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NATIONAL CANE SUGAR INDUSTRY RESEARCH CENTRE

DP|CPR|82|005

THE PEOPLE'S REPUBLIC OF CHINA

Technical report: Sugar refining technology and latest equipment for refinery *

Prepared for the Government of the People's Republic of China
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of R. Stuart Patterson
Expert in the sugar refining technology

United Nations Industrial Development Organization
Vienna

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Report For

NATIONAL CANE SUGAR INDUSTRY RESEARCH INSTITUTE

MINISTRY OF LIGHT INDUSTRY

GUANGZHOU, PRC

Prepared under Special Service Agreement

Between

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Project No. DP/CPR/82/005/11-10/31-7-C

and

R. Stuart Patterson, Consultant in Sugar Refining

Nature of Service - As expert in the Sugar Refining Technology to render assistance in establishing the sugar refinery industry in China. To furnish knowledge of sugar refining technology and the latest equipment for refinery. Through discussion with Chinese Experts, to find out the suitable refinery technology and types of products that meet the demand of the Chinese market. Duty station will be Guangzhou, with travel to related factories.

Duration of Agreement - December 5 to December 19, 1985 including travel time and completion of report.

SUMMARY REPORT

Arrived in Guangzhou on December 6, 1985. At the Sugar Industry Research Institute on December 7, toured the various departments of the Institute, discussed plans for the schedule for the next two weeks, outlined sugar refinery technology, demonstrated the Polaroid Camera set-up and Molasses Extraction Device.

On December 9 toured the Jiang Men Sugar Factory, discussed improvements with key members of staff. December 10 gave lecture on refining technology, soft sugar production and several other products as well as on vacuum pan construction, improvement of high grade and low grade crystallization, energy conservation, molasses exhaustion, etc. On December 11 toured the Zhinee Sugar Factory and repeated lecture as at Jiang Men. On December 12 and 13 toured the Mei Shan Sugar Factory, gave lectures as before and discussed many other sugar related technology subjects. Took Polaroid pictures of crystal quality as had been done at the Jiang Men Factory and created a lot of interest by sugar boilers and key people. A Video Tape of my tour of the factory and lectures was made. December 14, returned to Guangzhou. On Sunday, December 15, toured the Shitou Factory, being present at the official opening of the sugar cane campaign. Presented lectures and discussed sugar related technology as before.

On Monday, December 16 presented formal lecture on sugar refining technology, soft sugar and other sugar products production to the Guangdong Society of Sugar Technologists. In the afternoon discussed other organizations, SIT, SPRI, ISSCT, ASSBT, with officers and directors of Society. On December 17 and 18 discussed many other subjects as shown in Outline Report. On December 20 toured Guangzhou Sugar Factory and discussed sugar related subjects as before. December 21, final discussions at the Sugarcane Industry Research Institute.

LECTURE TO GUANGDONG SOCIETY OF SUGAR TECHNOLOGISTS

AT THE GUANGDONG SCIENTIFIC HALL

GUANGZHOU, DECEMBER 16, 1985

Introduction

At the invitation of the National Cane Sugar Research Institute and with the support of United Nations Industrial Development Organization, R.S. Patterson visited the People's Republic of China. The Project was assigned No. DP/CPR/82/005/11-10/31-7-C.

The purposes of the Project were to visit cane sugar factories, discuss their operations with the plant personnel and to lecture to the Guangdong Society of Sugar Cane Technologists on the subjects of refining technology, vacuum pan construction, soft sugar production, colored sugar production, and other sugar products produced in the United States. The assignment was also to make suggestions to the factory personnel and the sugar technologists group for improving factory operations for better quality sugar and recommendations for the refining of sugar to produce high quality refined sugar.

I China's Production Now And in the Future

The present production of Cane sugar in China is 3,400,000 tons and beet sugar is 700,000 for a total of 4,100,000 tons per year. Their goal is to increase the capacity to become self-sufficient in sugar so that raw sugar does not have to be imported. However, it is doubtful, even in China, that raw sugar could be produced as cheaply as the current world price of 5¢ per pound. It is not expected that the world price will stay this low so China needs to increase its production of sugar.

Experience shows that as the standard of living rises in the developing countries so does the demand for more sugar and for sugar of better quality. China's standard of living is improving so the demand for more and better quality sugar is increasing and will continue to increase. It is estimated that in 10 to 15 years China's need for sugar will increase to 10,000,000 tons yearly. To provide this quantity China will need to build more sugar factories and to expand existing factories.

To provide improved quality China will need to:

(a) Improve Quality at Existing Factories

The plantation white sugar being produced at most of the factories now at 99.6 to 99.7 polarization is quite adequate in quality for most of the Chinese people. However, it is not suitable for many of the industrial users. For sugar made by the sulphitation process, as most of the sugar in China is, color will develop in the sugar if it is stored very long and this can cause customer complaints. To avoid these customer complaints it is recommended that the factories supplying these customers shift to lime and carbonation, and perhaps use just a small amount of sulphitation. For better quality the amount of lime and carbon dioxide can be increased but this might require pressure filtration of the carbonate cake if it cannot be handled in the settling clarifiers.

Another means of improving quality at existing factories would be to treat the evaporator syrup with lime and phosphoric acid and a decolorizing agent such as Talofloc. This process is known as the Talodura process and is patented by Tate and Lyle of England. The calcium phosphate precipitate is handled in a flotation clarifier and 20 to 30% color removal is obtained.

An alternative to the Talodura process would be to treat the evaporator syrup with phosphoric acid and lime and also some powdered carbon as decolorizing agent. The treated syrup would be filtered in pressure filters.

(b) Improve Quality of Refined Sugar now being produced

For those factories now producing refined sugar from plantation white sugar, such as the Guangzhou factory, it should be relatively easy to produce refined sugar to meet the standard of the Coca Cola Company. If the present quality is not satisfactory, then a treatment of the melted plantation white sugar with powdered carbon and pressure filtration before the ion exchange resin columns will produce the desired color quality of the refined sugar. Another alternative would be to add more resin columns to increase the capacity of the resin station.

(c) Improvement at Factories Importing Raw Sugar

For factories running on imported raws using affination, lime and carbonation, further improvement in quality could be obtained, without much capital expenditure, by using powdered carbon before the pressure filtration. If ash removal is needed, powdered resin is also available to be added to the same treating tank as the powdered carbon.

(d) Build New Refineries

This is covered in Section II

II Refinery Operation

(a) Practices in U.S. and Canadian Refineries

There are different refining processes in use at the refineries in U.S. and Canada. All use affination of the raw sugar and centrifuging as the first step. The melted raw sugar liquor is treated at some refineries with phosphoric acid and lime and sent to either flotation clarifiers or pressure filters to produce the clear raw liquor. Other refineries use lime and carbon dioxide in the carbonation process and filter out the calcium carbonate cake in pressure filters. Some refineries then use bone char alone to remove color and ash content. Other refineries use a combination of bone char and granular carbon. Some use granular carbon and synthetic resins for decolorizing and deashing, while others use bone char and resin.

