STUDY ON SUGAR PROCESS MANUFACTURING PLANT PELWATTA SUGAR INDUSTRIES LIMITED

BY

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This is submitted in partial fulfillment of the requirement for the Degree of Bachelor of Science in Physical sciences of the Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka, Buttala, Sri Lanka.

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DECLARATION

The work is described in this thesis was carried out by me at the Pelwatta Sugar Industries limited and the Faculty of Applied Sciences under the supervision of Mr. P. J. Prematunga and Dr: D.B.M Wickramaratne. A report on this has not been submitted to any other University for another degree.

S Saliyakeerthi 2002/04/14

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(S.K. Saliya Keerthi)

Certified by,

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....

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AFFECTIONATELY DEDICATED TO
MY EVER LOVING PARENTS

ACKNOWLEDGEMENT

First I would like to give my special sincere thank to Mr. P. J. Prematunga, Factory manager, Pelwatta sugar industries limited, My external supervisor who advised me to get a good path to study the Sugar manufacturing process. And also my deepest gratitude to Dr. D.B.M. Wickramaratne, My internal supervisor, Head of the Dept of Physical sciences, Faculty of Applied Sciences, for his valuable guidance, encouragement and supervision given to me to complete this study program to a success.

Then I must thank to Dr.K.K.D.S. Ranaweera, Dean, Faculty of Applied Sciences, and the staff of the Faculty of Applied Sciences.

Abstract

Pelwatta Sugar Company Limited is a one of the major sugar producing company in Sri Lanka. The company contributes to 80% of the total sugar production of the country.

This study involves in-depth investigation of each and every important points in the processing plant at Pelwatta sugar Industries limited with a view to identify any weak points and to develop remedies to improve the quality and the yield of such steps.

Since most of the steps involve heavy machinery with my poor knowledge in technology, I had to learn the basic engineering principles during my study period that consumed lot of time allocated for the real study.

This thesis includes both the chemistry of the sugar production and the technology of the sugar production according to the knowledge gained from the study I carried out at the Pelwatta Sugar Industries Limited.

Suggestions that might improve the yield and the quality of sugar were given in the conclusion.

CONTENT

CHAPTER 1

1.1 INTRODUCTION

When we speak about SUGAR, we are talking and thinking of a particular kind of sugar known as Sucrose. There are two plants, which produce large quantities of sucrose, which can be easily extracted from them. They are sugar **Beet &** sugar **Cane.** Sugar beet generally grows in the cooler parts of world & sugar cane is most easily grown in the warmer parts if there is enough rainfall.

The sugar industry is essentially an agro-industry. Therefore it should be centrally Located within the vast area of cane cultivation. Otherwise it will increase the cost of transport. It should be established at a place where agronomic conditions favor the development of sugar cane plantation & where climatic conditions rainfall, land fertility facilities are such as ensure abundant supply of sugar cane with high yields per hectare. For cultivation of sugar cane a hot, moist climate with dry ripening season is needed (essential).

In Sri Lanka dry zone areas are most suitable for the sugar industry. Sugar was produced in Sri Lanka by the state owned three industries Kantale, Hingurana, Sevenagala, & Pelwatte Sugar Industries in the private sector. When these four Industries were being produced sugar. The domestic sugar production was nearly 15% of the annual local demand. But Kanthalai &Hingurana sugar factories have already been closed. Presently sugar is produced in Sri Lanka by only Sevenagala & Pelwatte sugar factories, it is nearly only 10% of the local demand.

Statistical Data of Sugar Consumption

YEAR	1993		1994		1995		1996	
Consumptio	462,418	100%	563,275	100%	488,225	100 %	454,339	100 %
Import	393,545	85%	491,000	87%	416,096	85 %	381,000	84 %
Local Production	63,897	15%	72,275	13%	71,416	15%	73,339	16 %

YEAR	1997		1998		1999	
Consumptio	609,055	100%	550,000	100%	544,220	100 %
Import	545,158	89%	488,500	87%	479,000	85%
Local Production	63,897	11%	61,500	13%	62,220	15%

Annual consumption is varied around 450,000 to 610,000 Mts. In last 7 years

Per capita consumption is around 22kg.

Data obtained from Central Bank Annual reports (1996-1999)
& PSIL Annual reports (1993-1999)

1.2. SUPPLY OF CANE

The supply of cane to the factory is from three sources, company managed NUCLEOUS ESTATE of 2700 hectares, a SETTLEMENT ESTATE of 3600 hectares where1500 families have been settled by the company with the assistance of the Government of Sri Lanka & over 8000 hectares of Private farmers (OUT GROWERS) growing cane as a commercial crop for sell to the factory. Cane is transported to the factory by trucks & Tractors. Before cane is dumped at the factory yard all cane entering to the factory is weighed at the weighbridge.

