Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 02, Issue: 06 (NOV-DEC, 2022)
Available online at http://www.agriarticles.com
©Agri Articles, ISSN: 2582-9882

New Design IISR Three Pan Furnace for Domestic Level Jaggery Production Industries

(*Suraj Kumar[1] and Dilip Kumar[2])
[1]Guest Lecturer, Department of Food Processing and Technology, Atal Bihari Vajpayee University, Bilaspur, CG, India
[2]Principal Scientist, Jaggery Unit, Indian Institute of Sugarcane Research (IISR), Lucknow-226002, (U.P.), India
*Corresponding Author's email: skbhardwaj2104@gmail.com

Abstarct
The production of jaggery is one of the most traditional processes generally produces in cottage industries. Sugarcane juice is used for the preparation of jaggery. There are many types of furnaces used for the jaggery preparation such as single, double, triple, and four pan furnaces. The improved three pan furnace has been developed at ICAR-Indian Institute of sugarcane research, Lucknow to reduce the excessive consumption of time and bagasse for jaggery preparation along with quality production of jaggery.

The performance of the IISR three pan furnace was evaluated through jaggery preparation and various parameter such as consumption of bagasse per kg jaggery production, the water evaporation rate of the pans, total consumption of time per batch jaggery preparation and thermal efficiency was estimated as 2.42 kg, 1.81 kg/ min, 2h 22 minutes, 28.82 % respectively.

Keywords : Jaggery, Bagasse, Furnace, Sugarcane.

Introduction
Sugarcane (*Saccharum officinarum*) is a major cash crop in India belonging to the family *Gramineae*. It is usually used to produce sweeteners like sugar, jaggery (*gur*), and *Khandsari*. After Brazil, India is the second largest producer of sugarcane in the world. In India namely, Utter Pradesh and Maharastra is the two largest sugar producing states. Solid jaggery is prepared by the concentrating the sugarcane juice.

Solid jaggery contains sucrose (65-85 mg per 100 g) and inverts sugars (3-15 mg per 100 g). It also contains important minerals viz. Iron (10-13 mg per 100 g), calcium (40-100 mg per 100 g), magnesium (70-90 mg per 100 g), potassium (10-56 mg per 100 g) etc.

The production process of jaggery performed on the furnace. There are many types of furnace designs available in India. Generally in Uttar Pradesh and Uttarakhand, three pan jaggery furnace popular, however in Maharastra single pan and four pans furnace are popular. The main part of construction of jaggery furnace involves combustion chamber, fuel feeding hole, chimney, and ash chamber etc.

Methods of Jaggery Preparation
During the jaggery preparation process the following steps are performed

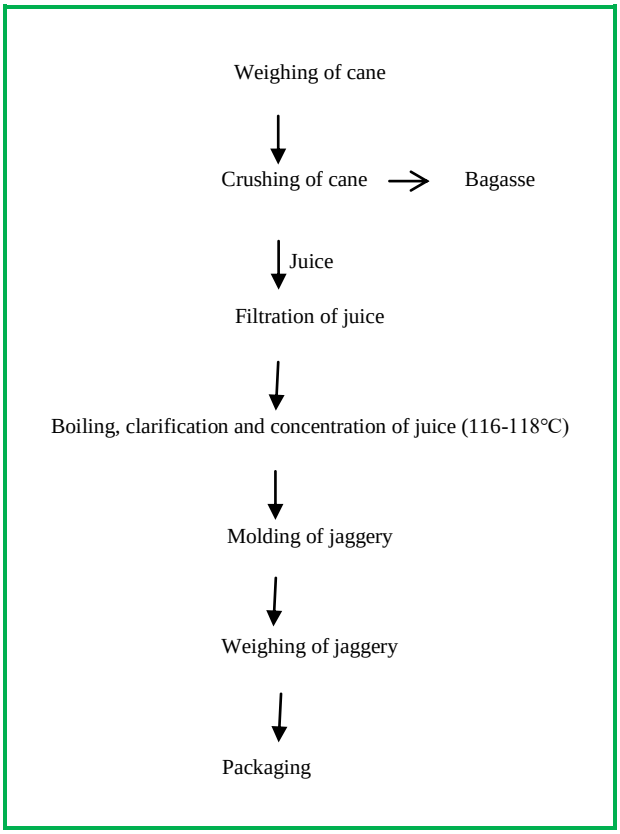

Fig.1 Process flow chart of jaggery production

Constructional Detail of the Three Pan Furnace

The main parts of the furnace are discussed below:

Primary pan (Boiling pan): Primary pan is also known as boiling pan where cane juice was heated upto a striking point and jaggery was prepared. The primary pan was made of mild steel (*IS2062*). It was only pan which was placed above the combustion chamber at 1219.2 mm height from the bottom of the ground. The outer and inner diameter of the boiling pan was 1828.8 mm, 1737.3 mm respectively. The depth of the pan was 277.3 mm along with a concave bottom. The primary was considered as the third and main pan where the juice concentration was takes place.