No new sugar refinery has been built in U.S. or Canada for many years due to the surplus of sugar in the world. Many refineries have been shut down because of the sugar surplus and the increasing use of high fructose corn syrup made from corn. The remaining refineries have put increased emphasis on the quality of the raw sugar they buy. With better quality raw sugar the cost of refining is lower. However, with the competition between refineries in selling their refined sugar the quality of the refined sugar also has to be better. If a new refinery were to be built, it is my opinion that phosphoric acid and lime treatment would be used, then to flotation clarifiers, then to pressure filters to insure very clear raw liquor. Then granular carbon columns would be used for color removal since granular carbon is the best color removal agent. Then the liquor would be sent to synthetic resin columns, first acrylic resin columns, then polystyrene resin columns to finish taking out color and remove ash content. The liquor would then be polish filtered in pressure filters, concentrated to 72° Bx in multiple effect evaporators and sent to the pan floor.

For future refineries in China I would recommend the use of synthetic resin columns for color and ash removal because China makes its own resin, whereas it does not make bone char or granular carbon. Existing refining or white sugar ends could improve quality by using resin.

(b) Main Line Refining Steps

Some or all of the following main line refining steps could be used in existing factories that have a refined end, or in the factories running on imported raw sugar or in the factories now refining sugar, but this description is mainly intended for consideration in planning new refineries.

The description of the refining steps that follows is based on the refining operation at the California and Hawaiian Sugar Refinery at Crockett, California — the largest sugar refinery in the world, refining as much as 4,000 short tons per day.

(b) 1. Storage of Raw Sugar

Raw sugar from different origins should be stored in separate bins or silos, as raw sugars vary in filterability, color, polarization, grain size, etc. This enables the refiner to blend some of the better raws with those of poorer quality in order to send a more uniform quality to the first step of the refining operation. At Crockett there are 9 silos, each holding 12,000 short tons, for total storage capacity of 110,000 tons

2. Weighing of the Sugar

The raw sugar is weighed as it is unloaded from the boat. At Crockett there are two automatic scales, each weighing 18 tons of sugar per dump. A small sample of each scale load is taken and these samples are composited and analyzed for polarization, whole raw color, crystal color, filterability and alcohol insoluble content.

The sugar going to the first step in the refining process is weighed in a 10 ton automatic scale so that the amount of sugar handled per 24 hour day can be determined. The sugar then goes to a surge bin holding 1200 tons of sugar, from which the sugar is elevated to the Affination Station.

3. Affination and Centrifuging

At the Affination Station the raw sugar is blended with a saturated syrup called Affination Syrup. The syrup is at 80°C and 72°Bx. The hot syrup softens the film of molasses on the raw sugar crystals without dissolving the sugar crystals. The blending or mingling is carried out in two parallel mixing scrolls called minglers. Addition of the syrup to the sugar is controlled by a consistency measuring instrument to maintain a heavy density mixture of the sugar and syrup which is called a magma. The magma at a Brix of 92° and temperature of 45-50°C is dropped into a mixing scroll for further softening of the film of molasses. From this mixer the magma is fed to the raw sugar automatic batch centrifugals. At C & H there are 16 centrifugals with 54 inch diameter and 40 inch deep baskets. The sugar is washed in the centrifugal using automatic sprays. The washed sugar is discharged into a melt tank equipped with a stirrer.

4. Melting

The washed raw sugar is dissolved in the melt tank to a density of 68° Bx and temperature controlled at 80°C. The washed raw sugar liquor is pumped to the Clarifier Station. The water used for dissolving the washed raw sugar is high purity sweet water.

5. Flotation Clarifiers Station

The washed raw sugar liquor is first passed through DSM screens to remove bagacillo and is then treated with phosphoric acid using .025% P_2O_5 on sugar solids in the liquor, and lime is added. The liquor is controlled at 67° Bx, 80 °C and 7.2 pH. It is pumped to the clarifiers with air being drawn into the suction of the pump to dissolve air at 80 psi in the liquor. A flotation agent is added to the liquor just before going into the clarifier. There are four clarifiers of C & H design, each handling 10 to 15,000 gallons of liquor per hour. In the clarifier the air comes out of solution and floats the scum of calcium phosphate and impurities to the top of the clarifier. Scrapers remove the scum from the top and it is discharged into a trough around the outside of the circular shape clarifiers. The clear sugar liquor at the bottom of the clarifier is collected in a circular pipe with holes in the bottom of the pipe for the entry of the liquor. The clarity of the sugar liquor is checked by a turbidity instrument and if one of the clarifiers starts to go cloudy the cloudy liquor is recycled. Residence time in the clarifier is 20 to 25 minutes.

The scums from the clarifier are sent to a secondary flotation clarifier where more air and flotation agent is added but no more phosphoric acid or lime. The scums are diluted to 20° Bx and again floated to the surface. These secondary scums are diluted to 3° to 5° Bx and sent to a tertiary clarifier. From the tertiary clarifier the scums are diluted further to less than 1° Bx and allowed to settle in a tank. The final mud is then discharged to a waste collecting tank.

6. Bone Char Filters and Granular Carbon (Decolorizing)

At C & H Sugar Refinery the clarified liquor is sent directly to the bone char filters because the turbidity instrument is used to protect against cloudy liquor. However it is recommended that for even better clarity the liquor should be sent through pressure filters using diatomaceous earth as filter aid. The bone char filters or columns are cylindrical columns 22 feet high and 10 feet in diameter. They each contain 35 to 45 tons of bone char depending on the grade of char, and about 8,000 gallons of sugar liquor. The sugar liquor percolates down through the bone char taking 3 to 4 hours to go through the char — 3 hrs. for the best bone char and 4 hrs. for the older poorer quality bone char.

The bone char is made from the heating of ground up cattle bones in the absence of air so that a deposit of carbon is left on the porous calcium phosphate structure of the bone. After treating the liquor the bone char is washed with water, removed from the char column, regenerated in a multiple hearth furnace, cooled and returned to the char column to be used over and over again.

The bone char takes out 80 to 90% of the color in the raw sugar liquor and 30 to 40% of the ash content of the liquor. Typical color values for the raw sugar being melted at the C & H refinery are 2500 to 3000 ICUMSA units for the whole raw sugar color, 1000 to 1200 units for washed raw liquor color, 700 to 800 for the clarified raw liquor, and 100 to 150 for the liquor from the bone char which is called No. 1 Liquor.

Some of the darker No. 1 Liquor from the bone char is given a secondary treatment over granular carbon columns to improve the color. These are similar in size to the bone char columns. Because the granular carbon is much lighter in weight than bone char the columns contain about 25 tons of granular carbon. The granular carbon has much better decolorizing ability than the bone char but removes no ash material. More recently C & H Refinery has been using a granular carbon that can be mixed with bone char and regenerated together.

7. Pressure Filtration and Evaporation

After the bone char or granular carbon the No. 1 Liquor is pressure filtered through filter presses using diatomaceous earth as a filter aid. Most of the pressure filters are automatic in operation and on No. 1 Liquor they have a 40 to 48 hour cycle. Turbidimeter instruments are used to maintain excellent clarity of the liquor coming from the pressure filters.

After the pressure filters the liquor is sent to a triple effect, falling film stainless steel evaporator where it is concentrated from 67° Bx to 75° Bx. The Brix leaving the evaporator is controlled by a refractometer. Temperature of the concentrated No. 1 Liquor is 80° C.

8. Crystallization

The concentrated No. 1 Liquor is pumped to the vacuum pan storage tanks from which it is drawn into the vacuum pans. There are 8 pans for boiling the white refined sugar. Four are 1960 cubic feet in capacity; one is 2200 cubic feet; one is 2000 cubic feet; one is 1600 cubic feet and one is 1200 cubic feet capacity. Four of the pans are old coil pans and four are relatively new stainless steel calandria pans.

