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SUGAR CANE DIFFUSION

Dr. Ravindranath V. Gabadi
Associate Professor & Special Officer, Dept of Sugar Technology,
GU. P.G.Centre , Bidar.

ABSTRACT:

Extraction of juice from sugarcane is most critical unit operation in cane sugar factory. It consumes about 40% of total energy requirements and loss of sugar at the stage is also around 40% of total loss. Sugarcane milling is most widely used method for this purpose in the country, however, cane diffusion is promising alternative.

A comparative analysis alongwith viability and feasibility study of these methods is done in present paper. Some Indian sugar factories installed diffuser plants in past, however these units miserably failed on account of various reasons. It is seen that the diffusion has strong claim for reconsideration in Indian sugar industry on account of improvements in Pl. mill Feeding Techniques. Energy Conservation Measures Exercised and possibility of Automation in operation at various stages. In addition to this the concept of Waste Heat Recovery (WHR) Boiler introduced here can meet additional steam requirements and makes the proposal viable and feasible. Diffusion reduces the bagasse loss by 0.3% cane with 2.5% improvement in RME.

KEY WORDS: *sugarcane , viability and feasibility, milling , waste heat.*

INTRODUCTION:

Extraction of juice from sugarcane is most important unit operation in cane sugar factory. The cane preparation and milling consume 18.8% and 24.7% of the grand total power requirements of sugar factory respectively (i.e. total juice extraction 43.5%). The breakup of losses shows that the extent of sugar loss at this stage is about 35-40% of total loss, while it needs major portion of capital cost up to 40% of total plant cost. Thus, this is major energy consuming stage and affects the plant efficiency and economics to great extent. of sidizzoq

The appropriate alternative for cane milling is diffusion and has strong claim for reconsideration in Indian sugar industry. In case of bagasse diffuser only 3 (out of 6) mills remain in operation and rest of the mills are replaced by suitable diffusers. It has a potential to achieve better results than milling in respect of juice extraction and saving of power. It uses more vapour to reach end point of boiling the mixed juice but reduces live steam consumption [1]. The performance abroad and in the country is discussed in forthcoming paragraphs.

DIFFUSION PERFORMANCE ABROAD.

The diffusion technology had been in use in beet sugar industry for a long time. It was later introduced in cane sugar industry in 1950s. The diffusion plants are most popular in countries like Australia, South Africa, Philippines, Egypt etc. The performance of diffuser is found to be excellent in these countries. The sugar factory at Felixton -II (FX-2 South Africa) having full cane diffuser recorded RME of 98.47% during 1984-85. This figure was adjudged to be the best in the world [2].

The various makes/types of diffusers used world wide are as follows [3].

- Dbs make-Denmark.
- De Smet
- BMA - Egypt
- Satrune -Paris.

DIFFUSION PERFORMANCE IN INDIA

The bagasse diffusers were installed in 13 sugar factories from 1966 to 197914]. At present only 4 of them are in operation. The operating data of these diffusers shows improvement in extraction of +2.60%, -0.46%, +2.70% and 2.31%. The average improvement is found to be +1.80%.

It is seen that majority of the factories shifted back to milling the reasons for this are as follows[4].

1.Excessive mechanical stopage.
2.Uneven distribution of bagasse in carriers and diffuser.
3.Excessive erosion and corrosion of diffuser parts.
4.Complicated layout and more maintainance.
5.Flooding of diffuser and wide fluctuation in juice flow.
6.Increase in steam consumption by 3-4%. 001-mudan
7.Heavy inversion due to low pH conditions.
8.Choking and slippage of dewatering mills.
9.Various problems in boiling house due to thin juice.

It can be concluded that, mechanical, chemical and flooding problems were observed frequently. The corrective design modifications were not undertaken. The high rate of imbibition was not possible due to poor steam economy and shortage of heating surface. The efforts to improve the preparation index only were not sufficient and it resulted into removal and decommissioning of diffuser in most of the cases.

RECONSIDERATION OF DIFFUSION

The ISSCT combined Factory/Energy workshop held in pune in Dec. 1994 [6] concluded that, bagasse diffusers installed in Indian sugar industry in the sixties miserably failed on account of improper designs and lack of good cane preparatory devices However, diffuser has strong claim for reconsideration on following grounds.

1. The high preparation index which is necessary for lixiviation has now reached up to 85 to 90%.
2.The spreader stoker type suspension burning boilers in use can easily burn the very fine bagasse available due to high PI.
3.The energy conservation measures so far exercised have brought down the steam consumption and additional steam requirement is not problem now a days. This makes possible to use high imbibition levels.
4.To avoid choking of dewatering mills the morden feeding devices like TRPF,GRPF can be used.
5.For close control of pH and temperature, automation of diffuser operation can be done.

Thus diffuser system has better prospects to improve the productivity. The energy requirment for juice extraction are reduce but needs more steam for heating and evaporation. This is due to high imbibition levels. It is proposed here to get this additional steam by use of low pressure WHR boiler.

