

Evaluation and Optimization of Hot Liming Process in Kenana Sugar Factory, White Nile State, Sudan

Waleed Nour Eldien *, Elham H . M. Ali **, Ahmed. Sohily **, Mortada Hamad E.A **

* Chemical Engineering Department, Elimam Elmahdi University, Sudan, waleed_salih2003@yahoo.com

** Chemical Engineering Department, Elimam Elmahdi University, Elhamhussain90@hotmail.com

** Chemical Engineering Department, Elimam Elmahdi University, Sudan, sohily74@gamil.com

** Chemical Engineering Department, Elimam Elmahdi University, Sudan, sohily74@gamil.com

** Food Processing Engineering Department, Elimam Elmahdi University, Sudan, morta27666@gamil.com

Abstract-The purification process is very important stage in sugar industries. The juice extracted from cane sugar is normally treated by addition of milk of lime and heating. This treatment helps settling of the coagulate, fulgent, salt, gums, and fiber impurities. This impurity affects to quality of juice and there chemical properties. After purification process the clear juice concentrated in evaporators then to the crystallizers to produce sugar crystals. Then sugar crystals were separated from molasses and to color improvement unit.

.In this study the samples of lime juice were taken and heated to different temperature (75, 80, 85, 90, 95, 100) °C were analyzed and determined the chemical properties which affected to quality of sugar production like: pH, polarization sugar, reducing sugar, color, phosphate contains, turbidity and purity. Then the sedimentation rate at this different temperature by measuring the volumes of settling material and the clear juice were calculated.

In output result, find that temperature which affected for this properties - turbidity change (37.3, 20.7), reducing sugar (0.77, 0.72, 0.77) it is found that from the result the optimum temperatures for good quality is (90, 85°C). Then The study recommended that used optimum concentration of milk of lime should be considered in liming and pre-liming processes.

Keywords: evaluation, optimization of hot liming process in sugar factory

I. INTRODUCTION

The liming station is one of the most important stations in the raw cane sugar factory. The importance of proper treatment of raw cane juice with milk of lime must be kept in mind when a sugar factory is designed or modified. Addition milk of lime to the raw cane juice is a chemical treatment for a small chemical treatment the correct procedure must be an accuracy followed.

Hydrated lime is essential to the production of sugar from both sugar cane and sugar beets .It is used to purify sugar from other sources such as maple or sorghum although these are produced in much smaller quantities.

Sugar cane and sugar beets are harvested and processed with water to form raw juice which has low pH and contains lime dissolved impurities.Hydrated lime is added to the juice to raise the pH and react with impurities to form insoluble calcium organic compounds that can be removed Excess lime is removed by carbonation or addition of phosphoric acid . This process may be repeated several times depending on the final product required.

Raw sugar cane juice is composed of great number of organic and inorganic compounds, acids, salt, in vary amount. When it comes from the mill tandem. the juice is an opaque liquid varying in color from greenish-gray to dark green, and it carries suspended matter such as fine bagasses (bagacillo), gums, wax, albumin, coloring matter, particles of soil, clay and muck the normal raw cane juice has pH 5.2-5.4 The wax and albumin make the raw juice rather viscous and it cannot be readily filtered but when cold liming and heating cause many impurities to become coagulated and precipitated out.

At the same time the Acids are neutralized and any phosphates present are flocculated adsorbing a large amount of coloring matter and other impurities. Usually the lime is added to the raw sugarcane juice in the form of milk preparing of lime for better dispersion and quicker reaction. Preparing the milk of lime more advantageous to use already prepared hydrated lime rather than to burn lime stone and slake.

The lime must be carefully selected it contain over 95% Ca (OH)₂ and not more than 1% MgO and almost free of iron, aluminums oxides and sand. The lime should be finely ground and pass through a400 mesh.

Lime which meets these specification will actually be more economical to use than a cheaper grade of lime about 50 Bome' all the lime will be in suspension and when dispersed in the raw can juice it will react much faster with acids and compounds in the sugar juice [1].

There are three Objectives of this study, to treat the limed juice by heating for different temperature at constant pressure, to carry out the properties of the clear juice after heating, (e.g.) polarization (pol%), Brix (Bx%), Reducing sugar(Rs), color, turbidity, pH, and phosphate contents, and determine the sedimentation rate.

