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Efficiency Improvement Strategies for Dyeing and Printing Mill Boiler – Case Study.

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Abstract— In this paper, the findings of boiler house efficiency improvement study is carried out in a large boiler house of a dying and printing mill has been presented. The causes of poor boiler efficiency is various heat losses such as loss due to unburnt carbon, loss due to dry flue gas, loss due to moisture in fuel, loss due to radiation, loss due to blow down and loss due to burning of hydrogen, etc. The various heat losses were analyzed and certain recommendations were made to the plant management for implementation in turn to increase the boiler efficiency. Economic analysis reveals that the expenditure on the proposed system will be recovered in a short span of time. This work, with only two recommendations implemented, has resulted in net increase of 7.7% in overall boiler efficiency and an annual saving of Rs. 44,47,352/-. In addition to this, regular monitoring of boiler operation can help a great deal in optimizing the energy usage and also improve boiler efficiency.

Keywords- Energy conservation, Boiler efficiency, Boiler heat losses, aspen +

I. INTRODUCTION.

Energy is an indispensable instrument in the progress of human race. Today's high standard living has been possible only through the thoughtful usage of various energy resources at command. Realizing the fact that energy is the sinew of economic growth, energy management and energy conservation are of supreme importance. The above along with energy efficiency improvement are the only cost-effective and viable means of ensuring the proper use of finite natural resources, minimizing operating expenses and increasing the profitability of enterprises. There is a need felt to carry out energy audit and efficiency test to analyze the various heat losses with an aim to identify the major heat losses and causes of poor boiler efficiency.

Aim of this work is not to present something new rather to raise awareness and to show the tremendous energy and cost saving opportunities missed as a result of observing some simple and obvious conservation measure. Objective of this work is to check and measure the efficiency of a dyeing and printing mill water tube boiler. Analysis on different parameters is done to improve the energy efficiency of boiler and steam system.

II. DETAILS OF THE CASE STUDY.

After calculation, the sum of various heat losses and boiler efficiency is 42.74 % and 57.26%, respectively [Table 1].

Table 1. Result of efficiency test.

Theoretical air requirement	4.225445	kg / kg of coal
% Excess air required for complete combustion of coal		
method 1 (from % O_2)	121.0526	%
method 2 (from %CO_2)	154.18587	%

Actual air requirement	9.34045	kg / kg of coal
Mass of dry flue gas exhausted from stack	7.014593	%
Heat loss in dry flue gas	10.1552	%
Heat loss due to H_2 in fuel	4.4864	%
Heat loss due to moisture in fuel	8.3346	%
Heat loss due to moisture in air	0.4080	%
Heat loss due to CO formation	3.3444	%
Heat loss in fly ash	0.0219	%
Heat loss due to unburned fuel in bottom ash	0.7056	%
Heat loss due to radiation & convection	2836.337	kcal / m^2
% surface loss	15.2768	%
Boiler efficiency	57.26885	%

i. **Heat loss due to Dry flue gas**: By using indirect method heat loss due to the dry flue gas is found to be 10.15%. This is the causes of excess air. N_2 present is 1.16% and the amount of sulphur in fuel is 0.8% which is undesirable. This loss due to dry flue gas can be controlled by damping the ash entering the boiler and optimising the stack temperature to reduce $N_{2.}$ Use of low sulphur content fuel is suggestible.

ii. **Heat loss due to H_2 in fuel:** On analysis, the fuel that is used here contains 2.89% of H_2. The total heat loss due to the presence of 2.89% of H_2 is 4.48%. Even though H_2 is a combustible gas, on oxidation it gets converted into water.

iii. **Heat loss due to evaporation of moisture in fuel:** The amount of moisture in the fuel is 48.32%. Because of this excess moisture in fuel, the heat loss due to evaporation of moisture is 8.33%. This can be rectified by preheating the fuel.

iv. **Heat loss due to moisture in air:** Heat loss due to the moisture in air is 0.40%. This is the effect of humidity present in the atmospheric air. This can be rectified by passing the combustion air through a super heater.

v. **Heat loss due to CO formation:** CO is formed because of incomplete combustion. Heat loss due to CO formation is 3.34%. To overcome CO formation, controlled combustion should be preferred.

vi. **Heat loss due to fly ash:** Heat loss due to fly ash is the cause of improper coal sizing and excess air. Here it is 0.021%.

vii. **Heat loss due to in unburnt in bottom ash:** On analysis heat loss due to fly ash is 0.7%. This is the causes of the presences of 9.10% of ash. This is also one of the effects of excess air and coal sizing. It can be controlled by using good burner design, proper fuel preparation and by damping the excess air.

viii. **Heat loss due radiation & convection:** Heat loss due to convection and radiation is 15.82 %. The main causes of this are poor structural design of boiler and insulation. This can be rectified by using proper insulating material and by modifying the boiler design.

