3,674,557

METHOD FOR DRYING SUGAR SOLUTIONS

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No Drawing. Continuation-in-part of application Ser. No. 36,738, May 13, 1970. This application May 3, 1971, Ser. No. 139,961
Int. Cl. C13f 1/02
U.S. Cl. 127—62 11 Claims

ABSTRACT OF THE DISCLOSURE

In a process for preparing dried, solid, sucrose-containing products from sucrose-containing solutions by drying droplets of the said solution in a current of heated air and in the presence of separately introduced recycled dried product solids, the improvement comprising maintaining the inlet temperature of the heated air in the range of from 400° to 500° Fahrenheit and the average air residence time in the drying zone in the range of 2 to 60 seconds.

This application is a continuation-in-part of U.S. patent application Ser. No. 36,738, filed May 13, 1970.

This invention relates to improvements in the production of dried sucrose-containing products from sucrose-containing solutions. In one particular embodiment it relates to a procedure for substantially reducing the drying time when spray drying sucrose-containing solutions in the presence of recycled product solids, and consequently increasing the dryer product output per unit of time for any given design capacity.

In the conventional methods of producing crystalline sucrose, the virgin syrup, as extracted from sugar cane or sugar beets, is first decolorized and deionized. The clarified syrup is then evaporated and fractionally crystallized in a series of precisely controlled steps, caramelization and inversion being reduced as much as possible by the use of vacuum to reduce the vaporization temperature. Fractional crystallization is essential since, during processing, inversion of the cane sugar takes place. This invert sugar, which is substantially uncrystallizable, is discarded together with up to about 20% of non-recoverable sucrose and finds its way into commerce as animal feed or other low grade sugar products generally referred to as molasses.

Other methods for producing dry crystalline sucrose-containing products proposed by the prior art include fluid energy milling with air at ambient temperature (Reimers et al.—U.S. Pat. 3,140,201); drying intimate blends of sugar solids and sugar solutions at temperatures of 50–100° centrigrade using "cold" air or "hot" air at dryer inlet temperatures up to 95° centrigrade (Oikawa—U.S. Pat. 3,271,194 and British Pat. 1,099,723) and simultaneous centrifugal distribution and spray drying of powdered sugar solids and a sugar solution at 50 to 100° centigrade using drying air at inlet temperatures up to 110° centrigrade (Japanese patent publication 20,384/69). Agglomeration of pulverized sugar using a liquid sugar syrup binder and drying of the agglomerated product under conditions such that product temperature does not exceed 140° Fahrenheit is taught in Harding et al.—U.S. Pat. 3,518,095. A similar agglomeration process is disclosed in Gidlow et al.—U.S. Pat. 3,506,457 wherein the agglomerates are dried using hot air having temperatures of up to 300° Fahrenheit. Spray drying of high D.E. glucose solutions in the presence of recycled solids is disclosed by Repsdorph et al. in U.S. Pat. 3,477,874 and corresponding British Pat. 1,075,161. No specific drying temperatures are suggested. Bishop—U.S. Pat. 2,698,815 suggests spray drying of molasses in the presense of very small amounts

of calcium phosphate dust as an anti-caking agent, using air at 200° Fahrenheit inlet temperature.

Belgian Pat. 742,249 dated Jan. 30, 1970 discloses a process for drying sucrose-containing solutions by dispersing sucrose particles in a current of heated air, separately dispersing the solution on the said particles, evaporating the water from the solution coated on the particles and recovering the resulting dry product from the hot air stream. Drying air inlet temperatures of 100–150° centigrade are suggested and one specific run (Run 6) discloses the use of hot air at 185° centigrade (i.e., 365° Fahrenheit).

It is known that sucrose melts at about 185–190° C., with some decomposition (e.g., Kirk-Othmer, Encyclopedia of Chemical Technology, Second Edition, Vol. 19, pp. 151–152 and Meade, Cane Sugar Handbook, Ninth Edition (1963) page 26). It is apparent from the foregoing summary of the prior art that all of the previous workers in the art of producing dried sucrose-containing products have considered themselves to be limited to processing temperatures generally well below the known melting point or melting range.

It is an object of the present invention to provide a new and more efficient process for producing dried sucrose-containing products from solutions thereof.

It is a specific object of the invention to provide a procedure for drying sucrose-containing solutions using heated air at inlet temperatures well above those disclosed by any prior art workers.

Other objects and the advantages of the invention will be evident from the following description thereof.

In accordance with the present invention it has been discovered that sucrose-containing solutions can be dried in the presence of recycled products solids, using hot air having an inlet temperature of at least about 400° Fahrenheit (i.e., about 205° centigrade) and up to as high as 500° Fahrenheit (260° centigrade) while maintaining the average air residence time in the drying zone in the range of from 2 to 60 seconds (calculated by dividing the drying zone volume by the volume flow rate of the hot drying air therethrough). While the relationship between air inlet temperature and average residence time is not necessarily linear, it is generally observed when other variables are substantially constant that shorter residence times should be used as the dryer air inlet temeprature increases.