1.3. MILLING SEASONS & CAPACITY

* Mid Jan. to mid April-60 days
    - 200000 Mt. Of Cane
* Mid May to mid October-150 days
    - 400000 Mt. of
* Total 600000 Mt. of cane –per annum

1.4. WORKFORCE

The permanent workforce of the company is a 1290 employer; additionally over 6000 workers are also employed on a Seasonal/Casual basis.

CHAPTER 2

2.1 MANUFACTURING PROCESS

Manufacturing Process consists with following steps

- CANE FEEDING FOR PREPARATION
- CANE PREPARATION
- MILLING
- JUICE CLARIFICATION
- EVAPORATION
- CRITALISATION
- CENTRIFUGATION
- DRYING & BAGGING
- SUPPORTING PROCESS
    - Boiler House
    - Power generation
    - Process control Laboratory
    - Wastewater treatment
    - Water treatment

2.1.1 CANE FEEDING FOR PREPARATION

Cane at the factory yard is delivered mechanically to the cane preparation cutters through cane unloader to the feeding table. Cane of the feeding table is delivered to the cane carrier and finally to the cane Cutters.

2.1.1.1 UNLOADING OF CANE

The way of unloading Cane, arrived to the factory is different from factory to factory. Çane arriving at the factory by trailers lorries and containers (specially designed for cane transport) are unloaded at the cane yard or directly to the feed table. Cane arrived by trailers which have self-lifting facility is directly unloaded at the cane yard or to the feed table. The Cane arrived by lorries as "packets" or bundles, which are bound by three chains or "slings" are unloaded directly to the feed table or to the containers, which are designed to the unloader. The cane transported by containers are directly unloaded to the feed table by a cane unloader.

2.1.1.2. CANE UNLOADER

Cane unloader is used to handled and unloaded the cane that are carried by containers into the feed table. Normally these are operated hydraulically and the lifting capacity is 20 tones. There are two cane unloaders at each factory.

2.1.1.3. FEEDING TABLE

To facilitate the switching of the full & empty truck, auxiliary cross carriers at right angles to the main carrier and feeding in to it, have been developed. These are usually made from 7m wide and 12 to 15m long and are strong enough to take a complete truck or wagonload. The speed of the auxiliary carrier or the feeding table is half of the main carrier. The feeding table consists of three strands of chains.

2.1.1.4. AUXILIARY CANE CARRIER

The cane carrier carries cane towards the cane knives, which are fallen from feeder table. It is constructed of mild steel framing with two endless chains of the roller type. They are about six inch pitch carrying overlapping steel slats to prevent chips of falling through. The carrier is driven by an independent steam drive attached to the top column or by a high slip ring (15 – 20 %slip.) electric motor. The speed of the cane carrier may be related to the peripheral speed of the mills. The carrier is divided into three portions:

(a) The horizontal,
(b) The inclined, and
(c) The head, which is where the cane arrives above the crusher.

The slope of the carrier is important and it should not exceed 16 to 18^{0}, otherwise it would have the tendency to make the cane slip, and let the conveyer move forward without picking it up.

2.2. CANE PREPARATION

On account of its bulky nature & the physical character of its outer structure, the cane presents considerable resistance to the action of the rollers. This affects the pressing out the juice. To promote the milling facilities & for economical juice extraction from cane, cane preparation is required. On the other hand it reduces the volume of the cane. To destroy the inherent resistant of the rind & nodes to open up the pith so that. It responds more effectively to the alternate processes of pressure & dilution. Following method or methods are used in cane preparation.

1. Cutting or slicing by revolving knives.
2. Crushing or rupturing by crushes.
3. Shredding or tearing by shedders.

2.2.1. CANE CUTTING KNIVES

Cane passes through two sets of rotating knives on it's way to the shredder. The knives are bolted to steel hubs threaded on a horizontal shaft, placed transversely across the cane carrier.These are coupled the through a flexible coupling either to a high-speed steam turbine or to an electric motor. The speed of knives should be about 500-700 r.p.m. The use of well designed knives for preparing cane before milling increases the efficiency of the milling plant and may also increase its capacity by as much as 10%. Knives chop and break up the cane into small pieces of various shapes and sizes.

1.Leveller knives

The levelers comprises of a set of knives, which cut the whole cane into small pieces and even out a layer of the cut cane. They are worked with high clearance normally about 4" to 10" from the carrier slats and consequently leave a large portion of uncut cane. The pitch between two adjacent knife blades in the case of levelers is often kept three inches apart.

2.Cutter knives

The cane cutter comprises knives of similar design as those of the levelers. They completely disintegrate or cut the cane into fine pieces. They work well with a small clearance of about 1"-1.5" from the carrier slats. The pitch between two sets of knives kept at two inches.

