EXPERIMENTATION ON SINGLE PAN JAGGERY MAKING FURNACE FOR PERFORMANCE IMPROVEMENT

MR. RELEKAR KEDAR MADANRAO
Lecturer, Sant Tukaram Polytechnic, Indori, Maharashtra, India

MR. MOHITE DIGVIJAY MOHANKUMAR
Lecturer, D.Y. Patil college of engineering & Polytechnic, Talsande, Maharashtra, India

MR. PATIL SAGAR VIJAYKUMAR
Lecturer, Sant Tukaram Polytechnic, Indori, Maharashtra, India

ABSTRACT
Jaggery is traditional Indian sweetener with several uses in daily food preparations. Jaggery is produced at village level small scale cottage industries. About 20.07% of total sugarcane produced in India is consumed by Jaggery & khandsari industries. It is estimated that, by 2020 the per capita consumption of Jaggery would increase to 40 Kg/annum from current level of 26.47 Kg/annum and the country would need about 23.75 MT against present production level of 8 MT.

The production process of Jaggery involves crushing of cane, boiling and concentration of juice, molding into the standard shapes and sizes & suitable packaging. There are strong indications that Jaggery cottage industry would continue to play an important role in processing sugarcane at rural level and in creating employment opportunities to millions of people in rural areas. However no much scientific and systematic work is carried out for improving the performance of this industry. This paper deals with evaluation of thermal efficiency of traditional single pan Jaggery furnace and modified single pan Jaggery furnace. The trials were conducted on prototype Jaggery plant and it was found that the thermal efficiency of traditional Jaggery plant increased by 9.15% due to modifications in the traditional plant.

KEYWORDS: Single pan furnace, Jaggery making process, Bagasse consumption

INTRODUCTION
In India 281 million tonnes of sugarcane is produced annually. This sugarcane is processed for producing sweetness like sugar, Jaggery or khandsari. Out of the total sugarcane produced, 66.7% is used for making sugar and 20.7% is utilized by Jaggery and khandsari under the decentralized sector. Remaining is used for seed, feed, chewing or raw juice drinking purpose [2]. Sugarcane juice concentration, while processing sugarcane for above sweeteners, is one of the important unit operations. Jaggery and khandsari, are manufactured in decentralized units, which are located mostly in rural areas. Due to technological limitations of these units, they employ open pan furnaces for juice concentration.

Sugarcane bagasse is the primary fuel used in Jaggery making furnaces, which is obtained during the process of juice extraction/cane crushing. It mainly contains fibers, sugar and water and its net calorific value is the result of calorific value of its constituents. (Fibre -19259 KJ/Kg, sugar – 16747 KJ/Kg and water – nil) [6].

Manohar Rao [6] reported that wet mill bagasse has moisture 50%, fibre 47% sugar 2.5% and minerals 0.5%. Before using it as a fuel bagasse is dried in counter-current type tunnel driers in most of the sugar mills but is normally sun dried in Jaggery units.

Many types of Jaggery making furnaces have been developed in India [4]. Main variation in design was due to number and size of pans, size of combustion chamber, size and geometry of flue gas channels, height of chimney, provision of air supply etc. Hemispherical bottom pans are generally in use with these furnaces. Shortage or even no saving of fuel is very common with these furnaces due to low heat utilization efficiency. The fibers of sugarcane rind are excellent sources of raw material for paper and pulp industries; the pith portion may effectively be converted and utilized as animal feed. So saving of bagasses may lead to the new way of extra revenue generation for Jaggery manufacturer. Lower efficiency also results in increased processing time of sugarcane juice so the product quality and productivity are also affected.

ISSN: 2394-3696
VOLUME 4, ISSUE 2, Feb.-2017

There has been limited effort made to improve the energy receiving component of the system, i.e. to improve the energy transfer efficiency from the flame to the pan. In normal cooking, when a pan is placed over fire, heat transfer takes place through convection and radiation. Combustion products and air form an insulating layer below the pan bottom resulting into poor heat transfer. Fins are useful in breaking the insulating layer and provide additional metallic area for heat transfer. In Jaggery making furnaces, flames and hot flue gases drift towards exit and therefore get a longer path and duration for effective heat transfer. This feature has been applied in this furnace.

