KNOWLEDGE SHARING SESSION SERIES
SLOP FIRED BOILERS

PRESENTED BY

YAMAN

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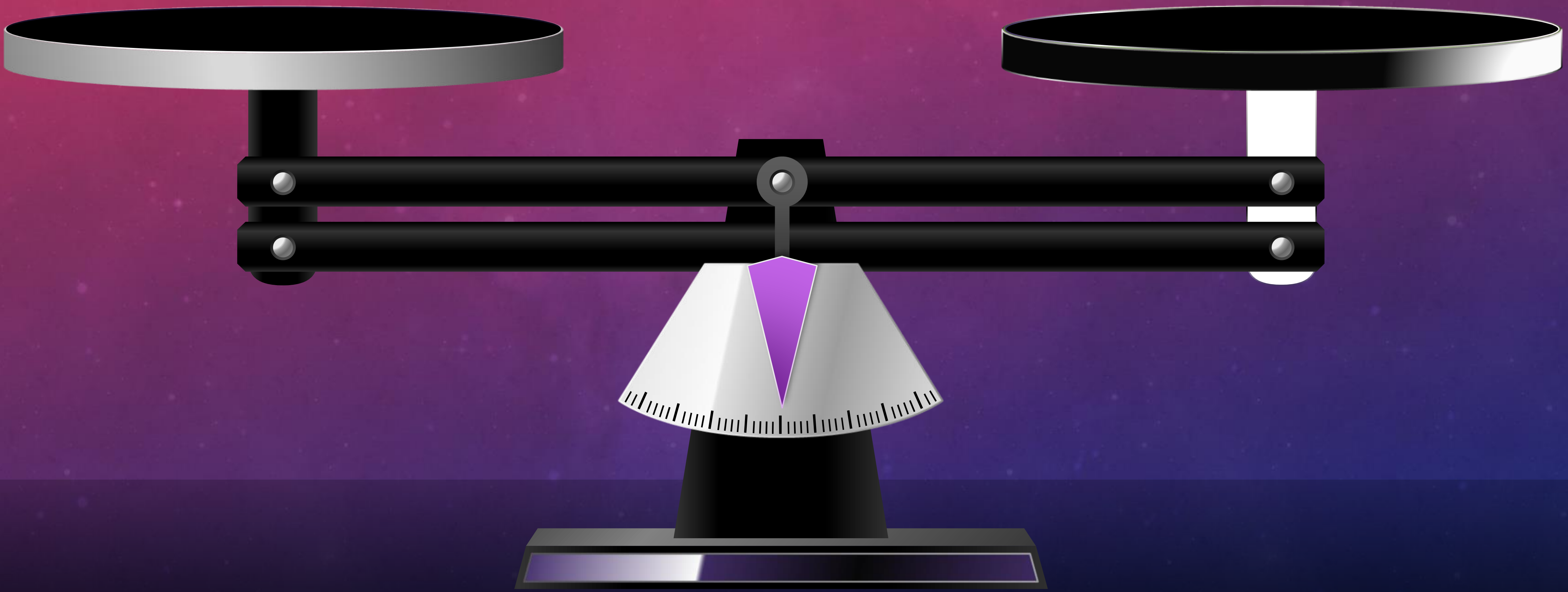
- Heat transfer area comparative
- Comparison of performance parameters of both boilers

FUEL CHARACTERISTIC

Proximate Analysis

Ultimate Analysis

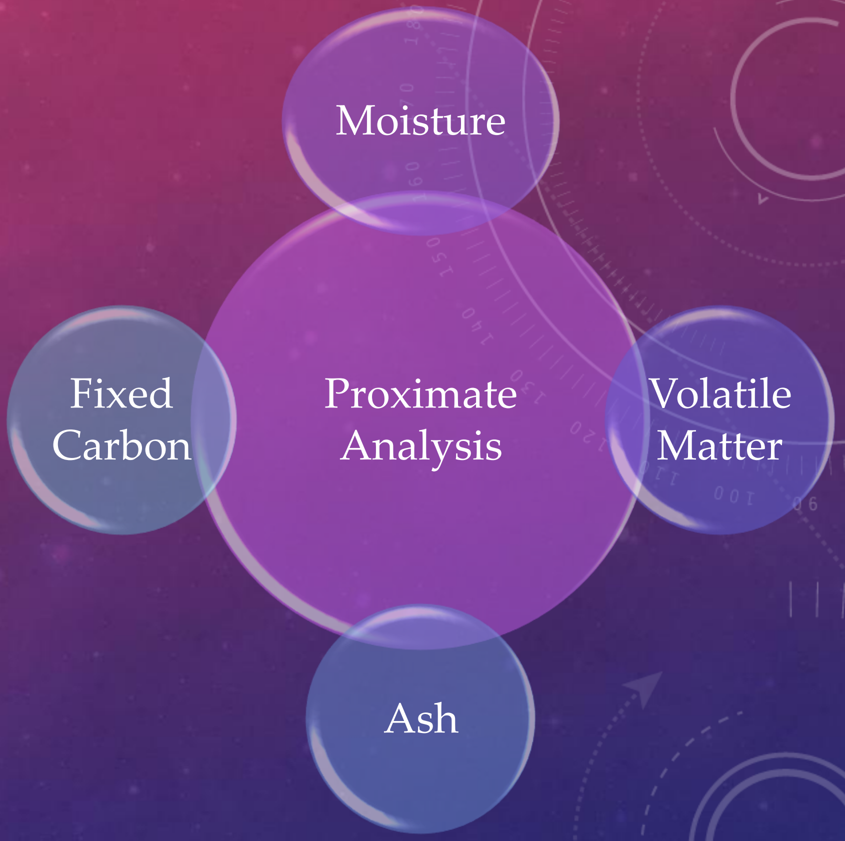


FUEL CHARACTERISTIC

PROXIMATE ANALYSIS

- **Moisture**
  - Higher %age in moisture , lower the calorific value.
- **Volatile matter**
  - It decides the volume of furnace.
  - Higher value cause smoke ,long flames, and decreased the calorific value.
- **Ash**
  - Higher the ash content lower the calorific value.
  - Ash characteristics influence design and operational efficiencies
- **Fixed carbon**
  - Higher the amount of fixed carbon , higher will be calorific value

$$\%FC = 100 - (\%M + \%VM + \%A)$$



- Quick analysis of fuel at low cost for assessing the potential impact on operations
- Bomb Calorimeter is used to determine GCV

ULTIMATE ANALYSIS

- Chemical composition of fuel are C, O, H, N and S.
- The ultimate **analysis** is very important to calculate calorific value of fuel.
- For assessment of air required.

Required for
Design of the combustion system of boiler
Assessment of air requirement and
Determination of efficiency by indirect method

GCV OF SLOP USING DULONG'S FORMULA

@ 51.5% Brix

COMPONENT	% BY WEIGHT
Carbon	19.07
Hydrogen	1.85
Oxygen	12.45
Moisture	48.5
Sulphur	0.53
Nitrogen	1.59
Ash	16.02
GCV	1654 Kcal/Kg

$$HCV = \frac{1}{100}\left[8080\ C + 34500\left(H - \frac{O}{8}\right) + 2240\ S\right] Kcal/Kg$$

$$HCV = \frac{1}{100}\left[8080\ \times 19.07 + 34500\left(1.85 - \frac{12.45}{8}\right) + 2240 \times 0.53\right] Kcal/Kg$$

$$HCV = 1654.07\ Kcal/Kg$$

$$LCV = HCV - 588.76\ m_w$$

$$LCV = 1654.07 - 588.76 \times 0.485$$

$$LCV = 1368.52\ Kcal/Kg$$

SLOP

@ 51.5% Brix

Component	% by weight
Carbon	19.07
Hydrogen	1.85
Oxygen	12.45
Moisture	48.5
Sulphur	0.53
Nitrogen	1.59
Ash	16.02
GCV	1654 Kcal/Kg

Component	Heat (Kcal/Kg)
Carbon	8080
Hydrogen	34500
Sulphur	2240

Chemical Equation during the combustion.

$S + O_2 = SO_2 + Heat$

$2H_2 + O_2 = 2H_2O + Heat$

$C + O_2 = CO_2 + Heat_1$ …………(1)

Or

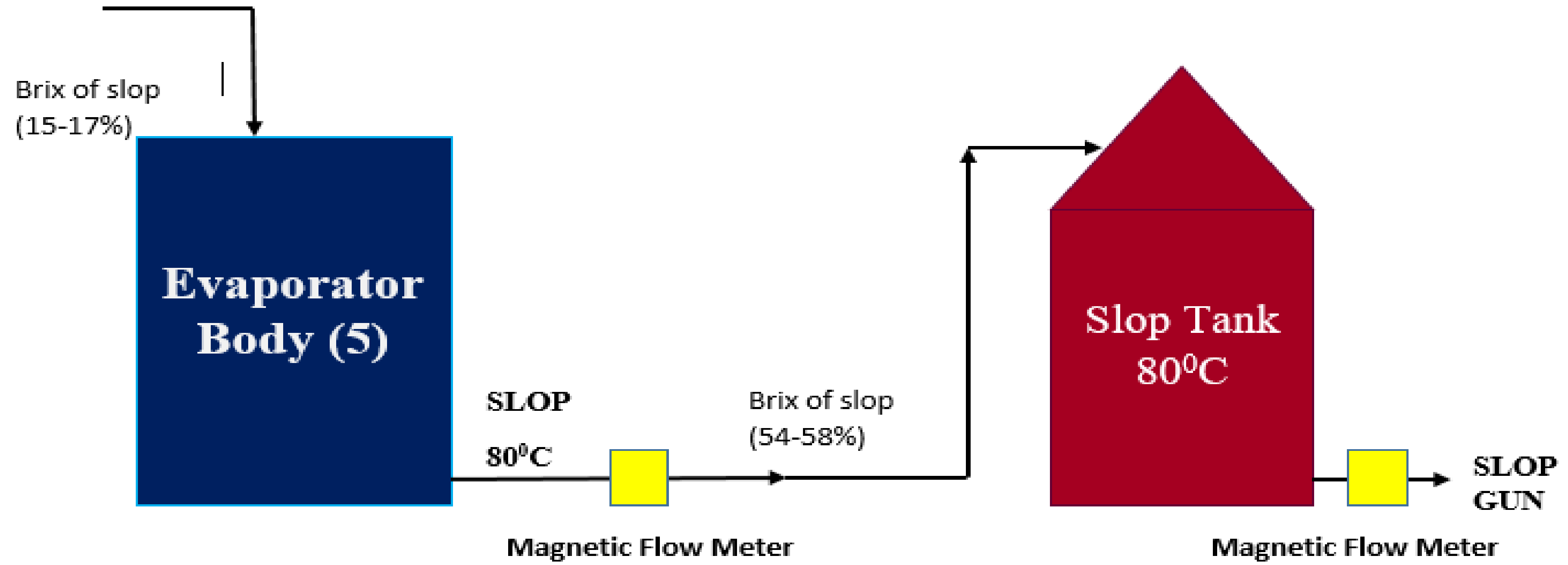
$C + \frac{1}{2}O_2 = CO + Heat_2$ ………..(2a)

$CO + \frac{1}{2}O_2 = CO_2 + Heat_3$ …………(2b)

$Heat_1 = Heat_2 + Heat_3$

GCV at about 80% of bagasse at same level of moisture

SLOP AS FED TO BOILER



Meters provided for monitoring slop usage

SLOP PARAMETERS

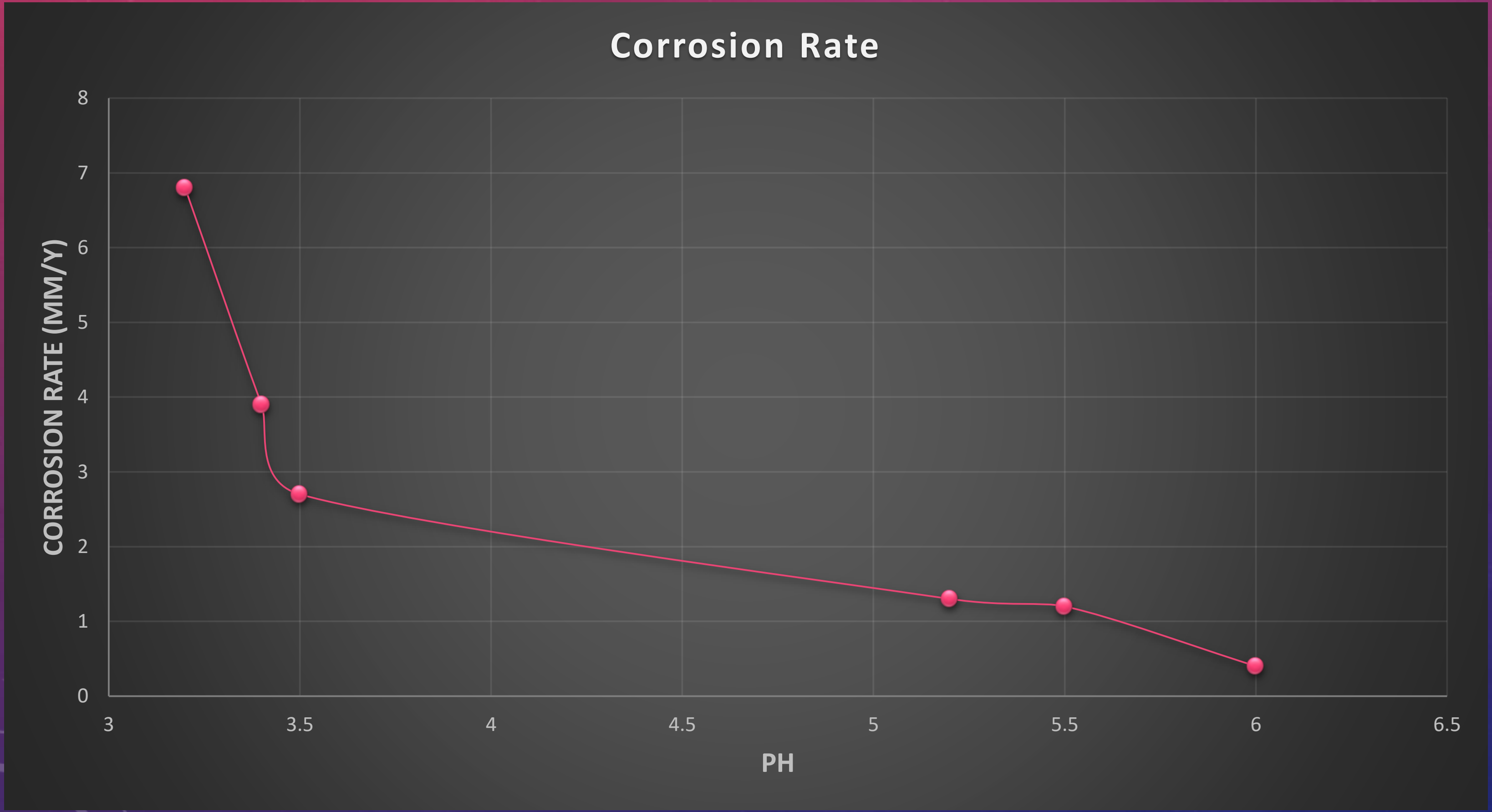
The characteristics of slop at **51.5% brix**.

Parameters	**51.5% Brix**
pH	3.9
Viscosity	4.5 (Pa S)
Hardness	14400 (ppm)

Implication of each parameters explained in the slides to follow

pH

Low pH-Slop is highly acidic



Impact on Boiler

- If pH is low, high corrosion.
- High material removal rate.
- Causes tube leakage.