2.2.2. SHREDDER

The shredder on the other hand, besides chopping and breaking up the cane, also disintegrate its fibrous layers, which account for the enormous success of the cane shredder as an adjunct for cane preparation. The disintegration of the fibrous layers results in the breaking up of practically all the cane cells in which the juice is contained. By shredding, both capacity and extraction, can be increased. Consequently the sugar loss in bagasse may be reduced by 2% and the capacity increased by 20%.

2.2.2.1. DESIGN OF SHREDDERS

There are various designs of shredders; almost every one is built on different principles to produce the same ultimate effect. In resent practice, preference is given to the sear by shredder with revolving hammers. The hammers are pieces of mild steel about 8" long and 2.5"wide, each weighing 1.75 to 3.5 lb .The length of the shredder recommended slightly smaller than the succeeding roller, and the usual difference is about is about 6 inches. A steam turbine or an electric motor generally drives shredder, and rotor speed is between 1000 to 1200 r.p.m. Before cane entering to the shredder magnetic separator is placed to remove the metallic parts that carries with cane chips.

2.3. MILLING

To extract the juice prepared cane passes through four sets of **four roller mills** (horizontal) in series. The top roller is driven by a steam turbine and it has a pinion, which meshes in with the pinions of other three rollers. The force feeder roller ensures an even flow of prepared cane to the top roller and lower left feed roller The cane is then crushed twice, first it passes between the top roller and the lower left feed roller, then it passes between the top roller and lower right delivery roller. The cane is crushed under greater pressure between the second two rollers than the first two rollers because the gap between them is less. A trash plate is fitted between the lower two rollers to guide the cane from the feed opening to the delivery opening.

2.3.1. Imbibitions (soaking up of Bagasse)

When the cane passes through the cane knives many of cells, which contained juice, are laid open and as the cane passes through the rollers and the cells are then broken. Because of the spring like properties of cane fiber not the all sugar juice can be squeezed out by the rollers. The cane fiber behaves like a blotting paper and some juice is trapped between the fibers. This juice can be washed out of the fiber by spraying it with water before it passes through the mill rollers. If the bagasse is passed through several sets of rollers and is sprayed before it enters each one the percentage of sugar juice left will become less and less after each crushing. The process of washing out the juice is called **Imbibitions.**

Imbibitions water is sprayed to the third mill bagasse before it enters the fourth mill. The very diluted sugar juice that is extracted from the fourth mill is sprayed on to the fiber entering the third mill, and the juice extracted from the third mill is sprayed on to the fiber before it enters the second mill, The only mill will does not receive any Imbibitions water is the first mill.

2.3.2. Conditions for good milling

Conducive to good milling of sugar cane could be achieved by using the following steps.
Even feed should enter to avoid choking or slipping. All hydraulics should float freely, i.e., regularly go up and come down. The top halves of roller journal brasses should not rest on the bottom halves while the mill is working. Pressure regulators are generally designed so that the maximum lift or rise of crusher top roll is from 1 1/2" to 2". There should be a gap of 1/8" to 3/8". The juice should be flowing down the entire length of the feed roller in full quantity. The flow from the feed roller should be much more than from the discharge roller.

"During the grinding, juice being discharged with considerable force and in gushes from back of the turn-plate, between the top and bagasse roll on the discharge side. In most cases, this is an indication that the front roll is open too wide and top roll not floating level. The back and top roll have to extract all the juice. If the opening between the back of the turn-plate, and the bagasse roll is of insufficient area for the volume of juice extracted, pressure will be set up on the turn-plate, crushing the mill to choke.

The juice in then discharged in gushes with considerable pressure. If the opening between the turn-plate and the bagasse roll is increased too, considerable fine bagacillo is discharged in to the juice pan. If bagacillo is put back on the mill, great quantity will likewise choke the mill. To make possible a very close setting between the turn-plate and the bagasse roll the writer installed some particular juice grooves in the back of the turn-plate. This give a desired discharge area and very little bagacillo found its way in to the juice pan. All of which adds to the grinding capacity. It is also very important that the turn-plate be set to a proper depth. The cross sectional area of the tip of the turn-plate, including the top roll groove area at the entrance, should be never less than 140-155 per cent of the total entrance area between the cane and the top roll; this area should be increased from 15 to 20 per cent, on the back of the turn-plate. Under grinding operations, great care should be exercised that the turn-plate is adjusted properly to the cane roll from time to time; if this is neglected, the grooving will ware and foul up with Bagasse, which in most cases choke the mill.

