

RESEARCH ARTICLE

Saving energy by improving the moisture of final bagasse using perforated with longitudinal channels rollers cane mills

Mohammed Helal^{1,2*}, Mahmud Tawfik³, Abdel Rahman Abdel Aziz³, Yasser Abdelrhman⁴, Ibrahim HassabAllah⁴

Received: 12 December 2023\ Revised: 19 January 2024\ Accepted: 27 January 2024\ Published online: 29 January 2024

Abstract

After the process of crushing the sugarcane and extracting the juice, the bagasse remains. The bagasse is used in many industries, such as making paper, wood, fodder and fertilizer, also as fuel that is burned in steam boilers to generate steam used in industrial processes. Spray water as imbibition is added in the penultimate mill to ensure better extraction and reduce final sugar loss . And the lower the moisture of the final bagasse , the greater its calorific value.In this research, an increase in the surface area of juice drainage with the rollers of the mills was studied by designing perforated rollers equipped with longitudinal channels to ensure that the final bagasse does not absorb the sugary water extracted from the last mill , and the exit of the final bagasse with the lowest moisture and the highest calorific value . The idea of the research was applied to lab mills operating in Deshna sugar factories on two lines , one of which is modified with perforated rollers and the other is unmodified rollers . Comparison of the moisture of the final bagasse in each line, which showed a decrease in the moisture of the final bagasse in the modified mills by a percentage up to $\pm 2.03\%$ that, was lower than that of the unmodified mills.

Keywords: Rollers; Mills; moisture; Imbibition.

¹ Faculty of Sugar and Integrated Industries Technology, Assiut University, Assiut,
² Egypt Sugar & Integrated Industries Company, Dshna, Qena, Egypt.
³ Egypt Sugar & Integrated Industries Company, EL Hawamdiyah, Giza , Egypt.
⁴ Mechanical Engineering Department, Faculty of Engineering, Assiut University, Assiut,71516 , Egypt.

*corresponding author; eng.helal55555@gmail.com.

Introduction

The final bagasse is considered one of the final ingredients in the last mills after separating and extracting the sugary water from the bagasse saturated with water which is added to the bagasse before the last mill in limited proportions to help extract all the sugars present in the bagasse before it exits the mills in order to reduce the loss of sugar in the final bagasse and on the other hand , reducing the moisture of the final bagasse to reduce the water content inside it to increase its caloric content. (Kaewpradap and Jugjai 2013). It may be noticed in the penultimate mill and after adding spray water on the bagasse to increase the extraction of the last mills the presence of the phenomenon of floating which is the re-absorption of the bagasse with sugary water after extracting it from the bagasse as the amount of spraying water reaches 300% fibers in the lines of mills that have diffusion devices such as lines operating with mills that have diffusion devices such as the lines operating in Dshna mills (Sembada 2017). In this research the design of perforated rollers equipped with longitudinal channels was studied to increase the drainage of sugary water extracted from the last mills and a procedure experiments of moisture extraction experiments from bagasse on one of the mill lines operating in Dshna sugar factories and the results of moisture extraction experiments were compared on the other line which contains unmodified rollers mills. The results are recorded steps will be shown and the procedure modifications and steps for conducting experiments and discuss the results of these experiments. (Wienese 1995). Figure 1 shows the before last mill floating phenomenon on mills Dshna factory.



Figure1. The before last mill floating phenomenon (Deshna factory)

The working theory of sugarcane mills

The basic theory of the work of mills is to apply a group of very high and different pressures to separate the sugary solution which contains sugar from the cane fibers or bagasse. (Elewa et al. 2020). The high pressures imposed on the mills are represented by hydraulic pressures, low speeds, entry and exit openings, the trash plate opening, the diameters and pitch of the mills' rollers, operating the mill with maximum capacity, and the degree of preparing of the cane. It is intended for cutting and opening the cane fibers (Hugot 2014).

The basic components of sugarcane mills

The traditional mill consists of 3 rollers that are installed in the shape of a triangle to generate the entrance and exit openings and each roller has V grooves, in addition to scrapers and a trash plate to clean these grooves. There is a hydraulic pressure station to generate high pressures on the cap mills which reach ± 230 bar, and a central lubrication unit to lubricate the rollers journal. Figure 2 shows the assembly of a typical three roller sugarcane mill (Rein and Attard 2007).