In boiling a strike the graining charge or footing of liquor, amounting to 25 to 30% of the total amount of sugar liquor to be boiled in the strike, is drawn into the pan at 7 inches Absolute Pressure and concentrated at 7 inches Absolute Pressure to the seeding point. The seeding point is determined by boiling point elevation instruments. Seed used at C & H Refinery is pulverized sugar (2 pounds to a 2,000 cubic foot pan) but I strongly recommend ball mill slurry in isopropyl alcohol rather than pulverized sugar for more uniform seeding. After seeding the steam pressure is reduced and the absolute pressure is increased from 7 inches to 9 inches. This raises the temperature and slows down the boiling process during this most critical time. After the crystals are bigger and can accept sucrose faster the absolute pressure is gradually reduced to 4 inches. This is done on a programmed absolute pressure controller and the strike is finished at 4 inches pressure.

All the calandria white sugar pans are equipped with circulators. I strongly recommend circulators because they

(1) Provide a minimum amount of circulation, particularly after seeding during this critical time

(2) Provide a means of liquor feed control to the pan because the motor load driving the circulator is used to open or close the feed valve to maintain the consistency of the massecuite in the pan

(3) Provides more capacity in the pan because with circulator you can take the massecuite to 7 feet above the top tube sheet of the calandria, whereas without the circulator you should not go more than 5 feet above the top tube sheet

(4) Provides a means of determining the dropping consistency of the massecuite at the end of the strike. After the feed is shut off the pan continues to boil until the motor load on the circulator reaches a pre set set point and a horn blows letting the sugar boiler know to shut off the steam, break vacuum and drop the strike.

9. Centrifuging The Sugar

The finished massecuite is dropped into a cylindrical, enclosed stainless steel mixer equipped with an agitator. From this mixer the massecuite is fed into automatic batch centrifugals equipped with automatic sprays for washing the sugar. There are 4 centrifugals for the 2,000 cubic foot pans. They operate on a 3 minute cycle and wash time is 5 seconds to 13 seconds based on the grade of sugar.

A strikes are boiled from the concentrated No. 1 Liquor, B strikes from A Syrup, C strikes from B Syrup and D strikes from C Syrup. The D Syrup is sent to the Remelt or Recovery Station. The A, B, C and D sugars are blended together to give the regular white refined sugar. Three pans are used for boiling the A Sugar, two for the B Sugar, one for the C Sugar and one for the D Sugar. One pan is used for boiling special grain size sugars called Sanding Sugar and Confectioners AA Sugar.

10. Drying the Sugar

After centrifuging, the wet white granulated sugar, at 1.5% moisture content, drops on to conveyors then goes up bucket elevators and into wet sugar bins feeding the rotary drum dryers or granulators as they are called. At C & H there are 7 sets of double drum granulators i.e. each set with an upper and a lower granulator. Hot air is blown into the granulator in counter current action through the curtain of falling sugar in the drum. The moisture content of the sugar leaving the upper drum is 0.5% and leaving the lower drum it is 0.025%

11. Screening the Sugar

After drying, the sugar is sent to Rotex screens for grading the sugar according to size. The three grades are regular granulated sugar comprising 80 to 85% of the total, coarse sugar amounting to about 10% and fine sugar amounting to 5 to 6%.

12. Packing the Sugar

The screened sugar is packed in 1 pound and 2 pound cartons, and 5 pound, 10 pound, 25 pound, 50 pound and 100 pound multi-ply paper bags. Automatic packing machines are used for packing the sugar. Small packets or envelopes of sugar are also packed in 4 gram, 6 gram and 7 gram packets in machines that make as many as 2,000 packets per minute.

13. Bulk Dry Granulated Sugar

For large industrial users, dry refined sugar is stored in bulk sugar bins. There are 15 bins that hold 65 tons each, four cylindrical bins that hold 250 tons each, and two large cement cylindrical silos that each hold 3,000 tons, for a total bulk sugar storage capacity of 8,000 short tons. In all of the bulk storage bins, air is blown up through the sugar to carry off moisture that is released as the sucrose in the syrup film on the crystals crystallizes and releases moisture. This process is called conditioning the sugar and is necessary to keep the sugar from caking. The moisture content of the sugar is reduced from 0.025% to about 0.015%. Sugar is conditioned in the large silos for 48 hours before being shipped out to customers. The sugar is weighed into bulk sugar trucks each holding about 25 tons of sugar, and also into bulk railway cars holding from 65 to 100 tons each. These rail cars are sent as far away as Chicago, over 2000 miles.

14. Remelt or Recovery Operations

The excess Affination Syrup not needed at the Affination Station to blend with the raw sugar is sent to the Recovery Station, also called the Remelt Station. The amount of syrup is about 10% of the total sugar handled. The purity of the syrup is 85, the Brix is 72° and it is sent to the Recovery Station at 75°C. The syrup is boiled into a No. 1 Remelt Strike and since its purity is 85 it is a very similar material to the Evaporator Syrup in the raw sugar factory. The strike is boiled at 7 inch Absolute Pressure and it takes 2 to 3 hours to boil a strike using 10 psi steam. Seed used is pulverized sugar in a slurry of Concentrated No. 1 Liquor. Here again I strongly recommend using ball mill slurry for seed rather than pulverized sugar. Normally 6 pounds of the pulverized sugar is used as seed for an 1100 cubic foot pan. The finished strike is dropped to a mixer and centrifuged in automatic batch centrifugals. The washed sugar is dropped to a melt tank where it is dissolved to make a 65° Brix sugar solution and this is pumped over to the Raw Melt Tank to join with the melted raw sugar.

When boiling a No. 2 Remelt Strike (similar to a B Strike in the Raw Sugar factory) it is the usual practice to boil a No. 1 Remelt Strike to nearly a full strike using 12 pounds of pulverized sugar for seeding, then cut the strike in half, finish one half as the No. 1 Remelt and finish the other half as the No. 2 Remelt using the No. 1 Remelt molasses (similar to A Syrup in factory) for feed. The purity of the No. 2 Remelt massecuite is 75 to 76.

The No. 2 Remelt Strike takes a total of 4 to 6 hours. It can also be boiled as a straight strike using a blend of the Affination Syrup and No. 1 Remelt Syrup to give a massecuite purity of 75 to 76. The No. 2 Remelt Strike when finished is dropped to a crystallizer and cooled to 60° C and then centrifuged in automatic batch centrifugals. The washed No. 2 Remelt Sugar is dropped to a tank where it is dissolved to a 65° Brix sugar solution and also pumped to the Raw Melt Tank the same as the No. 1 Remelt Sugar.

The final or No. 3 Remelt Strike, also called the Low Grade Strike, similar to the C Strike in the raw sugar factory is also usually started as a No. 1 Remelt Strike, then cut and finished as a No. 3 Remelt Strike using the No. 2 Remelt Syrup for the feed. The No. 3 Remelt massecuite purity is 65 to 66, higher than the approximately 55 Purity of the C massecuite in the factory. The No. 3 Remelt takes a total of 6 to 9 hours to boil. The finished strike is dropped to crystallizers where it is cooled from 70° C to about 40° C, then reheated to 50--55° C and centrifuged in continuous centrifugals. Steam and a small amount of water is used to control the feed of massecuite to the centrifugal. True purity of the final molasses is 42--44. The molasses is sold for cattle feed but some is sold for making yeast. The C sugar at 85--87 Purity is dissolved and recycled to the No.1 Remelt boiling.

