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# PERFORMANCE OPTIMIZATION OF EXISTING BOILERS AT SHAKARGANJ LLIMITED, JHANG

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## ABSTRACT

There are numerous well-documented phenomena that plague the efficient operation of bagasse boilers. Key Parameters that influence boiler combustion and operation are studied with the aid of combustion and flue gas analyzer. Combustion stability and efficiency is linked to various parameters such as fuel moisture and air temperatures supplied to the boiler and are investigated in this paper as part of a case study. The paper highlights number of modern developments that have been implemented at Shakarganj Limited, Jhang to optimize the existing boiler design to enhance the Boiler capacity from 65 tph to 80 tph. Along with that impact of various devices on performance improvement of boiler has been shown with experimental data for comprehensive evaluation of boiler operation and combustion efficiency. Results of suitable measures after installation of low cost retrofits to reduce losses including combustion instabilities, unburnt fuel, moisture in fuel and deposition of ash on tubes are also part of the paper.

**Key Words:** Bagasse, Boiler, Air Heater, Economizer, Spreaders, Bagasse Dryer, Ash Cyclones, Flue Gases

## INTRODUCTION

Shakarganj Limited, incorporated in 1967, transform renew-able crops such as sugarcane into value added products comprising of refined sugar. It has the manufacturing facility in Jhang District. An increase in alternative uses of bagasse (i.e. cane wood, Bio fuel, $CO_2$ & Steel plant), has developed an interest in energy efficiency of which the boiler efficiency forms an essential part. The boiler efficiency not only depends on the boiler configuration and operation but also on the fuel being used. This paper describes a conventional sugar factory boiler, the analysis of boiler operation and describes the modifications applied for improving boiler efficiency. Shakarganj has a capacity of 12000 TCD. Plant requires 263tph steam which includes 18tph steam required for the distillery. Sugarcane bagasse is used as boiler fuel containing 51-52% moisture. Brief introduction of boilers is as under:

***Observations of Existing Boilers:***

The efficiency of the boiler at 75 tons/hr. (01 No. Boiler) was approx. 64-66% @ NCV. Estimated losses due to: Unburnt 10 to 12 % Radiation and convection losses: 6 to 8% Heat losses through stack: 18 to 20 % High combustion instability was observed in boiler through furnace ash analysis i.e. Presence of unburnt bagasse particles in ash. High pressure losses at Ash Cyclones (16 mbar). Poor Air to Fuel ratio.

## REVIEW AND ANALYSIS OF BOILER OPERATION

**Major areas under analysis:** Boiler Configuration and Operation, Combustion stability, Boiler efficiency

Comprehensive evaluation of boilers was done considering the above mentioned areas with the help of Flue gas analyzer. Below table shows some results of evaluation:

## INSTALLATIONS/ MODIFICATIONS APPLIED TO EXISTING BOILERS

Based on the outcomes of evaluation, modifications in the existing boilers were applied. Modification and their results are discussed below.

**Installation of Boiler retrofits:**

Installation of Re Grit Re-Firing system
Installation of Pulsating Dampers
Installation of Over firing nozzles
Installation of Air distribution plate under the Grate
Installation of Bio Gas burners
Installation of Economizer

**Modifications Applied:**
Modification of Ash Cyclones

***RE GRIT RE FIRING SYSTEM:***

This system recovers the high unburnt bagasse from boiler through Ash hoppers and supplied with an Air duct from Secondary fan to push it in boiler furnace to use it again as fuel resulting in reduction in unburnt losses and saving bagasse.

***Before System Installation:***
Fly ash was blackish that means high unburnt bagasse in boiler. (Unburnt losses were 10%-12%)

***After System Installation Benefits:***
This System is used to recover unburnt bagasse from boiler. Unburnt bagasse is again fired in furnace to burn. Losses due to un burnt fuel reduced to 4 to 6% and increasing boiler efficiency by 2%.


**Re Grit Re Firing System installed at Boiler**

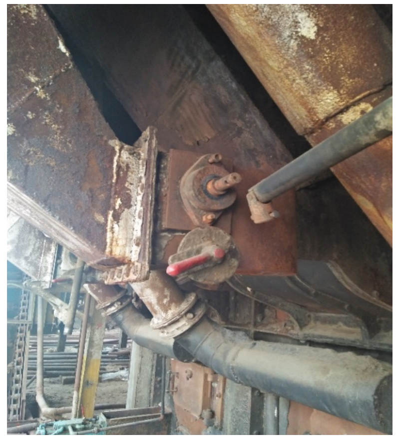
***Bagasse Saving By Re Grit Re Firing System:***

| | | |
|---|---|---|
| Efficiency rise at average of 75 Ton/hr load | = 02% | |
| Steam Saving at 01 Boiler | = 75x0.02 | = 1.5 Tons/hr |
| Bagasse Saving at 01 Boiler | = 1.5/1.9 | = 0.789 Tons/hr |
| Bagasse Saving at 02 Nos. Boilers | = 0.789x2 | = 1.57 Tons/Hr |
| Bagasse Saving per day | = 24x1.57 | = **37.89 Tons/day** |
| Total amount saved per day | = 3000x37.89 | ***Rs 113,670/-*** |