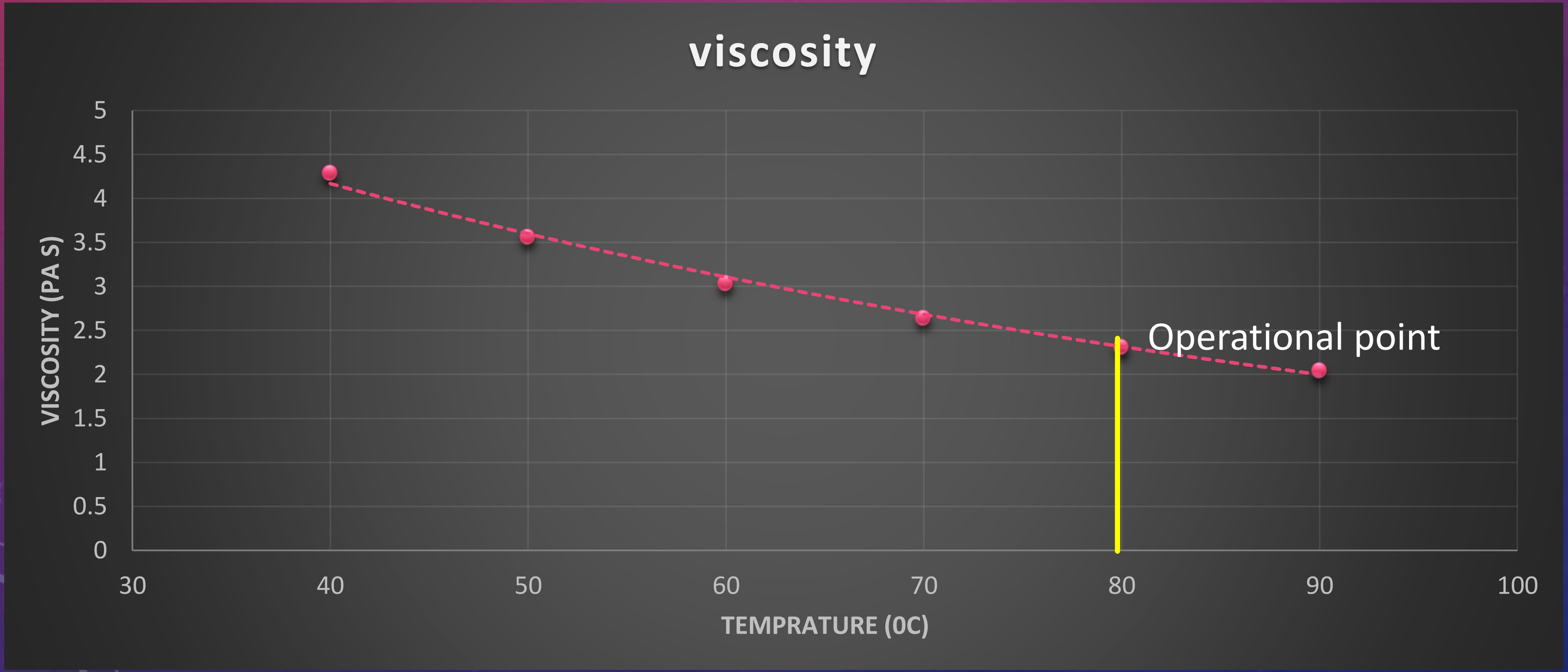
VISCOSITY (μ)

- Viscosity is the property due to which a fluid offer resistance to the movement of one layer to other.
- Effect of Temperature increase on μ

Fluid	μ	Fluidity
Liquid	Decrease	Increase
Gas	Increase	Increase

Impact on Boiler

- μ decreases, fluidity increases.
- Easily flow inside the pipe and passes through the slop gun.



HARDNESS

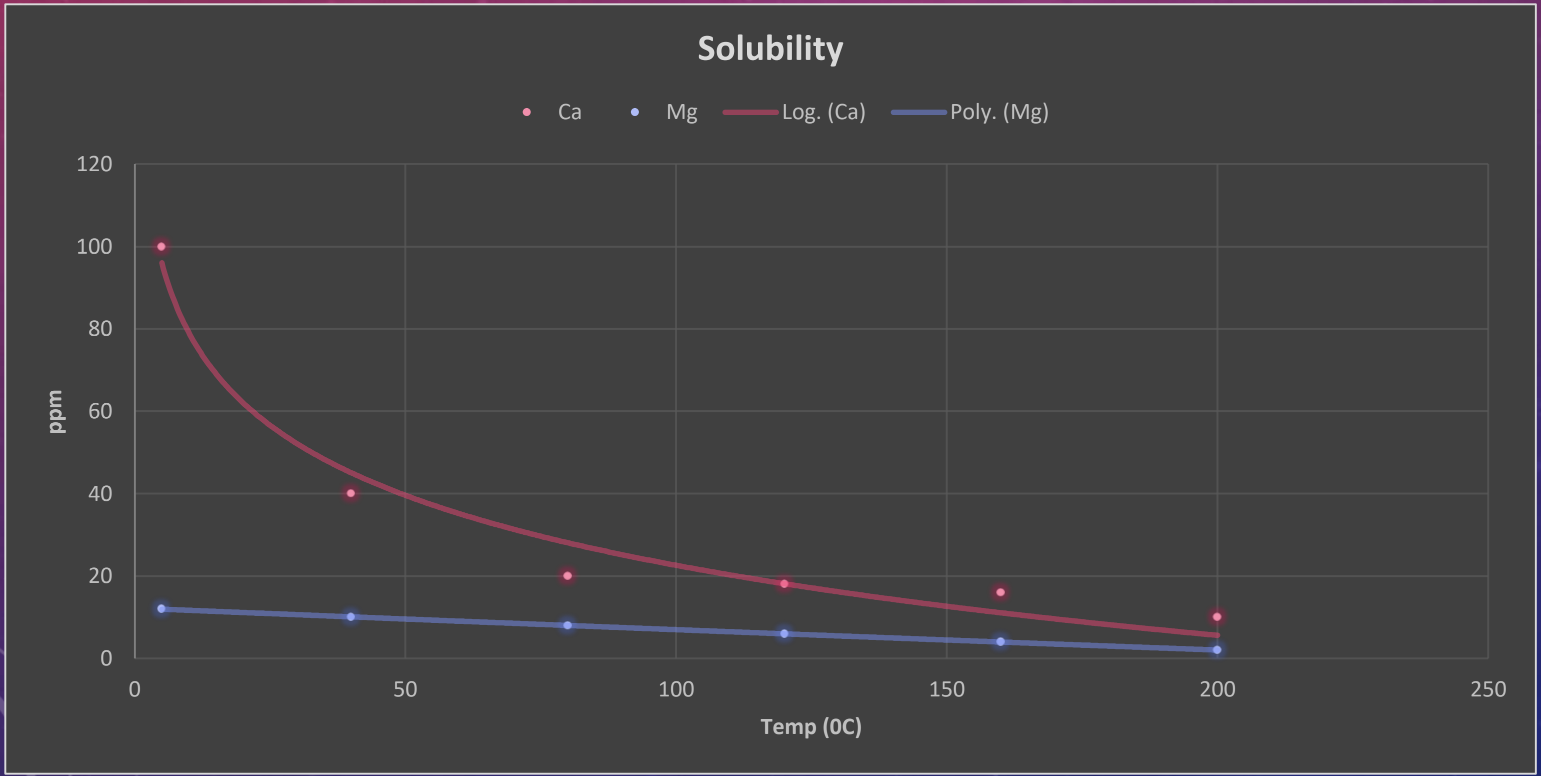
Temporary Hardness

- Presence of Bicarbonate (HCO_3^-) & Carbonate (CO_3^-) ions of Ca^{2+} & Mg^{2+}

Permanent Hardness

- Present of Chlorides Cl^- & Sulphates SO_4^{2-} ions of Ca^{2+} & Mg^{2+}

Hardness is expressed in terms of $CaCO_3$.



Impact on Boiler

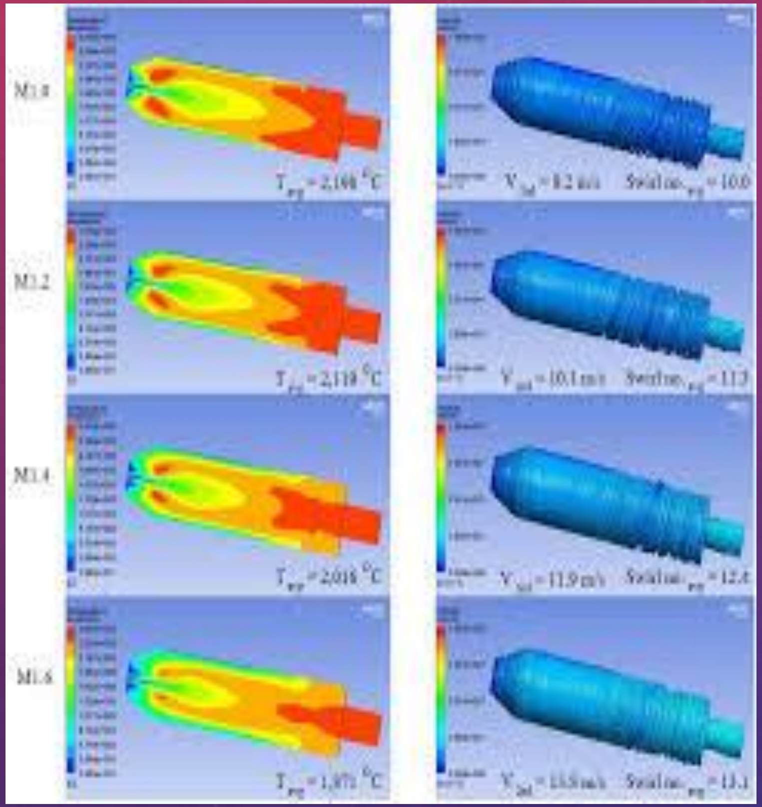
- Hardness form a scale on the water tubes.
- Decrease the heat transfer rate inside the water.
- Heat loss.

CHARACTERISTICS-MIXED FUEL

Composition(%)	Slop(1.87) + Bagasse(1)	Slop(3.73) + Indian Coal(1)	Slop(3.07) + Rice Husk(1)
Carbon	20.66	23.69	23.54
Hydrogen	2.35	1.99	2.14
Oxygen	15.78	11.19	17.20
Moisture	49.04	39.97	38.75
Sulphur	0.34	0.50	0.40
Ash	10.81	21.29	16.52
Nitrogen	1.02	1.37	1.45
GCV(kcal/kg)	1841	2087	1993

COMBUSTION

COMBUSTION



The process of oxidizing (burning) all the caloric matters (C, H, S) in the fuel for producing hot flue gas

- Ignition at the point of injection
- Completion of the burning process in the furnace

The entire combustion process to be completed in the furnace to prevent secondary combustion in the subsequent passes

3 T'S OF COMBUSTION

Temperature

- Ignition temperature for initiating the burning process.

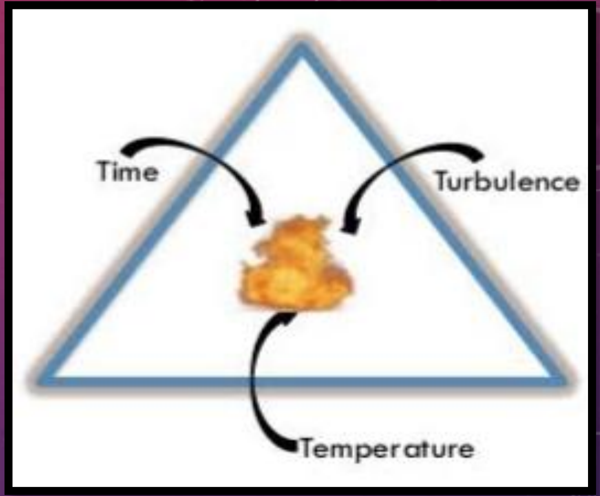
Turbulence

- The fuel and air should mix properly.
- The fuel can be burnt with less excess air.

Time

- Time required for complete combustion.
- Slop fired boiler have a very high residence time, >10.0 seconds. (Tall furnace)

Early ignition (Temperature) + Turbulence+ Enough residence time = Good combustion



Impact on Boiler

- Temperature above the ignition temp, the fuel burn immediately
- Proper mixing reduces the excess air.
- High residence time, more combustion.

REQUIREMENT OF AIR-STOICHIOMETRIC

Composition	(kg/kg)	Oxygen req. (kg/kg)	Total Oxygen req. (kg/kg)	Stoichiometric Air req. (kg/kg) *Slop*
Carbon (C)	0.1907	2.67	0.509	0.5378/0.23
Hydrogen (H)	0.0185	8	0.148	
Oxygen (O)	0.1245	-	-0.1245	
Sulphur (S)	0.0053	1	0.0053	
		Total	0.5378	2.34

Composition	(kg/kg)	Oxygen req. (kg/kg)	Total Oxygen req. (kg/kg)	Stoichiometric Air req. (kg/kg) ***Slop(1.87)+Bagasse(1)***
Carbon C	0.206	2.67	0.55002	0.5802/0.23
Hydrogen H	0.023	8	0.184	
Oxygen O	0.1578	-	-0.1578	
Sulphur S	0.0034	1	0.0034	
		Total	0.5802	2.522

Composition	(kg/kg)	Oxygen req. (kg/kg)	Total Oxygen req. (kg/kg)	Stoichiometric Air req. (kg/kg) *Slop(3.07)+Rice husk(1)*
Carbon C	0.2354	2.67	0.6285	0.6285/0.23
Hydrogen H	0.021	8	0.168	
Oxygen O	0.1720	-	-0.1720	
Sulphur S	0.0040	1	0.0040	
		Total	0.6285	2.73

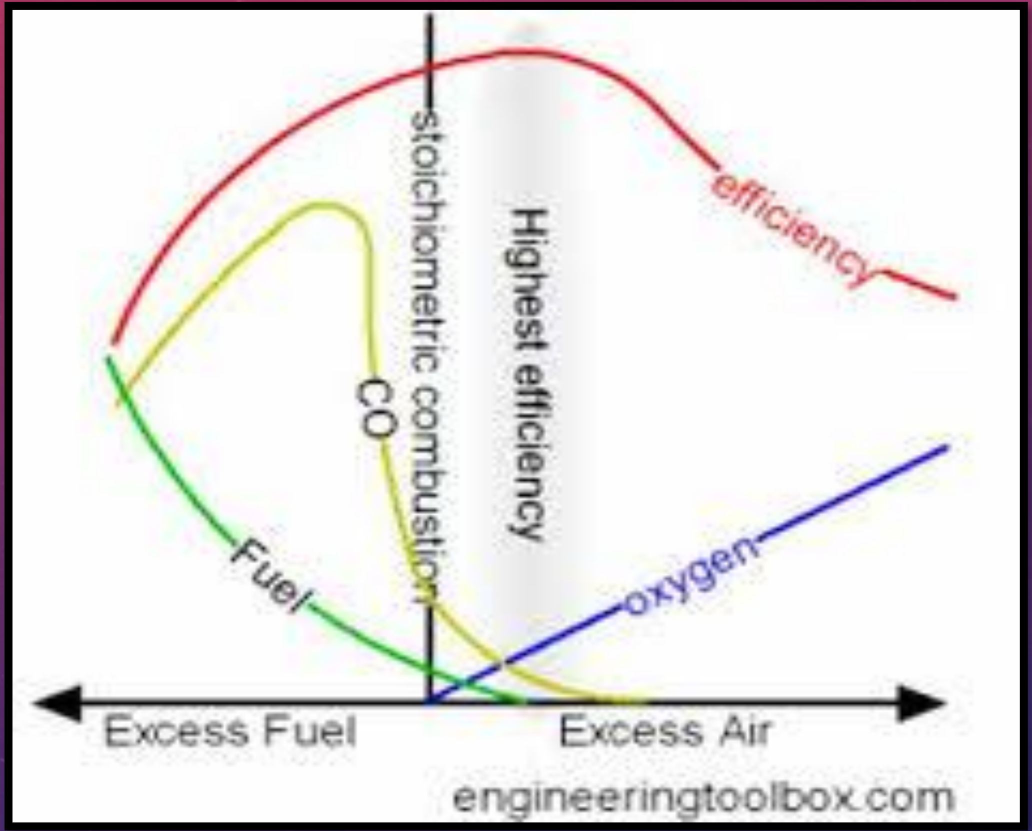
Composition	(kg/kg)	Oxygen req. (kg/kg)	Total Oxygen req. (kg/kg)	Stoichiometric Air req. (kg/kg) ***Slop(3.73)+Coal(1)***
Carbon C	0.2369	2.67	0.6325	0.6776/0.23
Hydrogen H	0.019	8	0.152	
Oxygen O	0.1119	-	-0.1119	
Sulphur S	0.0050	1	0.0050	
		Total	0.6776	2.94