There should be no vibration or undue noise from mill. Causes of vibration are made to insufficiently strong foundation; fault alignment; defective lubricating system; gear teeth differences or their undue wear; fly wheel looseness in the case of steam engine drive; difference of surface speed in co-acting rollers due to diameter differences; slipping of rollers; and defective rollers and trash plate setting.
The following points also required attention:

1. Proper lubrication of cane carrier and intermediate carrier chain.
2. Proper lubrication of the space between the top half of the top roller brass and the headstock.
3. Proper maintenance.
4. Examine the grooves for re-grooving according to life of the roller.
5. Keep the top roller 2mm longer in length than the length of the feed and discharge rollers for smooth and straight lift.
6. Keep the trash plate and scrapers 2mm lesser in length than their respective rollers.

7. Keep the mill bearings only 1mm bigger in diameter than their respective rollers. Any mill bearing which is more than 3mm diameter of the respective roller journal is re-metalloid and set right.

8. All the side bearings are to be provided with top cover guards and the side roller juice rings are kept in proper conditions to avoid the juice and bagasse coming in contact with roller journal. The wearing plate in the headstock is provided with a lubrication system and a check should be kept to see that the top half of the top bearing is properly moving. If these bearings are loose in the headstock they get twisted and do not float properly.

The first mill extracts about 65% of the sugar. After all four mills about (93-96)% of sugar have been extracted.

The waste fiber, which is called bagasse containing very small amount of sugar, is used to fire the Boilers, which produce the steam to operate the factory.

2.3.3. Juice screening

At each stage before juice leaving the mills the juice is passed through a fine mesh screen to remove particles of bagasse.

2.3.4. Sand extractor

Mixed juice is then fed to the sand extractor to remove sand that carries with cane. Sand extractor is a tank with slats, which are fitted to rotary two endless chains. While chains rotate the slats are swept the bottom of the tank and are removed settled sand.

2.4. JUICE CLARIFICATION

The juice that has been squeezed from the cane in the milling process is called mixed juice and it containing water, sucrose, reducing sugars, gums, salts of organic and inorganic acids, coloring matters, colloids, suspended matters.

Colloids include proteins, celluloses, pentosanes, waxes, fats, soaps & free silica. ***Colouring matters*** *include chlorophyll, anthocynin, saccharites, polyphenols or tannins.*

Organic acids *include arconite, glycolene. oxalic, malic, succanic, tannic & acetic acid.* ***Inorganic salts*** *include sulfates. phosphates, chlorides, nitrates, and silicates of potassium, magnesium, iron & calcium.*

2.4.1. Composition of cane juice

Water	(75-88)%.
Sucrose	(10-21)%.
Reducing sugars	(0.3-3.0)%.
Organic matters other than sugar	(0.5-1.0)%.
Inorganic compounds	(0.2-0.6)%.
Nitrogen compounds	(0.5-1.0)%.

Except **sucrose and reducing sugars**, the other materials present are unwanted for sugar manufacturing. Therefore the substances other than sucrose and reducing sugars should be removed at the manufacturing process, to obtain the maximum amount of crystallizable sugar.

2.4.2. Mechanism of clarification

According to the quality of juice to be treated and the quality of sugar to be produced (Raw sugar, Plantation white sugar, Refined sugar) the manufacturing process & clarification process are varied.

Raw sugar manufacturing.

Simple defecation: Only liming and heating

Modified defecation: The juice is treated with small proportion of sulfur dioxide (so_2) or super phosphate after liming & heating

Each process has its modification according to the mode liming, heating, settling, sulfuring or carbonating juice. Here more lime than in the defecation process is added and excess lime is neutralized back by SO_2 or CO_2..

The clarification of juice is done for two purposes, as removal of impurities and bleaching. Removal of impurities: This is performed in two methods as precipitation and separation. Precipitation is achieved by using lime. This helps to reduce dissolve inorganic non-sugars present in the juice in colloidal state. It helps to increase the percentage of available sugar.

Due to insoluble suspended solids in the juice in colloidal state give the juice opaque, viscous and dark in color and juice has an acidic nature of pH varying 4.9 to 5.5. These impurities cannot be separated by simple filtration but are separated along with non-sugars precipitated by the action of Lime {$Ca(OH)_2$} and heat, leaving the juice transparent.

The application of heat or addition of chemicals (electrolytes) brings about *flocculation or coagulation*. They may be coagulated by the action of electric current and adsorption by sucrose attraction using porous of flocculent material. Some colloids are flocculated easily while others do so with difficulty. Each colloid has a characteristic ' pH ' at which flocculation occurs most easily. It is known as the **isoelectric point** of the colloid.

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 by the addition of SO_2. This process is necessary for the manufacturing of white sugar but is not much importance for raw sugar.

After the chemical and heat treatment these non-sugars react with these chemicals and are made tiny tufts, which are known as flocks. If the juice is allowed to stand for a while these flocks are settled at the bottom of the tank. The impurities that are settled at the bottom of the tank are called MUDS, and the juice that had the impurities removed is called CLARIFIED JUICE.