II. MATERIALS AND METHODS

The cane juice comes from the mills contains many soluble and insoluble impurities it is turbid and viscous in nature, and is not fit to be worked for white sugar manufactory without suitable chemical treatment of it, it is necessary to remove the maximum quantity of impurities from the expressed juice at the earlier stags to be obtained pure crystallize sugar.

The clarification of juice is done for two purposes that are: removal of impurities and bleaching effects

Removal of impurities

To precipitate dissolved inorganic non-sugar present in the juice in colloidal state there by to increase the percentage of available or crystallizable sugar. To separate insoluble solid matters suspended in the juice in colloidal state rendering the juice opaque viscous and dark in colour. These impurities cannot be separated by simple filtration of the raw juice but are separated along with non-sugar precipitated by the action of lime and heat. [2]

Bleaching effects

After the impurities are removed by the chemical treatment of juice, bleaching is done to render the juice brilliant and light in color this process is necessary for the manufacture of white sugar but is not of much importance for the raw sugar Sulphur dioxide is the chief bleaching agent used in sugar house practice [3].

Methods of clarification process

The nature of the chemical treatment of the juice is determined by two considerations:

- The quality of juice to be treated
- The quality of sugar to be produced (raw sugar , white consumption sugar , refined sugar)

Defecation process

Three methods for the manufacture of raw sugar from cane these are classified as Simple defecation, compound defecation, neutral defecation Action of lime on cane juice in the defecation process

- It eliminates free organic acids (oxalic, tartaric, etc)

- The following non sugars are insoluble albumen both soluble and insoluble forms acid phosphates as tribasic phosphates Colorings substance anthocyanin (a small percentage) Nitrogenous compounds about 50-60% of the total Pectin a small percentage Gum (xylan) none of the cane juice gums the purification is physical in nature and the precipitate formed readily entraps the suspended impurities and brings them down. There is a small purity rise of 0.7 to 1.0 units due to removal of the non sugar and colloids in lesser proportion.

Simple defecation

Lime and heat are only used in this process, methods commonly followed are classified according to manner lime and heat is used. These are Liming in cold juice, liming hot juice, fractional liming with double heating, java method

Liming in cold juice (lime –heat method)

Milk of lime is added to the cold raw juice, as expressed from the mills in sufficient quantity so as to make the juice distinctly alkaline. The pH of treated juice may go up to 8.0-8.4 the criterion to judge the optimum quantity of lime required should be form the pH of clarified juice which should be about 7.2. The juice is then heated to 101.1°C or higher and allowed to settle, the clear juice is decanted of and muddy juice filtered The clear filtered juice is mixed with the clarified juice and concentrated in the multiple effect evaporator. In the case of vacuum filter the cloudy juice is mixed with the raw juice.

With the growth of technical knowledge liming in hot juice and fractional liming with double heating has come into practice.

Liming in hot juice (heat-lime method)

This is modification of original system of liming in cold juice .The precipitate is more flocculent when lime is added in hot juice and its settling qualities also improve.

Raw juice is first heated to (75-80°C) and milk of lime is added to it in sufficient quantity to raise its pH between 7.8 and 8.0, so as to give to the clarified juice final pH between 6.8 and 7.2 .The lime juice again heated to its boiling point as before 101.1°C (minimum) and allowed to settle. The drop in pH between the hot limed juice and the clarified juice in this case is less when compared with drop in case of original cold liming method this is due to the fact that by heating raw juice alone, certain colloids coagulate without the addition of lime [4]. made experiments in java and showed that heating juices alone to 80oC caused the precipitate of 1.4 grams of organic matter per liter of juice.

Fractional liming with double heating

This process is intended to treat refractory juices when ordinary liming becomes inefficient. In this system lime is added in two fractions and the juice is heated twice:

- Lime is added first in raw juice at ordinary temperature and a pH between 6.2 and 6.6 is maintained.
- Heat the partially limed juice to 71.1-79.4°C
- Add second dose of lime and pH between 7.6 and 8.2 (maximum) is maintained.
- Heat again to a temperature between 101.7°C and 104.4°C.
- Allow the juice to settle.

Advantages:

This procedure has the superiority over cold liming system in the following way.

- Settling is rapid.
- Scum formation is less.
- The clarified juice is much more brilliant.

- The mud filters better, giving dry and porous cakes.
- The nitrogenous colloid are separated to a much greater extent, about 80% instead of 50%
- Waxes are eliminated in much greater proportion, about 90% instead of 70% in the case of cold –liming method.