COMPARATIVE STOCHIOMETRIC AIR REQUIREMENT

FUEL MIXTURE	STOCHIOMETRIC AIR REQUIREMENT (kg/kg)
Slop + bagasse	2.522
Slop + Rice Husk	2.73
Slop + Coal	2.94

Requirement impacted by available oxygen in the fuel

AIR-SOURCE OF OXYGEN FOR COMBUSTION



- Requires some amount of excess air for completion of combustion
- Compromise between combustion losses (C, CO) and loss through flue gas

ASH CHARACTERISTICS OF SLOP

ASH COLLECTION FROM DIFFERENT POINT

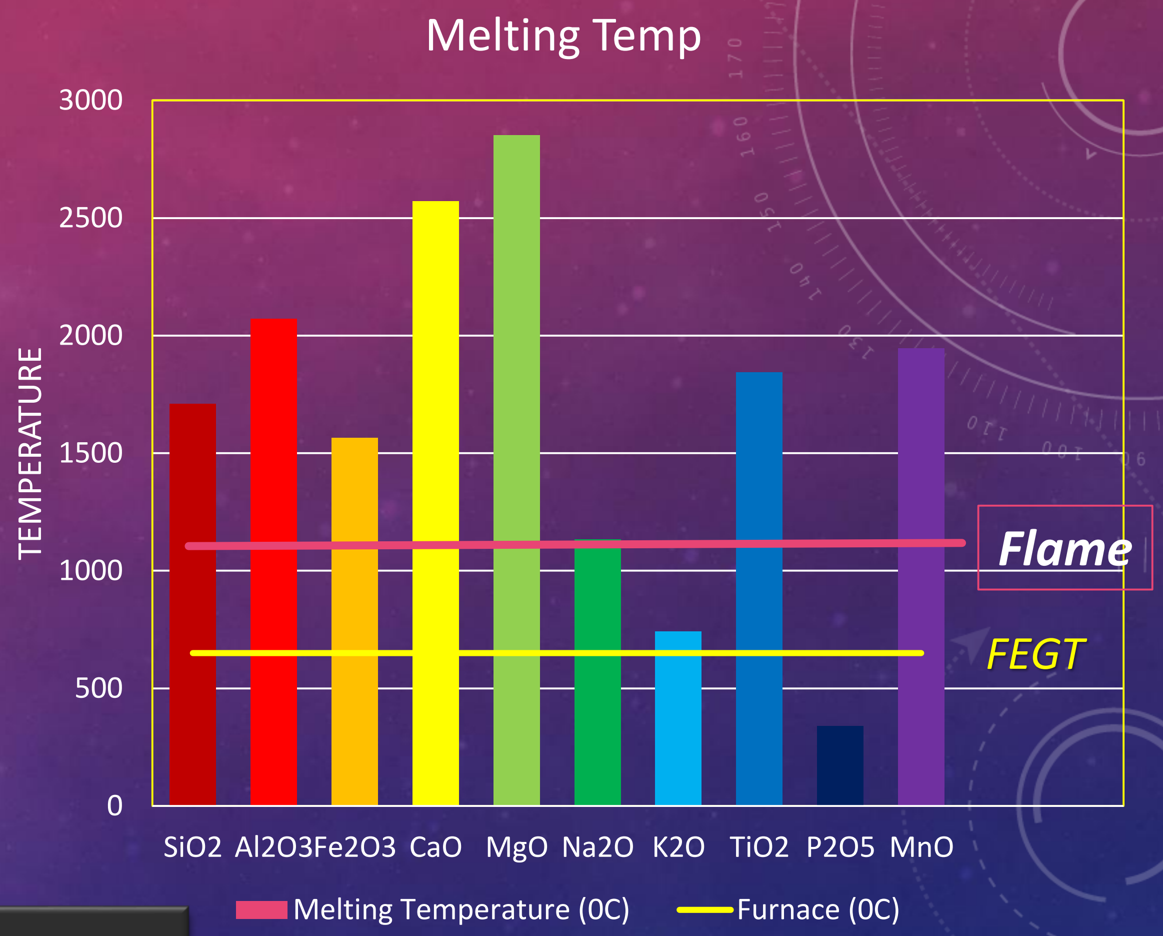
ASH %			
Collection Point	As per Fives Cail-KCP	As per PG Test (75 TPH)	As per PG Test (35 TPH)
Bottom Ash	30	20	20
2^{nd} Pass	15	5	5
Eva & Eco	15	5	5
Bag Filter	40	70	70
Total	100	100	100

ASH % as per Fives Cail KCP

Different percentages as per different reports. It would be desirable to carry out actual field test for getting close to the actual amounts

ASH CHEMICALS AND THEIR MELTING POINTS

S. NO	Element	Melting Temperature (^0C)
1	SiO_2	1710
2	Al_2O_3	2072
3	Fe_2O_3	1565
4	CaO	2572
5	MgO	2852
6	Na_2O	**1132**
7	K_2O	**740**
8	TiO_2	1843
9	P_2O_5	340
10	MnO	1945



Impact on Boiler

- The potassium oxide followed by sodium oxide would be creating problems like slagging and clinker due to low melting point and fusion temperature and also due to volatilization. (Data source—SPECTRO LAB REPORT)

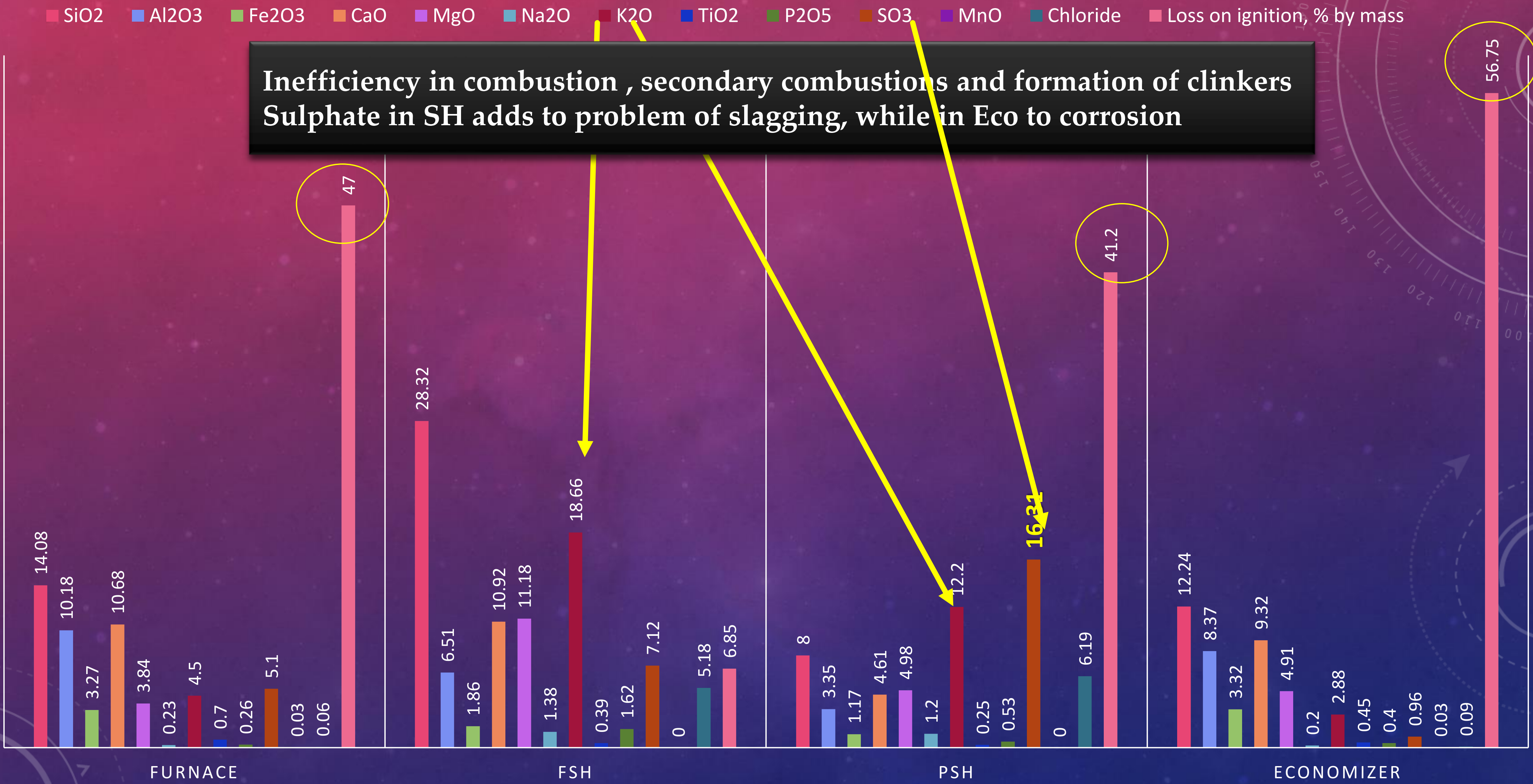
Flame-1000-1200 ^0C
FEGT-650 ^0C

ASH CONSTITUENTS-DIFFERENT COLLECTION POINT

S. No	Test parameters (% by mass)	Furnace	FSH	PSH	Economizer
1	Silica (SiO_2)	14.08	28.32	8.00	12.24
2	Alumina (Al_2O_3)	10.18	6.51	3.35	8.37
3	Iron Oxide (Fe_2O_3)	3.27	1.86	1.17	3.32
4	Calcium Oxide (CaO)	10.68	**10.92**	**4.61**	9.32
5	Magnesium Oxide (MgO)	3.84	**11.18**	**4.98**	4.91
6	Sodium Oxide (Na_2O)	0.23	**1.38**	**1.20**	0.20
7	Potassium Oxide (K_2O)	4.50	**18.66**	**12.20**	2.88
8	Titanium Oxide (TiO_2)	0.70	0.39	0.25	0.45
9	Phosphorus (P_2O_5)	0.26	1.62	0.53	0.40
10	Manganese Oxide (MnO)	0.03	----	----	0.03
11	Loss on ignition, % by mass	47.00	6.85	41.20	56.75

As per test reports from--- dated 4/11/2019 for the 35TPH boiler

ASH CONSTITUENTS (CONTINUED)



Inefficiency in combustion , secondary combustions and formation of clinkers
Sulphate in SH adds to problem of slagging, while in Eco to corrosion

Level of UC much higher compared to the level during PG test

Summarising

- Acid oxides are SiO_2, Al_2O_3 and TiO_2.
- Basic oxides are Fe_2O_3, CaO, MgO, Na_2O, K_2O.
- Base and acid oxides is formed during combustion and their ratio is used to determine the fusion (fusibility) temperature of reaction product.
- Ash exhibit low fusibility temperature with higher slagging potential when its base/acid ratio is in range **0.4 to 0.7.**
- The fusibility temperature of ash will be lowered when Fe_2O_3/CaO ratio is in range of **0.2 to 1.**

Base to acid ratio = $(Fe_2O_3+CaO+MgO+Na_2O+K_2O)/(SiO_2+Al_2O_3+TiO_2)$

=27.8275/23.21

=**1.198**

Slagging index= (Base to acid ratio) x Dry sulfur content.

= 1.198 x 0.53

=**0.635**

Fouling index =(Base to acid ratio) x (Na_2O + K_2O)

= 1.198 x 10.3125

=**12.35**

Fe_2O_3/CaO ratio= **0.26**

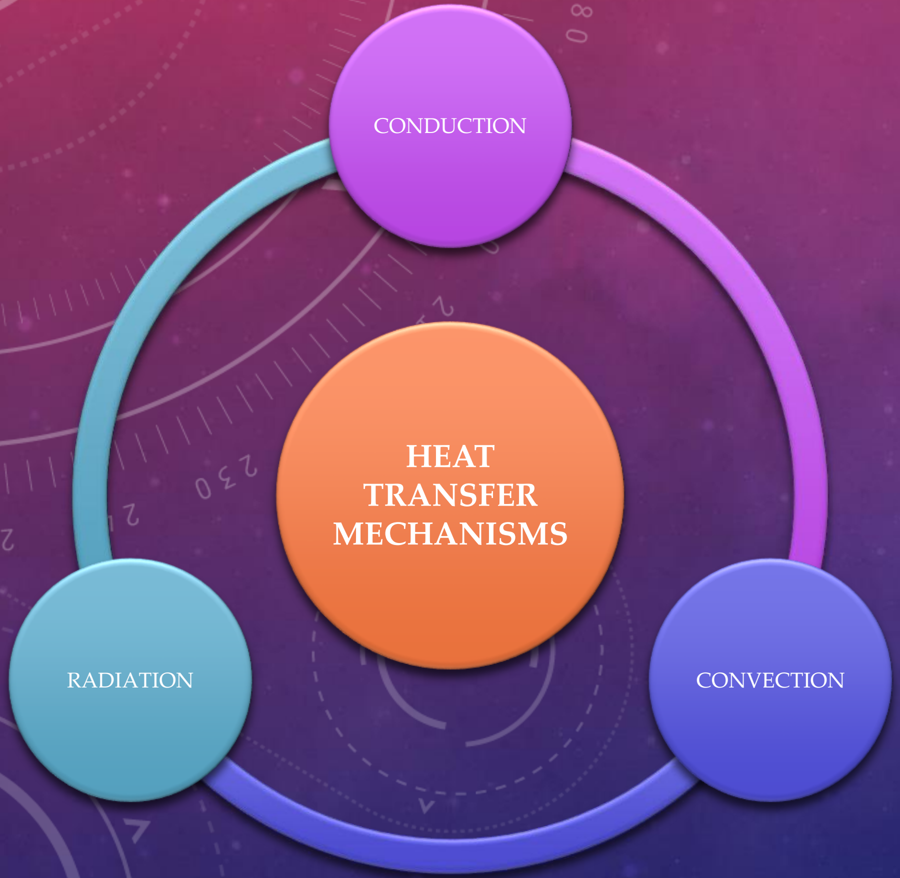
Slagging index	Fouling index
<0.6, low slagging inclination	≤0.6, low fouling indication
0.6–2.0, medium	**0.6–40, high**
2.0–2.6, high	>40, extremely high
>2.6, extremely high	

