The Manufacture of Liquid Sugar from Granulated

A. P. ANDERSON[1]

In the last few years there has been an increasing demand for liquid sugar in Detroit and the adjacent territory. This demand has been met by eastern refiners who ship it in from New York to Detroit by barge during the open season for navigation on the Great Lakes and by tank cars during the closed season. They maintain large storage facilities in Detroit and supply their customers by tank trucks loaded from these storage tanks.

In order to protect our distribution and to be in a competitive position to supply customers who wish to convert from granulated, our management decided to install factilities for making liquid sugar from granulated.

Plans were drawn up early in the spring of 1950 for a plant to have an estimated capacity of 10,000 gallons for an eight-hour day to be installed at the Caro factory. Caro was chosen because of its large warehouse capacity, fairly central location to possible customers and because, due to several changes which had been made *in* the sugar end, there was enough vacant space in the factory building to install the necessary equipment. Delivery of materials was slow, but we were able to make the first delivery the last of June when the demand was beginning to reach the seasonal peak. The equipment consists of:

2—Melter tanks, 2,000 gallons capacity each, with cover.
2—Vallez filters 5 feet long 2 feet diameter 65 sq. ft. filtering surface each. We had these on hand at another plant.
1—Inversion tank, 2,500 gallons capacity. This tank is enclosed with a manhole on top through which acid and soda ash are added. It has a steam jacket on the bottom.
1—Graham vacuum cooler. This is for cooling the syrup before storage to lessen the amount of condensate in the storage tanks.
1—Small tank for mixing filter aid.
1—Small two-compartment tank with cover for receiving syrup and sweet water from the filters.
2—Storage tanks of 10,000 gallons capacity each for syrup storage. Another 5,000-gallon storage tank was put in later for invert syrup storage.
3—Gould centrifugal pumps, 25 gallons per minute and 1,750 R.P.M.

The melter tanks, pre-coat tank and receiving tanks are coated inside with Tropelite, the inversion and storage tanks with Heresite. This is a baked on synthetic resin finish. The cooler tank is made of stainless steel, the condenser of cast iron and the vapor line is made of spiral welded pipe. The melter tanks, pre-coat and inversion tanks are equipped with "Lightnin" mixers. The melter tanks also have steam coils for heating. All piping is 2 inch and 3 inch copper. The liquid sugar equipment is entirely enclosed from the rest of the factory.

The storage tanks are equipped with two Sterilamps to prevent surface bacteria and mold growth, and a blower to exhaust condensate. The air inlet is covered with a glass wool air filter, the same type as used on the

[1] **Technical Assistant to General Superintendent, Michigan Sugar Company.**

sugar granulator. For further protection, it is covered with three thicknesses of Johnson & Johnson dairy filter cloth. These tanks are on the third floor, and the trucks are loaded by gravity flow.

The city water, which is used to melt the sugar, is high in hardness and iron content. To remove these, a softener containing a synthetic ion exchange resin called "Nalcite" is used. For heating the water, a Graham Heliflow heat exchanger is used; this produces hot water almost instantaneously.

During campaign, the amount of sugar estimated to be necessary to fill the demand for the year for Baker's Special, powdered and liquid sugar is put up in one hundred pound, plain cotton bags. This is brought out of the warehouse in the intercampaign period, as required, and the bags emptied into a hopper. A conveyor takes it from the hopper upstairs to a 66-mesh Tuftex Roball screen. The fines are sacked as Bakers' Special and the coarse goes to a bin where it is drawn off as required for powdering or to be made into liquid. During campaign, sugar for liquid is taken directly from the dry sugar bin and the amount of this sugar, as calculated from the analysis and weight of the liquid made, is added to the production for that day.

When this process was under consideration, the question of building silos for bulk storage was investigated, but the figures arrived at showed that it would be cheaper to use the method adopted than erect the silos. The cotton bags can be used over again for several years. Our figures show an average life of four years.

Two types of sugar are made, a No. 1 liquid sucrose and a No. 1 invert. The sucrose syrup has a brix of 67° and is practically water white; the brix of the invert syrup is 77°, and it has 55 percent invert sugar based on solid content. The color is light straw. Several inquiries have been made for syrups with different degrees of inversion, but so far none have been made.

When sucrose syrup is made, the granulated is dissolved in the melters with hot water and made up to 64° brix. The temperature is maintained between 80° and 85° C. The filter is pre-coated with Standard Super-Cel mixed in the pre-coat tank with some of the syrup from the melter and recirculated back to this tank until the filtrate is perfectly clear; then the syrup in the melter is cut in. Some Hy-flo is added to the melter as it goes out.