**BAGASSE SPREADING AND FIRING SYSTEM:**
Previously Bagasse spreading system was not so much efficient for feeding and spreading of bagasse over the full grate. Few improvements were done to make the existing system more efficient as below:
Improving the condition of the existing spreaders by proper adjustment facilities of guide plate from outside.
Installation of pulsating dampers with common drive so that the bagasse will be more equalized spread over the depth of the furnace.
Installation of over firing nozzles in side walls of furnace and fed with the air from secondary air fans.
Installation of air baffle in hopper under the grate.
Installation of twin roller feeders with picker roller in order to ensure continuous supply of bagasse and breaking of lumps so that fine particles can be spread.

***PULSATING DAMPERS:***
Shakarganj has installed 02 types of Pulsating dampers
Internal Pulsating Dampers

**Internal Pulsating Dampers**



**External Pulsating Dampers**

**External Pulsating Dampers**

***BIO GAS BURNER:***

As per previous practice biogas was blown into the boiler furnace without proper mixing it with combustion air. This resulted in in complete firing in boiler. Also resulting in high fouling and rapid corrosion of super heater.

***Bio Gas Burner at Shakarganj:***

Biogas burners (Wes man Design) with air supply through existing FD Fan have been installed.

Using this burner made combustion and temperature stable, also air to fuel ratio improved. Uniform spreading of Bio gas with boiler tubes. Which burner in furnace, hence minimizing it's direct contact with boiler tubes. Which decrease corrosion of tubes.

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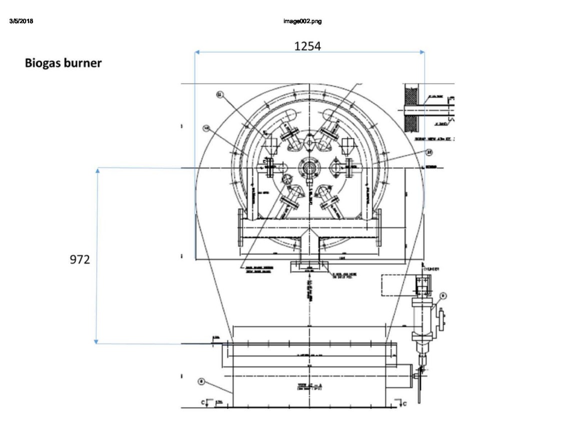


**Bio Gas Burner Design**

***ECONOMIZER for Pre Heating of Boiler Feed Water:***

Generally economizers are used to reduce energy consumption. In Boiler their function is to pre heat the boiler feed water temperature. Captures the waste heat from boiler flue gases and transfer it to the boiler feed water to raise the temperature up to 30°C.

***Economizer Installed at Shakarganj Boilers:***

Shakarganj has installed economizers at 04 Nos. of boilers with heating surface of 320 m². It raises the feed water temperature about 30°C from 100-105°C to 130-135°C. Below is some calculated data for savings made by economizers.

| | | |
|---|---|---|
| Efficiency Rise With 10 °C temperature rise in feed water | | = 01% |
| Efficiency with 20°C temperature rise of feed water. (01 Boiler) | | = 02% |
| Steam Saving at One Boiler | | = 75x0.02 |
| Steam Saving at One Boiler | | = 1.5 Tons/hr |
| Bagasse Saving at One Boiler | = 1.5/1.9 | = 0.79 Tons/hr |
| Bagasse Saving at 04 Nos. Boiler | = 0.79x4 | = 3.16 Tons/hr |
| Bagasse Saving per day | = 24x3.16 | = **75.44 Tons/day** |
| Amount Saving | = 75.44x3000 | **Rs. 227,520** |

Below graph explicit the bagasse saving when compared with different parameters after evaluation.