DIFFUSION SUPPORTED BY WHR BOILER

For better operation of diffuser plant, high PI is necessary for increase in lixiviation. As per observations of Mr. Gundurao; Maccerating type diffuser maintains homogeneity of mixture and gives better extraction. The performance and operation of diffuser is affected by various parameters as mentioned below:

PARAMETERS GOVERNING DIFFUSION :

The relationship given by Mr. Foster and Hill [8] is
E=0.1 t +0.185 T-3.0 S+91.2

Where,
E= Extraction
t =Temperature of diffusion °C
T= Time of diffusion, minutes
S = Average particle thickness in mm.

While Mr. M.K.G. Doss [7] has given the time of diffusion by

$$t \quad \frac{\frac{1}{2}\not\subset^{2}}{D}$$

Where,
t =Time of diffusion. minutes
¢ = Diffusion length mm (distance between core of prepared cane and maccerating fluid)
D= Diffusion coefficient of solute in medium

The equation (5.1) indicates that diffusion improves considerably with temperature and selection of temperature is important. The experiments in Australia showed that above 70°C the extraction of nonsugars is more, creating boiling house problems and below 70°C microbiological growth is more. Thus very fine temperature control is needed.

The rate of inversion and life of equipment is affected at low pH values. The colour formation and high viscosity are results of high temperature and pH. Hence it is necessary to maintain pH near neutral zone.

The dewatering of bagasse before entering the dewatering mills is necessary to avoid choking of these mills. It is necessary to control diffuser stoppages otherwise juice viscosity increases rapidly. The high imbibition levels increases the steam requirement.

ADDITIONAL STEAM REQUIREMENTS:

The high efficiency of diffusion is observed only when imbibition rates are high about 300% on fibre or about 45% on cane. While the average imbibition rates with milling range around 30% on cane. The additional steam requirement can be obtained from mixed juice quantity with the above mentioned imbibition rates.

The mixed juice quantity is obtained by considering mass balance at juice extraction stage as follows:

Cane Imbibition water = Mixed Juice - Bagasse
Substituting the appropriate values for milling and diffusion equation (5.3) becomes –

Milling =<100% = 30% = Mixed Juice = 33%
Diffusion = < 100% + 45% = Mixed Juice = 33%

This gives mixed juice quantities as 97.00% with milling and 112.00% with diffusion i.e. increase in quantity of mixed juice is 15.00% on cane.

The level of imbibition is higher, the juice from diffusion plant will be dilute, its brix can be obtained by considering brix balance i.e.

Total Brix in Milling Juice = Total Brix in Diffusion Juice .... (5.4)

(MJ X Bx) Milling = (MJ X Bx) Diffusion

$$\text{Bx Diffusion} = \frac{\text{(MJ X BX) Milling}}{\text{MJ Diffusion}}$$

$$\frac{97.00 \times 15.00}{112.00} = 12.990 \text{ Bx}$$

Thus, juice gets diluted and drop in mixed juice brix is 2o Bx.

Now additional steam requirement will be due to additional quantity. This additional quantity is 15.00% on cane and needs approximately 7.5% more steam on cane for complete processing.

Additional steam quantity per kg of sugar = 0.75 kg/kg of sugar or per 10 kg of cane.

Generally the condition of steam used for heating is 1 bar, 110° C, the heat content of this steam is :

Hsup =hg+cp (Tsup - Tg). With usual notations.
=2675.4 2.1 (115- 100)
= 2706.9 KJ/kg of steam

Additional heat requirement per kg of sugar

Additional steam requirement kg/kg of sugar X Enthalpy of steam KJ/kg.

WHR Boiler:

= 0.75 X 2706.9
=2030.2 KJ/kg of sugar.

The auditing of heat energy done by the author for typical selected sugar industries indicated total waste heat potential as detailed below [10].

Table 1

Waste heat potential in KJ/kg of sugar:

1.Heat content of chimney flue gasses.	**4211.9**
2.Heat carried by Boiler blow down.	**109.9**
3.Heat with Surplus spray water.	**820.6**
4.Heat carried by Hot Water Overflow.	**615.5**
	5757.9

If heat carried away by hot water overflow, spray water overflow and blow down water is kept reserved to meet additional imbibition water reqirement to be supplied at 75°C then waste heat available for steam generation in WHR boiler is heat carried away by main boiler flue gasses which is 4211.00 KJ/kg of sugar.

The heat quantity which can be transferred to WHR boiler steam with 75% efficiency comes out to be –

Heat transferred = Heat available X WHR Boiler Efficiency
= 4211.0 X 0.75
= 3158.25 KJ/kg of sugar

$$\text{Steam Generation Rate} = \frac{\text{Total Heat Transferred to steam}}{\text{Enthalpy per kg of steam}}$$

$$= \frac{3158.25}{2706.9}$$

= 1.167 kg/kg of sugar

$$\text{Steam Generation \% requirement} = \frac{\text{Generation Rate}}{\text{Requirement Rate}}$$

$$= \frac{1.167}{0.75}$$

= 1.556 i.e. 155%

Thus, possible steam generation is at rate of 155% of the requirement. Hence proposal of providing additional process steam by WHR boiler is feasible. The suitable WHR boiler with following specifications can be designed.