2.4.3. Steps of clarification

Juice weighing → Juice primary heating → Juice liming

↓

Juice Neutralization/ sulphitation (Secondary liming)

← Juice secondary heating

↓

Flashing → Juice flocculation → Juice settling at clarifier

But following clarification steps are described only under simple deification process for raw sugar manufacturing.

2.4.3.1. Juice weighing

To control the factory process carefully it is essential to know the exact weight of juice entering the process house. From the weight of this juice and from an analysis, that is knowledge of what this juice contains, and it is possible to find out how much sugar has entered the factory. The mixed juice is therefore weighed in the JUICE SCALE. This is a machine, which automatically weighs a tank of juice after it has been filled and weighs the same tank again when it is almost emptied. The difference between these two weights gives the exact weight of mixed juice that has entered the process.

As a result of all the weighing operations carried out we can get:

CANE + IMB.WATER = MIXED JUICE + BAGASSE

Because the first three quantities are known the weight of bagasse can be worked out.

1. Weighing
2. Juice Primary Heating (65-70 ^{0}c)
3. Liming (p^{H} 7.8 – 8.0)
4. Juice Secondary Heating (100-105 ^{0}c)
5. Mud sedimentation at Clarifier
6. Filtration

2.4.3.2. Juice heater

The juice heater is a multitubuler heating equipment. It is made of pipe and fittings. Each pipe constitutes a unit having a certain number of tubes expanded in to tube sheets. Each unit is one passes, like juice runs in parallel in althea tubes in one pipe pass. There are number of such passes made up of tubes, so that juice passes through each pass and finally goes out of the heater. Steam is run through the shell side as hating source while Juice is been circulated through tube side. Normally speed of juice running through is high (6-8) ft/sec. With this high-speed scale deposition of tubes are minimum.

2.4.3.3. Juice primary heating

To increase the reaction rates of non sugars with lime Ca $(OH)_2$ and to eliminate the effect of bacteria (Leuconostoc), which can leads the inversion of sugar the mixed juice is heated up to (65-70) °C in a juice heater.

2.4.3.4. Juice liming

Primary heated juice is then mixed with a mixture of milk of lime {Ca $(OH)_2$}. Here pH of mixed juice increased up to (7.5-7.8) in the simple deification process. The aim of this is to give the optimum pH, which non-sugars present can easily be precipitated with lime and tend to settle. The other reason is if the juice is slightly basic (high pH) inversion of sucrose is minimum at further heating. Normally lime is added 1-2 kg. Per cane tone.

The success or failure of the clarification process in most Cases depends on the precipitation and removal of inorganic non-sugars and of colloidal impurities. For proper manufacturing process good clarification of raw juice is essential. So the quality of lime and the use of optimum quantity of lime are important.

2.4.3.5. Juice secondary heating

Limed juice is then heated again till it boils (up to 105 ^{0}C) to increase the settling rate of impurities by removing dissolved gasses. When these gasses are present, flocks capture them and they tend to float other than settling when the juice boils the dissolved gasses are evolved.

2.4.3.6. Juice flashing

Secondary heated juice is then pumped tangentially to the flash tank. Here flash tank act as a cyclone and gasses are evolved at the top chimminy. Thus gasses are separated from the juice. This is called flashing.

2.4.3.7. Juice flocculation

Flocculent (ploy amide of sodium) is then added to the juice through its way to the clarifier. When Flocculent is added, the small flocks are trapped by the long chain of ploy amide and rapidly settle at the clarifier, by increasing the weight. Flocculent is added in (1-1.5) PPM. Concentration.

2.4.3.8. Juice clarifier

The clarifier consists of a number of trays (3 to 5) placed one above the other, dividing the vessel in to several compartments so as to increase the area of settling. These trays are sloped towards the center. The juice enters through a 2 ft. opening in to the upper compartment and through the center well into the lower ones, all of which have flush conical bottoms .all the compartments are scraped by scrapers which are attached to arms rotated very slowly (about 12 rev. per hour) by the vertical central shaft. The flocculation chamber is located at the juice entrance on the top of the clarifier.

Flocculated juice is allowed to stand for a certain time (normally 2 hours). The clear juice at the top of the tank is now clarified and is called Clarified juice. This clear juice contains sucrose and large quantity of water. The non-sugars that settle at the bottom of the clarifier are called Mud. They carry with a large amount of juice, which contain sucrose. This juice is separated at the filtration unit.

2.4.3.9. Filtration

Rotary vacuum filters separate the juice content of the mud. This is called filtration. For good filtration it is essential that the juice is passed through a substance which will capture the flocks and impurities, but let the juice through. For this the muddy juice is mixed with bagacillo, which are fine bagasse separated from the bagasse after the last mill by cyclone separator. The amount of bagacillo needed depends on the type of mud.

