Pre Clarification of Cane Juice by Centrifuge Technique

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Abstract— At present the demand of food products that contain minimum chemicals is increasing day by day in the domestic as well as international market. Keeping this in view and to reduce cost of production, Indian sugar industry is also very keen to produce good quality of sugar with minimum use of chemicals in sugar processing. The requirement of the institutional buyers becomes tough as they are interested to procure the sugar having least impurities. Although numbers of technologies have been tried in plantation white sugar factories to reduce the sugar colour but lack in their effectiveness and economic viability. Authors have attempted pre clarification of raw /mixed juice and in the process, centrifuged the cane juice obtained from laboratory crusher as well as mixed juice from sugar factory. Encouraging results were observed as reflected from removal to the extent of 80 % suspended impurities and also reduction in colour 10 to 40 % (IU) of juice depending upon the speed of centrifugation. Good quality of sugar with the reduce requirement of chemicals and having minimum impurities may be thus produced with the help of centrifugation before the conventional clarification process.

Keywords: Pre Clarification, Centrifugation, Gravity Factor, Suspended Impurities, Colour

I. INTRODUCTION

Raw juice obtained from mills contains various suspended impurities, as dirt, bagacillo particles, organic and inorganic impurities. During the processing of sugar cane juice, some of the suspended impurities cause colour development to the juice when limed. The sugar manufacturing process aims at the proper preparation of the raw material which consists of efficient cleaning, extraction of the sugarcane juice, and adequate treatment. The literature reveals[1-2] that centrifugation of cane juice was carried out way back in 1917 but process details are not well available.

In the previous study, the authors conducted the trial at 6000 rpm for 20 minutes' duration. However, in the current studies the same has performed at lower rpm to assess the efficiency and optimize the parameters. In the studies conducted earlier, juice was subjected to centrifugation directly after the milling of the cane. This treatment had been thought of particularly to clarify juices by removing the suspended particles[3] viz, bagacillo particles and organic impurities along with initial mud. In addition, the colloidal particles can also be separated out and resulting the colour improvement. This treatment significantly brings down the chemical load during the clarification process. Apart from centrifugation, the mechanical separation devices also tried earlier to remove impurities to get comparatively purified and low colour mixed juice. Studies on centrifugation of hot cane juice were carried out by Azad[4] by centrifuging mixed juice heated at 65 °C and results on relevant parameters were described in the study for mixed juice before and after centrifugation. The quality of the sugar produced is directly associated with the process of clarification of the cane juice, once the treatment is effective, it produces a better quality sugar, with low colour and impurities. This work evaluated the clarification of the sugarcane juice by addition of phosphoric acid and continuous centrifugation, through the physico-chemical parameters. Analyses were p^H, °brix, purity, reducing sugar, turbidity and ICUMSA colour. The results of the physico-chemical analysis that indicated the best operating conditions for greater reduction of color and turbidity by maintaining 300 ppm of phosphoric acid than heating at 70 ^{0}C. In the statistical planning, the reduction in colour and the turbidity were statistically significant.

The superior quality of raw cane juice as a result of mechanical clarification is likely to minimize consumption of chemicals for further clarification, better juice heating / evaporation, better working of crystallization process and better quality of sugar produced. Author has tried to remove the suspended impurities from raw cane juice by centrifugation of hot raw juice on laboratory scale by using high speed centrifuge. The results of the trials have been described in this article.

II. REVIEW OF LITERATURE

A centrifugal is a device for separating particles from a solution according to their size, shape, density, viscosity of medium and rotor speed. In a solution, particles whose density[5] is higher than that of the solvent, it sediments and particles that are lower than it floats on the top. The greater the difference in density, the faster they move. If there is no difference in density, the particles stay in steady state. To separate various particles from a solution, gravity factor plays a vital role with the much more powerful centrifugal force[6] to provide by centrifuge action. A wide variety of laboratory scale centrifuge are used in various food and chemical industries. Laboratory centrifuge often can accept a range of different fixed angle and swinging bucket rotors able to carry different number of centrifuge tubes and rated for specific maximum speed.

Ram Kumar et al (1993) carried out studies on cane juice samples which were subjected to centrifugation using a Remi R-8C batch type laboratory modal. This was operated at 6000 rpm for 5 minutes and obtained 20 % colour reduction. This treatment has been thought of particularly to clarify juices by removing the suspended particles in form of mud and observed that this treatment significantly brings down the chemical load on the juice.