III <u>Soft Sugar Production</u>

Brown sugar, or soft sugar as it is most frequently called in the U.S. is popular with both industrial users and housewives because of its pleasing flavor, as compared to refined white sugar. Soft sugar is used in making cookies, cakes, cereals, breads, candy, cake frostings, and many other products. Good soft sugar is more costly to produce than white granulated sugar because it is processed more to produce the right color and flavor. However the soft sugar is more profitable for the refiner because the invert, ash, moisture and organic non sugars in the soft sugar are sold at refined sugar prices, rather than ending up in the final molasses and sold at a much lower price.

A typical soft sugar can be made from Affination Syrup, but to produce the right color and flavor the Affination Syrup is diluted to about 60° Brix and passed through bone char columns at least twice and pressure filtered before and after the bone char. The writer found that Brown Sugar Pieces made in Kwangtung Province of P.R.C. had a very pleasing flavor. The syrup used for making these Pieces could be used for boiling soft sugar or other sugar factories could try to duplicate the same flavor and produce a soft sugar that would be quite acceptable to both industrial users and housewives.

Boiling of the soft sugar liquor is quite different from the boiling of white refined sugar. In white sugar we want clear, hard, well shaped individual crystals but in soft sugar we want a great deal of tiny crystals sticking together to form snowball-like agglomerates of sugar with syrup binding the agglomerates together. To do this the soft liquor is concentrated in the vacuum pan to a high supersaturation, a large quantity of seed is added, much more than for a white sugar strike, and the fine crystals allowed to stick together or agglomerate during an agglomeration period in the pan. The remaining soft liquor and syrup is then fed to the pan to build on the agglomerates to bring them to the desired particle size. Careful boiling techniques are needed to produce a well agglomerated sugar that has the soft feel and texture of a soft sugar. However, the agglomerates have to be durable enough so that they don't break up in the subsequent centrifuging and handling of the soft sugar.

A typical good soft sugar would have analysis of:

Polarization	88.0
Ash Content	2.2%
Moisture Content	3.3%
Invert Sugar Content	4.0%
Organic Non Sugars	2.5%
	100.0%

Because of the substantial economic benefits to be obtained by producing soft sugar (in the example above 12% of material that would be sold as molasses at $50 in the U.S. is instead sold as sugar at $600 per ton), it is recommended that high priority be given in P.R.C. to a project dedicated to developing a good soft sugar. C & H Refinery produces up to 10% of its total production as soft sugar.

More details of producing soft sugar are in a report left with the National Research Institute at Guangzhou.

IV Other Products

(a) Liquid Sugars

Two main grades of Liquid Sugar are produced at the C & H Refinery. One grade is straight Sucrose Liquid Sugar and is made by dissolving the wet white refined sugar from the white sugar centrifugals. The melting is done in a tall mixing column made of several compartments with a common vertical agitator. The wet white sugar and hot water is added at the top of the column and by the time it reaches the bottom it is fully dissolved. A refractometer at the outlet of the column controls the density at $66.5° \pm 0.1°$ Brix. The finished liquid sugar is cooled and sent out to storage tanks.

The other main grade of Liquid Sugar is Liquid Invert Sugar Type 50. The wet white granulated sugar is dissolved in another mixing column to 75° Bx. The liquid is then inverted using a small amount of hydrochloric acid for inversion. A polarimeter is used to control the inversion at 50% invert then soda ash is added to raise the pH to 5.5—6.0 to stop the inversion. The liquid invert sugar is then cooled and sent out to the storage tanks.

The storage tanks are equipped with ultraviolet lamps called Sterilamps and air is also blown across the air space in top of the tank to remove any condensation. Storage tank capacity for liquid sugars at C & H is over 3,000,000 U.S. gallons. Other liquid sugars made are brown liquid sugars made from the soft sugar syrup.

Liquid sugars are sold only to large industrial users. Tank trucks and railway tank cars are used to ship the sugar to the customers.

(b) Powdered Sugar

Powdered Sugar or Icing Sugar as it is called in Canada is made by pulverizing dry white refined sugar in high speed hammer mills. 3% corn starch is added to the sugar to keep it from caking. The Powdered Sugar is packed in 1 pound cartons, 2 pound clear plastic bags, 50 pound and 100 pound multi-ply paper bags. It is used by industrial users and for home consumption as icing or frosting for cookies, cakes and other baked goods.

(c) Colored Sugar

As a specialty item Colored Sugar is made by putting 500 pounds of Sanding or Confectioners AA Sugar (larger grain sugars than regular granulated sugar) in a rotating steam jacketed candy coating pan. The sugar is tumbled in the pan and warmed using the steam jacket. Then a food color solution is sprayed carefully into the pan and allowed to color the sugar evenly. A small amount of carnauba wax is added to give a better polish to the sugar. Just before the sugar is dry it is removed from the pan, screened to remove any crystals stuck together, and fines, then it is packed in 25, 50 and 100 pound bags. Several colors are made — red, green, yellow, orange, pink, violet and blue. The various colored sugars are also mixed with white sugar to make what is called Rainbow Crystals. Industrial users buy the sugars to sprinkle on cakes and cookies. Some Specialty stores buy the colored sugars, repackage it in fancy containers, either clear plastic bags or bottles, which sell at a high premium.

(d) Free Flowing Brown Sugar

At C & H Refinery the Free Flowing Brown Sugar is made by heating soft sugar syrup to a high density and temperature while the syrup is descending in a steam jacketed vertical stainless steel scroll. The hot high density syrup is discharged into horizontal high speed agitated scrolls where the moisture is flashed off and the sugar is converted to a free flowing granular product. The moisture content of the Free Flowing Brown Sugar is 0.5% compared to regular soft sugar moisture content of 3.5%

Free Flowing Brown Sugar could also be made by tumbling regular soft sugar in a rotary drum granulator similar to the white sugar drying granulators with hot air being used to lower the moisture content to 0.5%.

(e) Cube Sugar

Cube Sugar or Pressed Sugar is made at the C & H Refinery by using a process and equipment called the Vibro Process which has been patented in Sweden. Dry white refined sugar is tumbled in a rotary mixer and 2 to 2.5% moisture is added. The wet white sugar drops into plastic lined molding chambers on an endless belt. The sugar is vibrated actively to get the required amount of sugar in the molds. A pressure plate is used to press the sugar tightly into the molds. After the cubes are well formed they are dropped out of the molds onto a travelling steel belt. The empty molds are sprayed with water to wash out sugar particles, then blown dry then dropped down to receive fresh amounts of sugar. The cube sugar on the travelling belt is passed through two dielectric ovens, then two hot air ovens, then a cooling chamber. The cubes are then packed automatically into either 1 or 2 pound cartons. Moisture content is down to 0.5% and the finished cubes are usually held in storage two or three days to harden and dry out further before being sent out to customers.

(f) Transformed Sugar

Transformed Sugar is a specialty sugar made by a process patented by Tate and Lyle Company of England. The writer is not too familiar with the details of the process but it is somewhat similar to the C & H process for making Free Flowing Brown Sugar. White sucrose liquid is heated to a high density and high temperature then subjected to rapid agitation which flashes off the moisture and produces sugar particles without form, called Transformed Sugar. By producing the sugar in this way no vacuum pans, centrifugals or dryers are needed. A paper on Transformed Sugar Production presented by Tate and Lyle at a S.I.T. Conference has been left at the Institute.