2.4.3.9.1. Rotary vacuum filter

The filter is a large horizontal rotating drum. The out side of the rotating drum is covered with very fine stainless steel screens. There are suction pipes in side of the drum. As the drum rotates the lower part of the drum (between section 0 and 1) is dipped in the mud in the filter tank, and the vacuum on the in side of the drum starts to suck mud on the out side of the screen. In this way the mud sticks to the out side of the drum as it goes round and the liquid passes through the drum. As the drum rotates (between section 1 and 2) the **filter cake**, as it is now called, is sprayed with hot water. This washes out any sucrose that is between the particles. As the drum passes through the section 2 and 3 the vacuum on the in side of the drum sucks out the water and any sucrose that was with it. This dries the filter cake. On the last section from 3 back to 0 the filter cake falls off the screens in to the conveyer due to release of vacuum, and which it is carried away. The very diluted juice obtained from the filtration process is called **'Filtrate'** again passes through liming tank and clarifier a second time. In this way almost 99% of the sucrose is recovered.

2.5. EVAPORATION

Clarified juice contains about 85% of water and 15% of dissolved solids. Dissolved solids are made up of sucrose, reducing sugars and impurities that have not been separated out in the clarification process. Before it is possible to crystallize the sucrose a large part (say 75%) of this water has to be removed and this is done by **evaporation**. At the end of evaporation process, the product obtained is called '**syrup**' should have 60% dissolved solids.

2.5.1. Multiple effect evaporator

The four or five evaporators in series carry out the evaporation and it is called multiple effect evaporators. The evaporator is a vertical cylinder at the bottom of which is a CALANDRIA. The calandria is a series of **copper or brass** tubes between 4 and 6 feet in length. These tubes are held upright between two sheets of metal so that the open ends of the tubes come through the metal sheets. These tubes are sealed into the metal sheets so those two chambers are formed. One chamber is made up of the space inside tubes; this is why the clarified juice will be heated. The other chamber is the space out side the tubes and between two sheets. This chamber for steam, which is going to heat the clarified juice. The space above calandria is for the hot vapor, which has been evaporated from the clarified juice.

The clarified juice enters the evaporator at the bottom it is allowed to rise up the tubes of calandria. Steam enters the shell side of the calandria of **first effect**, and the heat of the steam is conducted to the juice through the walls of the tubes. Thus heats the juice and cool the steam. The steam need for this is obtained from the exhaust steam of the mill turbines and power turbines. When the juice is reached to its boiling point the water in the juice will evaporate. This vapor from first effect is used to heat the juice of the second effect and partially water evaporated juice from the first effect is fed to the tube side of the second effect. Thus the vapor from the previous effect is used to heat juice in the following effect. As the juice boils the small droplets of juice may be carried with vapor, to capture and send back these droplets, the special cover called 'SAVE-ALL' is located at the top of the evaporator.

The temperatures of each side of the following effect are less than the temperature of corresponding side of the previous effect. Because of this the last effect keeps under vacuum to boil the juice at each effect under lower temperature and pressure. Advantage of this low temperature boiling is minimum inversion of sucrose.

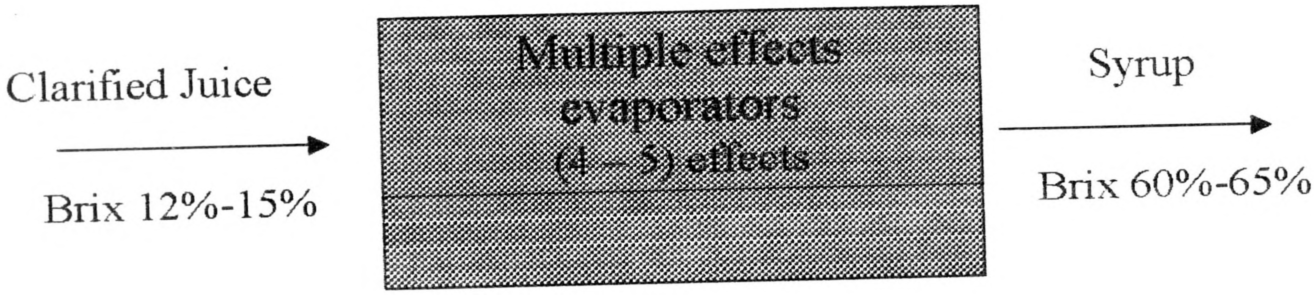
2.5.2. Rillieux's principles

Three important principles are involved in this inversion.

In a multiple effect evaporator, each pound of steam supplied to the first body will evaporate one pound of water in each body in series. With 'N' effects one pound of steam evaporates 'n' pound of water.