WHR boiler specifications -
MCR of boiler = 10.0 T/hr.

Steam Condition = 1 bar, 110 ± 5°C
gildianobbe bastaliod AHW
Heat Source Main boiler chimney flue gasses.

Diffusion System :

The heat and mass balance for bagasse diffusion system, for crush rate of 100 T/hr with 300% imbibition on fibre is shown in fig. 1. The system has lowest extraction of 97%. The total extraction is sum of primary extraction and diffuser extraction.

Total Extraction - Primary Extraction = Diffuser Extraction

97 68+ (32 X Diffuser efficiency)

$$\text{Required Diffuser efficiency} = \frac{97-68}{32}$$

= 90.6%

This can be very easily achieved in all makes of diffusers.

Comparison of diffusion and Milling :

The brief comparison of these two processes for 2500TCD factory is presented in Table-2

Table 2
Comparison of Diffusion and Milling.

Sl. No.	Particular	Diffusion	Milling
1.	Power for cane Preparation KW/TCH	5.3	5.3
2.	Power for Milling KW/TCH	3.45	6.9
3.	Diffusion plant Power KW/TCH	1.4	.....
4.	Juice Extraction - Total Power KW/TCH	10.15	12.2
5.	Imbibition.Water % Fibre.	300.00	180-200
6.	Mixed Juice % Cane	112.00	97.00
7.	Bagasse Pol % bagasse	1.4-1.5	2.0-2.2
8.	Bagasse loss % Cane.	0.5	0.8
9.	RME	97.5	95.0
10.	Steam Consumption % Cane.	54.00	46.50
11.	ExtraSteam Requirement % Cane. Extra Steam Requirement T/hr.	7.5 7.5	.....
12.	MCR of WHR Boiler T/hr.	10.00	
13.	WHR Steam available % need.	115.00	

The comparision given by Mr. Meade Chen [9] shows more loss of sugar in final molasses and undetermined on However he has quoted the improvement in extraction of 5.0% and bagasse loss reduced by more than half.

Economical Aspects

Capital Investments :

In case of conventional 6 mill tandem, diffuser replaces three mills and only three mills remain in operation. The diffuser cost is approximately equal to cost of two mills [3]. Thus, cost of one mill along with drive is saved. The additional equipment required is low pressure WHR boiler and additional heating surface. This will not need more than 15-20% of this saving.

Power Saving and improvement of Productivity :

The power requirements for juice extraction are reduced by 2.05 KW/TCH. The additional steam is generated using present waste heat so its cost is not considered. The diffusion improves the mill extraction by 2.5%.

CONCLUSION:

The cane diffusion only, has strong claim for reconsideration in Indian sugar industry, while the proposal of WHR boiler to meet additional steam requirements is promising one. This improves the reduced mill extraction by 2.5% and reduces bagasse loss by 0.3% on cane. This is considerable improvement and will increase the competitiveness and flexibility of Indian sugar industry.

Abbreviation :

BX - Degree Brix.
GRPF - Grooved Roller Pressure Feeder.
ISSCT - Internatioal Society of Sugarcane Technologists.
PI - Preparation Index.

RME - Reduced Mill Extraction.
TRPF - Two Roller Pressure Feeder.
WHR - Waste Heat Recovery.

REFERENCES

1. Paulo Sao (1989) - "Diffusion as Steam Saver" ISSCT Proceedings of XX Congress. PP 233.
2. Manohar Rao P.J. (1988) "PI and Mill Extraction in Indian Sugar Factories V/s Sugar Factories of Australia and South Africa -STA Kanpur PP-E31.
3. Manohar Rao P.J. (1995) - "Building up Indian Sugar Industry to top the World Sugar Industry."
4. Cooperative Sugar, NFCSF Ltd., Volume 26 No. 5. PP 353-358
5. Hugot E (1986) - "Hand Book of Cane Sugar Engineering." 3rd Edition Elsevier, New York, PP-196-226.
6. Bhagat J.J. (1994) - "Performance of Cane Diffusion in India." ISSCT Factory/Energy/Combined Workshop, Pune PP-313-331. Gehlawat J.K. (1999) - "Modernisation of Indian Sugar Industry." Arnold Publishers, New Delhi. ISSCT (1994) - "Summary or Workshop." Cooperative Sugar, NFCSF Ltd., Vol. 26 No. 3 PP-163. Doss S.K.G. (1969) "Cane Diffusion." All Indian Technical Seminar Proceedings. Foster and Hill (1977) - "Diffusion" Indian Sugar. ISMA, New Delhi, June Issue.
7. Meade Chen (1977) - "Cane Sugar Hand Book." 10th Edition. John Willey and Sons New York.
8. Jadhav M.G. and Madnaik S.D. (1995) "Energy auditing - A Tool for Conservation of Energy in Sugar Industry." National Seminar Proceedings, University of Roorkee. PP IV 8 to IV 12.