(g) Amorphous Sugar

In Brazil a popular product called Amorphous Sugar is made by heating good quality white sucrose liquid in small open kettles to high temperature and density. The hot syrup is then quickly poured into rapid agitation mixers to flash off the moisture and produce the Amorphous Sugar. (amorphous means without form)

SUBJECTS DISCUSSED AT SEMINAR

GUANGDONG SCIENTIFIC HALL

GUANGZHOU, DECEMBER 17, 1985

I Vacuum Pan Construction and Specifications

C & H Refinery has eight vacuum pans for boiling white sugar. Four of these pans are very old coil pans (over 60 years old). These pans have 1960 cubic ft. capacity each and use 65 psi steam because the heating surface to massecuite volume ratio is very low-- 0.65. Each pan boils 14 strikes a day. All vacuum pans built at C & H in the last 30 years are of calandria design because the calandria pan offers the most in structural soundness of heating surface and has less maintenance costs. The following fundamental design characteristics are used by C & H Refinery:

(1) For white refined sugar the pans should be of stainless steel construction, either Type 316 or 304. The four calandria pans at C & H are of Type 304 stainless steel. This eliminates iron scale contamination and the stainless steel provides smooth polished finish that has a long life.

(2) The tubes should be as large in diameter and as short in length as possible yet not sacrifice too much in heating surface for pan capacity. We prefer 4 inch diameter tubes and less than 36 inches long. However, the newest white sugar pan put in(March of 1985) has 39 inch long tubes with 3½ inch diameter. The pan volume is 2200 cu. ft. and heating surface to volume ratio is 2:1.

(3) The center well diameter should be in a ratio of 0.4 to 0.5 of the pan diameter. The newest pan has a 0.39 ratio.

(4) The pan should be straight sided and have a streamlined dish bottom to avoid pockets of poor circulation. Two of the pans have some flare above the calandria but the other pan and the new pan is straight sided. Many of the pans in the factories in China that I visited have too much flare above the calandria.

(5) The final strike height should not exceed half the pan diameter above the top tube sheet.

(6) If steam pressure or vapor pressure used in the calandria is less than 10 -- 15 psi the heating surface to massecuite volume ratio should be 2 or more. The newest pan has a 2:1 ratio and uses 10 psi steam. In other pans where a lower ratio exists higher steam pressure is used.

(7) The maximum in functional control instrumentation should be provided to eliminate guesswork and to provide a more consistent result.

(8) The condenser and vacuum system must be of adequate capacity to produce rapid response to control changes.

(9) Mechanical circulators should be provided. All the calandria pans at C & H have circulators. The reasons for recommending the use of circulators are listed under the crystallization step in the refining operation description.

Details of vacuum pan construction and specifications of the C & H Refinery vacuum pans have been left at the National Research Institute.

II Seeding Practices

The factories I visted in Guangdong province are mostly using ball mill slurry in isopropyl alcohol for seeding the B strike and C strikes. B Sugar is used as a footing for A strikes. I strongly recommend 24 hour ball mill slurry in isopropyl alcohol for seeding strikes and an instrument should be used for determining the seeding point. Either refractometer, conductivity, boiling point elevation or consistency meter can be used for determining the seeding point. In Louisiana it is customary to use 2 pounds of sugar in 1250 ml. of isopropyl alcohol for 24 hours in a ball mill to make a 1,000 cu. ft. seed strike with finished grain size of 0.24 to 0.25 mm. This amount of seed is enough for four 1,000 cu. ft. C strikes or 4,000 cu. ft. of C massecuite with the C sugar between 0.30 and 0.40 mm.

III Improving High Grade and Low Grade Crystallization

At most of the factories visited the A and B massecuits were being boiled at too loose a consistency. Because of the large grain size it was frequently necessary to add water to dissolve out false grain. I recommend that the strike be boiled tighter and no water to be added or at a very low amount to avoid the extra energy needed to boil off the water. With tighter consistency the crystals are closer together and scrub off the exhausted film of syrup so that fresh syrup can deposit its sucrose on the growing crystals. Consistency control by instrument gives much more consistent results than manual control.

For C or low grade massecuite in addition to good seeding technique and consistency control for feeding the B Molasses I recommend the following:

(1) Use of a molasses extraction device to follow C massecuites as dropped from the pan and as dropped to the final centrifugals. A sketch of a suitable extraction device, similar to the Nutsch Bomb, has been left at the Institute. This device gives a good measure of the apparent crystal content. Keep the crystal content up.

(2) Use of a Polaroid camera set-up on the pan floor to follow crystal quality of the massecuites. This set-up was used effectively at the C & H Refinery, in Hawaiian raw sugar factories and in Louisiana factories.

It created a great deal of interest by the sugar boilers and helpers at the Jiang Men and Mei Shan factories. Pictures of the crystals were left at the factories and a set was left with Mme. Bao. The Cole-Parmer Instrument Company, Chicago, U.S.A. sells a Polaroid Camera and Adapter that can be attached to a laboratory microscope for taking Polaroid pictures of the massecuite crystals. Pictures can also be taken of the final molasses to see if crystals are present. At one of the Chinese factories visited some fine crystals were found in the molasses.

(3) Run apparent densities on the C massecuite at the beginning and end of the crystallizer system to determine whether significant sugar break down is taking place. If the final massecuite going to the centrifugals is lighter in density than when dropped from the pan it is evidence that the Maillard or "browning" reaction is taking place in which invert sugar, primarily fructose, is reacting with amino acids and liberating carbon dioxide, which causes the massecuite to be lighter in apparent density. The test is run by weighing a 1,000 ml beaker full to the brim with the massecuite and comparing weights at the start and end of the crystallizer system. One of the factories showed a significant drop in weight while another factory showed a slight gain in weight.

(4) Cool C massecuites as low as practical in the crystallizers, e.g. down to 40° C, then reheat to 50--55 °C for centrifuging. Crystallizer capacity should be sufficient to allow a 48 hour holding time to get more sucrose crystallized out and provide lower molasses purity. Most of the factories visited did not have enough crystallizer capacity and could only hold massecuite a maximum of 24 hours.

(5) Consider providing crystallizer capacity for dropping A and B massecuites into crystallizers for 6 to 8 hours to improve yield of sugar and reduce recycling of A and B molasses.

(6) Use saturated molasses at 72° Bx to improve fluidity if necessary in crystallizers rather than water.

(7) Use a minimum of wash water on the final centrifugals. Most factories were just using steam with no water. My experience has been that a small amount of water lowers the viscosity of the molasses film, causing better separation of the molasses from the crystals and actually producing a lower molasses purity.

IV Molasses Exhaustion

Molasses exhaustion has been covered in the discussion on improving low grade crystallization. It is important to point out that the factories are mostly using Apparent Purity for molasses, i.e. Polarization divided by Spindle Brix. This is as much as 10 points lower than the True Purity which is sucrose determined chemically or by double polarization divided by solids by drying. I much prefer using True Purity. Every effort must be made to get molasses purities down so that more sugar can be sold at about 1,000 yuan per ton, and less as molasses at 72 yuan per ton.

V Energy Conservation

Energy conservation is not quite as critical in China as it is in the U.S. but it is still important to conserve energy wherever possible. No water should be used in boiling the vacuum pans because all this water has to be boiled away and this takes extra energy. The evaporator syrup should be concentrated to 67° to 68° Bx in the multiple effect evaporators, rather than to 60° to 64° Bx because several pounds of water are evaporated per pound of steam or vapor in the evaporator, compared to only one pound of water per pound of steam in the vacuum pan. Excess washing of equipment or floors with water that is returned to process should be avoided. All steam traps must be kept in good mechanical condition.