If a weight of vapor 'W' is bled from effect 'M' of 'N' effects and used in place of steam for a given duty, the saving in steam is equal to W*M/N.

In any apparatus in which steam or vapor is concerned, it is necessary to withdraw continuously the non-condensable gases, which are unavoidably



Effect no	1^{st}	2^{nd}	3^{rd}	4^{th}	5^{th}
Steam Pressure	1.5 Kg/cm^2	1.2 Kg/cm^2	0.6 Kg/cm^2	20 Hgcm	60 Hgcm
Steam Temperature (^0C)	120	110	100	90	70

2.6. CRISTALIZATION

2.6.1 Sugar Boiling

The operation known in the factory as *sugar boiling* is carried out to convert the thick syrup (obtained from the multiple effect evaporators) into crystal form. This is done in a single effect vacuum pan evaporators, which is known as 'vacuum pans'.

2.6.2 Theory of sugar boiling

At a given temperature, only a fixed amount of sucrose can go in to solution and no more. If more sucrose were added into this solution it will remain undissolve. This solution is called 'saturated'. This saturated solution at the same time will not crystallize out any sucrose dissolved in water at given temperature. Thus a portion of equilibrium between solvents solid is obtained. But the saturated solution cooled or if a portion of the water is evaporated without change of temperature, then there is more sucrose in solution over the theoretical amount.

Which could be held in the saturated solution. A solution in which more sucrose is dissolved than that required theoretically for saturation at a given temperature is said to be a supersaturated solution. It is only abnormal condition and on slight disturbance or on the addition of a crystal of sugar the excess of separates as crystals.

Syrup from the evaporators being further concentrated in the vacuum pan to the maximum crystal content practicable becomes A- massecuite (mixture of sugar crystals and mother liquor is known as masscuite). This masscuite is dropped in a strike receivers and then passes through centrifugal which separate the mother liquor from the crystals which are known as finished raw sugar designated as

A sugar. The separated mother liquor is known as A molasses and formed the basis for the second or B massecuite. B massecuite is separated in to B sugar and B molasses by centrifuging which forms the basis for third or C massecuite. This is the final massecuite and on discharged from the C pan is gone to crystallize to complete the crystallization by gradual cooling. The massecuite is then centrifuged; the molasses in this case being the final molasses, which is a waste product as far as the sugar process is concerned. The C sugar is carried with it some final molasses.

The C sugar being of small grain size (approx.: 0.3mm) forms a convenient footing for the high-grade strikes, which are finished at a grain size approaching 1.0mm. The utilization of C sugar and B sugar as footings for the high grades is known as *magma system*. However, in some cases, because of filterability problems, C sugar is re-melted completely in water and used as re-melt for manufacturing process.

2.6.3. Principles of sugar boiling

1.Cristalization

Crystallization can be carried out in three zones of super saturation.

(a) Meta stable zone-being the nearest saturation (existing crystals increase in the Size but new crystals cannot form.

(b) Intermediate zone-new crystals can form in this zone, but only in the presence of existing crystals.

(c) Labile zone-in this zone existing crystals grow and new crystals can form even in the absence of existing crystals.

2.Graining

The main requirements in the sugar boiling process are:

(a) The formation or introduction of a definite number of crystal nuclei.

(b) The building up of these crystals, without the formation of additional crystals, to the required final size.

Graining may be effected by one of three methods:

- Spontaneous grain formation-it consists of simply concentrating the material (i.e. syrup or A molasses) until grain appears. The formation of grain must be controlled as soon as the required quantity is attained; observing (using a microscope or magnifier) a sample spread on a piece of glass effects this control.
- Shock seeding- a quantity of powdered sugar is introduced into the pan and when sufficient grain has formed, the super saturation is reduced up to the point where these crystals can be grown without the formation of additional crystals.
- True seeding- the quantity of seed added is calculated according to its average crystal size and the average size desired for the finished crystals. With this method the correct number of seed crystals are added while the material is in the Meta stable zone and the charge is held in that zone throughout. Thus no additional crystal is formed in the pan, the final crystal representing simply the growth of the seed crystals added.

(3) False grain and conglomerates

Fundamentally after the grain has been obtained, the concentration must be brought back to the Meta stable phase where it must remain for the duration of the strike. If the concentration carried too high false grain will form and must be dissolved by dilution with water. Even before false grain appears, conglomerates may take place. (Conglomeration means a grouping of a number of crystals, which grow together as one) Formation of false grains and conglomerates should be avoided as much as possible, due to these are detrimental to the quality of commercial sugar.

(4) Bringing the mass together

When grain has been secured, the most difficult and important step is to bring the mass together, because small grains are widely separated and critical condition exists. At this stage instruments or sense of the operator is essential.