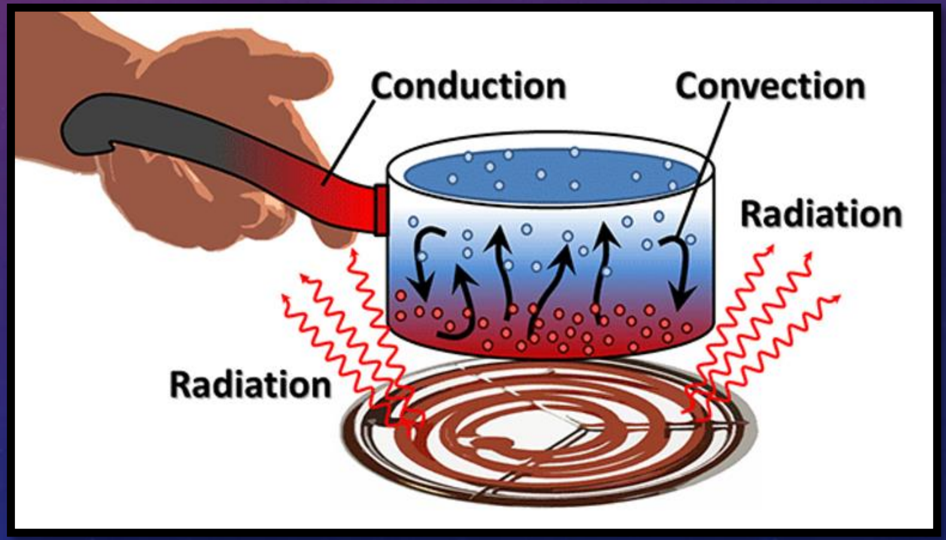
Primarily governed by the pick up of chemicals by cane from the soil (variety impact). Improving base ratio by external means unlikely to be cost effective –monitoring regularly for fixing the soot blowing schedule as well as schedule for cleaning. Operational care to maintain the combustion and FO temperatures

HEAT TRANSFER

HEAT

The overall efficiency of boilers is product of **combustion** and **heat transfer efficiencies**, the later governing the heat loss through the flue gas and some loss through the boiler outer surfaces to the atmosphere (known as radiation & convection losses)

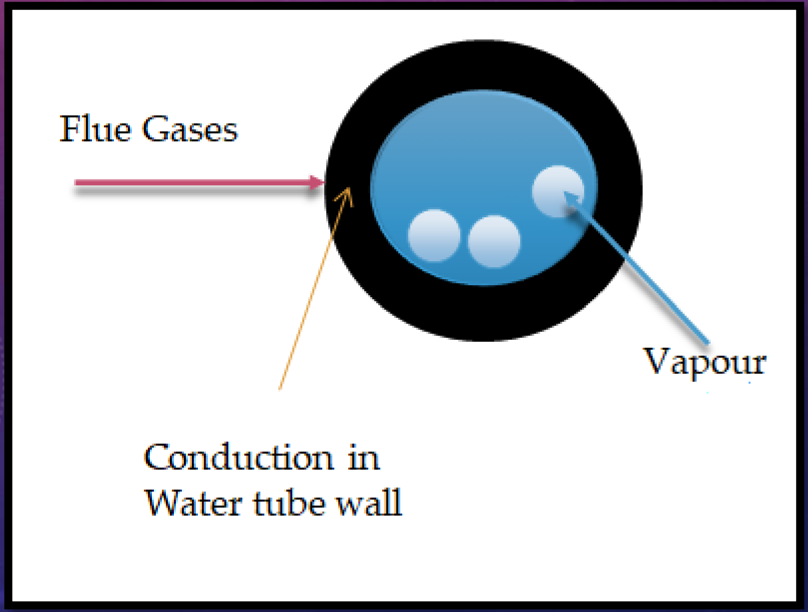




CONDUCTION

- Conduction can take place in solids, liquids, or gases.
- In solids, it is due to the combination of **vibrations of the molecules** in a lattice and the energy transport by **free electrons**.
- In gases and liquids, conduction is due to the **collisions** and **diffusion** of the molecules during their random motion.

$$Q_{Cond} = -KA\frac{dT}{dx}$$

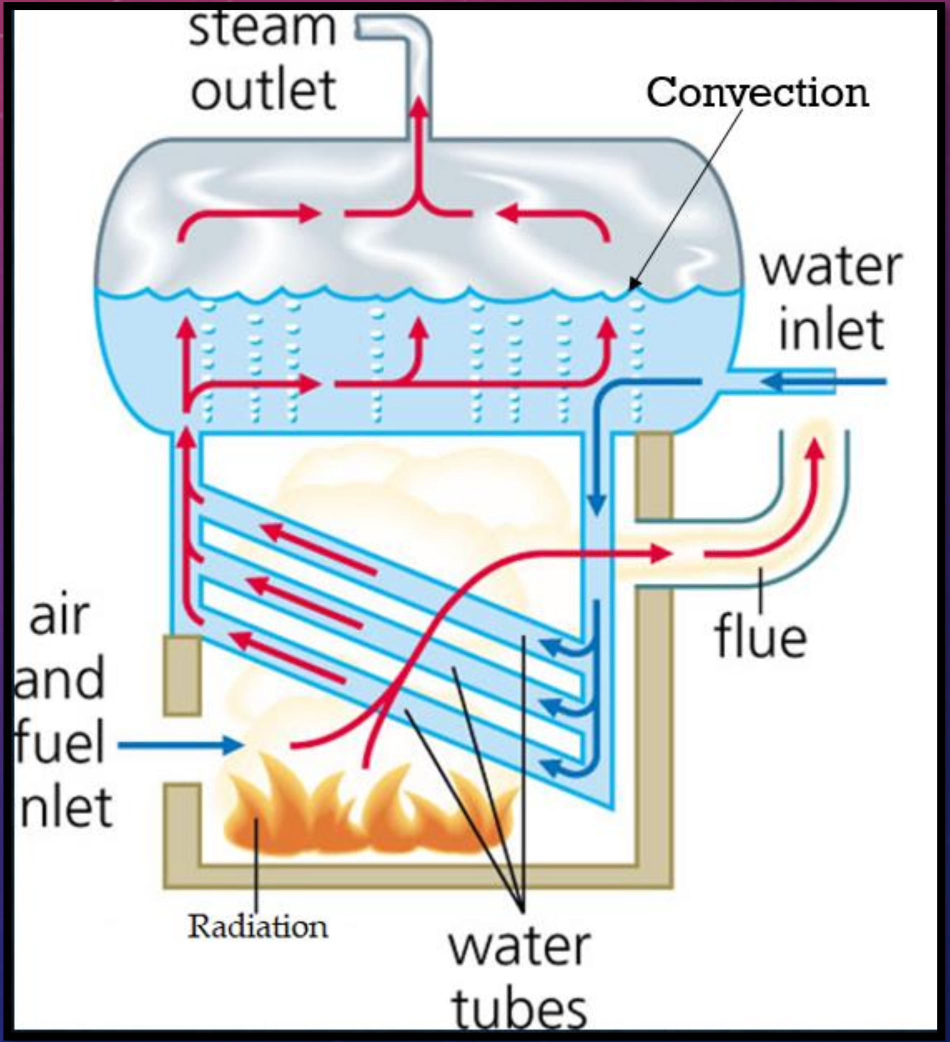


CONVECTION

- **Convection** is the mode of energy transfer between a solid surface and the adjacent liquid or gas that is in motion, and it involves the combined effects of *conduction* and *fluid motion*.
- Convection heat transfer depends on the fluid properties dynamic **viscosity** (μ), **density** (ρ), and **fluid velocity** (v).

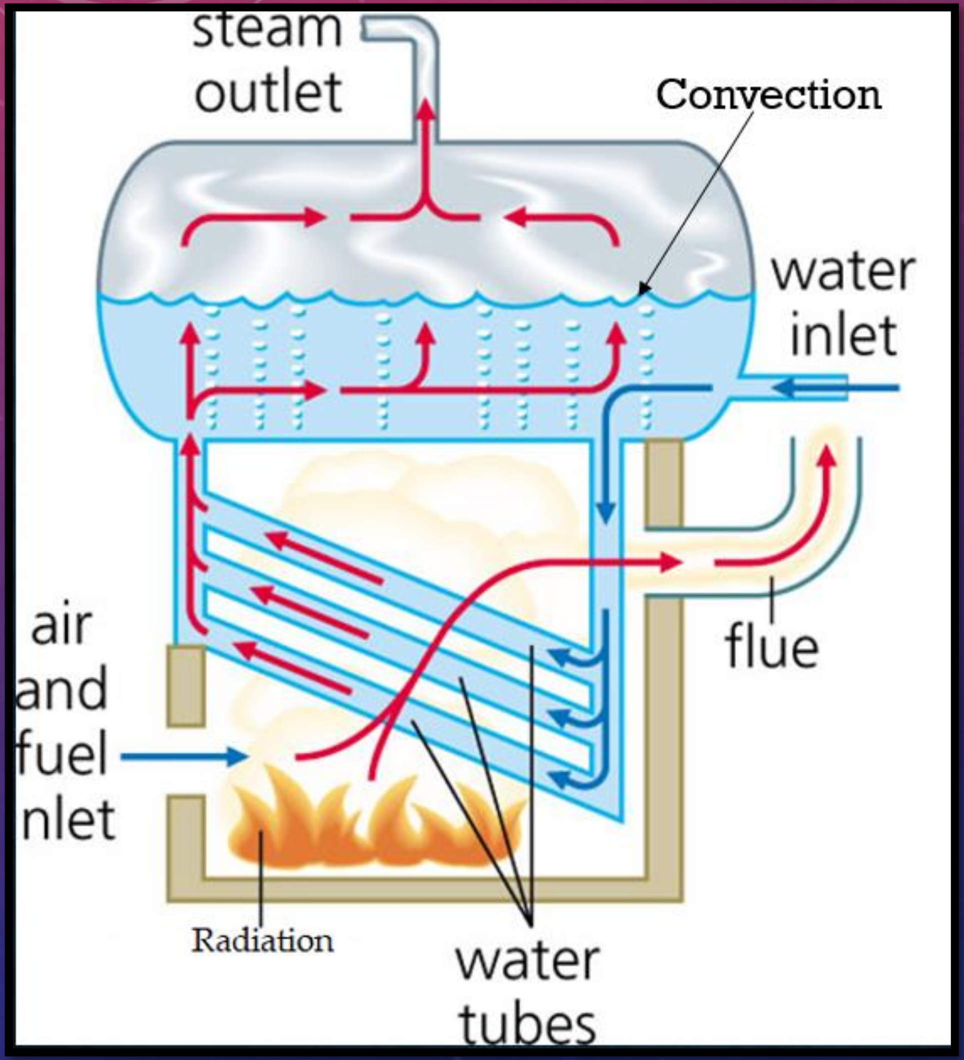
$$Q_{conv} = h\, A_s\, (T_s\ -\ T_\infty)$$

- This is also know as **newton's law of cooling.**

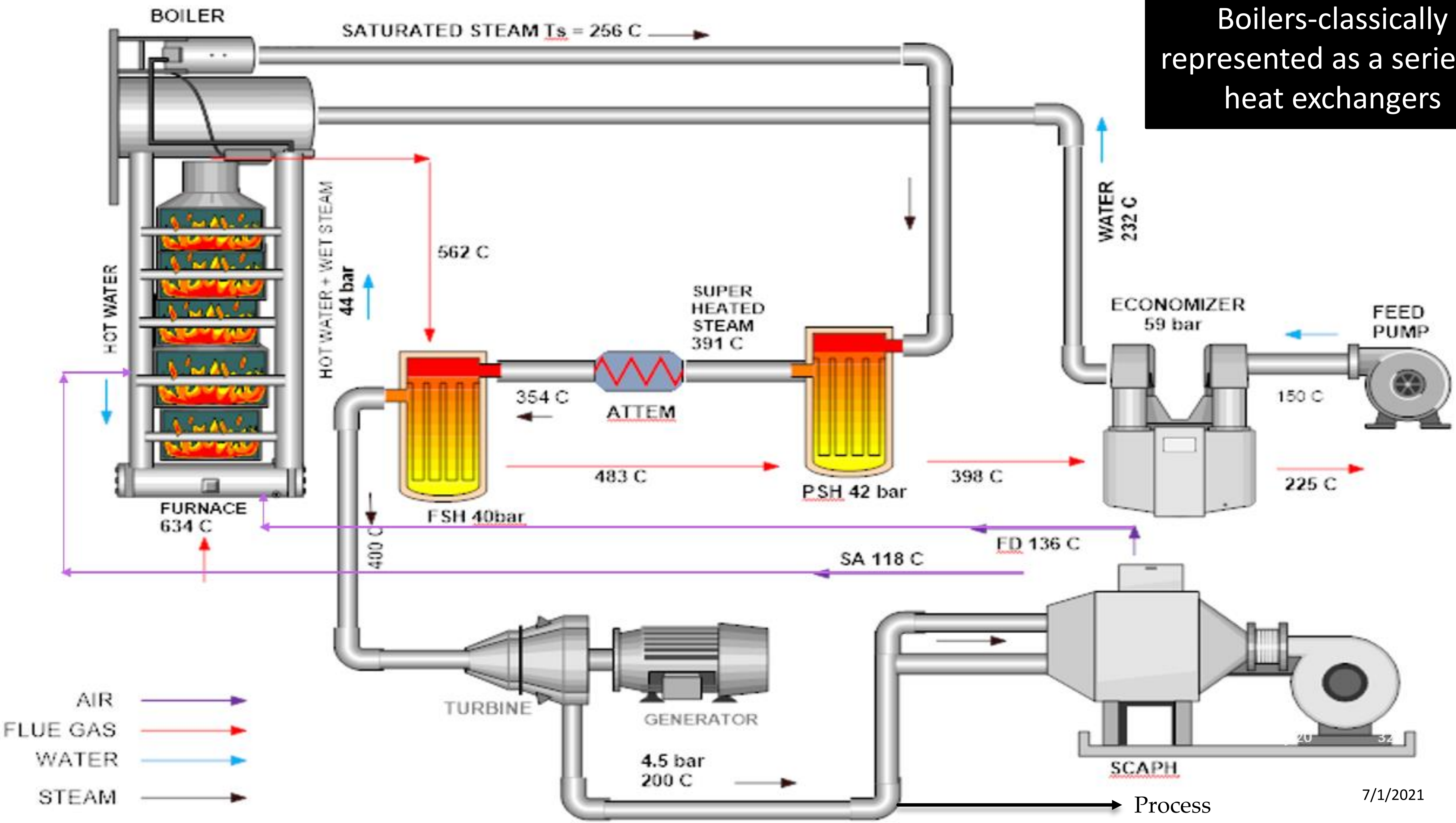


RADIATION

- **Radiation** is the energy emitted by matter in the form of **electromagnetic waves** as a result of the changes in the electronic configurations of the atoms or molecules.
- Heat transfer by radiation is fastest (at the **speed of light**).
- All bodies at a temperature above absolute zero (-273.15 ^{0}C) emit thermal radiation.