At C & H Refinery when fuel costs went up from about 1973 to 1980 by a factor of nearly 10, i.e. in 1972 steam cost about 50¢ per 1,000 pounds, whereas in 1982 it cost $6 U.S. per 1,000 pounds. C & H has had an Energy Committee of key people for many years and energy consumption has been reduced by over one third.

VI Build or Buy Equipment

China has done an outstanding job in building its own equipment of all kinds for the sugar factory and this is considered to be the best procedure for China. I discussed the possibility of negotiating with large U.S. companies that buy and sell second hand equipment of all kinds to find out what the cost of dismantling, shipping, and installing second hand equipment would be, compared to building new equipment in China. A big advantage of second hand equipment is that it is well tested and can be available much faster than building new equipment.

I left with Mme. Bao the details of the equipment of a complete raw sugar factory for sale in Hawaii, the sale of which is being handled by the John Dumond Company, U.S.A. It is expected that other sugar equipment will be available for sale due to the shut down of several refineries and beet sugar factories, as well as raw sugar factories in the U.S. and Canada.

VII Pressure Filters

Pressure filters are used at the C & H Refinery to give a tight filtration for No. 1 Liquor and Soft Liquor coming from the bone char and granular carbon filters. Filter aid, called diatomaceous earth is added to the liquor before filtering, first as a precoat, then in the body feed to the pressure filter. Some older Sweetland filters of 900 sq. ft. filtering surface of 74 X 80 mesh stainless steel metal cloth are still being used. Newer, automatic Sparkler Company pressure filters are being installed to replace the Sweetland filters. The Sparklers are either 1,000 or 1850 square feet of filtering surface. These filters are automatic for sweetening off, sluicing, etc. but are opened up occasionally for inspection. Sluice pressure in the Sweetlands is 50 psi while in the Sparklers it is up to 150 psi. Cycle lengths are from 4 to 48 hours long depending on which service the pressure filter is in. Filtration pressure used is 50 psi. Turbidimeter instruments are used to make sure the liquor leaving the pressure filters has very good clarity.

VIII Practice in Louisiana, Hawaii, Florida

In Louisiana and Florida the sugar cane is a one year crop being planted in August, September and October. In Louisiana the grinding campaign is from early October to the end of December, while in Florida it usually runs from early November to nearly the end of March. In Hawaii the sugar cane is a two year crop and yields of cane per acre are much higher, averaging 100 tons per acre compared to an average of 30 tons per acre in Louisiana.

Sugar factories in Louisiana and Hawaii range in capacity from 3,000 to 6,000 tons per day while some of the factories in Florida can grind over 20,000 tons per day. Some of the factories in Hawaii use the diffusion process rather than roller mills. Articles on operation in Louisiana, Hawaii and Florida have been left at the Institute.

IX Recommendations for Improvement at the Factories in China

In the lectures and discussions held while visiting the factories many recommendations were made for improvement. Different recommendations apply to different factories and some are fundamental recommendations that apply to all factories. The recommendations are as follows:

(1) The sugar cane from the farmers should definitely be tested for quality so that payment is made by quality as well as weight. Proper sampling of the boat loads or truck loads of cane is difficult but payment by quality of the cane as well as weight provides more incentive for the farmers to produce good cane, not to add water to the cane, and also provides better results for the factory. The clean, hand cut cane in China with usually less than 1 or 2% trash is of course a big help to the factory. Hawaii, Louisiana and Florida all sample the incoming cane and pay on quality and weight. Some Chinese factories do pay the farmers for better variety of cane with better yield.

(2) Cane must be taken to the factory as quickly as possible after being cut, particularly in hot or rainy weather. Cutting of the cane and shipment to the factory should be carefully scheduled. Too many boat loads of cane should not be kept waiting at the factory. Sugar deterioration starts after the canehas been cut and the cane should be processed in less than 24 hours.

(3) Retention time in the clarifier must be kept as short as practical. One factory reported as low as 20 minutes retention time in the clarifier. while one said one hour, another $1\frac{1}{2}$ hours, and one as long as two hours. The time should be less than one hour because at the normal temperature of 100° C or more in the clarifier the juice will darken in color and sugar decomposition will start.

(4) The Evaporator Syrup density should be increased to 67° to 68° Brix from the 60° to 64° Brix being used at the factories I visited. This gets more water evaporated in multiple effect evaporators and less in the single effect vacuum pans, thus saves more energy.

IX (5) Opinions differ on whether liming should be done cool or hot. My opinion is that hot liming, i.e. over 75° C is more effective for color removal than cooler liming and sulfitation.

(6) Many vacuum pans that I saw at the factories have too much flare above the calandria. Straight sided pans are much better for good circulation. I also prefer that the calandrias fill the pan to the shell of the pan rather than have space between the calandria and the shell of the pan, as most of the Chinese pans have. Bigger diameter center wells, preferably with a ratio of 0.4 or better for center well diameter to pan diameter, provide better circulation.

(7) Pans should have more instruments for better control and more consistent results. Seed point in particular should be done by instrument, either refractometer, conductivity, boiling point elevation or consistency meter to eliminate guess work by the sugar boiler.

(8) I am a firm believer in the value of circulators and recommend strongly that mechanical circulators be provided in any new pans installed in Chinese factories. The many reasons for circulators are outlined in the section on pan construction.

(9) Larger Research and Development or Experimental groups should be established at the factories because only small groups (2 to 5 people) are present now. These people could conduct tests at each station of the factory to find the best combination of operations and improve efficiency. Sugar factories in China are quite profitable now and this is the time to have larger R & D groups.

(10) The consistency of the massecuite in most of the pans is too low in my opinion. For faster and more effective crystallization, massecuites should be boiled tighter so the crystals scrub each other better, removing the exhausted syrup film and bringing fresh syrup so that the sucrose can crystallize out faster. Also, do not add water during the boiling of the strikes. A consistency controller would carry the density at a more optimum value and considerably reduce or eliminate water addition which has to be boiled off and takes more energy.

(11) To improve the quality of the plantation white sugar, I recommend serious consideration be given to the production of two products. For the housewives and many of the industrial users, combine the A and B sugar as one product. For customers wanting better quality, seed the A sugar with ball mill slurry rather than the B sugar footing and make at least one cut to get up to the desired A sugar size. This would reduce or stop the recycling of B sugar and improve productivity.

(12) All outside experts coming to China have advocated reducing the crystal size of the plantation white sugar. I also recommend strongly that the size be reduced because it takes substantially more time and energy to produce such a large crystal size and also produces more color in the longer boiling time. I don't know of any other country producing such a large size crystal for regular production.

IX (13) Steam out and down time of the vacuum pans between strikes was usually 30 to 40 minutes at the factories. This is too long and reduces productivity of the pans. Aim for about 20 minutes down time.

(14) The use of hand held hoses for washing the sugar in centrifugals is very bad practice. Every effort must be made to install automatic sprays in the centrifugals for more consistent results.

(15) Operators should consider the use of CO control of boilers in addition to CO_2 control. A paper presented by C & H at a S.I.T. Conference, on CO control of boilers will be sent to Mme. Bao of the Institute.

(16) The mud cake on the rotary vacuum filters which I saw at the factories was very thin and tended to keep travelling around on the cloth rather than dropping off. Better cleaning of the filter cloth is needed. If spare filter capacity is available the filters should be taken out of service one at a time to clean the cloth with dilute hydrochloric acid inhibited with some molasses.