From the filter, it goes to the cooler and then to storage. The cooler brings the temperature down to about 40° C. and the brix up to 67.

When making invert, the brix at the melter is made to 72° and the syrup goes first to the inversion tank. The pH of the syrup is brought to 2.5 with C.P. hydrochloric acid and held there for about one-half to three-fourths of an hour with the temperature about 75°. Too high a temperature will, of course, cause darkening. When the inversion has reached the desired point, soda ash is added to bring the pH to 6.0, stopping the inversion. About 2 to 3 liters of acid are used and 3 to 4 pounds of soda ash. After the inversion, the invert syrup follows the same path as the sucrose syrup, filtration, cooling and storage.

To control the inversion, tests are made to determine when the desired point is reached. Nineteen ml. of syrup are taken, made up to 100 and polarized. The brix minus this polarization divided by 1.36, the specific gravity, gives the approximate amount of invert sugar present. The invert sugar is determined again by the Lane-Eynon method on all shipments.

As the plant is operated only nine hours a day and usually five days a week, it is necessary to sweeten off the filters every night. The sweet water is used in the melter the next day.

Tank trailers were adopted as the best method of delivery because of faster and more flexible delivery and because all our customers are within a radius of 100 miles. The management initially considered purchasing, operating and maintaining the trucks, but after a study calculated that it was more economical to have the delivery made by a contract carrier. He bought three tank trailers made according to our specifications and had them painted in the company's standard colors and name.

These tanks are 3,300-gallon units, lined with Heresite and equipped with a motor-driven pump. The pumps are Yale rotary piston, positive displacement type, 90 gallons per minute and run at 615 R.P.M. They have $2^{1/2}$ inch connections and are driven by a 220-volt V-belt motor. The tanks have five baffles which make driving easier, as they prevent the surging of the syrup when hauling a short load as is sometimes necessary because of weight restrictions in the spring and on second and third class highways. However, these baffles have made cleaning more difficult.

The trucks have no meters and the customer is billed for the weight of syrup actually delivered, calculated from the weight of the truck full and when emptied. The gas tank is also filled for each weighing, and all mud and dirt picked up on the trip is cleaned off. Our laboratory reports brix, weight per gallon, number of gallons, weight of solids, and on invert syrup, the percent invert sugar, to the customers on each load delivered.

Since dairying is one of the largest agricultural industries in Michigan, the bulk of our business has been to supply liquid sugar to manufacturers of milk products. The growth of fruit packing has not matched in volume that of the Pacific coast states. There, a few packers with a large volume take care of most of the fruit, while in Michigan we have smaller plants and their volume has not as yet justified their conversion to liquid sugar.

The dairy industry requires a sucrose syrup for making ice-cream mix and for sweetened, condensed milk, and we also have customers in the baking business for this syrup. Invert syrup is sold to bottlers and manufacturers of jams, jellies, preserves and pickles.

Producers of sweetened, condensed milk demand a sterile syrup, and for this reason it has been necessary for us to take every precaution to keep our plant and tank trucks clean and sanitary. In the melters and where the syrup is hot, we have found no signs of bacterial growth, but in the coolers, storage tanks aand trucks where the syrup is cool at times we have found the presence of a variety of Torula. This is a wild yeast which is tolerant to heavy concentrations of sugar and forms a pink colony. It does not ferment sucrose or lactose and would do no great harm in the finished product

if it should escape the pasteurizing process. The concentration of the syrup and the use of Sterilamps as well as ordinary cleaning and sanitation have prevented the presence of other yeasts, bacteria and molds, but for the elimination of Torula, extra precautions are necessary.

A regular cleaning and sanitation routine has been adopted which has been successful so far. The cooler is washed out and steamed after each day's run, and hot water is pumped through all pipe lines possible. The other lines, such as the ones to the storage tanks, are steamed. The two sucrose storage tanks are used alternately, and one is taken out of service each week, emptied and hosed out with hot water containing a detergent, steamed and then fogged with a chlorine solution. The trucks, before loading, are washed out, a man getting inside with a hose and going into each compartment, then the trucks are steamed and fogged with a hypochlorite solution. This is then pumped out to clean and sterilize the pump and hose connections.

Although the manufacture of liquid sugar is a relatively new thing in the Midwest, there is every indication as time goes on that it will prove more profitable for the sugar industry. In addition, it provides beet refiners with another product which places them in a position to compete effectively with cane sugar producers of liquid sugar.

By being prepared to offer this product to consumers who want to take advantage of the savings possible by using liquid sugar, beet sugar manufacturers are able to keep their market in areas of greater freight earnings as well as more efficiently meeting customers' demands.