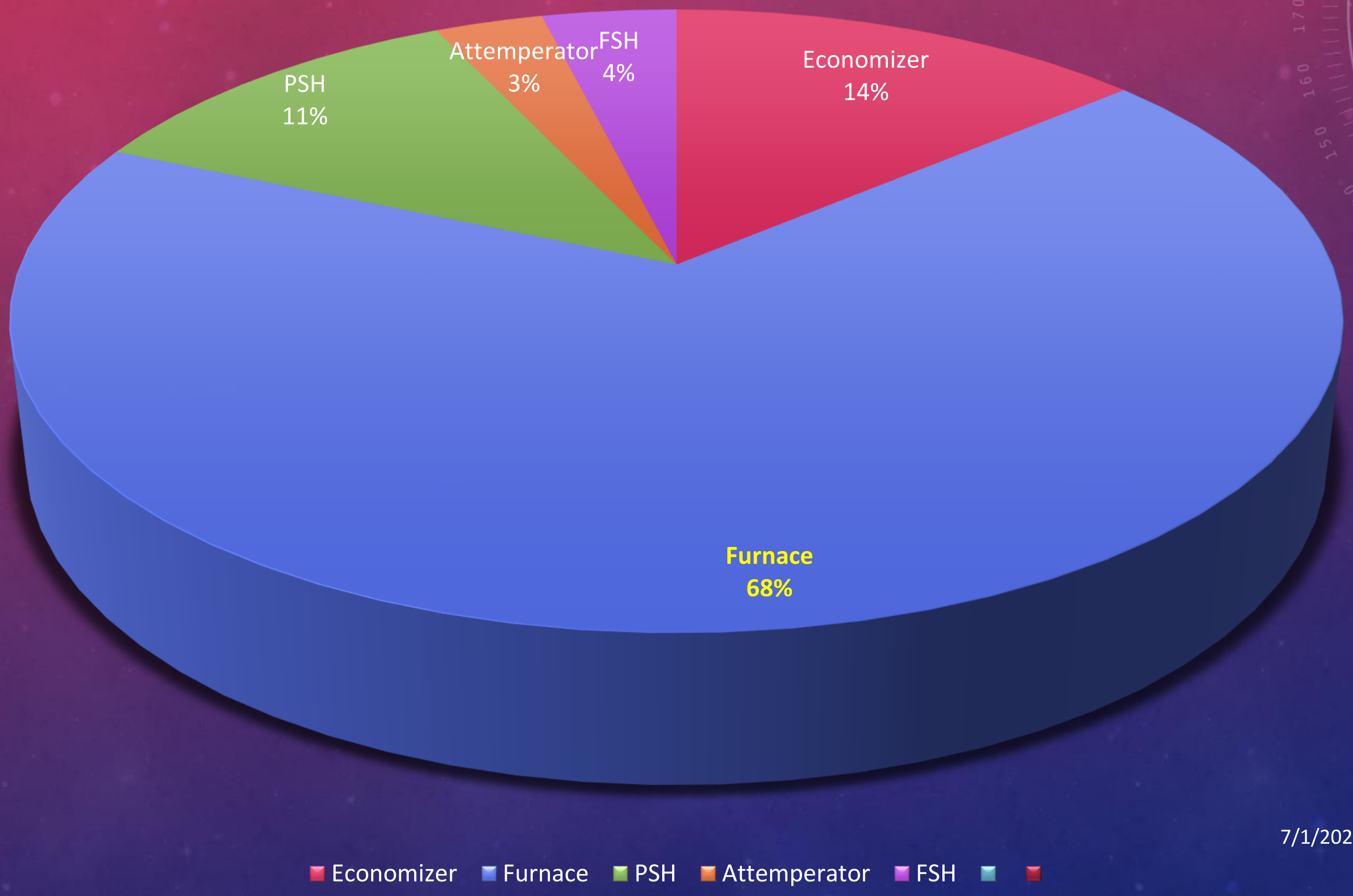
Boilers-classically represented as a series of heat exchangers



HEAT BALANCE

Heat Exchangers	Economizer	Furnace	PSH	Attemperator	FSH
Dominant Heat Transfer mode	Convection	Radiation	Radiation & Convection	Convection	Radiation & Convection
Types of Heat	Sensible Heat	Latent Heat	Sensible Heat	Sensible cooling	Sensible Heat
Heat gain formulae	$c_{Pl}(T_{out} - T_{inl})$	$h_g - h_f$	$c_{Pg}(T_{su} - T_s)$	$c_{Pg}(T_{su1} - T_{su2})$	$c_{Pg}(T_{spF} - T_{sp2})$
Calculation	4.18 (232-150) = 342.76 kj/kg	2798.6 - 1115.5 = 1683.1 kj/kg	2.1 (391-256) = 283.5 kj/kg	2.1 (391-354) = 77.7 kj/kg	2.1 (400-354) = 96.6 kj/kg

HEAT BALANCE



HEAT TRANSFER IN SCAPH

Heat Exchangers	SCAPH (FD)	SCAPH (SA)
Dominant Heat Transfer mode	Convection	Convection
Types of Heat	Latent Heat	Latent Heat
Heat gain formulae	$h_g - h_f$	$h_g - h_f$
Calculation	2743.4-622.5 = 2120.9 kj/kg	2743.4-622.5 = 2120.9 kj/kg

PERFORMANCE PARAMETERS

PERFORMANCE PARAMETERS	DATA
EVAPORATION CAPACITY	Rated capacity of the boiler
	Top 5 Maximum TPH (steam) generation boiler using slop
	Decline graph between stoppage
SLOP BURNING RATE	Rated capacity of boiler
	Top 5 slop burning boiler in the world
	Ton of slop per ton of steam
SUPPORTING FUEL CONSUMPTION	Type of supporting fuel
	GCV
	Minimum consumption of supporting fuel Per ton of steam generation
	Minimum consumption of slop Per ton of steam generation

PERFORMANCE PARAMETERS	DATA
MEAN TIME B/W STOPPAGES	No of days
	No of hours
	Total steam generation b/w stoppages
	Reason for stoppage
AUXILIARY POWER CONSUMPTION	Specific power consumption (kWh per ton)
BOILER EFFICIENCY	Slop consumption
	Auxiliary Fuel consumption
	Ultimate analysis of both fuels
	Oxygen content in a flue gas
	Temperature of inlet air and exhaust flue gases
	Specific heat of flue gas
	Unburnt carbon data in ash in different zone
	CO in flue gas

1) EVAPORATION CAPACITY

FOR DIAGNOSTIC OF EVAPORATION CAPACITY		
Data Needed	**Possible Source of Data**	**UOM**
a) Draft profile	Manual , Log Book	mmWC
b) Flue gas temperature profile	Manual , Log Book	^0C
c) Water and steam temperature profile	Manual , Log Book	^0C
d) Heating Surface Area	Manual	m^2
• Furnace	Manual	m^2
• FSH	Manual	m^2
• PSH	Manual	m^2
• EVA	Manual	m^2
• ECO	Manual	m^2

2) SLOP BURNING RATE

FOR DIAGNOSTIC OF SLOP BURNING RATE		
Data Needed	**Possible Source of Data**	**UOM**
a) BRIX	Manual , Log Book	%
b) Slop Temperature in the tank	Manual , Log Book	^0C
c) Furnace temperature Before entering the slop into furnace	Manual , Log Book	^0C
d) Steam tracing		
e) Burning Rate	Manual , Log Book	TPH
f) Gun Cleaning History	N/A	Hours

3) SUPPORTING FUEL CONSUMPTION

COMPARISON OF SUPPORTING FUEL		
Data Needed	**Possible Source of Data**	**UOM**
Type of supporting fuel	Manual, Daily Report	Numbers
GCV of supporting fuel	Manual, SELF	kJ/kg
Minimum consumption of supporting fuel Per ton of steam generation	Log Book	TON
Minimum consumption of slop Per ton of steam generation	Log Book	TON

4) AUXILIARY POWER CONSUMPTION

FOR DIAGNOSTIC OF AUXILIARY POWER CONSUMPTION

Data Needed	Possible Source of Data	UOM
a) All equipment rating	Manual , Log Book	kW
b) Energy meter reading Meter map	Log Book Physical inventory	kWh

5) BOILER EFFICIENCY

FOR DIAGNOSTIC OF BOILER EFFICIENCY

Data Needed	Possible Source of Data	UOM
a) Slop consumption	Manual(25.5TPH) , Log Book	TPH
b) Auxiliary Fuel consumption	Daily Report	TPD
c) Ultimate analysis of both fuels	SELF	
d) Oxygen content in a flue gas	DCS & Log Book	kg
e) Temperature of inlet air and exhaust flue gases	DCS & Log Book	^{0}C
f) Specific heat of flue gas	SELF	kJ/kg
g) Unburnt carbon data in ash in different zone	LAB	kg
h) CO in flue gas	N/A	kg

Comparative Evaluation of 75&35 TPH

Heat Transfer Area Comparative

Heat Exchanger	MANUAL DATA (75TPH)	MANUAL DATA (35TPH)	75TPH	35TPH
	Surface Area (m^2)	Surface Area (m^2)	m^2/TPH	m^2/TPH
Furnace	1862	1106	**24.82**	**31.6**
SH	1448	924	**19.3**	**26.4**
EVA	472	238	6.29	6.8
ECO	3050	1386	40.67	39.6
TOTAL	6832	3654	91	104.4

With increase in capacity rating, specific heat transfer areas do get reduced. However, reduction in the Furnace and SH areas by over 26% looks very high.

Date	Steam Generation (TPH)	Flue gas temp(^{0}C) drop in between (75 TPH)				
		Furnace & 2nd pass	2nd pass & PSH I/L	PSH I/L & Evap. I/L	Evap. I/L & Eco. I/L	Eco. I/L & Eco. O/L
Before Maintenance/cleaning						
03/3/2020 (15:48:47)	68.33	4	48	139	29	175
19/3/2020 (18:46:33)	69.44	-2	44	143	22	178
23/3/2020 (10:28:34)	70.53	**-6**	43	145	18	168.5
23/3/2020 (10:55:58)	70.1	-1	45	141	19	170.5
23/3/2020 (16:00:21)	70.46	**-14**	38	147	22	170.2
After Maintenance/cleaning						
25/5/2020 (08:08:07)	70.53	-7	57	147	31	120.6
25/5/2020 (15:33:07)	70.46	**31**	51	136	32	116.8
25/5/2020 (17:29:31)	70.1	5	60	141	31	119.8
25/5/2020 (18:52:40)	69.44	**-32**	66	150	32	119.3
24/5/2020 (22:54:49)	68.33	**-22**	59	151	33	129.3

Wide fluctuation indicates furnace instability and possible secondary combustion. Temperature drop across eco has gone down Post cleaning

Date	Steam Generation (TPH)	Flue gas temp(^{0}C) drop in between (35 TPH)				
		Furnace & 2nd pass	2nd pass & PSH I/L	PSH I/L & Evap. I/L	Evap. I/L & Eco. I/L	Eco. I/L & Eco. O/L
Before Maintenance/cleaning						
16/3/2020	34	116.3	44.8	95	2	142.6
22/3/2020	32.9	117.5	38.1	95.5	4.7	142.6
24/3/2020	32	80.6	42.1	98.1	9.1	143.7
25/3/2020	34.4	114.5	46.2	105.6	1.8	138.7
26/3/2020	34	112.4	60.5	107.7	4.6	148.8
After Maintenance/cleaning						
13-04-20	34.4	128.5	41.4	117.1	17.8	131.6
14-04-20	34	110.4	37.7	121.1	22.7	134.3
16-04-20	32	110.5	33.3	109.2	17.3	127.9
17-04-20	32.9	112.1	33.5	110	18.1	129
20-04-20	34	116.8	35.9	115.1	23.2	141

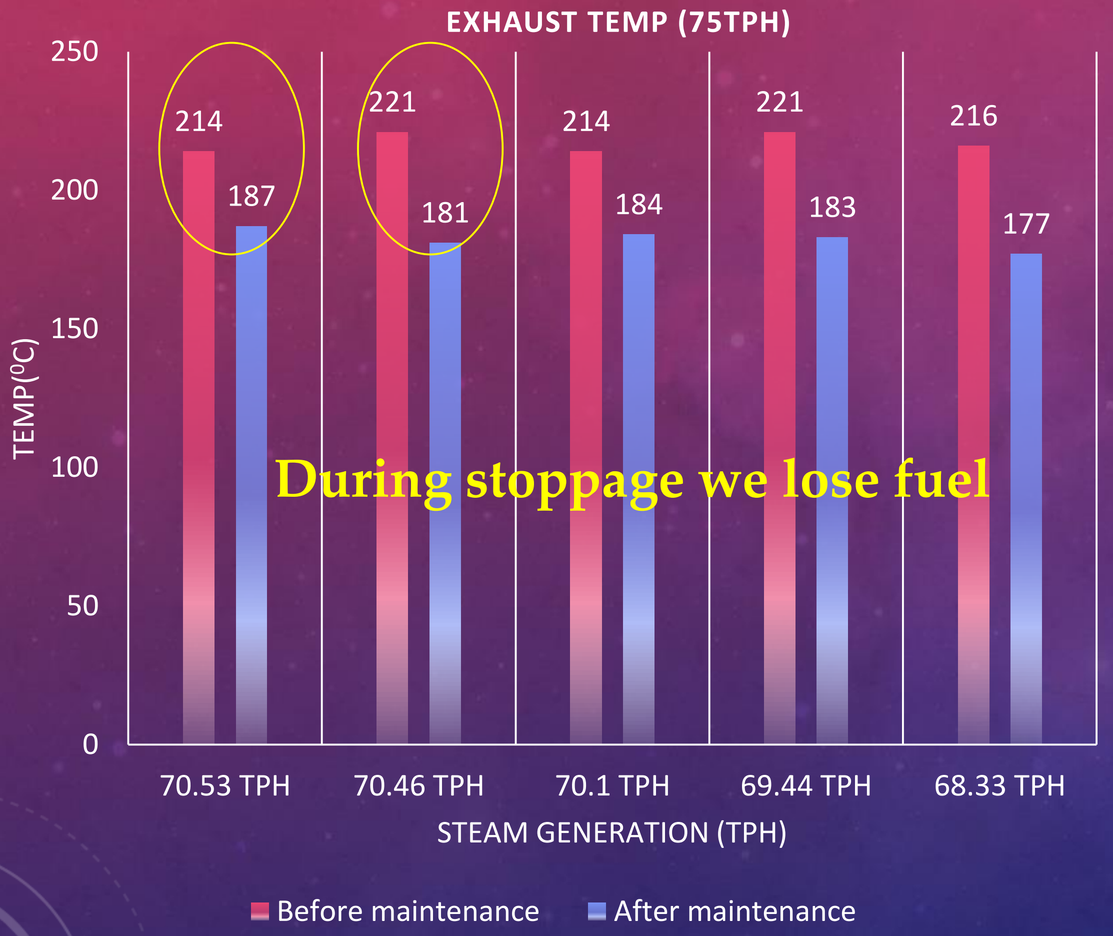
Shows that there has been Secular improvement Post cleaning. Marginal reduction in Eco drop can be explained. Improved performance of the evaporator post cleaning

