PERFORMANCE IMPROVEMENT OF A SINGLE PAN TRADITIONAL JAGGERY MAKING FURNACE BY USING FINS AND BAFFLE

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ABSTRACT

The jaggery furnace is used for manufacturing jaggery and related products in the rural area of India. It gives good employability and revenue to the farmers. In this study the concept of fins and baffle has been used for heating purpose for improving efficiency of open pan jaggery making furnace. Pan is the integral part of these furnaces where boiling of sugarcane juice takes place. Parallel fins were provided to the bottom surface of pan. Fins were placed parallel to the movement of flames and hot flue gases generated due to combustion of bagasse. Fins helped in more heat transfer to the sugarcane juice being concentrated and baffle retains the contact of flue gases. Thermal efficiency increased by 9.44% compared with traditional furnace, which resulted in saving of fuel and energy (31.34%).

Keywords: Jaggery Furnace, Fins, Baffles, Energy Saving.

I INTRODUCTION

The jaggery is obtained from sugarcane juice after crushing it and remaining material is called bagasse. Bagasse may be used in jaggery furnaces, sugar industry, manufacturing bricks, chemical industries, textile industries for steam generation, etc. It is a traditional process industry in India, which provides rural employment. Bagasse is used as a fuel, which saves the other fuel. Heat generated in the combustion of the bagasse is utilized for evaporation of the water in the juice. Any efficiency improvement in the thermal performance of a jaggery furnace saves the bagasse fuel and the atmosphere.

At village level jaggery making is done using juice obtained after crushing sugarcane at the site with a crusher. The bagasse left after crushing is sun dried in open yard for reducing the moisture content and used as fuel in the furnace for jaggery making. A study was conducted to evaluate the overall heat utilization efficiency of these furnaces.

A typical jaggery making furnace consists of fuel feeding, opening, grate, fire place, chimney, and ash chamber. At rural place, it is constructed with brick and mud below the ground level as the revenue is less with farmers. The smoke produced during combustion is made to go out through a chimney of the furnace. Manually the bagasse is continuously fed through the fuel feed opening at regular interval of time. The sugarcane juice is kept in a GI vessel placed over the fire place and boiled. The study revealed that 650 kg of juice and 350 kg of bagasse were obtained from one tonne of sugarcane crushed[2]. The crushed bagasse has 50% moisture content and after sun drying it

reduces to 20% [6]. Nearly 50% of total sugarcane produced in the country is used for manufacture of about 8 million tonnes of jaggery[4].

The scope suggested by Deshpande et. al.[1] is taken as the basis for the study. Also the poor finiancial condition of the rural farmers is considered for improving the traditional furnace instead of major changes in construction. In this study actual environment is created and sugarcane juice is heated to get closer reading.

Figure 1. Photo of Jaggery Furnace

Figure 2. Photo of Jaggery Pan With Fins

II LITERATURE REVIEW

A Sardeshpande et. al.[1] have calculated the termal efficiency of the frnace to be 29% of the total energy supplied. Also they have proposed the procedure for calculating the thermal performance of the jaggery furnace. K. Sada Shiva Rao et. al. [2] have studied the traditional jaggery furnace and laid the procedure for calculation of thermal efficiency. And thermal efficiency was 14.75%. Also they have suggested the methods to increase it. Dr. R. D. Singh et.al.[3] done the investigation of two pan jaggery furnace and found about 15% in increase in overall efficiency.

H. K. Madan et. al.[4] have improved the design of the furnace and chimney. In this the refractory cement fire bricks were used. Three pans of M.S. material were placed over the furnace and found increase in thermal efficiency of the furnace. Anwar S.I. [6] has modified the traditional jaggery pan and gutter with fins and found improvement in the thermal efficiency. He has used water as the working fluid instead of sugarcane juice. We found this area for studying the effect of fins and baffles on the traditional jaggery furnace using sugarcane juice instead of water.

III EXPERIMENATL SET UP AND PROCEDURE

The Figure 1. shows the photo of the actual single pan jaggery furnace. It is having a pan of 200mm outer diameter, 165 mm inner diameter, 49 mm height and having thickness 2 mm. It was of mild steel material. The total seven fins were welded to the pan of thickness 3mm and depth 25 mm having the length 30cm(1No.) placed at centre, 28cm(2Nos.),23cm(2Nos.),15cm(2Nos.) were placed symmetrically. The combustion chamber was built of brick work having size 900mm x 900mmx 600mm. The grate was placed to accommodate bagasse. The bagasse feeding

hole was placed at the top. The readings were taken for traditional furnace. Then the fins were welded to the pan to bottom side, parallel to the flue gas direction. That is why these are known as parallel fins. The baffle of 500 mmx400 mm size was placed at the centre of the furnace from the top side near the exit of flue gases.

