Available Online at http://www.recentscientific.com

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 9, Issue, 5(B), pp. 26563-26565, May, 2018

ISSN: 0976-3031

International Journal of Recent Scientific Research

DOI: 10.24327/IJRSR

Research Article

DEVELOPMENT OF EFFICIENT FURNACE FOR JAGGERY MAKING

Sunildatta N. Kulkarni and Babruvahan P. Ronge

SVERI's College of Engineering, Pandharpur, India

DOI: http://dx.doi.org/10.24327/ijrsr.2018.0905.2082

ARTICLE INFO

Article History:

Received 16th February, 2018
Received in revised form 12th March, 2018
Accepted 20th April, 2018
Published online 28th May, 2018

Key Words:

Energy Efficiency, Jaggery Making Process, Jaggery Furnaces

ABSTRACT

Jaggery is a traditional Indian sweetener prepared by the concentration of sugarcane juice. Farmers make jaggery in their own farms using juice obtained after crushing sugarcane with a crusher. The filtered juice is boiled in open pans placed over furnace in which bagasse is burnt for generation of heat. By applying the principles of combustion and heat transfer, fuel efficient furnace can be developed which will result into saving of bagasse. This paper discusses the various concepts of heat transfer which can be used to develop fuel efficient furnace.

INTRODUCTION

Jaggery (also called as Gur in India) is traditional sweetener in addition to sugar from sugarcane. Jaggery has many health benefits compared to sugar and has several uses in daily food preparation. It is also used to make many sweet food preparations. Jaggery is produced in 25 countries with a world annual production of 11.05 million tonnes (FAOSTAT, 2003), the major produces being India with 6.89 million tonnes. In India, nearly 35% of about 250 million tonnes of sugarcane cultivated is used for jaggery preparation [Indian sugar, 2005].

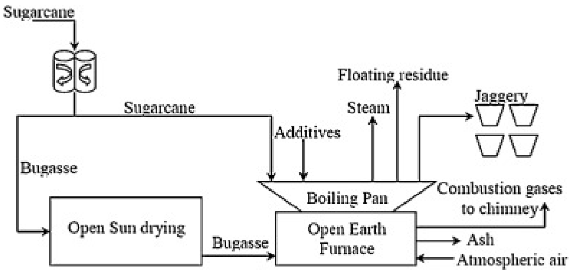

Figure No 1 Process Flow Diagram for Jaggery Plant

Stages of Jaggery Making

Sugarcane cutting and transportation are the two steps before extracting juice from sugarcane. The steps in jaggery making are as follows

Extraction of Juice from Sugarcane

The first step in jaggery manufacture is the extraction of juice by crushing sugarcane. Usually three rollers horizontal crusher driven by oil engine or electric motor is commonly used. One tonne of sugarcane crushed yields 650 kg of juice & 350 kg of bagasse (50% moisture content, wb). The bagasse is sun dried in open ground. After drying around 245-250 kg with 20% moisture content is obtained from 350 kg bagasse which is used as fuel in jaggery making furnace for the concentration of juice.

Juice concentration & clarification

Extracted juice is collected in a masonry settling tank and kept for few minutes for separation of light floating particles & heavy particles like mud, dirt if any. The clear juice is then transferred to an iron open pan for boiling.

The juice which is heated needs to be clarified during heating & boiling stage. it is mostly clarified by additing various clarificants like lime (calcium hydroxide), sodium hydrosulphate (hydros), phosphoric acid, chemifloks etc. vegetable clarificant like mucilage of bhendi, chicken, kateshorum are also used. Use of natural clarificants is encouraged over chemical clarificants.

Addition of clarificants helps to bring the impurities scum to the surface of the pan. This scum is removed continuously and thus the juice is clarified. To prevent excess frothing during

Corresponding author:* **Sunildatta N. Kulkarni
SVERI's College of Engineering, Pandharpur, India

boiling approximate quantity of groundnut or mustard oil is sprinkled. Boiling is continued for 2-2.5 hours till the striking point temperature which is about 118^0c-120^0c is reached.