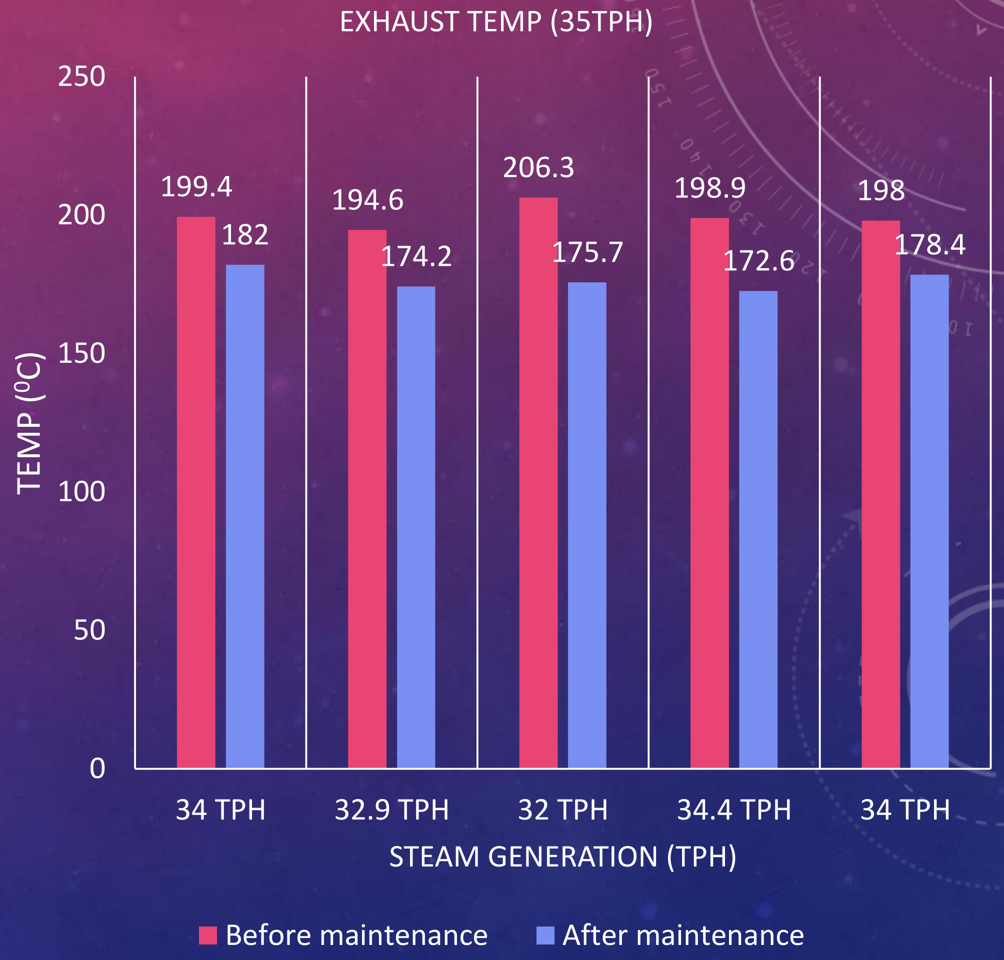
COMPARISION OF TEMPERATURE DIFFERENCE B/W FURNACE & 2nd PASS

Temperature Difference B/W Furnace & 2nd Pass			
Before Maintenance		After Maintenance	
75 TPH	35 TPH	75 TPH	35 TPH
-6	116.3	-7	116.8
-14	117.5	31	112.1
-1	80.6	5	110.5
-2	114.5	**-32**	128.5
4	112.4	**-22**	110.4

Rise in temperature in the 2nd pass indicates either instrument error or secondary Combustions or both

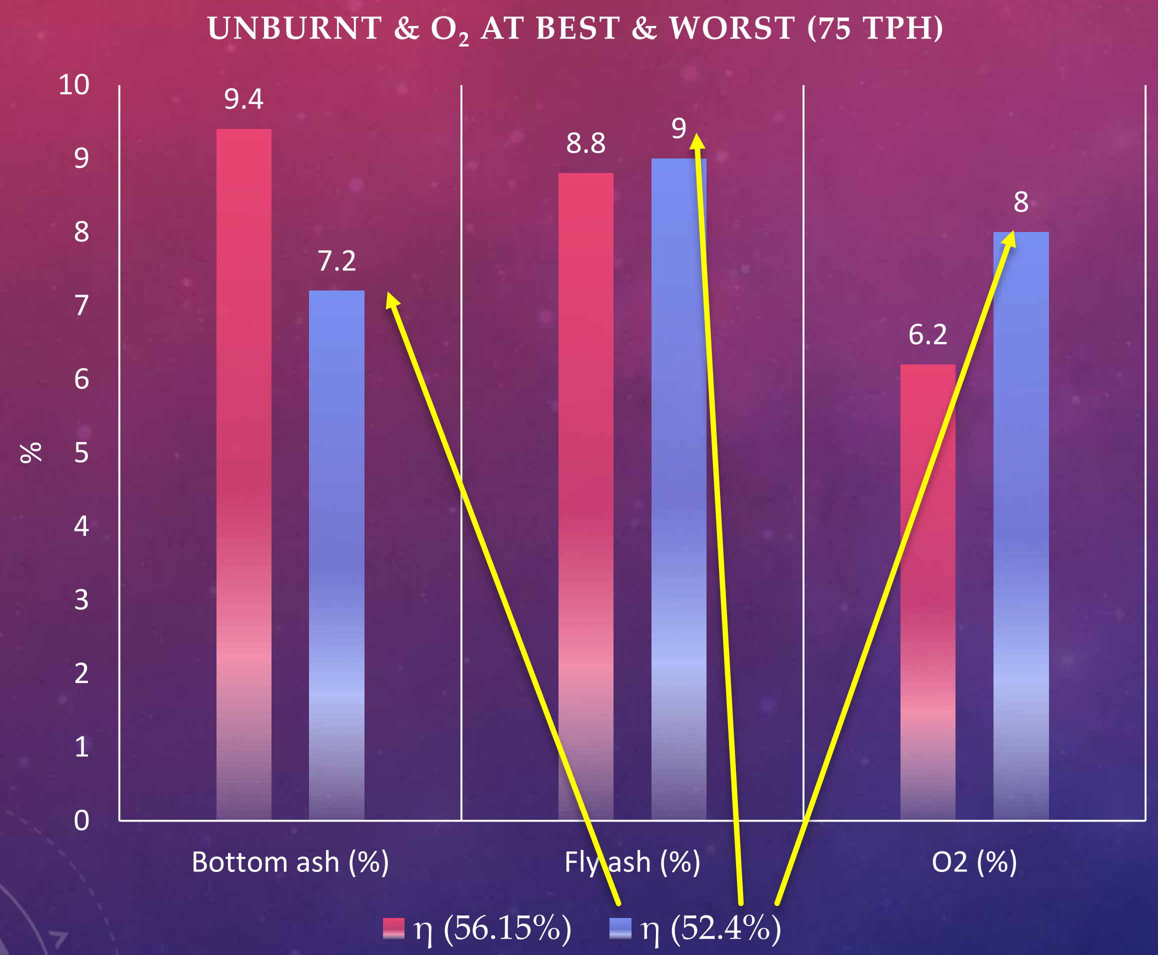
Flue gas temperature at exit comparison “After & Before Maintenance/Shut down”.

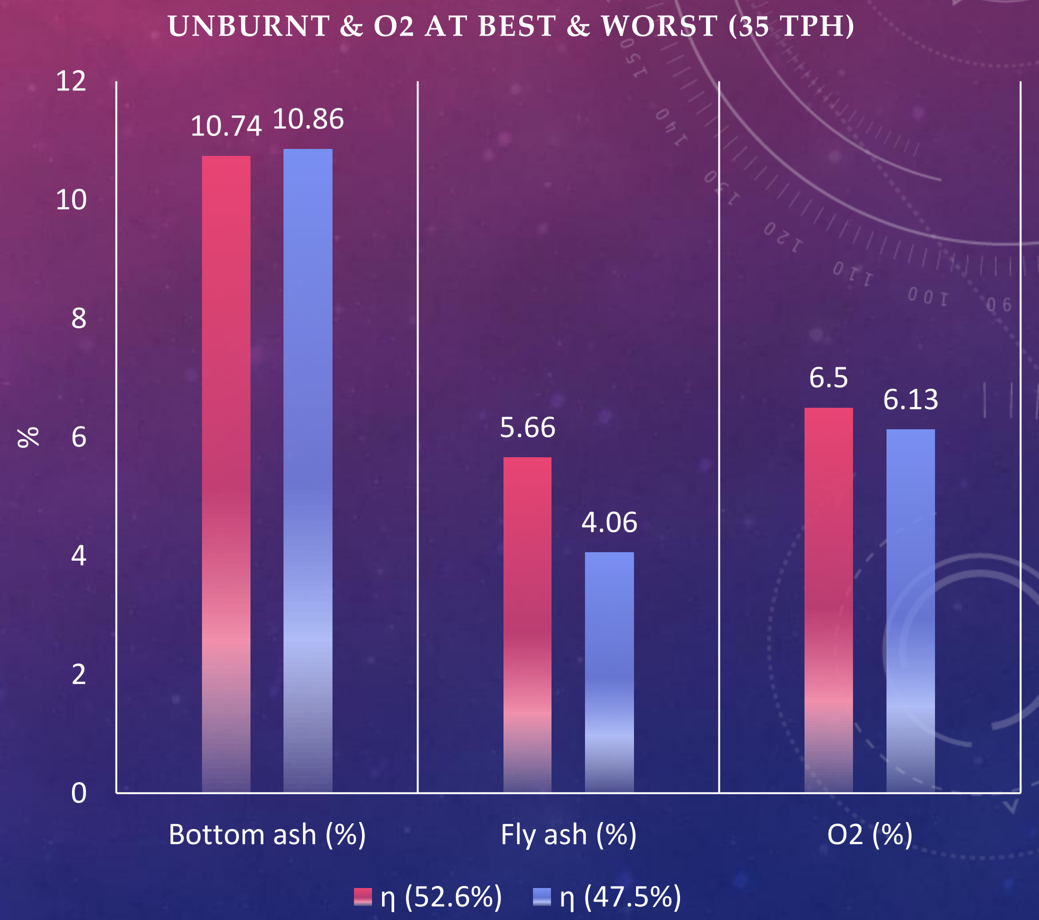




Reduced flue gas losses post cleaning as per expectation

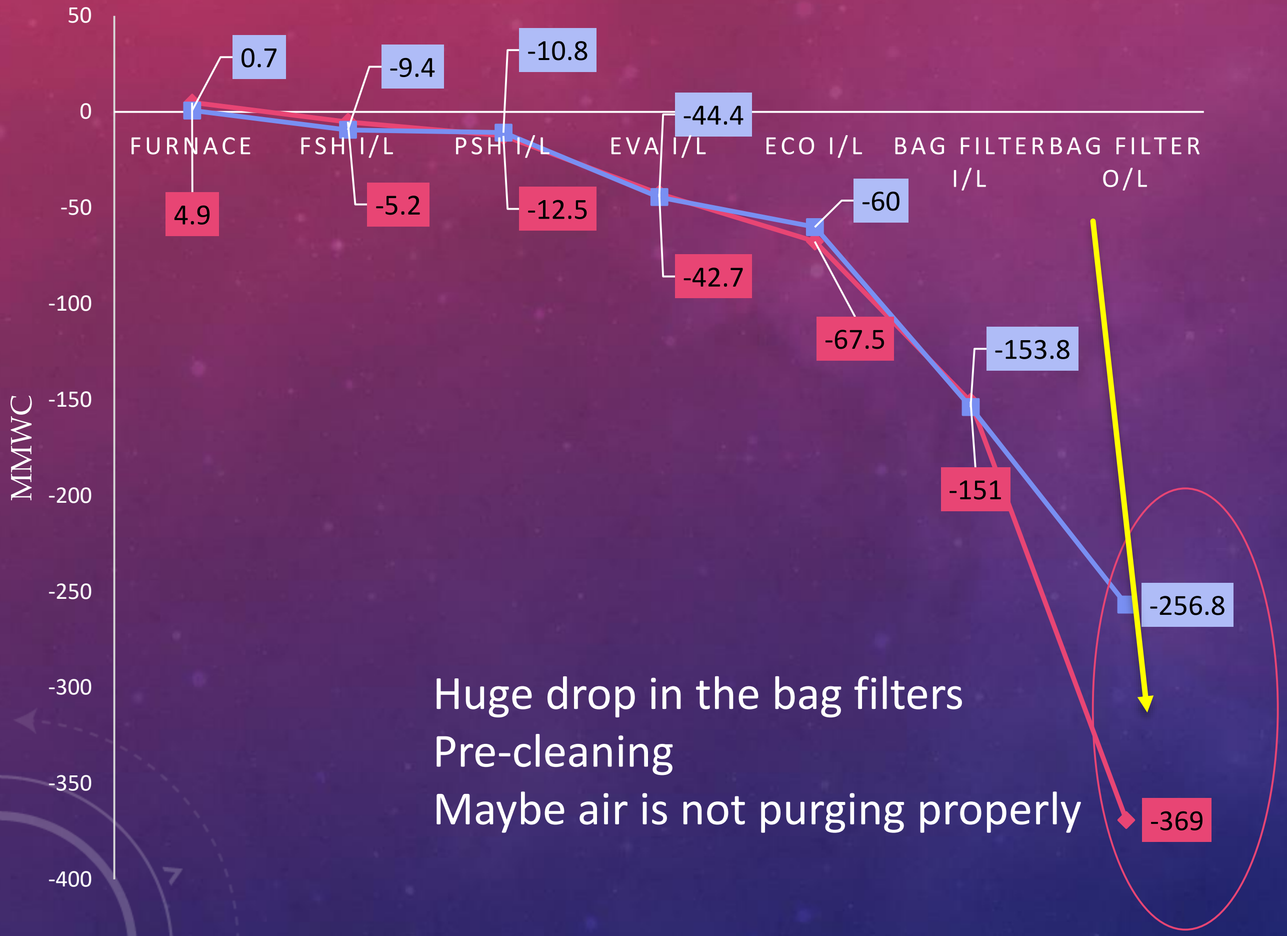
UNBURNT & O_2 AT BEST & WORST EFFICIENCY OF BOILER



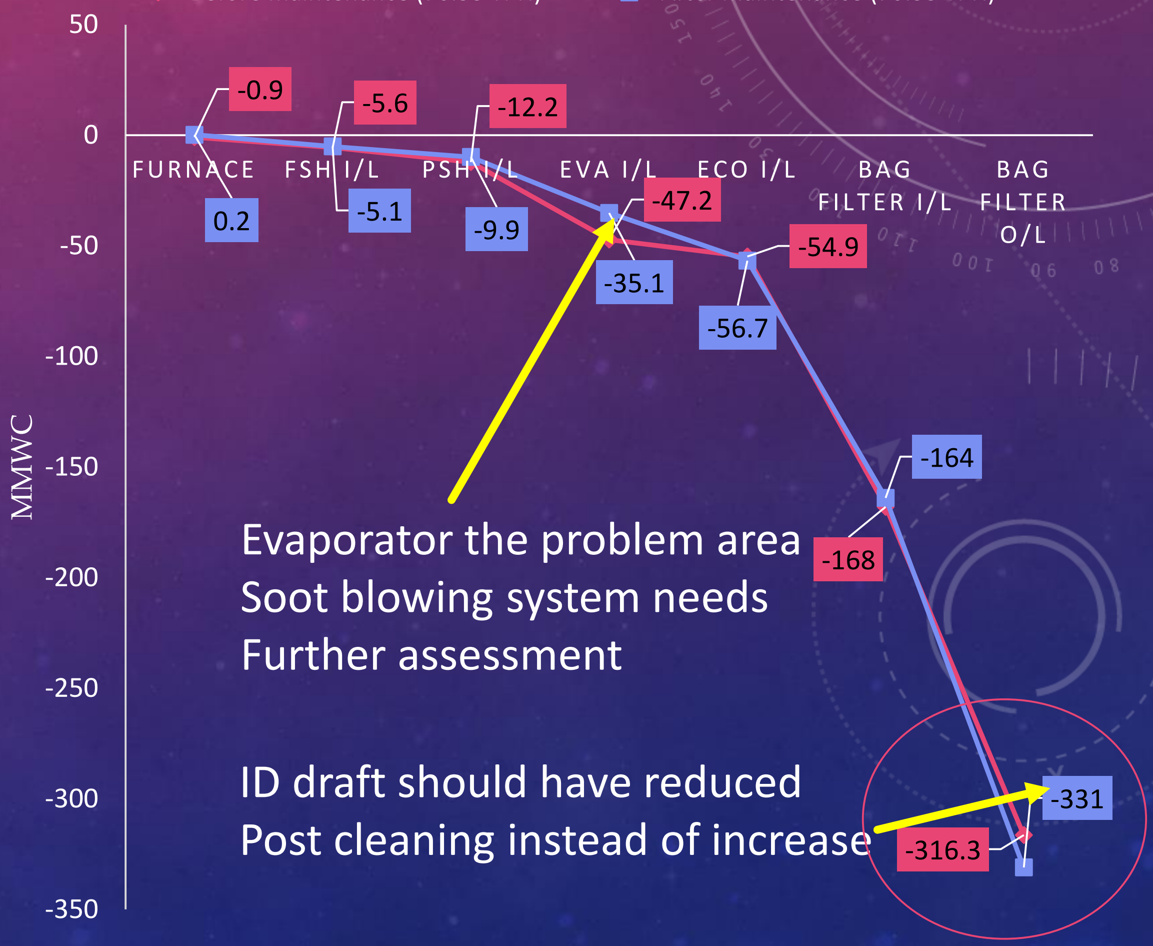


By and large consistent performance-still scope for improvement by operating at benchmark

