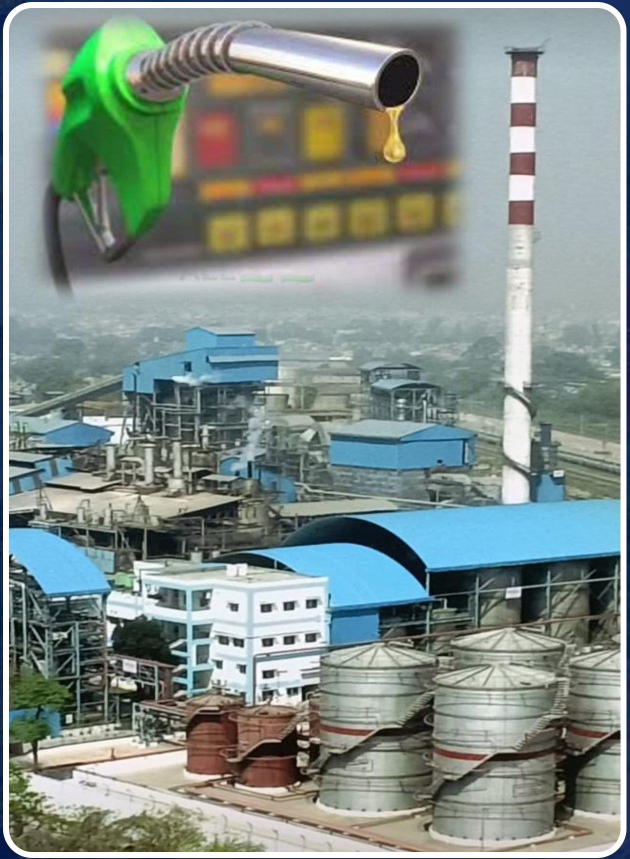
CONCLUSION

Understanding the Vinasse and its properties generating from distilleries through Various feed stock is critical for designing a vinasse fired boiler.

To achieve Zero Liquid Discharge in distilleries and plants, it is important to follow the set of operating practices /guidelines while consuming them or mixing with Vinasse before MEE.

More and More distilleries are now operating with Syrup as feed stock from this season. Isgec is critically monitoring the performance of such boilers.

Success of Traveling grate based vinasse boilers is now established for distilleries on various feed stock is now proving to be a great contributor to achieve.



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Thank You!