J.S. Claudio et al (2019)[7] studies sugarcane juice clarification with the centrifuge (Brand: West), capacity of 50L/ h, gravity 9 g, add 150 ppm phosphoric acid and heat at 90 ^{0}C then centrifuged and achieved 20.36% colour reduction.

Raj Kumar et al (1994)[8] reported trial of high speed centrifuge machine at 6750 rpm for removal of suspended impurities from raw juice and sulphited syrup in their factory and observed removal of suspended impurities up to 85% in suspension free raw juice by which low colour clear juice obtained after sulphitation.

Vishal Kumar et al (2008)[9] developed a centrifugal clarifier based on the principle of hydro cyclone with an impeller for centrifugal clarification of sugar cane juice. The developed clarifier and exiting standard sedimentation disc centrifuged were tested at 3400 rpm. The separation efficiency was maximum. (66.03% for the centrifugal clarifier and 66.97% for the disc centrifuge).

As discussed above the centrifuge is being used in various industries for polishing of liquid also. Therefore, it was decided to carry out experiment with the centrifuge for separation of suspended impurities from mixed juice at comparatively lower rpm i.e.1500 and 2500 rpm and also as desired by the industry person during the presentation of earlier paper.

III. Material & Methods

It is common to use centrifuge to separate mixtures, which are not easily separated by decantation of one or more components being liquid / liquid or solid / liquid. Centrifugation is a mechanical process, which has the function of separating or clarifying a mixture, from different densities of its components. This process used in the development of this study, aiming to clarify the sugarcane juice, reducing the amount of inputs used and optimizing the process steps.

During the study, the work was carried out under following conditions to asses most favorable conditions for the best results.

- Remi make bench top centrifuge containing six tubes having the juice holding capacity of 40 gm. in each tube was used for the trials.
- The samples of various mixed juice were collected and maintained 300 ppm phosphate content level then heat up to 70 ^{0}C and add flocculent @ 1 ppm then centrifuged at 1500 and 2500 rpm for a duration of 10, 15 and 20 minute.
- The purity was analyzed using Automatic Saccharimeter (MCP 5300 Sucromat).

The following parameters were observed to reach significant conclusion.

- ICUMSA colour measurement before and after centrifugation was carried out by method GS1/3-7 after adjusting p^H 7.0.
- The turbidity measurement before and after centrifugation was done by turbidity meter.
- Reducing sugar analyzed as per ICUMSA method GS1/3/7-3 (2005).
- Estimation of wet mud % on weight basis as per standard practice.

IV. Results and Discussion

As discussed[2-9] the centrifugation technique has been used in various industries for polishing of liquid. Therefore, it was decided to carry out the lab experiment with bench top centrifuge for separation of suspended impurities from hot (70°c) mixed juice. It was observed that mixed juice obtained from as a result of centrifugation was free from coarse suspended impurities and yellowish in colour.

All the experimental data has been presented in the following table No. I to V and all the observations are given on the average value of three sets of each experiment.

- These experiments had been conducted[10] during crushing season :2018-19, at 6000 rpm for 20 minutes' duration with flocculent @ 2ppm and heat at 70 ^{0}C.

Set	Set I		Set II		Set III		Average	
Particulars	Untreated Juice	Treated Juice	Untreated Juice	Treated Juice	Untreated Juice	Treated Juice	Untreated Juice	Treated Juice
PH	5.35	5.35	5.62	5.62	5.4	5.4	5.46	5.46
Brix %	12.50	12.50	13.6	13.6	12.85	12.85	12.98	12.98
Pol %	10.18	10.18	11.26	11.26	10.26	10.26	10.57	10.57
Purity	81.44	81.44	82.80	82.80	79.84	79.84	81.39	81.39
Turbidity	33	2.8	36	3.5	33.8	2.9	34.27	3.07
ICUMSA Colour	26290	15377	26580	15881	27176	15995	26682	15751
Mud % (w/w)	..	2.32	..	2.41	..	2.45	..	2.39
Turbidity Reduction (%)	..	91.54	..	90.28	..	91.4	..	91.07
Colour Reduction (%)	..	41.51	..	40.30	..	41.15	..	40.99

TABLE 1

- These experiments have been conducted during crushing season :2019-20, at 1500 & 2500 rpm for 10,15 & 20 minutes' duration with optimum level of phosphate content up to 300 ppm, flocculent @ 1 ppm, and heat at 70 ^{0}C to optimize the duration of centrifugation.