(17) Evaporators are cleaned in most cases with some soda ash then manually cleaned by pushing rods up and down the tubes. Normal procedure at C & H Refinery is to use soda ash solution first in the evaporators for 4 or 5 hours to soften up the scale, then to dissolve the scale with dilute hydrochloric acid inhibited with molasses. This would be more efficient and save mechanical wear and tear on the tubes.

(18) At most of the factories visited there was not enough crystallizer capacity to get low enough molasses purities from the C massecuites. For better results the C massecuites should be cooled below 45 C then reheated to 50--55 C for centrifuging. Cycle time should be 48 hours rather than less than 24 hours which is the case now.

(19) It would be helpful if crystallizer capacity is provided in any new factory for holding the A and B massecuites for 6 to 8 hours before centrifuging. This permits more sucrose to crystallize out, increasing productivity and reducing the recycling of A and B molasses. Factories in Florida provide crystallizer capacity for A and B massecuites with good results.

Answering Questions

Many questions from the key people at the factories I visited and from those attending the lectures at the Science Hall were answered. No record was made of these questions and answers. Some questions will be answered in more detail by articles left at the Institute or which will be sent to the Institute. This includes more information on the design and sealing of mechanical circulators in pans, more design details of the C & H Flotation Clarifiers, more information on the drying and conditioning of refined sugar, more description of pressure filters.

SUBJECTS COVERED, DECEMBER 18

I Sugar Organisations

Sugar Industry Technologists (SIT)

As SIT Executive Director I am most familiar with the administration and operation of SIT. SIT has been in existence since 1941 and is now an international organisation composed primarily of sugar refining technologists together with engineers and technical people from equipment and material suppliers to the sugar refining industry. There are 45 sugar refining companies as Corporate Members and 45 Allied Corporate Members. Individuals who are employees of these Corporate Members may join SIT as Associate Members. University professors interested in sugar chemistry, directors of sugar research institutes and similar professional people not associated with a Corporate Member may join as Affiliate Members on approval of the SIT Executive Committee. Corporate annual dues are $375. U.S. funds; Affiliate dues are $50. and Associate dues are $15. per year. There are also Emeritus Members who had belonged to SIT for at least 10 years but then retired. In all there are over 500 individual SIT Members around the world, including 2 Affiliate Members from China.

Conferences are held once a year in a city where there is a sugar refinery to act as the host. In 1985 the Conference was held in Saint John, New Brunswick, Canada, with Lantic Sugar Company as host. In 1986 the Conference will be in Baltimore with Amstar Refinery as host. In 1987 it will be in Sydney, Australia, with CSR as host.

The Officers of SIT are: President, Vice President, Vice President of Finance, Immediate Past President as Program Chairman, and the Executive Director. There is an Executive Committee of 9 Members appointed by the President. There is a Board of Directors made up of representatives of most of the Corporate Refiner Members. Executive Committee meetings are held 3 times a year. Proceedings of the Annual Conference are published each year. At the Conference there are usually 15 technical papers presented and also there is a half day symposium with a panel committee presenting different aspects of a subject chosen for its interest to the Members.

Each year a coveted "Crystal Award" is presented to the sugar technologist considered by the Crystal Award Committee to have achieved the best contribution to sugar technology over the years. An award called the "George and Eleanore Meade Award" is also presented each year to the author or authors presenting the best paper at the Annual Conference.

SPRI, ASSCT, ISSCT, ASSBT

Many details were also presented on these other organisations, particularly on the Sugar Processing Research Institute (SPRI).

Guangdong Society of Sugar Cane Technologists

The President of the Guangdong Society presented details of the operation of their Society, which I found very interesting.

Discussion was then held on how communication between SIT and the Guangdong Society of Sugar Technologists could be established. I suggested that a good way would be for one or two of the Guangdong Society, such as the President and Mme. Bao, to become Affiliate Members of SIT. This would require the payment of $50. U.S. for each membership but each would then receive Notices of the Annual SIT Conference, Proceedings of the Annual Conference, Roster of Members and other correspondence. They also would be able to attend the Annual SIT Conference by paying the appropriate registration fees. Copies of the 1983 and 1984 SIT Proceedings were left at the Institute.

II Future of Raw Sugar Quality

With the present surplus of raw sugar in the world, the refiners who are buying the raw sugar can be more selective in whose raw sugar they will buy. Since better quality raw sugar costs less to refine, the refiners will preferentially buy the better quality raw sugar. There has been a strong trend in recent years for countries to produce a better quality raw sugar. Australia has been producing raw sugar of 99.0 or better polarization for many years. Hawaii has improved the quality of its raw sugar such that the polarization averages above 98.8. Color, filterability and ash content are substantially better than a few years ago. South Africa has been producing raw sugar averaging 99.0 polarization and above, in fact they produce an even higher polarizing sugar and add back invert syrup to give the desired polarization. The refineries in South Africa handle the 99.3 to 99.4 pol raw sugar and do not have to put it through the Affination Station. Keeping qualities of the high pol raw sugar are much better than with lower pol sugar.

Other countries are also finding it necessary to produce better quality raw sugar to satisfy the demand of the refiners. China is in a good bargaining position to preferentially buy the better quality raw sugar for the factories or refineries that handle imported raw sugar so that refining costs can be reduced.

For a good article on the future of raw sugar quality, reference can be made to Dr. Margaret Clarke's report, copy of which was left at the Institute.

III Cleaning of Equipment

The factories that I visited relied mostly on manpower to clean the tubes in the calandrias of the evaporators and pans with soda ash solution being used in some cases before plunging out the tubes with rods. This requires a lot of manpower and tends to be destructive of the tubes. I recommend that cleaning of the calandria tubes be accomplished by first using 10% soda ash solution for 3 to 4 hours, letting it boil in the evaporator or pan under vacuum. Then drop out the soda solution, rinse, then use either a .5% hydrochloric acid solution for mild scale conditions, or up to 3% for heavy scale conditions and treat that for 3 to 4 hours. Molasses at a concentration of 0.5% or a chemical inhibitor is added to the acid solution so that the acid doesn't eat away the equipment.

For cleaning the leaves from pressure filters it is recommended that the leaves be removed from the filter and cleaned in a tank capable of holding several of the leaves at one time. A suggested treatment is first with 10% soda ash solution and boiled for 1 hour, then with a 5% hydrochloric acid solution inhibited with molasses for 1 hour.

At some of the factories I noticed that the cake leaving the rotary vacuum filters was quite thin and not peeling off the cloth properly. This indicates that the cloth is nearly blinded and needs better cleaning. I recommend that a set-up be provided so that the filters can be taken out of service, one at a time, and cleaned by spraying inhibited hydrochloric acid at about 10% concentration onto the cloth for 15 to 20 minutes.

For further details on cleaning of equipment reference can be made to the paper presented by R.S. Patterson at the 1974 SIT Conference on the subject "Equipment Cleaning Procedures".

IV <u>By-Products</u>

My discussions with the personnel at several of the factories I visited indicate that China is doing a much better job of using by-products than most of the other countries. For instance, bagasse is used almost entirely for fuel in Hawaii, Florida and Louisiana. Molasses is mostly used for blending with other materials for cattle feed, or used for producing yeast, with a relatively small amount being used for producing alcohol. In contrast to this the Jiang Men factory uses its final molasses to produce alcohol, liquid carbon dioxide, dry ice and yeast. They also make fiberboard, paper and furfural from their bagasse. It is obvious that the U.S. could learn from China as to better utilization of by-products.