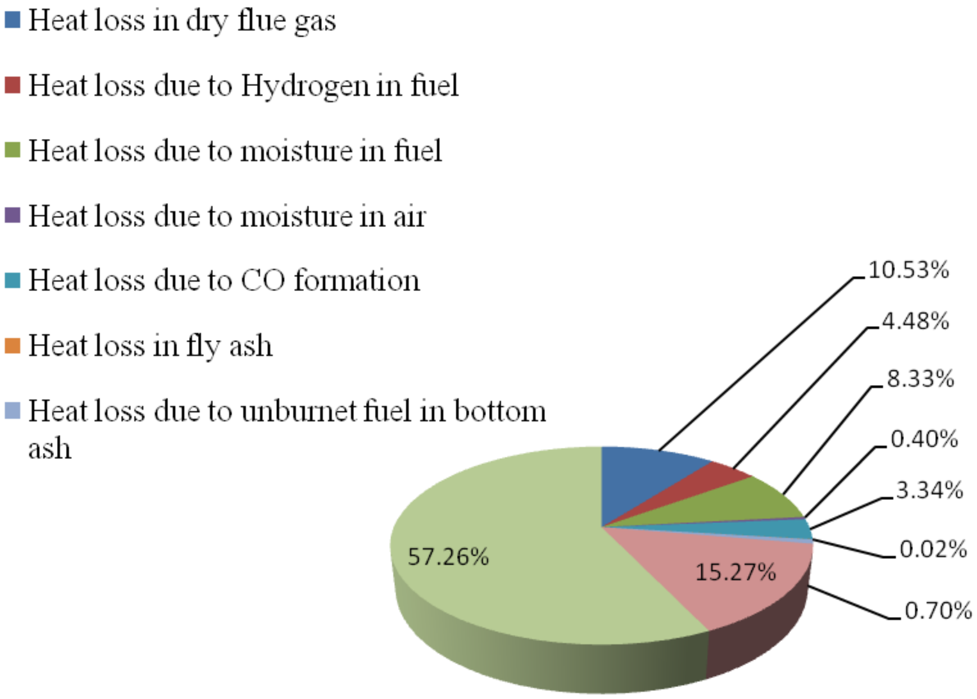


Figure 1. % Heat Losses by using indirect method

III. IMPLEMENTATION AND RECOMMENDATIONS.

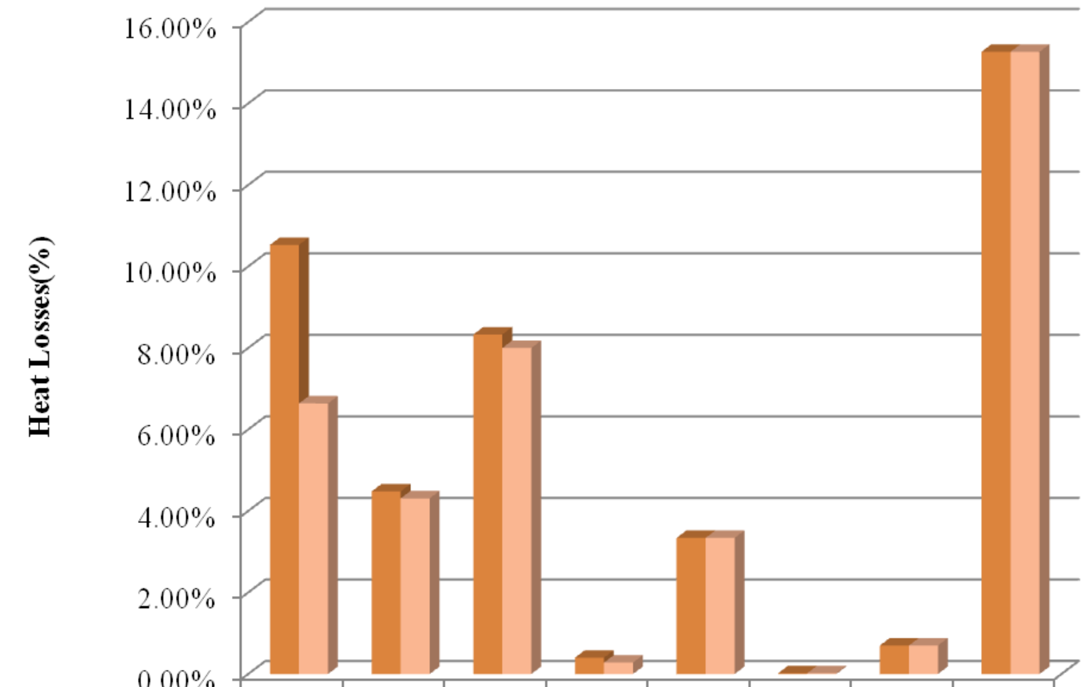
3.1. Proposed model of Single pass counter current shell and tube heat exchanger.