The proper concentration of juice is judged by taking a small quantity of hot syrup from the pan & is cooled in cold water & finally shaping with finger to make a ball. The ball is thrown on surface of pan giving metallic sound. This is called ball test. it indicates completion of the boiling process & the pan can be remould from the furnace.

Cooling & Moulding

After juice is concentrated to 90^0 Brix, it is taken out of fire. Hot syrup is transferred to cooling basin where it is stirred continuously to cool down to 76^0c. Then hot syrup is transformed to a wooden or aluminium moulds. This serves both the purpose of cooling and moulding. Finally solidified jaggery after 24 hours is taken out from moulds, packed & sent to market.

Types of Jaggery Furnaces Used

Table No1 Information Related to Jaggery Process

Details	Single Pan Furnace	Two Pan Furnace	Three Pan Furnace	Four Pan Furnace
Capacity of Sugarcane Crushing (tonne/day)	6	6	12-13	16-20
Specific fuel consumption kg of bagasse / kg of jaggery	2.0	1.5	1.25-1.0	1.0-0.75
Jaggery production in tonne/ tonne of sugarcane processed	0.09	0.09	0.095	0.110
Time required to process 0.1 tonne of jaggery (minute)	180	150	120	45

From above table it is seen that four pan furnace gives more yield of jaggery in less processing time (45mins) compared to single pan furnace processing time of 180mins. However from previous research work conducted (Kiran Y Shiralkar, 2013), it is reported that in case of four pan furnace, the heat transfer to the pan near the bagasse feeding hole is due to both convection and radiation, and for the rest of the three pans, the heat transfer is mainly due to convection. This is because the rest of the pans are far away from the flame & the view factor is very less. Thus there is no much gain in terms of energy saving in the existing four pan jaggery furnace. Further four pan process is semi continuous in nature compared with single pan process.
In Kolhapur district of Maharashtra, farmers use conventionally single pan type units. Kolhapur is the main market for jaggery in the country as it ranks first in qualitative terms and second in terms of quantity. In Kolhapur district, near about 25,000 farmers and their dependants are engaged in jaggery production. They produce around 9 lakhs quintal jaggery per year. Further Kolhapur jaggery due to its attractive appearance (yellowish golden colour), various shapes, and excellent taste has great demand in country as well as it is exported to around 44 countries in Europe & Asia. Hence author feels that if scientific principles of combustion and heat transfer are used to design fuel efficient furnace, it will result into increase in energy efficiency, productivity and improvement in quality of jaggery.

Concept of Achieving Energy Efficiency

The two concepts can be utilised for developing fuel-efficient furnace for jaggery making.

- Carryout the total combustion of the bagasse with as little excess air as practicable to generate highest possible temperature of the flue gases.
- Maximise heat transfer to the panels in boiling operations

in order to achieve maximum combustion efficiency, combustion is to be carried out over a suitable fire grade in an enclosed fire box, with the requisite combustion volume and providing ports of suitable size, suitably located, for the controlled entry of primary and secondary air and a chimney of adequate cross sectional area & height for creating the required draught. The theoretical amount of air required for complete combustion of bagasse can be calculated from balancing the combustion reach on for bagasse (see appendix 1).