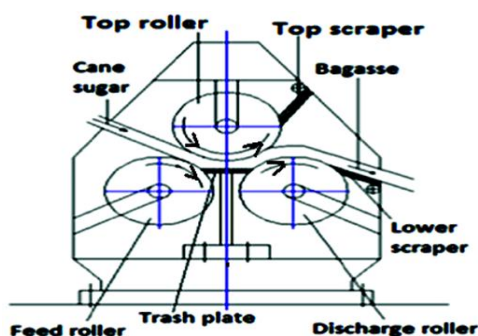


Figure2. The assembly of a typical three roller sugarcane mill (EL Sawy and El Mahallawi 2017).

Mills extraction factors

Many factors that affect the efficiency of mill extraction when caring out for it we get the highest extraction of the sugar solution and we also get the lowest bagasse moisture. (Elkelawy et al. 2022). . These factors can be summarized as follows: index preparing sugar cane, mills setting, mills speed, imbibition (Bazooyar et al.2015; Nassr et al.2020) hydraulic pressure , capacity and the technical expertise of the workers Nassr et al. (2020). Figure 3 shows the flow of juice from mills. (Birkett et al 1987).

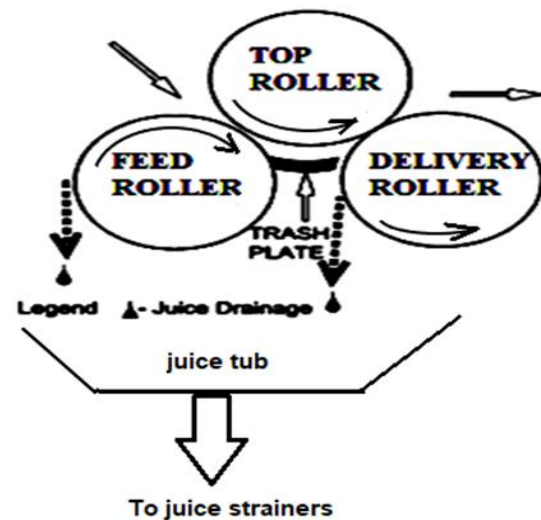


Figure 3. The flow of juice from mills. (Helal et al. 2020)

Experimental work, results and discussion

The idea of study and research as a moisture extraction experiments has been performed at the 1st line of lab Czech mills that working in mills Deshna sugar factories it diameter size $\phi 300$ X length 400 mm, a perforated with longitudinal channels rollers are designed on mills and then comparing the moisture extraction of bagasse results with unmodified typical rollers mills without perforated or longitudinal channels that operating on 2nd line , taking into account the same operating conditions and the conditions of the saturated bagasse sample that used in both unmodified and modified mills, Each line is made up of a number of two mills. Designing the perforated with longitudinal channels roller stages were as follows : Review the dimensions of the column and review the dimensions of the shell after finishing lathing, then making a longitudinal hole as channels on shell then putting the shell on stove. Figure 4 shows the shell after making a longitudinal hole.



Figure 4. The shell after making a longitudinal hole (Deshna factory).

Figure 5. shows the roller during perforation longitudinal channels. Figure 6 shows the modified rolls during mounting on mill.



Figure 5. The roller during perforation longitudinal channels (Deshna factory).



Figure 6. The modified rolls during mounting on mill (Deshna factory).

The mills operating conditions have been checked as setting, power, speed, reduction ratio, hydraulic pressure as illustrated on Table1. Moisture extraction experiments were applied on 15 saturated bagasse samples of different imbibition % cane in each mill and results are recorded as illustrated on Table 2 for the modified rollers mills and the unmodified rollers mills. The symmetry of the samples in each experiment is taken into account with the value of spraying water being recorded as imbibition % of cane, it should be washing and cleaning mills before conduct experiments by weighting ± 100 gm unsaturated sample for each experiment before putting the unsaturated sample on the electric oven at a temperature $\pm 105^\circ$ C for a period of 8 hours' time. The results of the moisture extraction experiments were recorded with the number of the imbibition % cane and then compared the results for both the unmodified and modified rollers mills .Table 2 illustrates the moisture extraction for both the unmodified and modified rollers mills and the difference between them with the imbibition % cane for each sample.

Table 1. The operation conditions for both modified and unmodified mills (Deshna factory).