Secondary pans: Secondary pan involves two pans which were place adjacent by one another. The outer and inner diameter of the secondary pan was 1828.8 mm, 1737.3 mm respectively. The depth of both the secondary pans was pan 277.3 mm along with concave bottom. These pans were placed just above the passage line of flue gas escaping from the combustion chamber. The first and second secondary pans were placed at 1828.8 mm, 1524 mm height above from the ground respectively. In the secondary pans the juice was heated by utilizing the waste heat of the flue gas that escapes through the chimney.

Chimney: It was built of masonry structure with 3657.6 mm height from the ground surface level. The wall thickness of the chimney was 63.5 mm. The internal opening of the chimney was square in shape and dimension was 330×330 mm^2 Chimney was made to allow exit of flue gases from combustion chamber of the furnace.

Flue gas passage: An arrangement was made to escape the hot exhaust gases below the ground surface. Passage was made with fire bricks in square shape and connected from the

combustion chamber to chimney. This passage was square in shape having 300 × 300 mm^2 cross-sectional area. The length of this passage was 4267.2 mm. The hot gases were directed to escape from the combustion chamber to chimney hole towards the open atmosphere. The exhaust flue gases were used to pre-heat the cane juices in secondary pans before reaching to the boiling pan.

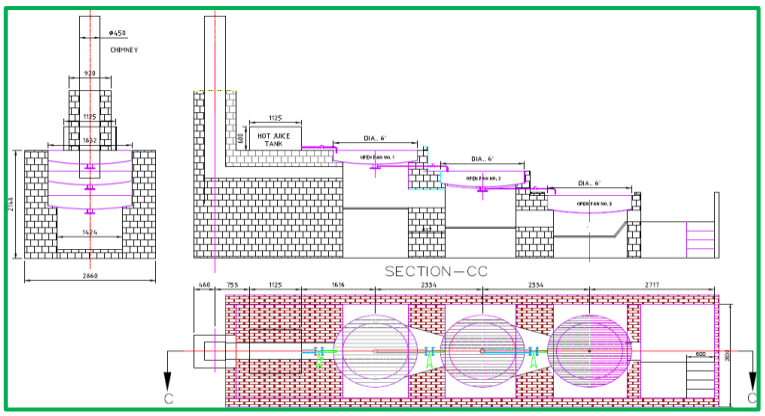

Fig2-IISR three pan furnace

Step grate: It was an iron rod which was mounted 914.4 mm height. The number of iron rod was fitted with parallel arrangement for making the platform for burning of bagasse into the combustion chamber. The bagasse was fed to the step grate into the combustion chamber and the burning of bagasse take place. The ash pit was available below the step grate to collect the ash after burning the bagasse.

Observation of Furnace Performance

The temperature variation of the furnace was periodically recorded till the attainment of striking point of cane juice. Prior the boiling of the cane juice the initial climatic parameters as well as juice temperature and TSS was recorded As per the observation the initial test parameter such as ambient temperature, relative humidity, initial juice temperature, total soluble solid (TSS) were recorded as 26℃, 60.50%, 22℃, 20°Brix respectively. Further the first boiling was started and the temperature was recorded after each 15 minute interval.

Fig3- Jaggery preparation

It was noticed that the temperature of cane juice was increased continuously .The concentration process of juice was continues till the attainment of the striking point i.e. 117± 1℃ of the juice. The time required to reach the striking point temperature was found as 70 minutes for the first boiling operation during the preparation of solid jaggery. At the same time the temperature of the juice in the secondary pan 1 & 2 was 80℃ and 95℃ respectively. The reason behind the temperature enhancement of second and third boiling pan might be due to flue gas escaping through the inner passage flowing towards the furnace chimney. The waste heat was used by the heating of secondary pans. This was the benefit of the three pan furnace. Again the second boiling operation was started by transferring the juice from second pan to boiling pan and first pan to second pan. The total time required to reach the striking temperature of the juice during the second boiling operation was recorded as 42 minutes.

Further the third boiling operation was started by the transferring the sugarcane juice from the second pan to the boiling pan.