Particulars	Untreated Cane juice	1500 RPM		
		10 Minute	15 Minute	20 Minute
P^H	5.22	5.11	5.10	5.08
Brix %	15.62	15.60	15.59	15.60
Purity	80.55	80.54	80.53	80.50
P_2O_5 (ppm)	250	300	300	300
RS% /100 ^{0}Bx	5.28	5.19	5.30	5.26

ICUMSA Colour	23456	21415	21157	20524
Turbidity (NTU)	425	146	136	100
Colour Reduction (IU %)	..	8.70	9.8	12.50
Turbidity Reduction (%)	..	65.67	68	76.55
Wet mud % (w/w)	..	1.98	2.00	2.10

TABLE 2

Particulars	Untreated Cane juice	2500 RPM		
		10 Minute	15 Minute	20 Minute
P^H	5.22	5.10	5.12	5.09
Brix %	15.62	15.59	15.58	15.55
Purity	80.55	80.48	80.50	80.42
P_2O_5 (ppm)	250	300	300	300
RS% /100 ^{0}Bx	5.28	5.19	5.30	5.26
ICUMSA Colour	23456	21275	20407	19938
Turbidity (NTU)	425	115	98	73
Colour Reduction (IU %)	..	9.30	13	15
Turbidity Reduction (%)	..	73	77	82.94
Wet mud % (w/w)	..	2.22	2.30	2.35

TABLE 3

From the above tables, it can be observed that reduction in colour, turbidity and wet mud % are the maximum at 20- minutes duration of centrifugation. Therefore, it was decided to carry out the further experiments at 20-minute centrifugation.

– These experiments have been conducted during crushing season :2019-20, at 1500 & 2500 rpm for 20 minutes' duration with optimum level of phosphate content up to 300 ppm, flocculent @ 1 ppm, and heat at 70 ^{0}C.

Particulars	1500 RPM Set II Set III						Average	
	Set I		Set II		Set III			
	Untreated Juice	Treated Juice	Untreated Juice	Treated Juice	Untreated Juice	Treated Juice	Untreated Juice	Treated Juice
P^H	5.60	5.45	4.87	4.79	5.22	5.10	5.23	5.11
Brix %	12.69	12.37	14.87	14.82	15.62	15.58	14.39	14.26
Purity	83.69	83.91	81.31	81.55	80.55	80.81	81.85	82.09
P_2O_5 (ppm)	250	300	250	300	250	300	250	300
RS% /100 ^{0}Bx	3.13	3.15	4.20	4.25	5.28	5.30	4.20	4.23
ICUMSA Colour	20637	18099	25396	22202	20938	18253	22324	19518
Turbidity (NTU)	306	68	435	105	425	99	389	91
Colour Reduction (IU)	..	12.30	..	12.58	..	12.82	..	12.57
Turbidity Reduction (%)	..	77.78	..	75.86	..	76.71	..	76.78
Wet mud % (w/w)	..	2.01	..	2.08	..	1.95	..	2.01