M	STATEMENT	DATA
1	1 st mill pitch/depth top roll	
2	1 st mill pitch/depth feed roll	9.52 / 8 mm
3	1 st mill pitch/depth delivery roll	
4	1 st mill opening (Inlet/outlet/knife)	4/20mm
5	2 nd mill pitch/depth top roller	
6	2 nd mill pitch/depth feed roller	9.52 / 8 mm
7	2 nd mill pitch/depth deliveryroller	
8	2 nd mill opening (Inlet/outlet/knife)	2/0/14 mm
9	1 st &2 nd mill reduction ratio	250: 1
10	1 st &2 nd mill power/speed	18.5 kW / 975 rpm
11	1 st &2 nd mill Hydraulic pressure	220 bar
12	1 st &2 nd mill mills speed	3.9 rpm (9.18 m / s)

The moisture extraction experiment depends on the weight of the saturated bagasse sample before and after entering the electric oven for a period of 8 hours with fixing the weight of the sample before entering the electric oven to be 100 gm. The moisture extraction results for each mill were studied with the amount of spraying water as imbibition % cane and a graph was made as shown in Figure 7 to conclude the observations that will be mentioned, we notice that the moisture extraction of the modified rollers mills is

better than the moisture extraction of the unmodified rollers mills especially when increasing imbibition % cane, at imbibition % cane 43.19 the moisture extraction for modified rollers mills was 53.17% while the moisture extraction for unmodified rollers mills was 54.18% and at imbibition % cane 47.71 the moisture extraction for modified rollers mills was 51.30% while the moisture extraction for unmodified rollers mills was 53.33%. The moisture of the bagasse has an influential role for the heat content of the bagasse.

Table 2. The results of the moisture extraction for both the unmodified and modified rollers mills and the difference between them with the imbibition % cane for each sample (Deshna factory).

M	Imbibition % cane	1 st line modified mills Moisture % bagasse	2 nd line unmodified mills Moisture % bagasse	Difference Moisture % bagasse
1	43.19	53.17	54.18	1.01
2	43.30	52.99	54.04	1.05
3	43.41	52.85	53.95	1.10
4	43.79	52.73	53.90	1.17
5	43.90	52.62	53.82	1.20
6	44.21	52.44	53.74	1.30
7	44.30	52.39	53.78	1.39
8	44.38	52.28	53.70	1.42
9	45.10	52.15	53.60	1.45
10	45.28	51.99	53.57	1.58
11	45.49	51.80	53.43	1.63
12	45.61	51.67	53.41	1.74
13	46.05	51.44	53.28	1.84
14	47.47	51.40	53.36	1.96
15	47.71	51.30	53.33	2.03

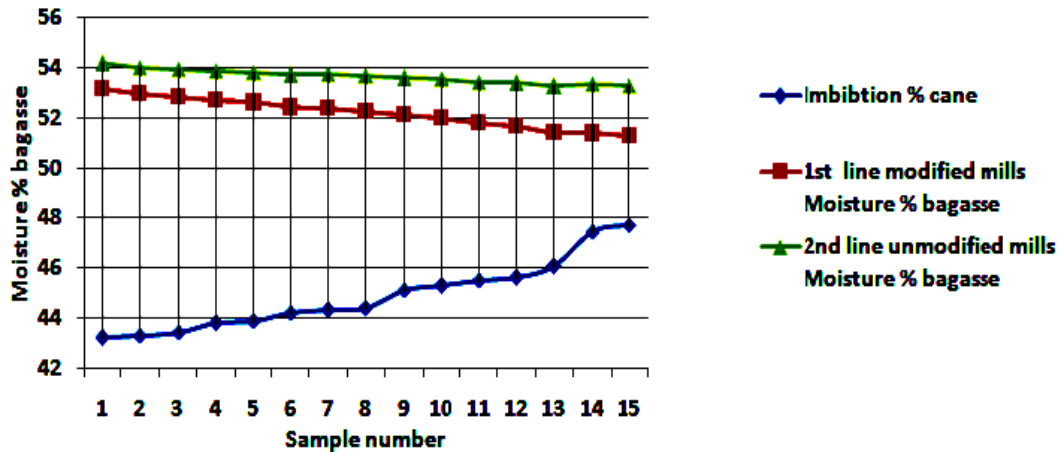


Figure7. The moisture extraction curve for both unmodified and modified mills (Deshna factory).

The net calorific value of bagasse when used as fuel in steam boiler can be determine from the following equation (Hugot 2014) :

$$\text{N.C.V} = 4250 - 48.5 W - 12 S$$

Where:

N.C.V = Net calorific value of the bagasse, kcal /kg.

W = Moisture % Bagasse.

S = Sucrose % Bagasse.

When we neglect sucrose % bagasse (S) and at moisture % bagasse ± 51.30 the bagasse net calorific value was ± 1761.95 kcal / kg from the modified mills while at moisture % bagasse ± 53.33 the bagasse net calorific value was ± 1663.495 kcal / kg from the unmodified mills .

