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Energy Analysis and Efficiency Assessment of Water Tube Boiler

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Abstract: *Energy is most precious thing, so it can be used most efficiency way. Most types of energy now a day's use in form of electricity, which is mainly generated in steam power plant and rest of source are wind, hydro and solar. The heart of steam power plant is boiler and to maximize efficiency of power plant, there is need to increase efficiency of boiler. The boiler efficiency can be evaluated by direct and indirect method, in direct method the energy gain by working fluid is compared with energy content of fuel while in case indirect method various losses compared to the energy input. Present work is concern on energy analysis and efficiency assessment of water tube boiler for sugar industry. By using catalyst what kind of effect on exhaust gas, combustion quality, environment friendliness, economy and up to what extent efficiency increase. By increasing boiler efficiency one can save fuel input to power plant and also earn carbon point and can increase profit to plant. From considering overall analysis and results it is concluded that, the pre boiler efficiency measured by O_2 gas analyzer remains same as defined value without using solid combustion catalyst. It also shows that the efficiency of the pre-boiler leads to increase of the order of 2.82%, 2.86%, 2.35% and 2.4% related to four different observed boilers with use of solid combustion catalyst, which is more supportive and required for the reduction of cost. The overall 2.61% improvement in the boiler efficiency as well as 3.3% reduction in baggase consumption. The overall saving of rupees 41, 19,000 with this efficiency is done after using the catalyst.*

I. Introduction

Present time source of energy and its conservation and efficient production methods are researchable so present work focus on energy analysis and efficiency assessment of water tube boiler which is root cause of energy generation. The objective of trial at " shree Mahuva Pradesh S.K.U.M. Ltd, Mahuva" on their 2 × 20 TPH, 1 × 25 TPH, and 1 × 45 TPH boilers Was establishing the efficiency of THERMACT-B by improving the boiler efficiency measured by O_2 gas analyzer. The performance of water tube boiler is judge by THERMACT-B solid combustion catalyst. In solid combustion catalyst test comparison of flue gas parameters of boiler using THERMACT-B.

II. Performance assessment of boiler

Pre trial test was conducted from 10th Jan '14 to14th Jan '14 for five days. The performance of boiler in pre-trial test was measuring required data like oxygen at APH outlet, carbon dioxide at APH outlet, carbon monoxide at APH outlet, excess air at APH outlet, APH outlet temperature and boiler efficiency by O_2 gas analyzer.

Table 1: pre audit flue gas parameters

Parameters of flue gas	Unit	Boiler 1	Boiler 2	Boiler 3	Boiler 4
O_2 at APH outlet	%	12.66	11.03	8.82	9.30
CO_2 at APH outlet	%	754.15	783.95	996.1	1167.35
CO at APH outlet	ppm	8.15	9.78	11.98	11.51
Excess air	%	157.7	113.45	73.1	80.95
APH outlet temperature	˚C	150.95	144.2	149.0	129.65
Boiler efficiency	%	**59.01**	**61.26**	**61.51**	**62.42**

Post-trial was conducted from 20th Jan '14 to 4th Feb '14 for 15 days. The performance parameter of boiler in post-trial test was considering same as above pre-trial test.

Table 2: post audit flue gas parameters

Parameters of flue gas	Unit	Boiler 1	Boiler 2	Boiler 3	Boiler 4
O_2 at APH outlet	%	7.98	7.35	7.30	7.23
CO_2 at APH outlet	%	14.91	13.44	13.50	13.57
CO at APH outlet	ppm	662.27	669.13	648.92	722.78
Excess air	%	62.6	54.02	53.22	52.60
APH outlet temperature	˚C	149.0	144.7	147.68	130.65
Boiler efficiency	%	**60.67**	**63.01**	**62.96**	**63.92**

III. Thermact-B (solid combustion catalyst)

THERMACT-B additives, it works to counteract the effect of moisture in the bagasse fuel. Typically the moisture in bagasse absorbs heat from the bagasse combustion, losing heat both prior 100˚ C and further

losing energy during the vapor phase (latest heat of vaporization). The THERMACT-B additive is a solid mixture of primarily carbon the helps breaking the bond between the two hydrogen and oxygen molecule. The additive essentially lowers the activation energy required for breaking the H-O-H bond. The THERMACT-B then increases the reactivity between the carbon and the moisture in bagasse. The first catalyst action creates CO_2 and H_2 from the C and H_2O, while the second catalyst reaction brings together the C and H_2 to create CH_4, which is then destroyed to provide additional heat. The results is that amount of heat generated per unit of fuel increases, and thus less fuel is required to achieve the same level of heat output.