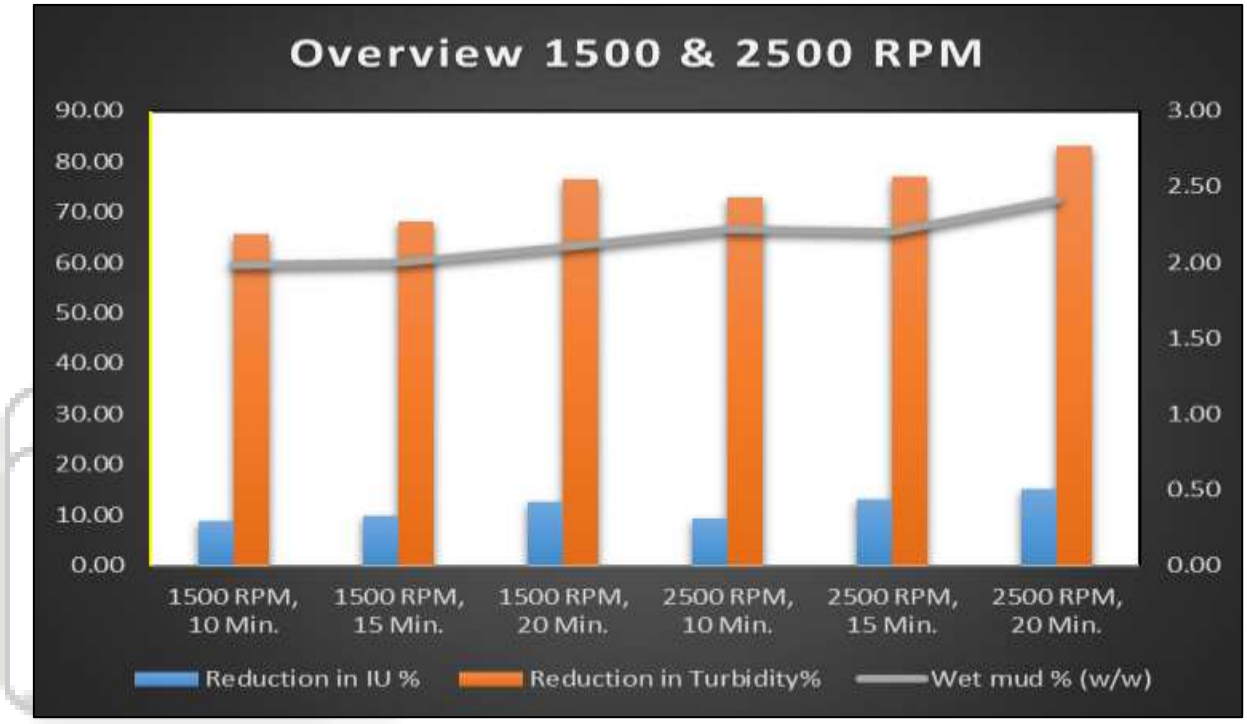
TABLE 4

Particulars	2500 RPM Set II Set III						Average	
	Set I		Set II		Set III			
	Untreated Juice	Treated Juice	Untreated Juice	Treated Juice	Untreated Juice	Treated Juice	Untreated Juice	Treated Juice
P^H	5.60	5.50	4.87	4.72	5.22	5.1	5.23	5.11
Brix %	12.69	12.61	14.87	14.80	15.62	15.50	14.39	14.30
Purity	83.69	83.73	81.31	81.50	80.55	80.27	81.85	81.83
P_2O_5 (ppm)	250	300	250	300	250	300	250	300
RS% /100 ^{0}Bx	3.13	3.10	4.20	4.35	5.28	5.31	4.00	4.25
ICUMSA	20637	17388	25396	21688	20938	17610	22324	18895

Colour								
Turbidity (NTU)	306	58	435	68	425	70	389	65.33
Colour Reduction (IU)	..	15.74	..	14.60	..	15.89	..	15.41
Turbidity Reduction (%)	..	81.05	..	84.37	..	83.53	..	82.98
Wet mud % (w/w)	..	2.35	..	2.15	..	2.41	..	2.30

TABLE 5

A. Graphical Representation



- From the above tables, (I-V) it is clear that suspended solids are eliminated as mud to a greater extent and the effect on dissolve solids, reducing sugar and purity are negligible.
- The required quantity of lime and Sulphur is expected to reduce due to better quality of raw juice availability for further clarification.
- Separation of such solids as mud is approximately 2.0-2.5 % (w/w), slightly increase with respective of centrifugation speed. This reduction of mud may also reduce the mud load in further clarification process.
- Reduction in turbidity is approximately 65 to 80 % and it is approx. 90 % in case of 6000 rpm, which shows increase with respect to centrifugation speed. This will also reduce viscosity hence it will help in better exhaustion during crystallization process and reduced scale formation in evaporators also.
- Reduction in raw juice colour as a result in centrifugation is approximately 10-15%, and it is approx. 40 % in case of 6000 rpm, it varies with the centrifugation speed applied.
- Apart many advantages as given above, colour reduction shall also help in producing better quality of sugar.
- It has been observed on the basis of practical and theoretical approach that in case of cane juice clarification the mechanical means have an edge over chemical process for its better control without affecting the system.

V. Conclusion

It may be concluded from above presentation that the centrifugal separation has an edge over chemical methods with proven advantages. The removal of suspended impurities will reduce the chemical consumption load on clarifier and will give clear juice of lower colour. Studies related to centrifugation of mixed juice indicate that the benefits may not be limited to colour and mud solid reduction only, but also there may be additional advantages of better recovery of sugar, lower lime and Sulphur consumption, lesser scale formation, increased capacity of clarifier and vacuum filter etc. Data obtained are encourages for scaling up the centrifugation studies from laboratory scale to commercial scale for the clarification of mixed juice.

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