In one particular embodiment the present invention is applied to the sucrose solution spray drying process which has been described in the aforementioned Belgian Pat. 742,249. In general, this involves atomization of the sucrose-containing solution to be dried into the hot air flowing in the spray dryer while separately feeding substantial proportions of solid sucrose particles. The sucrose-containing solution may contain from about 60 to about 90 weight percent solids. Where appropriate or desirable, the solution is preheated, e.g., to a temperature of 50 to 100° centigrade to preclude premature crystallization and to aid in feeding and atomization. The solid sucrose, preferably recycled product, is separately and concurrently fed to the dryer in amounts sufficient to provide a weight ratio of from 0.5 to 4.0, preferably about 1.5 to about 3 parts of solids, for each part, by weight, of solids in the solution to be dried. Stated conversely, the weight ratio of solids in the solution to the separately introduced product solids ranges from about 0.25 to about 2, preferably from about 0.33 to about 0.67. The inlet temperature of the hot drying air preferably is in the range of from about 425° to about 475° Fahrenheit and the average air residence time is preferably from about 5 to about 25 seconds.

The presently most preferred embodiment of the present invention includes as further features, the use of recycled product solids having an average particle size of not greater than about 200 microns and preferably not greater than about 150 microns; and dispersion of the recycled fine-sized solids at the outer periphery of the drying zone as an enveloping solids-bearing atmosphere about the droplets of solution to be dried. It will generally be undesirable to reduce the average particle size of the product to be recycled below about 25 microns and preferably the recycled solids will have an average particle size within the range of from about 50 to about 100 or 150 microns. Average particle size as used herein means that size where 50 weight percent of the particles are larger and 50 weight percent are smaller.

The control of recycled product particle size as an improvement, per se, is the subject of commonly owned copending U.S. application Ser. No. 139,852, filed May 3, 1971. Commonly owned, copending U.S. application Ser. No. 139,664, filed May 3, 1971, discloses and claims this feature in conjunction with the feature of dispersing the fine-sized solids as an enveloping atmosphere. This type of dispersion can be accomplished by spraying the recycled solids in a powder atomizer, by introducing the recycled solids tangentially at the dryer walls or in any other suitable manner.

The most surprising aspect of the present invention is the observation that the unusually high drying air inlet temperatures do not result in any further noticeable inversion, burning, caramelization and/or darkening of the dry product. This is a truly unexpected result when considered in light of the closest known prior art, in which the air temperatures are at least 30–40° Fahrenheit and mostly 100 to 200° Fahrenheit lower than those used in the present invention.

Any number of sucrose-containing solutions may be dried in accordance with the present invention; including, for example, refined sugar syrups, raw sugar syrups, affination syrups, syrups resulting from various strikes (e.g., the second, third or subsequent strikes) in conventional sugar crystallization processes, remelt syrups, edible molasses, and the like; or mixtures of the foregoing. The solutions are appropriately decolorized, where required, if a white product is desired and are concentrated or diluted to the desired solids content prior to drying.

The invention will be further understood from the following illustrative examples.

EXAMPLE 1

This example is based upon Example III of U.S. patent application Ser. No. 36,738; of which the present application is a continuation-in-part.

Affination syrup (70.2° Brix and specific gravity of 1.351) from a commercial sugar refinery was dried in a spray dryer having a 7.5 foot diameter and a 60° product collection cone, providing an overall dryer volume of about 240 cubic feet. This syrup was atomized with a high vane centrifugal wheel type atomizer rotating at about 21,600 revolutions per mintue. Recycle solids were fed to the drying chamber through four separate one-inch outside diameter tubes equally spaced about the periphery of the atomizer.

In one exemplary run in this dryer the affination syrup was fed to the atomizer at about 170° Fahrenheit and at a rate of about 22 gallons per hour (this was equivalent to a syrup solids feed rate of about 2.9 pounds per minute). The ratio of recycled solids to syrup solids was approximately 3.2. For start-up, ground product from a previous run was used. Thereafter a blend of ground product from the run in progress and from the previous run was used. Air was fed to the dryer at an inlet temperature of 437° Fahrenheit and at a rate of approximately 1,000 cubic feet per minute, giving an average dryer residence time of about 14–15 seconds. The outlet air temperature was 161° Fahrenheit.

Product recovered from the above-described exemplary run was medium brown in color. It had a moisture content of about 1.5 percent, a loose bulk density of about 19 pounds per cubic foot and a packed bulk density of about 23 pounds per cubic foot. After screening the packed bulk density was about 33 pounds per cubic foot. The particle size of the product was mostly in the range of 50–100 microns with some agglomerates in the range of 150–300 microns. The product was not noticeably caramelized and had no noticeable "burned" taste. It was suitable for human consumption or use in goods intended for human consumption.