Formula

Juice boiling per kg of bagasse consumed = $\frac{W_{juice}}{B}$

Energy of bagasse (Q_{Input}) = $W_{bagasse} \times C_{bagasse}$

Water evaporation rate = $\frac{W_{water}}{T}$

Energy required for heating the juice (Q_{juice}) = $W_{juice} \times Cp_{juice} \times (T_{juice} - T_{initial})$

Total energy for vaporization of water (Q_{water}) = $W_{water} \times h$

The energy required for jaggery production (Q_{jag}) = $W_{jag} \times Cp_{jag} \times (T_{striking} - T_{evap.})$ …(11)

Total energy required for jaggery making (Q output) = Q juice + Qwater+ Qjag …(12)

Thermal efficiency = $\frac{Q\ output}{Q\ input} \times 100$

Where,

W_{juice} = Weight of juice (kg), W_{jag} =Weight of jaggery produced per batch (kg), $W_{deola\ solution}$ = Weight of deola solution (kg), W_{scum} = Weight of scum removed per batch (kg), W_{water} = Weight of water evaporated during boiling (kg), B = Weight of bagasse consumed (kg), T = Time required for jaggery preparation(min), Q_{output} = Total energy required for jaggery making (MJ), Q_{input} = Heat energy input per batch (MJ), $\eta_{thermal}$ = Thermal efficiency (%), $C_{bagasse}$ = Calorific value of bagasse (kJ/kg) Cp_{juice} = Specific heat of juice (kJ/kg K), Cp_{jag} = Specific heat of jaggery(kJ/kg K). $T_{initial}$ = The initial temperature of the juice(℃), T_{final} = Final temperature of juice (℃), $T_{striking}$= Striking temperature of jaggery(℃), T = Total time required for jaggery making (min), Q_{juice} = Energy required for heating the juice(MJ), h= latent heat of vaporization, kJ/kg. $T_{evap.}$ =The temperature of evaporation of water,(℃).

Results

IISR three pans was a well-designed furnace. The total consumption of time per batch jaggery preparation was 2h 22 minutes and thermal energy was 28.82 % respectively. Also the consumption of bagasse was estimated as 2.42 kg/kg jaggery and thermal energy was 28.82 %.The water evaporation rate of the furnace 1.81 kg/min that was good and also it consumed less time and bagasse for jaggery preparation. This three pan furnace will be helpful to boost the income of farmers and jaggery industries also.

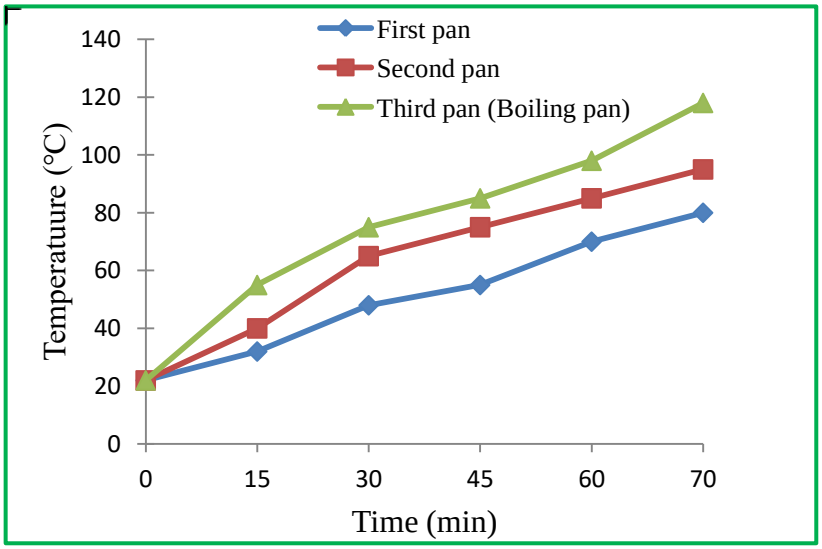

Fig4- Temperature profile of furnace during jaggery making

References

1. Anwar, S.I, 2010. Determination of moisture content of bagasse of jaggery unit using microwave oven.*Journal of Engineering Science and Technology*., 5: 472 –478.
2. Anwar, S.I. 2009. Fuel and energy saving in Open Furnace used in Jaggery Making Through modified juice boiling/concentrating Pans. *Energy Conservation and Management.*, 51: 360-364.
3. Agalave, G.B. 2015. Performance improvement of a single pan traditional jaggery making furnace by using fins and baffle. *International Journal of Advance Research in Science and Engineering.*, 4: 85-89.
4. Annual yield of sugarcane in India FY(2014-2019). Statista Research Department.
5. Arya, P.K., Kumar, S. and Jaiswal, U.K. 2013. Design based improvement in three pan jaggery making plant for rural India. *International Journal of Engineering Research (IJER).*
6. Kulkarni, S.N. and Ronge, B.P. 2018. Case study on heat and mass balance of single pan jaggery making plant.*International journal of Advance Mechanical Engineering.,* 8 : 143-151.
7. Kulkarni, S.N. and Ronge, B.P. 2018. Development of efficient furnace for jaggery making. *International Journal of Recent Scientific Research.,* 9:26563-26565.
8. Kumbhar, Y.S. 2016. Study on Gur (Jaggery) Industry in Kolhapur. *International Research Journal of Engineeringand Technology*., 3: 500-504.
9. Nath, A., Dutt, D.,Kumar, P and Singh J.P. 2015. Review on Recent Advances in Value Addition of Jaggery based Products. *Journal of Food* . 6: 2157-7110.