$C + H_2O \longrightarrow H_2$

$CO + ½\ O_2 \longrightarrow$

$C + 2H_2 \longrightarrow$ HEAT

IV. VibroFeeder Assembly

THERMACT-B is added directly in to the bagasse feeder. THERMACT-B was added directly into bagasse feeders with the help of Vibro-feeder assembly. The feed rate of THERMACT-B was controlled by the Vibro-feeder and regulator as per the bagasse consumption. 1kg of THERMACT-B is dosed for 20 tons of bagasse.

Figure 1: Vibrofeeder assembly

Table 3: Vibro-feeder assembly parameters

Feed rate	10 kgs/hr to 30 kgs/hr	**Motor capacity**	0.5 HP
Screw RPM	10 to 300	**Power supply**	220 V/ 440V, AC, 50 HZ
Hopper capacity	500 kgs	**Power consumption**	0.5 KW
Accuracy	± 2.5%		

V. Comparison result of THERMACT-B

THERMACT-B, solid combustion catalyst added in bagasse fuel. The effect of product after and before results shown below

Unburnt in fly ash

Figure 2 (a) Without THERMACT-B

(b) With THERMACT-B

- The effect of without THERMACT-B fly ash and bottom ash is blackish in color indicating presence of unburned carbon from an incomplete combustion.
- The effect of with THERMACT-B fly ash and bottom ash is whitish indicating absence of unburned carbons.

Clinker formation

- The effect of without THERMACT-B heavy and hard clinker.
- The effect of with THERMACT-B soft and reduced amount of clinker.

Figure 3 (a) Without THERMACT-B (b) With THERMACT-B

Flame characteristics

Figure 4 (a) Without THERMACT-B (b) With THERMACT-B

- The effect of without THERMACT-B flame colors is blackish indicating lower flame temperature and incomplete combustion.
- The effect of with THERMACT-B flame colors is bright orange/ yellow indicating higher flame temperature and more complete combustion.

VI. Results and discussion

Present work concern on increase boiler efficiency by studying various heat loosing activity during combustion process. Boiler efficiency can be reach as high as to pick point by minimizing the various heat losses. With reference of Mahuva sugar factory, there are four boilers mainly use bagasse as solid fuel. Considering energy audit data mainly heat loss occurs due to moisture content of bagasse only. By considering that fact, using catalyst efforts are make to reduce moisture content & also due to catalyst reaction CH_4 introduce in that process so addition heat produce within this process.

Table 4: Parameters of Flue Gas

		BOILER 1		BOILER 2		BOILER 3		BOILER 4	
PARAMETERS OF FLUE GAS	**UNITS**	**Pre trial**	**Post trial**	**Pre trial**	**Post trial**	**Pre trial**	**Post trial**	**Pre trial**	**Post trial**
O_2 at APH outlet	%	12.66	7.98	11.03	7.35	8.82	7.3	9.3	7.23
Co_2 at APH outlet	%	8.15	14.91	9.78	13.44	11.98	13.5	11.51	13.57
Co at APH outlet	ppm	754.15	662.27	783.95	669.13	996.1	648.92	1167.35	722.78
Excess air	%	157.7	62.6	113.45	54.02	73.1	53.22	80.95	52.6
APH outlet temperature	˚C	150.95	149	144.2	144.7	149	147.68	129.65	130.65
Boiler efficiency	**%**	**59.01**	**60.67**	**61.26**	**63.01**	**61.51**	**62.96**	**62.42**	**63.92**
Remarks	**%**	**2.82 % Improvement**		**2.86% Improvement**		**2.35% Improvement**		**2.4% Improvement**	