FLUE GAS DRAFT PROFILE (BEFORE & AFTER MAINTENANCE)



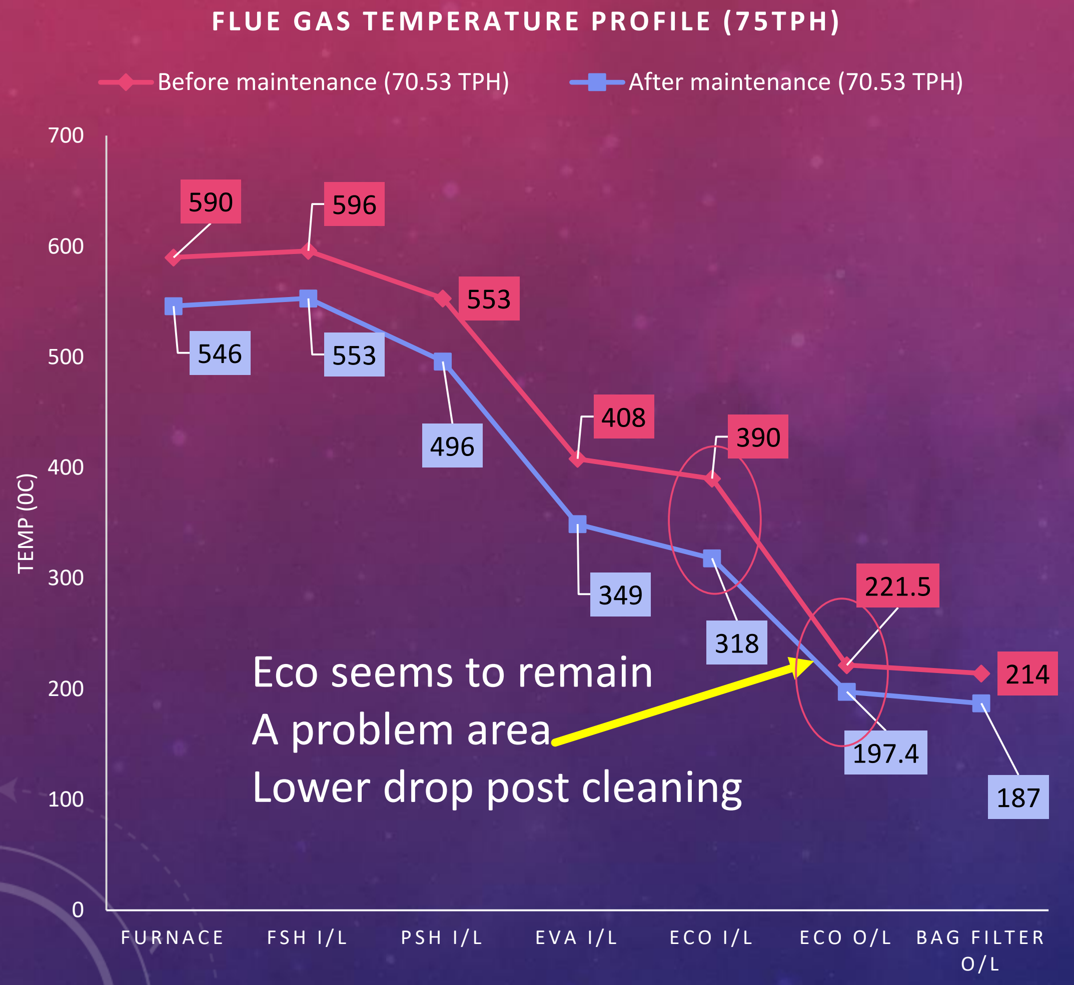
Huge drop in the bag filters
Pre-cleaning
Maybe air is not purging properly

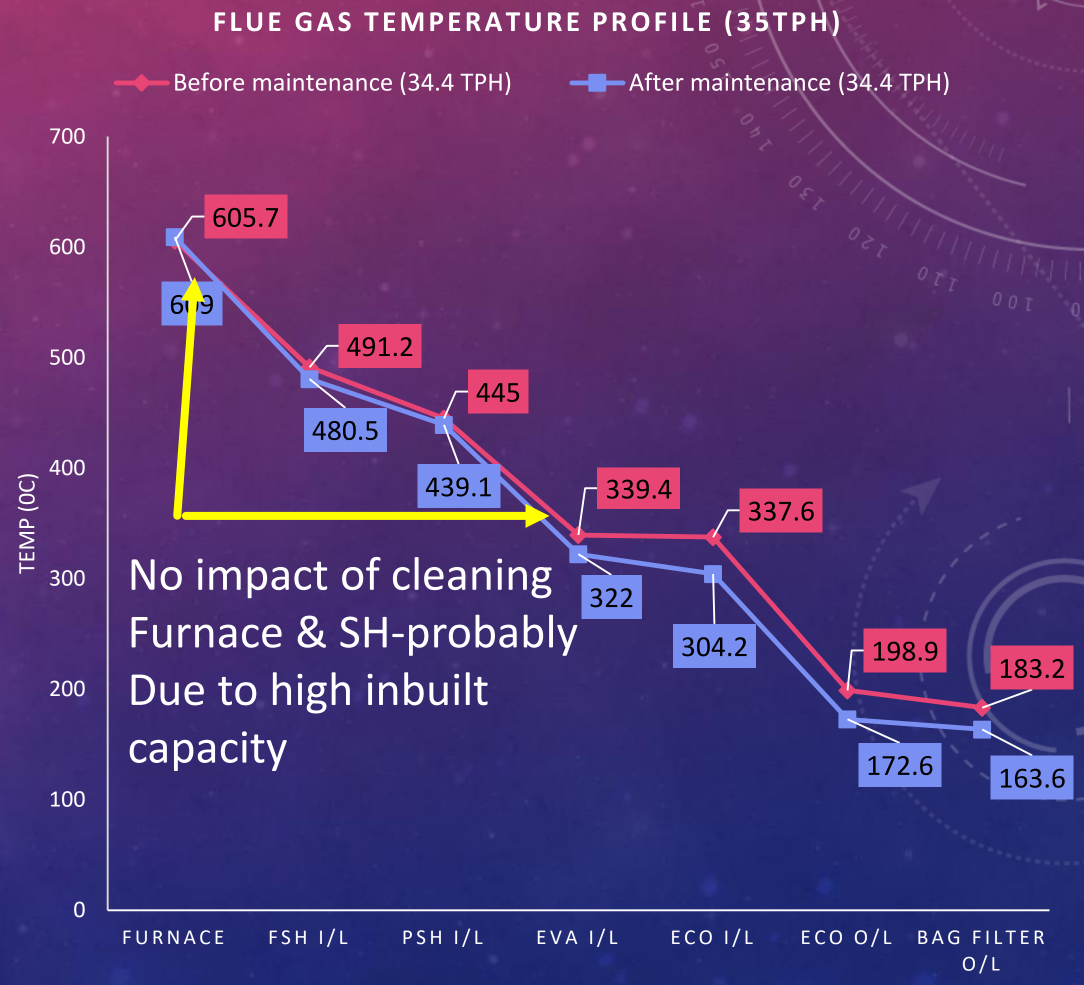


Evaporator the problem area
Soot blowing system needs
Further assessment

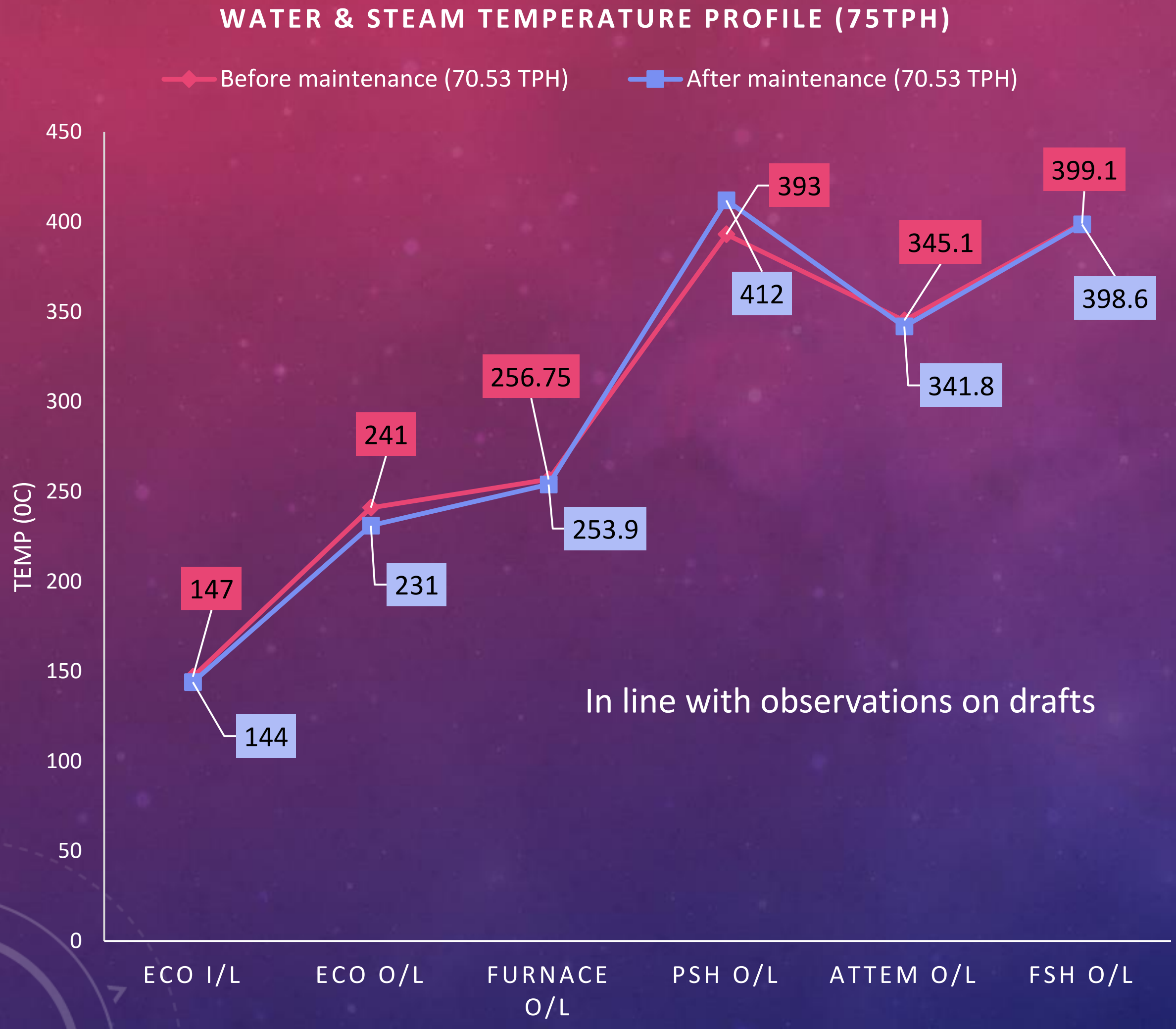
ID draft should have reduced
Post cleaning instead of increase

FLUE GAS TEMPERATURE PROFILE (BEFORE & AFTER MAINTENANCE)

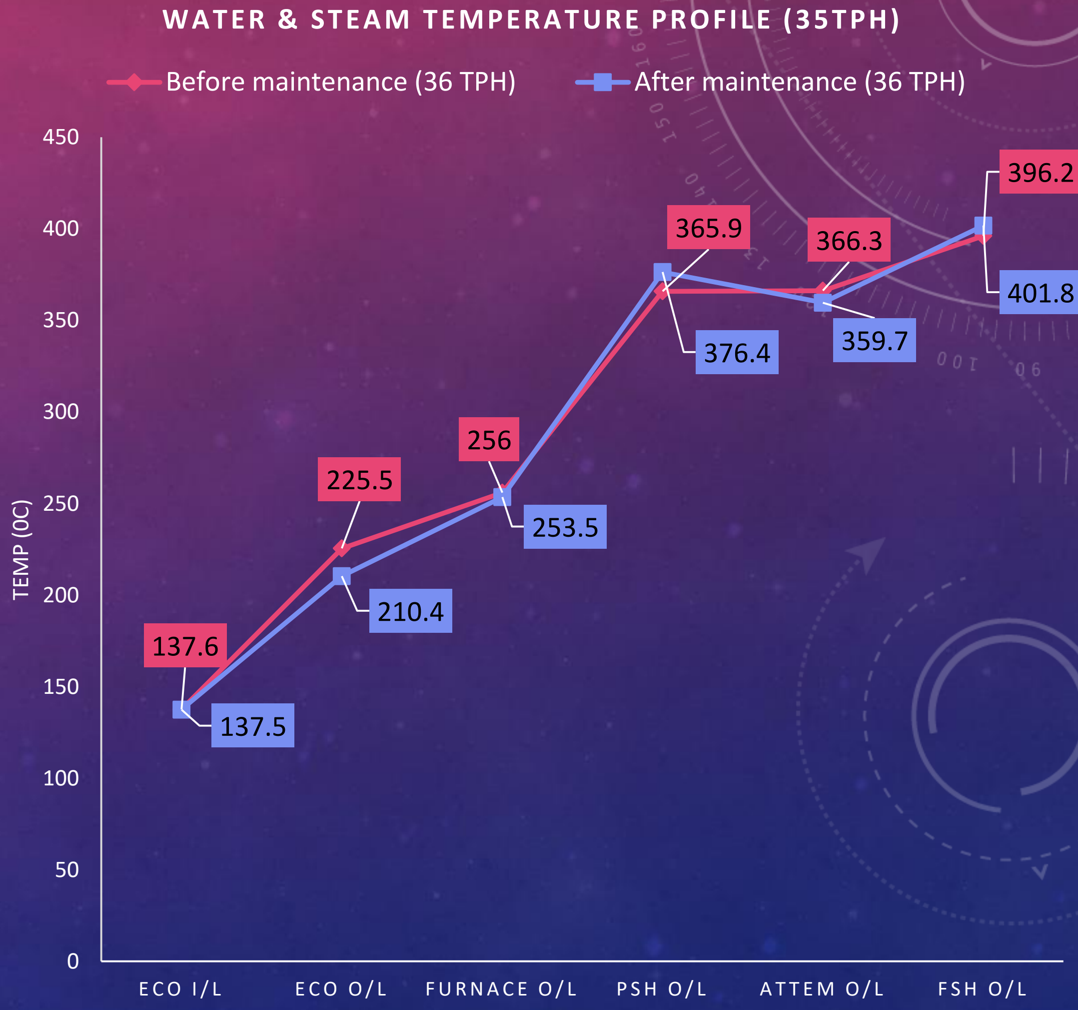




Water & Steam Temperature Profile (Before & After Maintenance)