V <u>Sugar and Health</u>

Unfortunately, in recent years, there has been a strong trend in the U.S., Canada and Europe, to say that sugar is bad for you and that you should cut down on the consumption of sugar. Sugar has been blamed by a few doctors for causing heart trouble. Others have said it can cause cancer; others that it causes hyperactivity in children, overweight in people, etc. etc. To investigate this the Sugar Research Association and the World Sugar Organisation have sponsored many carefully conducted scientific studies. Their findings have repeatedly shown that there is no basis in fact for sugar causing any of these health problems. The general recommendation is that sugar usage in moderation is helpful in making foods more palatable. Consumption of 100 pounds of sweeteners a year is considered

V moderate for an individual since per capita consumption in the U.S. is over 100 pounds per year. Compare this with China's per capita consumption of about 10 pounds per year.

On the plus side for sugar it should be pointed out that the growing of sugar cane is beneficial for the atmosphere. The sugar cane, in the process of photosynthesis, absorbs carbon dioxide, sulphur dioxide and other gases from the atmosphere and releases oxygen. It is estimated that the 200,000 acres of sugar cane in Hawaii release more than 6,000,000 tons of oxygen into the atmosphere each year.

VI <u>Summary of Presentations</u>

A short review of the subjects covered over the three days of lectures and discussions was made and questions answered on various subjects.

<u>VISITS TO CANE SUGAR FACTORIES IN CHINA</u>

A major part of the project assignment was to visit cane sugar factories in the Guangzhou area. In each case a tour of the factory was made with the key management personnel. During the tour I would make comments on good practices in the factory, as well as on what I considered to be bad practices. At some of the factories I was able to take Polaroid pictures of the boiling massecuites in the vacuum pans. This created a lot of interest by the management personnel, the sugar boilers and helpers, as I was able to demonstrate to them whether the crystal quality of the sugar being boiled was good or bad. I left several pictures on each of the pan floors, gave a set of pictures to each manager and also left a set with Mme. Bao.

Following the tour in each case I sat down with the management personnel and presented recommendations for improving operations. I also discussed techniques for improving quality of the sugar and refining techniques for future use. Many of the subjects presented at the lectures in the Scientific Hall in Guangzhou were also discussed because many of the factory personnel would not be able to attend the for[illegible]ectures to the Guangdong Society of Sugar Cane Technologists. Many que[illegible] were answered because the personnel were not hesitant to ask questio[illegible] this less formal group at each factory. I believe these visits and discussions at the factories were very helpful to the factory personnel. In all cases they were very friendly, cooperative, and eager to learn more.

The following factories were visited:

December 9 and 10 - <u>Jiangmen Factory</u> - This factory processes 5,000 tons cane per day and after the cane grinding season it processes about 700 tons of imported raw sugar per day. They produce alcohol, liquid and dry carbon dioxide, yeast, fibreboard, paper and furfural.

About 15 people were present for the lectures and discussions including Xiao Zhi Jian, Vice Chairman; Zhu Shaoming, Head of Engineering Department and Chen Shu Chang, Chief Engineer.

December 11 - Zhinee Factory - This factory processes 5,000 tons cane per day and also processes 500 tons of imported raw sugar per day after the cane run is finished. About 10 people were present for the lectures including Wang Shao Chich, Yao Bin-Joung, Ju Ho-Cheng, Wong Ken Sunrig, Kuang Chao Dong.

December 12, 13, 14 - Mei Shan Factory - This factory was just finished in 1983 and is a well laid out and spacious factory. All the equipment and instrumentation etc. has been made in China. Its capacity has just been increased to 6,000 tons cane per day. 20 to 25 people attended the lectures and discussion. Mr. Fang Xue Gao, the manager, arranged to have a Video Tape made of my visit and lecture presentation.

December 15 - Shitou Factory - This is about the oldest cane sugar factory in China, having started in 1934. Its capacity is 5,5000 tons cane per day. I was present at the official start of this year's grinding campaign and witnessed the fireworks and opening ceremonies. This factory has a big machine shop and a lot of mechanical equipment. They manufacture equipment of all kinds for their own factory as well as other factories. About 10 people attended the lecture and discussions. Mr. Liu Shao-An is the manager.

December 21 - Guangzhou Factory - This factory had not started their campaign yet this year but we toured the plant to see the equipment. They also refine some sugar, starting with their plantation white sugar and using resin columns for removing color and ash content to produce the refined sugar. About 8 people attended the lecture including Mr. Huang, Chief Engineer and Ms. Ho, Production Superintendent.

TECHNICAL LITERATURE LEFT AT THE NATIONAL CANE SUGAR RESEARCH INSTITUTE

Many articles on various subjects were left at the Institute for reference purposes. Included were the following:

(1) Soft Sugar Production Write-up by R.S. Patterson
(2) SIT Proceedings 1983
(3) SIT Proceedings 1984
(4) SIT Roster 1984
(5) SIT By-Laws 1980
(6) Raw Sugar Quality Standards, SIT paper, 1980, by Pablo Carreno
(7) Future of Raw Sugar Quality - Report by M.A. Clarke, 1985
(8) Transformed Sugar, SIT Paper, 1978, by W.M. Nicol of Tate & Lyle Co.
(9) Improving Low Grade Crystallization, ASSCT Paper, 1982, R.S. Patterson
(10) Molasses Exhaustion, ASSCT Paper, Louisiana Section, 1981 by R.S. Patterson

(11) Performance of C & H Pans, SIT Paper, 1958, by R.S. Patterson
(12) C & H Pan Specifications, 1985
(13) C & H Process Description Booklet for SIT Tour 1977
(14) Colored Sugar Production at C & H
(15) Imperial Sugar Company Tour Booklet for SIT, 1984
(16) Lantic Sugar Company Tour Booklet for SIT, 1985
(17) International Sugar Journal's Buyer's Guide, 1985
(18) Raw Sugar Producer Comparison, Sugar Journal article by R.S. Patterson
(19) Properties of C & H Liquicanes
(20) Statistics on U.S. and Canada Beet Sugar Factories 1982
(21) Alcohol and the Cane Sugar Refiner, SIT Paper by M.C. Bennett of Tate & Lyle Company
(22) Molasses Survey Results in Louisiana, Florida and Texas, article by R.S. Patterson, 1983
(23) Importance of Flavor in Brown Sugar, SIT Paper, 1980, by G. Christianson and L.A. Anhaiser
(24) UNIDO Review on Alcohol --- Conference 1979
(25) Brochure on Automatic Boiling from DDS Company
(26) Manual on Crystallization at C & H
(27) Booklets on Florida's Sugar Cane Industry
(28) White Sugar Operations, SIT Paper 1985, by Ian Knight, Redpath Sugar Co.
(29) Remelt Operations, SIT Paper 1985, by J. Alberino, Savannah Sugar Co.
(30) Continuous Vacuum Pans for White Sugar, SIT Paper, 1985, by E.D. Bosse of BMA Company
(31) Automatic Pan Boiling Control Using the Rheometer and Microprocessor, 1985, by H. Hashimoto of Ensuiko Sugar Company and T. Satori of Yokogawa Hokushin Electric Company, Japan
(32) Brochure on Automatic Batch and Continuous Centrifugals from Western States Machine Company

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