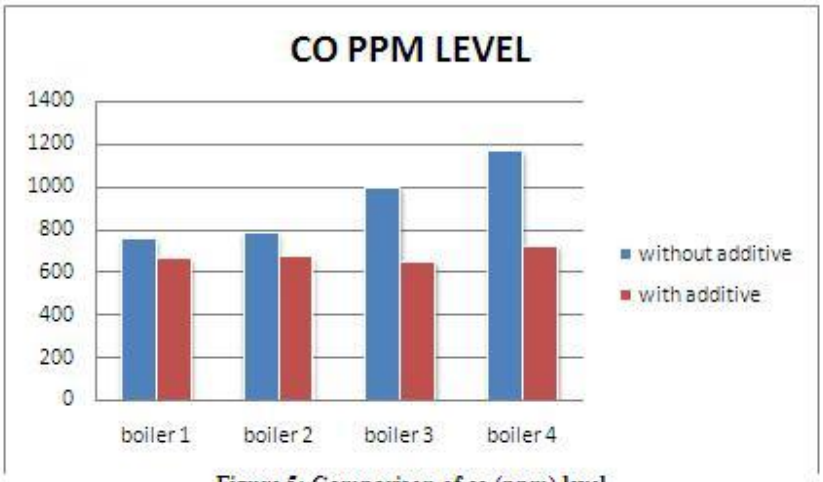

Figure 5: Comparison of co (ppm) level

Figure 5 shows that all boilers have tremendous reduction in CO PPM level due to catalyst reaction, in first catalyst reaction H_2O reacts with C and make CO then after during second catalyst reaction C react with H_2 and form CH_4 mean while part of CO reacts with ½ O_2 and form CO_2.

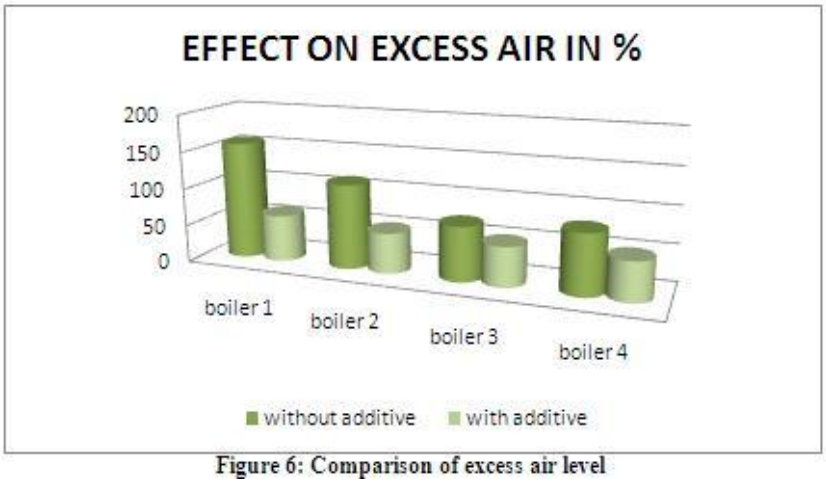

Figure 6: Comparison of excess air level

Figure 6 shows that with using additive there is great amount reduction in excess air in flue gases due to complete combustion of fuel.

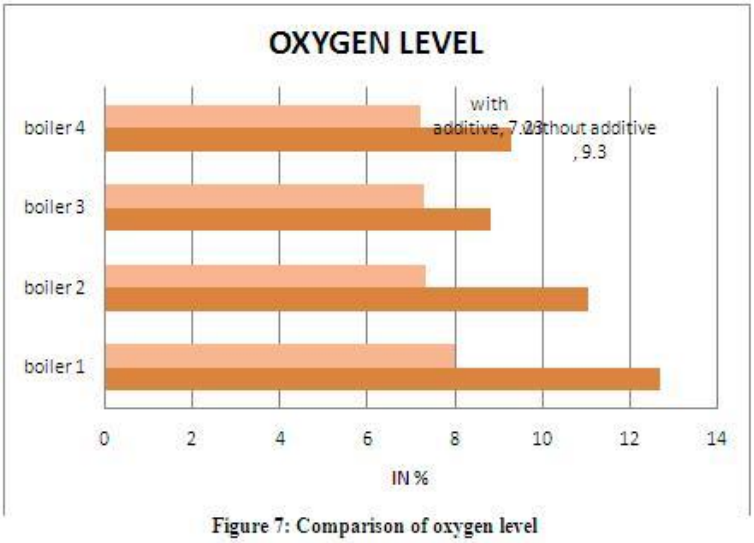

Figure 7: Comparison of oxygen level

Figure 7depicts that due to complete combustion there is reduction in oxygen level in flue gases. Due to catalytic reaction maximum amount of O_2 utilize in combustion process.