IV MATHEMATICAL MODELING

The following procedure is used for finding the thermal efficiency of the furnace [6] and [2];

1. Mass of jaggery produced = mass of juice – mass of water evaporated – mass of slag

$$m_{jaggery} = m_{juice} - m_{slag}$$

2. Heat energy required for heating the juice, $Q_{juice} = m_{juice} C_{pjuice}(T_{juice} - T_{atm,})$
3. Total latent heat of vaporization of water , $Q_{evapoation} = m_{water} \times h_{fg}$
4. Total heat utilized for heating the juice = Heat energy required for heating the juice + Total latent heat of vaporization of water

$$Q_{output} = Q_{juice} + Q_{evapoation}$$

5. Heat energy input per batch, $Q_{input} = m_{bagasse} \times C_{pbagasse}$
6. Thermal efficiency, $\eta_{thermal} = Q_{output} / Q_{input}$

V EXPERIMENTAL RESULTS AND DISCUSSIONS

In order to evaluate the system performance of jaggery making furnace, various details such as juice recovery obtained after crushing sugarcane, amount of bagasse obtained, the moisture content before and after sun drying, the amount and frequency of feeding bagasse into the furnace were noted. The temperature of juice during boiling and the temperature of flue gas were also observed. A model of jaggery making furnace was constructed in the workshop. The collected data for traditional and improved furnace is given in the Table1.

Table 1. Comparison between convetional and improved furnace

Sr.No.	Particulars	Traditional furnace	Improvred furnace
1	Mass of sugarcane juice per batch, m_{juice}	3 kg	3 kg
2	Mass of bagasse required per batch, $m_{bagasse}$	2.3 kg	1.10 kg
3	Mass of jaggery produced per batch, $m_{jaggery}$	0.60 kg	0.45 kg
4	Mass of slag (mud) removed per batch, m_{slag}	0.025 kg	0.020 kg
5	Mass of water evaporated per batch, m_{water}	2.375 kg	1.825 kg
6	Initial room temperature of furnace, T_{atm}	33 ^{0}C	33 ^{0}C
7	Initial temperature of juice, *Tji*	30 ^{0}C	30 ^{0}C
8	Final temperature of juice, *Tjo*	95 ^{0}C	95 ^{0}C

9	Flue gas temperatura, T_{gas}	217 ^{0}C	152 ^{0}C
10	The temperature of furnace during combustión, $T_{furnace}$	570 ^{0}C	570 ^{0}C
11	Time required for one batch, t	45 min.	24 min.

VI CONCLUSIONS

The heat utilization efficiency of single pan open jaggery making furnace increased by 9.44% by using modified pan having fins and baffle. It resulted in saving of bagasse from 2.3 kg to 1.1 kg as shown in Figure 3. The saved bagasse can be diverted to other sectors for extra revenue generation and leads to added advantage to the jaggery manufacturer. Improvement in efficiency would also be helped in time saving from 45 min. to 24 min.

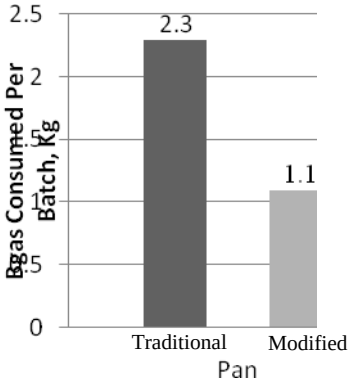

Figure 3. Effect of modifed pan on bagasse consumption.

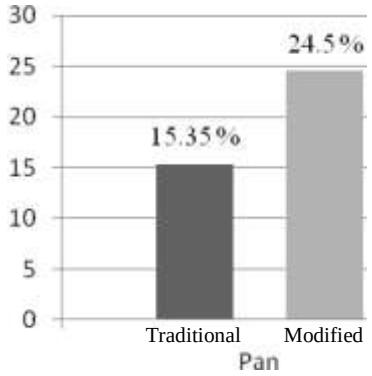

Figure 4. Effect of modifed pan on termal efficiency

VII SCOPE FOR IMPROVEMENT

While working with the existing and improved jaggery plants, it has been experienced that there is still scope of further improvement of the plant.

a. By using more than two pans preheating of the juice can be obtained before releasing the flue gases in the atmosphere through chimeny.
b. Optimum bagasse feeding to jaggery furnace is required. For this a semi automatic mechanical feeding system may be designed.
c. Use of air blowers may be exercised for better combustion.
d. CFD simulation can be done.

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Nomenclature

m_{juice} = mass of sugarcane juice per batch, kg.
$m_{bagasse}$ = mass of bagasse required per batch, kg.
$m_{jaggery}$ = mass of jaggery produced per batch, kg.
m_{slag} = mass of slag (mud) removed per batch, kg.
m_{water} = mass of water evaporated per batch, kg.
$C_{pbagasse}$ = specific heat of bagasse, kJ/kg K.
C_{pjuice} = specific heat of juice, kJ/kg K.
T_{atm} = initial room temperature of furnace, ^{o}C.
T_{ji} =initial temperature of juice, ^{o}C.
T_{jo} = final temperature of juice, ^{o}C.
T_{gas} = flue gas temperatura, ^{o}C.
T_{f} = the inside temperature of furnace during combustión, ^{o}C.
t = time required for one batch, min.

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