Conclusion

The moisture extraction of perforated with longitudinal channels rollers modified mills is better than the moisture extraction of typical rollers unmodified mills as a result of the increased drainage of sugary water through the modified rollers mills . Also there is no floating phenomenon that it causes the bagasse to be reabsorbed with the juice after it leaves the mill. At imbibition % cane ± 43.19 the moisture % bagasse of modified mills is lower than the moisture % bagasse of unmodified mills by a difference of ± 1.01 % and At imbibition % cane ± 47.71 the moisture% bagasse of modified mills is lower than the moisture% bagasse of unmodified mills by a difference of ± 2.03 % . Also the difference of bagasse net calorific value from the modified mills will be higher than the bagasse net calorific value from the unmodified

mills up to ± 98.455 kcal / kg from the unmodified mills.

References

- Bazooyar B, Shariati A, Hashemabadi SH (2015). Characterization and reduction of no during the combustion of biodiesel in a semi-industrial boiler. Energy & Fuels 29: 6804-6814. DOI: [10.1021/acs.energyfuels.5b01529](https://doi.org/10.1021/acs.energyfuels.5b01529).
- Birkett, H.S., Clarke, S.J., Cho. Y.K., Keenlside and W. et al.(1987). Factors affecting mill extraction, Journal - American Society of Sugar Cane Technologists (USA).5:101 – 108.
- Elkelawy M., Kamel Abdel-Rahman A., Abou-Elyazied A., Mostafa Elmalla S. (2022)., Experimental investigation on emission and combustion characteristics of an industrial burner using biogas co-fired with diesel and biodiesel, Egyptian Sugar Journal (2022), 19:.29-43.DOI: [10.21608/ESUGJ.2022.164403.1025](https://doi.org/10.21608/ESUGJ.2022.164403.1025)
- EL Sawy EET, EL-Hebeary MR, El Mahallawi (2017).Effect of manganese, silicon and chromium additions on microstructure and wear characteristics of grey cast iron for sugar industries applications wear Elsevier, 390-391,p115. DOI:[10.1016/j.wear.2017.07.007](https://doi.org/10.1016/j.wear.2017.07.007)
- Elewa M, El-Saady G, Ibrahim K, Tewfik M, Elhossieny H (2020) A novel Method for Brix Measuring in raw Sugar Solution. Egyptian SugarJournal15:69-86.DOI: [10.21608/ESUGJ.2020.209517](https://doi.org/10.21608/ESUGJ.2020.209517)

- Helal M. Mustafa H, Abdelrhman Y, HassabAllah I. (2020) Improving the Efficiency of Extraction of Sugar Cane Mills Using Rollers with Compound Triple Pitch, Egyptian Sugar Journal 14:119-132.
[DOI:10.21608/ESUGJ.2020.219226](https://doi.org/10.21608/ESUGJ.2020.219226)
- Hugot E (2014) Handbook of cane sugar engineering, New York, Elsevier ,4th ed. , pp. 251 - 260 .
- Hugot E (2014) Handbook of cane sugar engineering, New York , Elsevier ,4th ed. , pp. 658 – 694.
- Kaewpradap A, Yoksenakul W, Jugjai S (2013) Effects of Moisture Content in Simulated Bagasse by Equilibrium Analysis,” TSME International Conference on Mechanical Engineering (TSME-ICOME) ,Pattaya, 4th Chonburi , pp. 1-7.
- Nassr, A. A., Khair Aldien, W. M., Mahmoud, W. A., & Othman, M. A. (2020). Performance Evaluation of a Sugarcane Peeling Machine. Egyptian Sugar Journal 14:1-18.
[DOI:10.21608/ESUGJ.2020.219205](https://doi.org/10.21608/ESUGJ.2020.219205)
- Rein P.and Attard R. G. Cane sugar engineering Berlin: Verlas Dr. Albert Bartens KG, 2nd ed. pp.107–108.[DOI: 10.1016/j.indcrop.2023.117163](https://doi.org/10.1016/j.indcrop.2023.117163)
- Sembada A (2017) Effect of Imbibition Water to Sugar Loss in Bagasse, Process Efficiency, and Purity of Sugarcane Sap in Milling Station Pabrik Gula Djombang Baru, PT. Perkebunan NusantaraX,14:80-100.
[DOI:10.13140/RG.2.2.24595.02081](https://doi.org/10.13140/RG.2.2.24595.02081)
- Wienese A (1995) The Effect of Imbibition and Cane quality on the Front End Mass Balance The South African Sugar Technologists' Association, Sugar Milling Research Institute, Durban, June 1995: 1-5.