Malekdzadeh et al. [6] have done shape optimization of non-symmetric, convective-radiative annular fins. It was shown that by using fewer grid points, highly accurate results are obtained. Malekdzadeh and Rahideh [6] also did an incremental differential analysis (IDQ) of the two-dimensional non-linear transient heat transfer analysis of variable section annular fins. Less computational efforts of the method with respect to the finite difference method is shown. Naphon [6] studied the heat transfer characteristics of the annular fin under dry-surface, partially wet-surface, and fully wet-surface conditions. The mathematical models were developed and solved by the central finite difference method to obtain temperature distribution along the fin. Thermal analysis and optimization of longitudinal and pin fins of uniform thickness subject to fully wet partially wet and fully dry surface conditions were carried out by kundu [6]. Form the results, it was also highlighted that for the same thermo-geometric and psychometric parameters, a longitudinal fin gives higher efficiency than the corresponding pin fin irrespective of surface conditions. Rosario and Rahman [6] presented the analysis of heat transfer in a partially wet annular fin assembly during the process of dehumidification. Calculations were carried out to study the performance of the heat exchanger. The commuted results included the temperature distribution in the wall and the fin and the fin efficiency. Khaled [6] modeled and analyzed analytically the heat transfer through joint fins. The work showed that the design of machine components such as bolts, screw and others can be improved to achieve favorable heat transfer characteristics in addition to its main functions such as rigid fixation properties. An analysis was carried out to study the efficiency of straight fins of different configurations when subjected to simultaneous heat and mass transfer mechanism by Sharqawy and Zubair [6]. Analytical solutions are obtained for temperature distribution over the fin surface when the fin is fully wet. The effect of atmospheric pressure on the fin efficiency was also studied, in addition to fin optimum dimensions. Huang and Shah [6]. Presented a critical assessment of different idealizations and some specific design recommendations were made for the determination of the fin efficiency for plate- fin heat exchangers.

Although, usage of fins is not new but such concept for heating purpose in Jaggery making open pan furnaces has not been tried yet.

EXPERIMENTAL SETUP, PROCEDURE & TESTING

Main pan of furnace were modified in which fins were provided to the bottom of this pan.
Constructional details of the conventional pan
It has a shape of inverted and truncated cone.
It has a flat bottom as shown in fig. no. 3
Material used is mild steel

Top (outer) diameter	20cm
Bottom (Inner) diameter	16.5 cm
Depth of the pan	4.9cm
Thickness of pan	0.2 cm
Pan capacity	5300 cm^3

Total area of the pan = 367.66 cm^2

CONSTRUCTIONAL DETAILS OF THE MODIFIED PAN

This pan is provided with 7 fins of suitable dimensions at the bottom. It is used to increase total sectional area of the pan to get maximum heat from the combustion chamber. The dimensions of modified pan fins are as follows.

Fin No.	Length in cm	Height in cm	Thickness in cm	Working s/c area cm^2
Fin no.1	31	2.5	0.3	1*46.5=46.5
Fin no.2 & 5	29	2.5	0.3	2*43.5=87
Fin no.3 & 6	25	2.5	0.3	2*37.5=75
Fin no.4 & 7	15	2.5	0.3	2*22.5=45

Total surface area of the fins = 253.5cm^2
Total s/c area of the pan bottom = 621.16 cm^2
The percentage increase in s/c area of pan bottom due to application of fins =68.94 %

Fig.no.6 Juice in pan for Boiling

CALCULATIONS FOR TESTING WITH CONVENTIONAL PAN

Heat energy input = m_b*c_b
= 2.3*18000
= 41400 KJ

Heat energy required for heating the juice = Mj* CPw (Tj-Ta)
= 3* 4.187 (95-30)
= 816.46 KJ

Mass of water evaporated Mw

Mass of Jaggery produced = mass of juice- mass of water evaporated- mass of slag
0.600 = 3- Mw-0.025
Mw = 2.375 Kg

Total latent heat of vaporization of water = Mw* hfg
= 2.375*2271
=5540.87 KJ

Total heat of evaporation required =
= Heat energy required for heating the juice + Total latent heat of vaporization of water
= 816.46 + 5540.87
= **6357.87 KJ**

Thermal efficiency = Heat output/ heat input
= 6357.87/41400
Thermal efficiency = 15.35%

CALCULATIONS FOR TESTING WITH MODIFIED PAN

Heat energy input = m_b*c_b
= 1.10*18000
= **19800KJ**

Heat energy required for heating the juice = Mj* CPw (Tj-Ta)
= 2.25* 4.187 (95-30)
= **612.34 KJ**

Mass of water evaporated Mw

Mass of Jaggery produced = mass of juice- mass of water evaporated- mass of slag
0.450 = 2.25- Mw-0.020
Mw = 1.825 Kg