To maximise heat transfer to the panels in boiling operation of jaggery making basic principles of heat transfer can be used effectively. Heat transfer takes place by conduction, convection and radiation according to the following equations;

Conduction: $Q = KA (T_h - T_c) / L$
Convection: $Q = hA (T_h - T_c)$ and
Radiation: $Q = \epsilon\sigma A (T_h^4 - T_c^4)$

Where, (all in consistent – units; for radiation the temperature are in absolute units)
Q = heat transfer rate,
K = thermal conductivity
A = area of heat transfer
T_h = temperature of hot medium
T_c = temperature of cold medium
L = thickness of conducting medium
h = convective heat transfer coefficient
ϵ = emissivity and
σ = Stefan – Boltzmann constant
these equation indicates that the rate of heat transfer by all the mechanisms increases with the area of heat transfer, the temperature difference between the hot & cold media i.e. flue gases and pans respectively and the coefficient (conductivity, convective heat transfer coefficient, emissivity). For conduction, it decreases with the increase in thickness of the conductivity medium (pan thickness). Thus to maximise heat transfer, we must increase the area temperature difference and coefficient and decrease the thickness of the pans.

By carrying out the combustion in an enclosed furnace and by controlling the primary and secondary air entry with parts of proper size, we can generate maximum possible combustion temperature. Thus a higher temperature difference can be achieved.

The area of heat transfer can be increased by adopting any or all of the following

- Multiple Pans,
- Using extended surface fins on the heat transfer areas
- Using the maximum external area of the pan by dipping it in the flue gases
- For improving the coefficient, for radiation, this can be done by increasing the view factor. Also the

emission of these surfaces could be increased. Normally, in a multipan furnace, radiation plays a role in the first and may be in the second pan for the further pans view factor is negligible and hence its transfer by radiation is negligible. However improvement in the convective heat transfer plays a major role in improving thermal efficiency.

The convective heat transfer coefficient increases with the velocity of the gases pass the surface of the pan. This velocity can be increased for a given volumetric flow rate of the gases by decreasing the cross section of the flow. Also use of baffles can be made to increase residence time of flue gases in combustion chamber.

Conduction plays a minor role so far as the heat transfer to the pan is considered. Conduction is important in reducing the heat lost through the walls of the furnace to the surrounding. The use of fire bricks in the construction furnace can be made to reduce wall heat losses.

CONCLUSION

To develop high thermal efficiency furnace for jaggery making we can use following principles of combustion and heat transfer carryout the combustion of bagasse in an enclosed furnace made up of fire bricks over a suitable grade with proper openings for primary and secondary air, suitably located and a chimney, to generate the highest combustion temperature.

- To maximise the heat transfer to pans by
- An interior compatible in shape to the pans for a higher radiation heat transfer
- A flue gas passage below the pans such as to facilitate maximum gas pan contact and as high a velocity of gases as is practical.
- Multiple pans, extended surfaces (fins), and maximum immersion of the pan in the furnace to increase the area of heat transfer, and
- A chimney of adequate height and diameter to create a draught and disperse the smoke away from the furnace

Future research may be aimed at developing CFD model for both single pan and multipan methods and analysis the same for various design parameters discussed above to develop optimum design for thermal efficient furnace for jaggery making.

References

1. Kiran Y. Shiralkar, Sravan K. Kancharla, Narendra G. Shah, Sanjay M. Mahajani, "Energy Improvement in Jaggery Making Process", Energy for Sustainable Development, Vol.18, Pp.No. 34-48, 2014.
2. M. Esther Magdalene Sharon, CV Kavitha Abirami & K Alagusundaram, "Energy Losses in Traditional Jaggery Processing", Indian Food Industry Mag, Vol.32, Pp. No. 22-25, May-June 2013.
3. S. S. Lokras, "Development and Dissemination of Fuel Efficient Biomass Burning Devices", *Journal of the Indian Institute of Science*, Vol.92:1, Pp.No. 99-110, 2012.
4. Yogesh Shankar Kumbhar, "Study on Gur (Jaggery) Industry in Kolhapur", *International Research Journal of Engineering and Technology*, Vol.3, Pp.No. 500-504, 2016.

How to cite this article:

Sunildatta N. Kulkarni and Babruvahan P. Ronge.2018, Development of Efficient Furnace for Jaggery Making. *Int J Recent Sci Res.* 9(5), pp. 26563-26565. DOI: http://dx.doi.org/10.24327/ijrsr.2018.0905.2082

****