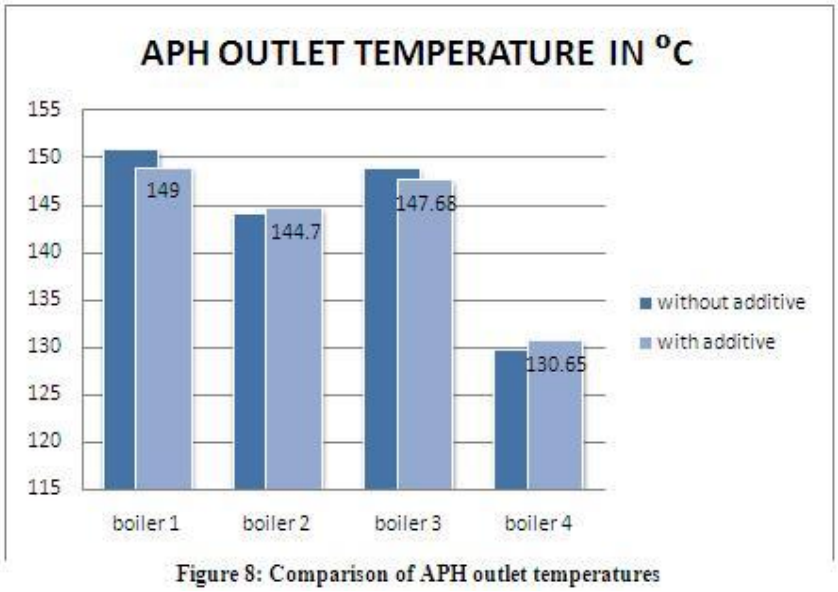

Figure 8: Comparison of APH outlet temperatures

Figure 8 shows that there is minor temperature reduction at APH due to reduction in moisture content during combustion process, major amount of heat is carried by moisture and reduction of moisture ultimately results in reduction in temperature.

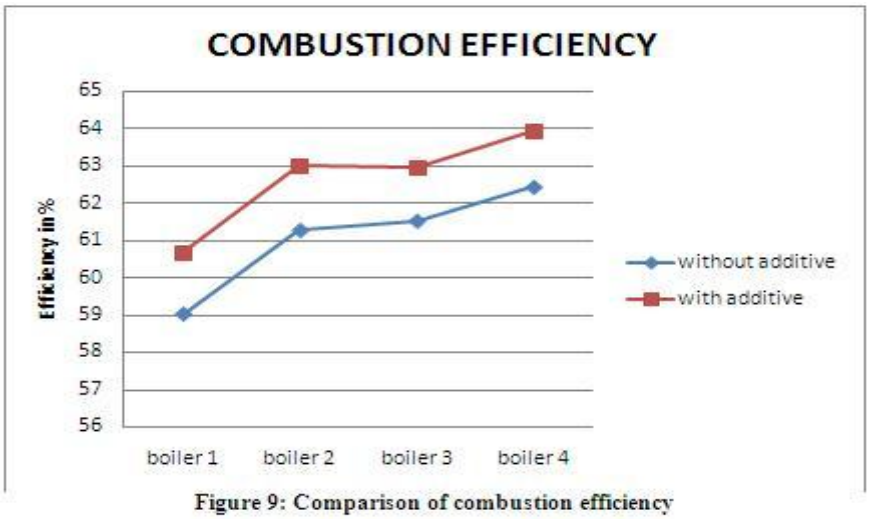

Figure 9: Comparison of combustion efficiency

Figure 9 shows that with the use of additive there are increasing in combustion efficiency due to reduction in heat loss activity and introducing CH_4 which provides extra heat.

VII. Conclusion

From considering overall analysis and results it is concluded that, the pre boiler efficiency measured by O_2 gas analyzer remains same as defined value without using solid combustion catalyst. It also shows that the efficiency of the pre-boiler leads to increase of the order of 2.82%, 2.86%, 2.35% and 2.4% related to four different observed boilers with use of solid combustion catalyst, which is more supportive and required for the reduction of cost. The overall 2.61% improvement in the boiler efficiency as well as 3.3% reduction in baggase consumption. The overall saving of rupees 41, 19,000 with this efficiency is done after using the catalyst.

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