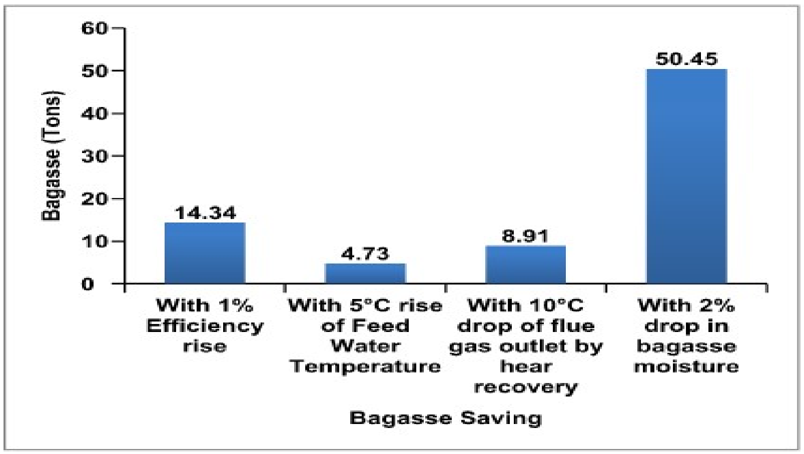


**Fig.1 Bagasse saving vs Improved Boiler Parameters**

***THE ASH CYCLONES:***
Smaller cyclones replaced with greater size (5-6 % of existing cyclones size) t2 Where allow a pressure drop of 8 mbar at 80 tph capacity.

***Problems Faced:***
Ash Cyclone size was too small. Boiler was running overpressure at higher loads which made difficult to keep the boiler load in control.
The angle of the swirls in cyclones was very small, which made the cyclone efficiency very low.

***Modifications:***
Size of cyclones increased (5-6 %) so that boiler can be run properly under pressure in furnace with maximum clearance. The angle of swirls also changed to improve the dust collection. Pressure drop of 8 mbar at 80 tph capacity.

***CAPACITY ENHANCEMENT OF I.D FANS AT BOILER***
Volumetric capacity of all ID fans enhanced to 5600 m³/min from 4750 m³/min.

**BOILER EFFICIENCY**
Boiler efficiency is the percentage of heat input utilized in generation of steam. Efficiency of solid fuel boiler depends upon different factors like type of fuel, proper Where of fuel and combustion method. The easiest and most cost effective method is to calculate the efficiency value on five broad elements: Boiler stacks temperature, Heat content of fuel, Fuel specification, Excess air levels & ambient air temperature and relative humidity.

**Boiler Efficiency = Energy Steam – Energy BFW x100**

**Energy Fuel**
This method is known as direct method which is based on simply that efficiency is equal to output divide. Where by input. The other method is the indirect method of calculating boiler efficiency. To account the boiler losses a better and precise formula for efficiency calculation is given below:

$$\eta = \frac{Mv}{NCV} \times 100$$

Where
Mv= Heat transfer to steam per kg of bagasse burnt (Kcal/Kg)

NCV=Net calorific value (Kcal/Kg)
Mv= (N.C.V-Q). α.β.γ

Where
Q= Sensible heat loss in flue gas (Kcal/Kg)

α.β.γ = Co-efficient if x-tics of combustion efficiency

α = Co-efficient representing heat loss due to un-burnt 2solids.

B= Co-efficient to account for heat losses by radiation.

γ = Co-efficient of incomplete combustion.

For spreader stoker furnaces, its normal value α is taken as 0.975. β value varies from 0.95 to 0.99 for more or less efficient lagging. γ value is taken as 0.97.

Q= [(1-M) x (1.4RA-0.13) + 0.5] t

Where:
M= % Moisture in Bagasse
RA=Ratio of excess Air
t=Temperature of Flue gases

Here RA is ratio of excess air usually taken 1.45 for bagasse.

**Calorific Value:**
There are two different calorific values, a gross calorific value (GCV) and a net calo calorific rific value (NCV).

The GCV is the total energy released during the combustion process and can only be accurately determined by using a bomb calorimeter.

The NCV is the GCV minus the latent heat of the water formed by the combustion process and is obtained by calculation. The experimental procedure and method of calculation are laid down in ISO 1928 (Anon 1995).

Some comparison of bagasse NCV vs Moisture is shown in below graph:

The Boiler efficiency is also linked with flue gas temperature at the outlet. Trend with comparison is shown as below.