EXAMPLE 2

Another run was conducted in the same equipment and under conditions generally similar to those described in Example 1. In this run the syrup feed rate was equivalent to 174 pounds of syrup solids per hour and the recycle solids were fed at a rate of 556 pounds per hour (recycle solids ratio of about 3.1). The recycled solids were made up from the product of a previous run for start-up and thereafter from the run in progress. In accordance with commonly owned U.S. application Ser. No. 139,852, filed May 3, 1971, all recycle solids were ground in a Cumberland mill (a commercially available attrition mill) to an average particle size within the range from 100 to 150 microns prior to being fed to the dryer. The inlet air temperature was 437° Fahrenheit, outlet air temperature 161° Fahrenheit and product temperature 151° Fahrenheit. Average air residence time was about 15 seconds.

The recovered product had an average particle size within the range from 200 to 300 microns and a moisture content of 1.2 to 1.6 weight percent. Again there was no noticeable caramelization or "burned" taste.

During the course of this run the dryer walls remained relatively clean, with no heavy wall accumulations. No difficulty was experienced with large solids masses plugging the outlet. Total wall accumulation after 1.3 hours operation was only about 60 pounds, distributed in thin layers. The general condition of the dryer was judged to be quite satisfactory for prolonged continuous operation.

EXAMPLE 3

A subsequent run was conducted in the same equipment and under conditions similar to those described in Examples 1 and 2. In this run the syrup feed rate was equivalent to 147.5 pounds of syrup solids per hour via a centrally located single fluid spray nozzle and the recycle solids were fed at a rate of 390 pounds per hour (recycle weight ratio of about 2.65). The recycled solids were made up from the product of a previous run for start-up and thereafter from product of the run in progress. In accordance with commonly owned U.S. application Ser. No. 139,664, filed May 3, 1971, all recycled product solids were deagglomerated to an average particle size within the range from 50 to 150 microns prior to being fed to the dryer by pneumatically conveying them through a circuitous recycle conduit and the reduced size particles were introduced to the dryer through a centrally located centrifugal powder atomizer located above the syrup atomizer so as to form a solids-bearing atmosphere about the syrup droplets. The inlet air temperature was 445° Fahrenheit and the outlet air temperature was 194° Fahrenheit. Average air residence time was about 18 seconds.

The recovered product was high agglomerated microspheres having agglomerate particle size ranging up to 1/32 inch to 1/16 inch and a moisture content of about 0.8 percent.

During the course of this run, the dryer walls remained very clean, with only minor wall accumulations. No difficulty was experienced with any large solids masses plugging the outlet. Total wall accumulation after almost 3 hours operation was only about 15 pounds. The general condition of the dryer was judged to be quite satisfactory for virtually unlimited continuous operation. Further-more, all product leaving the dryer was dry and free-flowing and could be directly recycled without requiring any storage or other further post-crystallization treatment. Product recovered for use was not noticeably caramelized and had no noticeable "burned" taste.

Operation in accordance with the present invention surprisingly provides quality product at higher production rates (for any given dryer capacity) than previously thought possible. This results in substantial technical and economic advantages over any known prior art processes.

What is claimed is:

1. In the process for preparing dried, solid sucrose-containing products from a sucrose-containing solution by drying droplets of the said solution in a current of heated air and in the presence of 0.5 to 4 parts by weight of separately introduced recycled product solids per part by weight solids in the solution to be dried, the improvement which comprises supplying the hot drying air at an inlet temperature of at least 400° Fahrenheit while maintaining average air residence time in the drying zone at about 60 seconds or less.

2. Improvement as defined in claim **1** in which the hot drying air temperature is in the range of from 425° Fahrenheit to 475° Fahrenheit.

3. Improvement as defined in claim **2** in which the average air residence time is maintained between 5 seconds and 25 seconds.

4. Process for preparing dry sucrose-containing products comprising:

(a) dispersing sucrose particles in a current of heated air having an inlet temperature of at least 400° Fahrenheit;

(b) separately dispersing in the heated air from about 0.25 to about 2 parts by weight, dry solids basis, of a sucrose-containing solution, per part by weight of said particles;

(c) evaporating the water from the solution;

(d) separating the resulting dry product from the hot air stream;

(e) recycling the necessary amounts of dry product material from step (d) to provide the particles used in the dispersion step (a); and

(f) recovering the remainder of the dry product.

5. Process as defined in claim **4** wherein the sucrose-containing solution is an affination syrup.

6. Process as defined in claim **4** wherein the sucrose-containing solution is a last-strike liquor from sugar refinery crystallization.

7. Process as defined in claim **4** wherein the product recycled in step (e) is reduced to an average particle size of about 200 microns or less before introduction to the dispersion step (a).

8. Process as defined in claim **7** wherein the size reduction is sufficient to provide an average particle size within the range of from about 50 to about 150 microns.

9. Process as defined in claim **7** wherein the reduced size recycled product material is dispersed in step (a) at the outer periphery of the drying zone as an enveloping solids bearing atmosphere about the droplets of sucrose-containing solution.

10. Process as defined in claim **9** wherein the sucrose-containing solution is an affination syrup.

11. Process as defined in claim **9** wherein the sucrose-containing solution is a last-strike liquor from sugar refinery crystallization.

References Cited

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U.S. Cl. X.R.

99—199; 127—58; 159—48 R