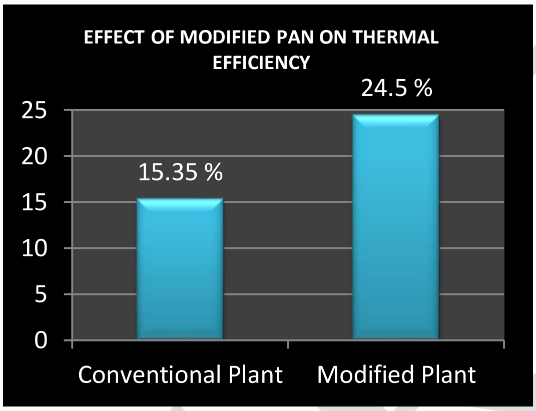
Total latent heat of vaporization of water = Mw* hfg
= 1.825 *2271
=**4257.72 KJ**

Total heat of evaporation required =
= Heat energy required for heating the juice + Total latent heat of vaporization of water
= 612.34 + 4257.72
= **4870.06 KJ**

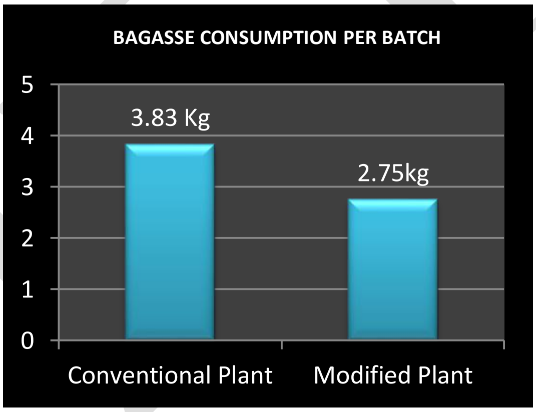
Thermal efficiency = Heat output/ heat input
= 4870.06/19800
Thermal efficiency = 24.50%

EXPERIMENTAL RESULTS & DISCUSSIONS

The thermal efficiency of conventional single pan Jaggery furnace was found to be 15.35%, which was increased to 24.5% with modified Pan & furnace. Thus the net increase in efficiency obtained is 9.15%. The bagasse consumption with traditional plant was 3.83 Kg/Kg of Jaggery which has been reduced to 2.75Kg/kg of Jaggery. Thus the bagasse required per batch was reduced by 28%. The time required with traditional plant was 45 minutes which was reduced to 30 minutes.



Graph No.1 effect of modified pan on thermal efficiency



Graph No.2 bagasse consumption per batch

CONCLUSION

The heat utilization efficiency of Jaggery making furnace increased considerably by using modified pans having fins. Modification resulted in saving of fuel and energy. The saved bagasse can be diverted to Paper and pulp industry for extra revenue generation. Improvement in efficiency would also be helpful for quality enhancement of the product due to less time requirement for sugarcane juice concentration in Jaggery making.

REFERENCES

1) PVK Jagannadha Rao et al, *"Jaggery- a traditional Indian sweetener", Indian Journal of traditional knowledge, vol 6(1), Jan 2007, pp 95-102.*

2) Dr.R.D.Singh et al, , *"Performance Evaluation of Two Pan Furnace For Jaggery Making", IE(I) Journal-AG,PP.27-30,Volume-90,June 2009.*

3) Dr.Amitkumar Dwivedi & Dr.Amodkant Mishra, "*A Study On Gur Industry In India",co-operative sugar,Vol40,Jan 2009.*

4) Ajit K .Ghosh, Ashok K.Shrivastava and V.P.Agnihotri,Production "*Technology Of Lump Sugar-Gur/Jaggery", Daya Publishing House, Delhi, 1998.*

5) K.Sada Siva Rao , A. Sampathrajan & S. A. Ramjani, "*Efficiency of traditional jaggery making furnace" , Madras Agricultural Journal 9091-30P.P 184-185,Jan-Mar 2003.*

6) S.I.Anwar, "*Fuel & Energy saving in open pan furnace used in Jaggery making through modified juice boiling / concentrating pans", Energy Conversion and Management,51,PP 360-364,2010.*

7) H.K.Madan, U.K.Jaiswal , Satish Kumar & S.K.Khanna, "*Improvement In Jaggery Making Plant For Rural Areas", Journal for rural Tech.,Vol.11,No.4,PP 194-196,2004.*

8) S.I.Anwar, "*Waste Heat Recovery System For Open Pan Jaggery Making Furnaces", Agricultural Engg. Today,Vol.32(4),2008.*

9) Yunus A. *Cenzel,"Heat & Mass Transfer", Tata mcgraw Hill Publishing Co.Ltd.,New Delhi,2008,pp159-169,562-572.*

10) Anonymous, "*Sugar Production from Sugarcane", practical action, the Schumacher Centre for Technology and Development, UK.*

11) Frank Kreith, Mark S. Bohn, "*Principles of Heat Transfer", Thomson Learning, Indian Edition, 2001,pp 95-105,627-649.*