Table 2. Thermal results

Stream	Inlet parameters	Outlet parameters
Flue gas, m =3.824 kg/ s	Temperature: 210°C	Temperature: 152°C
Feed water, m = 1.44 kg/s	Temperature: 60°C	Temperature: 100°C

Specification of the economizer obtained by simulation software aspen +

Particulars	**Value**
Heat –duty	208069 kcal/hr
Over –all heat transfer coefficient	850 w/m^{2}k
LMTD	100
Actual Heat exchange area	2.9 m^2
Design Heat exchange area	3.2 m^2
Diameter of the tube	19.04 mm
Number of tube	26
Length of pipe	2 m
Diameter of the shell	8 inch



	1	2	3	4	5	6	7	8
Without Economizer	10.53%	4.48%	8.33%	0.40%	3.34%	0.02%	0.70%	15.27%
With Economizer	6.64%	4.31%	8.00%	0.28%	3.34%	0.02%	0.70%	15.27%

Figure: 2 graphs representing the heat loss with and without economizer

1. Heat loss in dry flue gas.
2. Heat loss due to H_2 in fuel.
3. Heat loss due to moisture in fuel
4. Heat loss due to moisture in air.
5. Heat loss due to CO formation.
6. Heat loss due to unburnt fuel in fly ash
7. Heat loss due to unburnt fuel in bottom ash
8. Heat loss due to radiation & convection

3.2. Controlling excess air.

Controlling excess air to optimum level always results in reduction of flue gas heat losses. For every 1% reduction in excess air there is approximately 0.6% rise in efficiency.

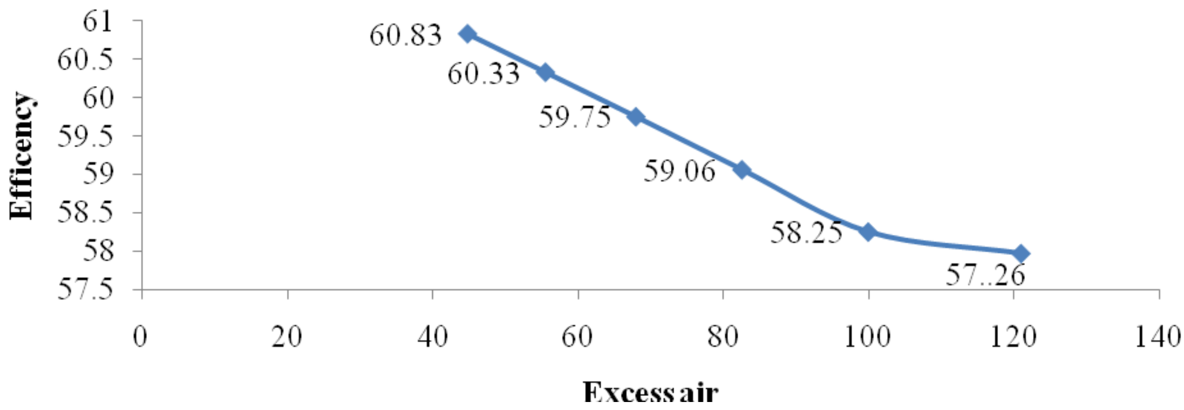


Figure: 3 graph representing efficiency Vs excess air

III. CONCLUSION.

1. On installing the economiser, efficiency of the boiler increases by 3.95% with a fuel saving of 102 Kg/Hr and an annual saving of Rs. 23, 23, 152/-
2. By controlling the excess air, utilization of O_2 can be made optimum by bringing down the liberation of O_2 from 11.5% to 6.5 %. The efficiency of the boiler increases by 3.57% and a fuel saving of 93 Kg/Hr with an annual saving of Rs.21,24, 200/-
3. The moisture control in the fuel is 48.21% which is undesirable. It has to be properly treated or preheated before introducing into the combustion chamber.
4. On visiting the coal storage area, it is found that the size of the coal is 12-15 mm which is not beneficial for combustion. On decreasing the size to 4-5 mm, combustion can be made more effective.
5. Surface losses are around 15.28% which can be reduced by proper insulation

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