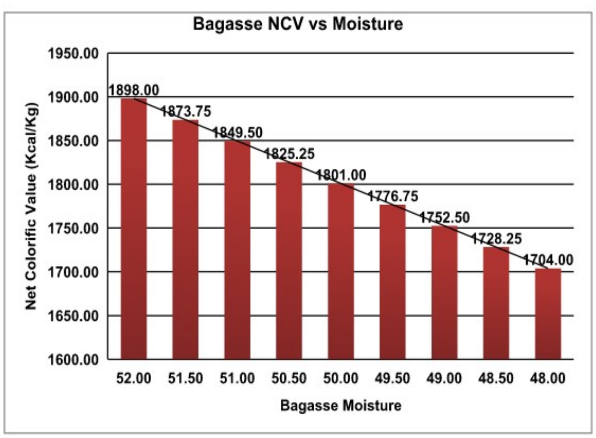


Fig.2 Bagasse NCV vs Moisture

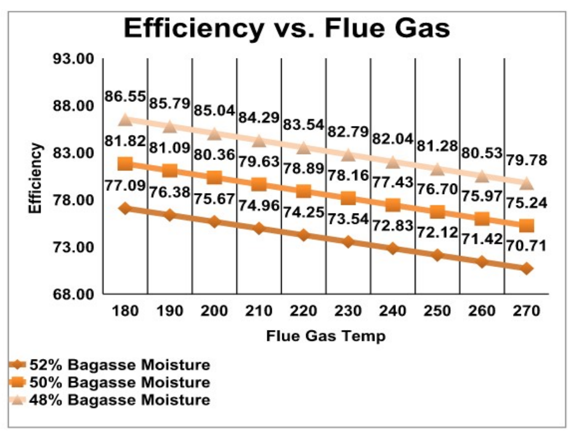


Fig.3 Boiler Efficiency vs Flue Gas Temp.

**CONCLUSION**

The modifications done in the existing boilers system has given much improvement and benefits for performance optimization and efficiency enhancement of existing boilers. i.e.

**Boiler Efficiency:**
Increase from 66% to 76%
Re Grit Re-Firing System:
Increased efficiency by 2%
Bagasse
Saving 37.89 Tons/Day
Un burnt losses reduced 4-6%

**Pulsating dampers:**
Uniform spreading of bagasse

**Bio Gas Burner:**
Complete Combustion of bio gas, Minimized corrosion formation on tubes

**Economizer:**
20°C Feed Water Temperature raise
02% efficiency rise
Bagasse Saving 75.44 Tons/ Day
Increase in size of Ash

**Cyclones:**
Boiler runs under pressure

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**Table-1 Boilers Installed at Shakarganj**

| Design | Type | Heating Surface (m²) | Steam Production (Tons/Hr.) | Type of Fuel | Operating Pressure Kg / cm² | Operating Temperature |
|---|---|---|---|---|---|---|
| Babcock & Wilcox | Water Tube Boiler | 1,361 | 40 | Bagasse/ Bio Gas/ Sui Gas/ Furnace Oil | 25 | 350 °C |
| FCB Franc | | 2,071 | 80 | | | |
| Yoshimini Japan | | 2,220 | 80 | | | |
| Yoshimini Japan | | 2,220 | 80 | | | |
| Yoshimini Japan | | 2,220 | 80 at NCR | | | |

**Table-2 Evaluation Results with Flue Gas Analyzer**

| Description | Value | Description | Value |
|---|---|---|---|
| Furnace Pressure | -4.38 mmH2O | Flue Gas Outlet Temperature Boiler | 321 °C |
| Flue Gas Temperature Outlet Flue Gas Arrestor | 187 °C | Air Temperature Air to Grate | 173 °C |
| O2 Flue Gas Outlet Boiler | 2.8/3 Vol%dry | CO Flue Gas Outlet Boiler | 2500 ppmv |
| O2 Flue Outlet ID Fan | 5.8-6.8 Vol%dry | CO Outlet ID Fan | 2000-8000 ppmv |
| Flue Gas Pressure at ID Fan suction | -2 mbar | Flue Gas Pressure at Outlet ID Fan | -18 mbar |
| Air Pressure at Outlet FD Fan | 7 mbar | Air Pressure at Outlet Secondary Air Fan | 20 mbar |
| Pressure Drop Over Fly Ash Arrestor | 16 mbar | Calculated Pressure Drop Over Fly Ash Arrestor | 16.4 mbar |

**REFERENCES**

Cengel, A. Yunus, 20.15. *Heat and Mass Transfer Fundamentals & Applications*, 5th Edition, McGraw-Hill Education, New York.

WIENESE, A. *Boilers, Boiler Fuel and Boiler Efficiency,* Sugar Milling Research Institute, Durban 4041, South Africa

Adriano V. Ensinas; Silvia A. Nebra, *Energy Department – State University of Campinas* Miguel A. Lozano; Luis Serra, *Mechanical Engineering Department – University of Zaragoza* Analysis of Cogeneration Systems In Sugar Cane Factories - Alternatives Of Steam And Combined Cycle Power Plants

DESCON 2011. Engineering Limited, Efficiency Improvement in Existing 80 Ton/Hr. Bagasse Fired Low Pressure Boiler. Paper in 45th Annual Convention PSST.

http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0104-66321998000100006
https://boilersinfo.com/increase-boiler-efficiency/