(5) Tightening the mass

It is not advisable to increase the volume of the strike until the crystals have grown enough to nearly fill the void spaces occupied by the syrup or the mother liquor. The massecuite then said to be tight. The rate of crystal growth is faster under these conditions.

(6) Final concentration

When the volume of the strike is reached the full pan capacity, shutting off the feed and allowing the evaporation to proceed until the required Brix (percentage total soluble solids) is attained effects the final concentration.

(7) Steaming out and washing out

After dropping the massecuite a certain proportion of crystals and mother liquor remains on the pan wall; this must be completely removed by admitting steam into the pan.

2.7. CENTRIFUGATION

The sugar crystals mixed with the mother liquor have been obtained. What remains now is to separate them by the centrifugal force in proper marketable form. Such separation known as a machine performs sugar "curing" or purging called a centrifugal.

There are two categories of centrifugals.

Continues centrifugals are used for low-grade sugar separation.

Batch centrifugals are used for high-grade sugar separation.

2.7.1. Three massecuite boiling scheme for defecation raw sugar

Defecated syrup is to be use for making raw sugar.

The boiling and curing processes are followed as under:

2.7.1.1. Massecuite-A

The first massecuite –A is made of 78-80 purity with syrup on the footing of double cured, unwashed C –sugar seed and finished with the return of A-heavy molasses. The massecuite is cooled in the crystallizer for 4-6 hours or even more if the conditions permit. The massecuite is cured once and the sugar is bagged as raw sugar.

Care is to be taken that the grain size of the A –massecuite remains between 0.8-and 1.2 mm.

2.7.1.2. Massecuite-B

The second massecuite of 68-72 purity is made with A –heavy molasses on the footing of double cured, unwashed C-sugar seed and finished with A heavy molasses. The massecuite is cooled for 6-8 hours before curing. At the centrifugal, the massecuite is cured once and bagged with A-sugar.

Care is to be taken that the grain size of the massecuite remains between 0.6 and 1.0-mm preferably 0.8 mm.

2.7.1.3. Massecuite C

The C –massecuite of 58-60 purity and of 101-1020 Brix is made. Grains for 3-strikes are usually made one for B and two for Strikes. The granulation is done with A-heavy molasses or with a mixture of syrup and B –heavy molasses, using slurry method, if possible. After the grains are formed, a little more of A heavy molasses is added to bring down the purity of the graining medium between 74-76, one 'cut' may be given for B-boiling and two 'cuts' for C – boiling. Each 'cut' is then developed with B-heavy molasses till the massecuite purity reaches to the desired level. The massecuite is cooled in the crystallizers for 20-30 hours.

At the centrifugal, the massecuite is cured twice without washing and the sugar thus obtained is made into magma with syrup or A –heavy molasses and used as footing of A and B –boiling.

2.8. DRYING ANG BAGGING.

All sugars undergo microbiological decomposition under humid conditions and consequently there is loss of sugar polarization. This applies to both white consumption sugars as well as raw sugars. But after drying, the susceptibility for microbiological growth decreases, but also as consequence of drying the polarization of raw sugar increases and its value in turn increases. In the case of white consumption sugar, its keeping quality lasts longer.

Wet sugar received from centrifugals is dried using hot air in the sugar dryer. The operating temperature of sugar dryer is about 60-70 C.

Thereafter sugar crystals with correct sizes are bagged (50 Kg bags) at bagging plant.

CHAPTER 3

Discussion

Efficient use of the by-products of sugar manufacturing process namely Badasse and Molasses can increase the total yield of sugar and also reduce the overall coast of production.
This will also decrease environmental impacts.

The by-products of sugar industry can be divided in to three categories;

1. Bagasse.
This is being utilized as a fuel to produce steam in the boiler house and to heat up the water. Incomplete burning of bagasse release ash and carbon particulates to the atmosphere. This will cause lots of health and environmental hazards. We can mix ash with water to decrease this phenomenon.

2. Filter-cake.
In the process of clarifications filter cake will be formed. This filter cake has been using as manures. This filter cake has low amount of environmental impacts. There for this is environmental friendly.

3. Molasses
This is being used to produce alcohol. The residual portion after distilling the alcohol is cold spent wash. This is discharge as useless. But there can be use full chemicals. By using chemical analysis we can have an idea about its composition then we can purify if any valuable chemical exist. In the modern process of sugar manufacturing in overseas they're using this portion to produse gums.

In the case of wastewater treatment at wastewater treatment plant methane is produce. This gas is incinerated at the time of producing as useless. But we can use this gas to promote heat in the boiler house.

CHAPTER 4

Conclusion

Lot of measures can be taken to enhance the overall sugar production.

Such as;

1. We can increase the production by installing modern machine but due to high initial and maintenance cost that is not profitable.
2. Breading of high yielding sugar cane that consist high amount of sucrose content.
3. Modifying the crystallization process.

References

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