The following materials which were used in this study were collected from Kenana Sugar Factory (K.S.F) used Sugar cane lime juice. And determined the properties which affected to the quality of produce sugar according to (ICUMSA) [5]. International commission uniform methods of sugar analysis and South African Sugar Technologist’s Association methods were used [6].to determined the properties which affected to the quality of sugar like : polarization sugar (poll), Reducing sugar (RS). Turbidity, color phosphate contents, Brix, pH and determined the sedimentation rate. Then output results of optimum properties at various temperatures.

III. RESULT AND DISCUSSION

The following tables shows the result of clear juice samples after added 2ml sepan at different temperatures:

Table1: Result for properties of clear juice samples

| Propertie s | Value at temp.75 ^o C | Value at temp.80 ^o C | Value at temp.85 ^o C | Value at temp.90 ^o C | Value at temp.95 ^o C | Value at temp.100 ^o C |
|-------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|----------------------------------|
| pH | 7.84 | 7.81 | 7.70 | 7.67 | 7.72 | 7.54 |
| Bx | 13.24 | 13.31 | 13.53 | 13.64 | 13.72 | 13.83 |
| Pol | 11.6 | 11.75 | 11.16 | 11.38 | 11.21 | 11.28 |
| P ₂ O ₅ | 13.6 | 12.7 | 17.2 | 19 | 10.9 | 18.1 |
| RS | 0.74 | 0.73 | 0.72 | 0.77 | 0.77 | 0.77 |
| Turbidity | 37.3 | 27.6 | 26.8 | 21 | 9 | 7.1 |
| Color | 22789.3 | 15469 | 20738.3 | 14258.2 | 19389.76 | 15840.3 |
| Purity% | 88 | 84 | 83 | 85 | 85 | 84 |

Table2: Relationship between time and T.D.S

| Time(min) | 30 | 60 | 90 | 120 | 150 | 180 | 210 | 240 |
|---|-----|-----|-----|-----|-----|-----|-----|-----|
| Volume of T.D.S (ml) at Temp.26 ^o C | 190 | 165 | 150 | 140 | 135 | 128 | 125 | 124 |
| Volume of T.D.S (ml) at Temp.75 ^o C | 135 | 125 | 115 | 110 | 106 | 105 | 105 | 100 |
| Volume of T.D.S (ml) at Temp.85 ^o C | 148 | 140 | 132 | 128 | 122 | 120 | 120 | 120 |
| Volume of T.D.S (ml) at Temp.90 ^o C | 130 | 118 | 110 | 105 | 101 | 100 | 100 | 100 |
| Volume of T.D.S (ml) at Temp.95 ^o C | 190 | 180 | 168 | 160 | 158 | 152 | 151 | 150 |
| Volume of T.D.S (ml) at Temp.100 ^o C | 155 | 140 | 135 | 128 | 122 | 121 | 120 | 120 |

Table3: Volume of clear juice after 240min

| | | | | | |
|---|-----|-----|-----|-----|-----|
| Volume of T.D.S(ml) | 100 | 120 | 100 | 150 | 100 |
| Volume of clear juice=500-volume of T.D.S(ml) | 400 | 380 | 400 | 350 | 380 |

It is clear that from Figure.1, Figure.2 and table.1shown that:

- PH decreases as temperature increases. The Brix increase as temperature increases.

There no significant change in pol as temperature change but at high temperature this affect for Brix value if it is low Brix and high polarization of sugar this lead to increase value of sugar purity [purity%=[pol/Brix]x100.The turbidity decreases with increases temperature depending to the rat of reaction it rise for temperature .No change for Reducing sugar is this rang of temperatures but if

it high temperature this lead high value of reducing sugar and that is bad affect for quality of sugar production. The color also depended at Brix factor. There no significant change in phosphate continues as change in temperature but phosphates (P_2O_5) are added when it less than optimum required (300ppm).The phosphate reaction with juice leads to the formation of a heavy flocculent precipitate of tri calcium phosphate and removes the other impurities.

From table. 2 and table .3 Volume of turbidity depended at result of reaction (settled material) at change temperatures ,and it is found that the best result at settling time two hours at temperatures (85 , 90) $^{\circ}C$ the settling material is const at short time and the clear juice is pure with impurities (settling is raped).