In line with observations on drafts



75 TPH Performance Parameters-summary

Date	Steam Generation (TPH)	Feed water Temp. (^{0} C)	Main Steam Temp. (^{0} C)	Main Steam Pressure (kg/cm2)	Furnace Temp. (^{0} C)	Fuel Consumption (TPD)	Bagasse Moisture	Slop brix	GCV Of Bagasse (kcal/kg)	GCV of slop (kcal/kg)	Efficiency (%)
8/3/20	Max 74.1	148	404.2	40	580.3	$Slop_{Min}$ =579 $Bagasse_{Max}$ =420	49.7%	56	2272	1800	55.411
17/3/20	73.2	150	407.4	40.3	615.8	Slop = 645 Bagasse=360		57.5		1848	54.336
19/3/20	71.2	148	403.5	41	627	$Slop_{Max}$ =648 Bagasse=360		57.4		1845	52.744
25/5/2020	70.53	144	398.6	40	546	Slop =638 Bagasse=336		57		1832	54.556
25/5/2020	Min 70.46	146	387.3	40.2	558	Slop =638 $Bagasse_{Min}$=336		53		1703	56.157

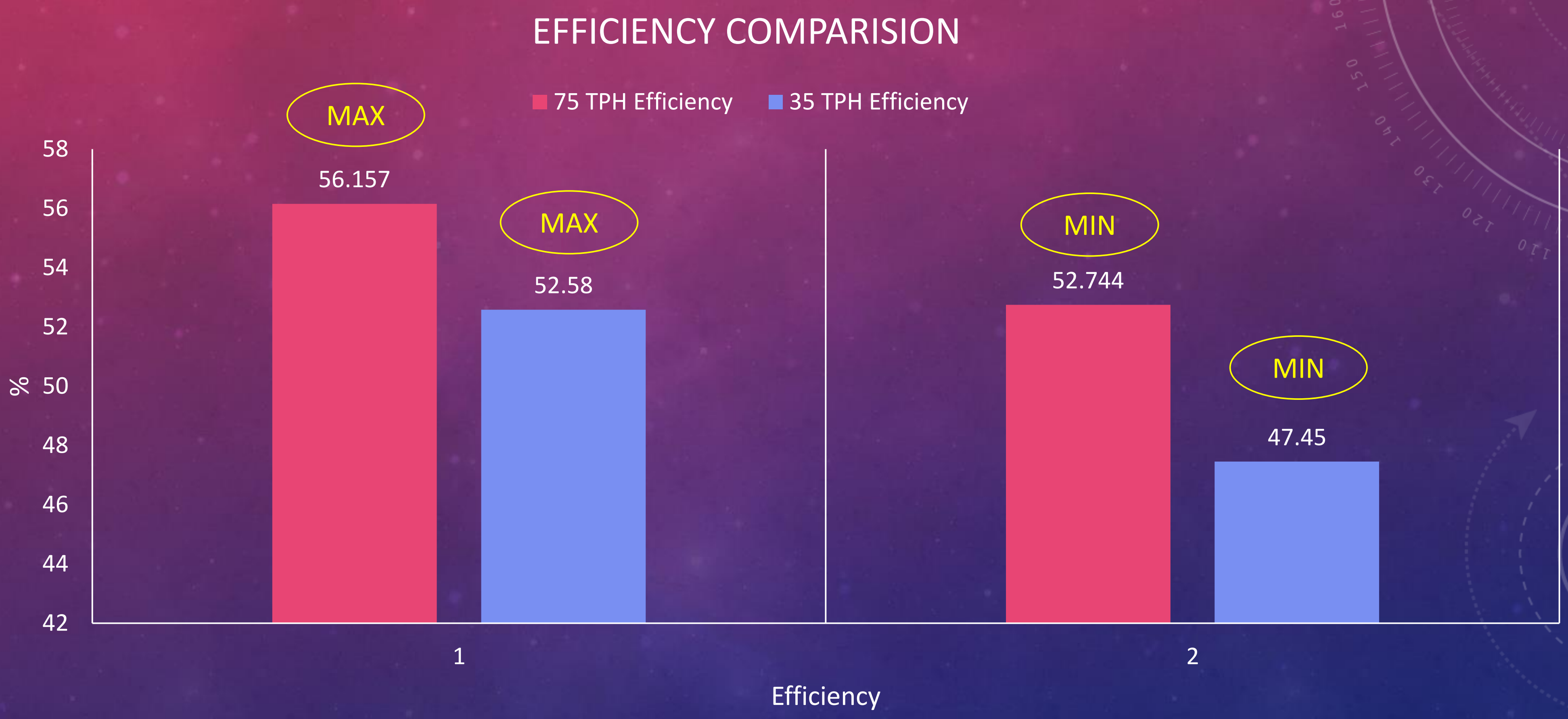
High rate of generation even under fouled condition indicates inbuilt over capacity. Scope for increasing slop consumption and reducing aux fuel

Calculated by direct method with enthalpy

35 TPH Performance Parameters-summary

Date	Steam Generation (TPH)	Feed water Temp. (^{0}C)	Main Steam Temp. (^{0} C)	Main Steam Pressure (kg/cm2)	Furnace Temp. (^{0}C)	Fuel Consumption (TPD)	Bagasse Moisture	Slop brix	GCV Of Bagasse (kcal/kg)	GCV of slop (kcal/kg)	Efficiency (%)
22/1/20 4:00	35.9	137.6	396.2	42.9	634.2	Slop = 295.2 Bagasse = 228.7	47.67%	57.33	2272	1840	50.94
01/4/20 21:00	35.4	143	398.8	43.3	635	$Slop_{Max}$ = 299.52 $Bagasse_{Max}$ =253.2		56		1798.4	47.45
11/4/20 5:00	Max 36.5	136.9	401.8	43.9	636.8	Slop = 296.4 Bagasse =220		57.80		1856.29	51.44
12/4/20 6:00	36.1	137.5	401.8	42.3	644	**Slop = 299** Bagasse = 225.12		54.70		1756.7	52.58
13/4/20	Min 35.1	146	401	43.1	597	$Slop_{Min}$ = 288.24 $Bagasse_{Min}$ = 210		56.50		1814.55	52.35

EFFICIENCY COMPARISION OF 75 TPH & 35 TPH BOILER

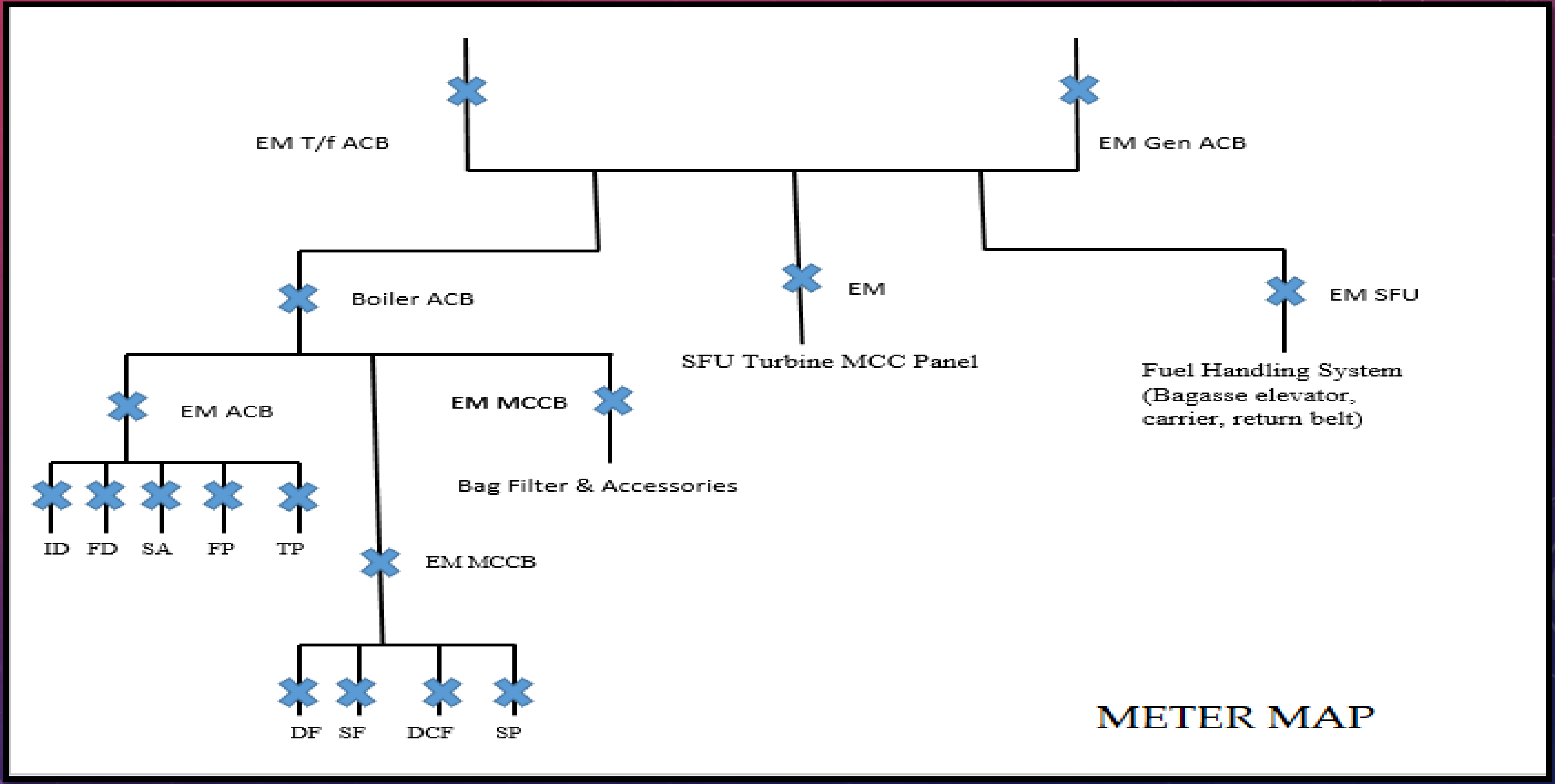


COMPARISION WITH PG TEST PERFORMANCE

PARAMETERS	75 TPH				35 TPH			
	PG TEST REPORT	PG TEST η BY INDIRECT METHOD	PG TEST η BY DIRECT METHOD	η BY DIRECT METHOD	PG TEST REPORT	PG TEST η BY INDIRECT METHOD	PG TEST η BY DIRECT METHOD	η BY DIRECT METHOD
LOAD (TPH)	74.6	73.4	73.4	70.46	35.2	35.2	35.2	35.2
FUEL CONSUMPTION (TPD)	942.19	970	970	974	430.1	430.1	430.1	515.28
FLUE GAS TEMPERATURE ECO O/L (0C)	213.2	209	209	191.2	201.5	201.5	201.5	178.5
AUXILARY POWER (kWh)	15480	27390	27390	23960	317.5	317.5	708	708
UNBURNT (%)	9.65	9.65	9.65	9.53	9.2	9.2	9.1	9.1
O_2 (%)	7.3	7.4	7.4	6.2	6.5	6.5	6.5	6.5
Efficiency (%)	63.57	59.5	58.57	56.15	57.58	61.5	60.31	52.58

Our initial assessment on lower efficiency is possibly related to bagasse accounting. Would require further study.
We would also suggest that we must have **two portable instruments-one flue gas analyser and a radiation thermometer**.
This would help us in better monitoring of the efficiency performance on a regular basis.

METER MAP


EM T/f ACB
EM Gen ACB
Boiler ACB
EM
EM SFU
SFU Turbine MCC Panel
Fuel Handling System
(Bagasse elevator,
carrier, return belt)
EM ACB
EM MCCB
Bag Filter & Accessories
ID
FD
SA
FP
TP
EM MCCB
DF
SF
DCF
SP
METER MAP

AUXILARY POWER CONSUMPTION

75 TPH			
Date	Auxiliary power (kWh/Day)	Steam generated (TPD)	Power/Steam (kWh/Ton)
8/03/20	27230	1778.4	15.31
17/03/20	26450	1756.8	15.05
19/03/20	26770	1708.8	15.66
25/05/20	23960	1692	14.16

35 TPH			
Date	Auxiliary power (kWh/Day)	Steam generated (TPD)	Power/Steam (kWh/Ton)
1/4/2020	17000	821.19	20.70
2/4/2020	17000	805.79	21.09
11/4/2020	17000	838.60	20.27
13/4/2020	17000	804.64	21.12

Scope for improvement particularly post cleaning

FUEL-MCQS

Q1) PH of slop is________.

a) 1 b) 3.9 c)7

Q2) Viscosity varies with temperature_________.

a) Logarithmically b) Directly c) Inversely

Q3) Higher the moisture content lower will be________.

a) Calorific value b) combustion rate c) Both a) & b)

Q4) Impact of hardness on boiler_________.

a) Form scale on water tubes b)decrease heat transfer rate, heat loss c) Both a) & b)

Q5) PH of slop is __________.

a) Acidic b) Basic c) Neutral

COMBUSTION-MCQS

Q1) ________ the residence time , _________ will be combustion.

a) Higher , more b) higher , less c) lower , more

Q2) Slop fired boiler has very _______residence time,>________secs.

a)High , 5 b) low , 10 c) high , 10

Q3) Proper mixing of fuel and oxygen __________ rate of combustion.

a) Increases b) decreases c) remains constant

Q4) If temperature is __________ the ignition temperature the fuel will burn immediately.

a) Below b) equal c) above

Q5) Turbulence in terms of combustion refers to mixing of_________.

a) Fuel & fuel b) fuel & air c) air & air

ASH-MCQS

Q1) Potassium & sodium oxide creates problems like slagging & clinker due to ________M.P.

a) Low b) high c) constant

Q2) High content in ash would help in combating slagging problems.

a) Mg b) Ca c) Al

Q3) Ash exhibit low fusibility temperature with higher slagging potential when its base/acid ratio is in range_________.

a) 0.4-0.7 b) 0.7-0.9 c) 0.2-0.7

Q4) % of ash is same in _________&__________.

a) Bag filter & 2nd pass b) Eva , Eco & bag filter c) 2nd pass & Eva , Eco

Q5) Impact of MgO and CaO on boilers

a) Prevent corrosion b) decrease heat transfer rate c) Both a) & b)

MCQ HEAT TRANSFER

Q1) There are ________ methods of heat transfer.

a) 4 b) 3 c) 2

Q2) Conduction can take place in

a) Solid , Liquid b) Liquid, Gas c) Solid , Liquid , Gas

Q3) Convection is the mode of energy transfer between solid surface and adjacent ______or______ that is in motion.

a) Liquid Or Gas b) Solid or Liquid c) Solid or Gas

Q4) _______ is also known as Newton's Law of cooling.

a) Convection b) Radiation c) Conduction

Q5) _______ is energy emitted by matter in form of electromagnetic waves.

a) Conduction b) Radiation c) Convection

PERFORMANCE PARAMETERS-MCQS

Q1) How many factors are required to determine performance parameters?

a) 5 b) 6 c) 4

Q2) What is the unit of draft?

a) Kg/cm b) MMWC c) N

Q3) GCV of slop as 1654kcal/kg is calculated on what % of brix according to manual?

a) 55% b) 51.5% c) 52.6%

Q4) What is the rated capacity of slop consumption as per manual?

a) 26.5TPH b)27.5TPH c)25.5TPH

CONCLUSION

- This study has helped us in developing a better understanding of boilers in general and the physics, chemistry, engineering, operation and maintenance of slop fired boilers in particular
- In the process, we have also identified few performance enhancement possibilities
- We would consider it a privilege should we get opportunity to participate in our group's program for improving boiler performance
- We would also look forward to get similar learning opportunities in different technical areas of operation of the sugar, chemical and cogeneration facilities.

We Are Thankful To All Our Seniors And Colleagues For The Help Extended For The Study

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