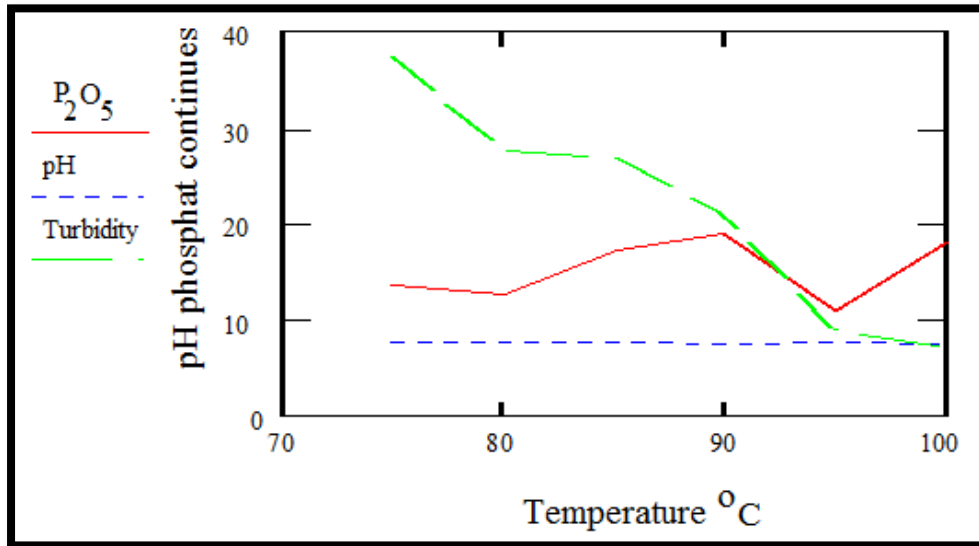


Figure 1: Relationship between temperature, phosphate contains, pH and turbidity

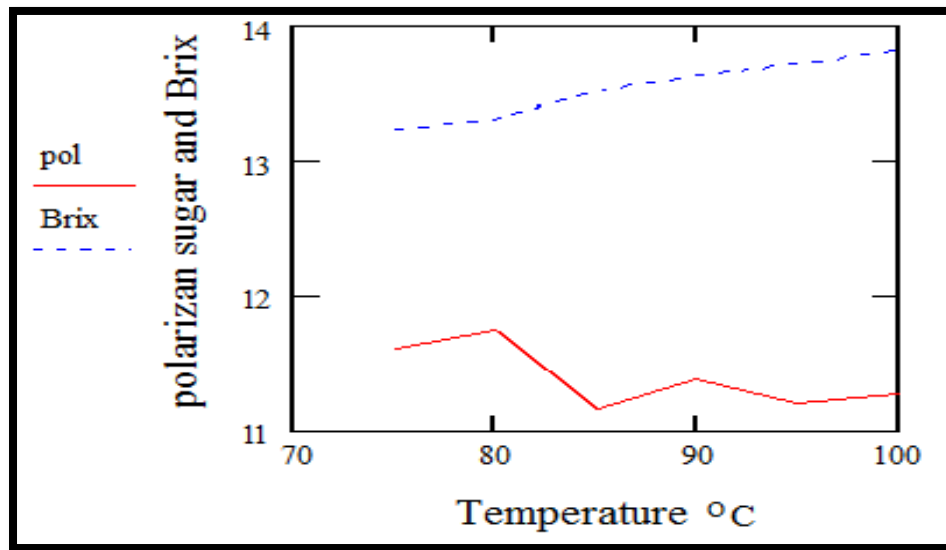


Figure 2: Relationship between temperature, Brix, pol

IV. CONCLUSION

This study concluded and recommended for the following points:

- optimum concentration of milk of lime should be used because if the concentration increases this effect not good settling and cause scaling in evaporators and added load to filter and if it is less effect to higher turbidity higher acidity product dusts sugar.
- Clarifiers should be developing and use optimum operation is to be good to decrease the higher quantities of mud carry out.

- More refined sugar will give more income so purification should be considered before recycle the filtrate to pre lime instead of lime juice tank these decrease the quantities of lime added and acidity

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REFERENCES

- [1] BaCkow,V.E. "Manufacture and Refining of raw cane sugar", Second edition, Elsevier publishing Co, Amsterdam,(1982)
- [2] E.Hugot (ibid), "cane sugar Technology" Elsevier publishing Co, Amsterdam ,(1972) ,p.402
- [3] Noel Deerr,"can sugar", Elsevier publishing Co, Amsterdam: p. (267).
- [4] p.Honig. "Technology of sugar", (1953) part 1, p.(598).
- [5] International commission uniform methods of sugar analysis to, (2005).
- [6] Horne`s dry lead method (South African Sugar Technologist`s Association (1985).