United States Patent

Woodruff et al.

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[45] **Dec. 19, 1972**

[54] **SUGAR DRYING METHOD**

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[52] **U.S. Cl.** .....**127/62,** 99/199, 127/16, 127/58, 159/4 S

[51] **Int. Cl.** **C13f 1/02**

[58] **Field of Search**.....127/58, 61, 62; 159/4 R, 4 S

[56] **References Cited**

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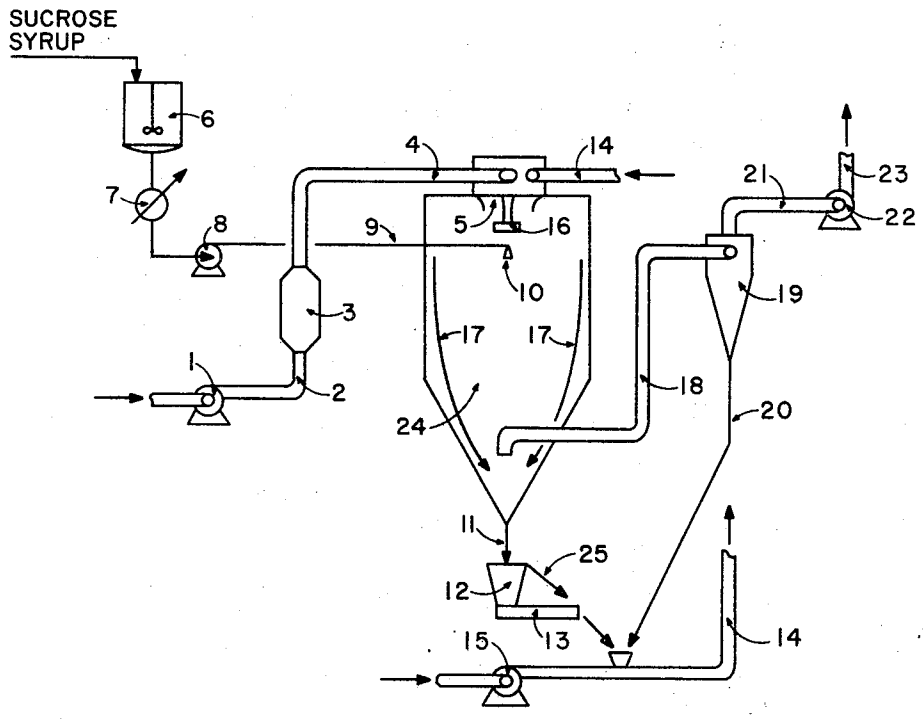
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[57] **ABSTRACT**

In a process for drying droplets of sucrose-containing solution in a current of heated air and in the presence of 0.5 to 4.0 parts by weight of separately introduced recycled product solids per part by weight of solids in said solution the improvement which comprises controlling the average particle size of the recycled product solids at about 200 microns or less and dispersing the recycled fine-sized solids at the outer periphery of the drying zone as an enveloping solids-bearing atmosphere around the solution droplets. Apparatus is disclosed for carrying out the process including a spray drying chamber, a centrally located liquid atomizer, drying air inlet and outlet conduits, solids product collection means, means for deagglomerating product solids, and means for recycling product solids to the drying chamber and introducing them tangentially as an enveloping curtain of solids adjacent the walls of the drying chamber.

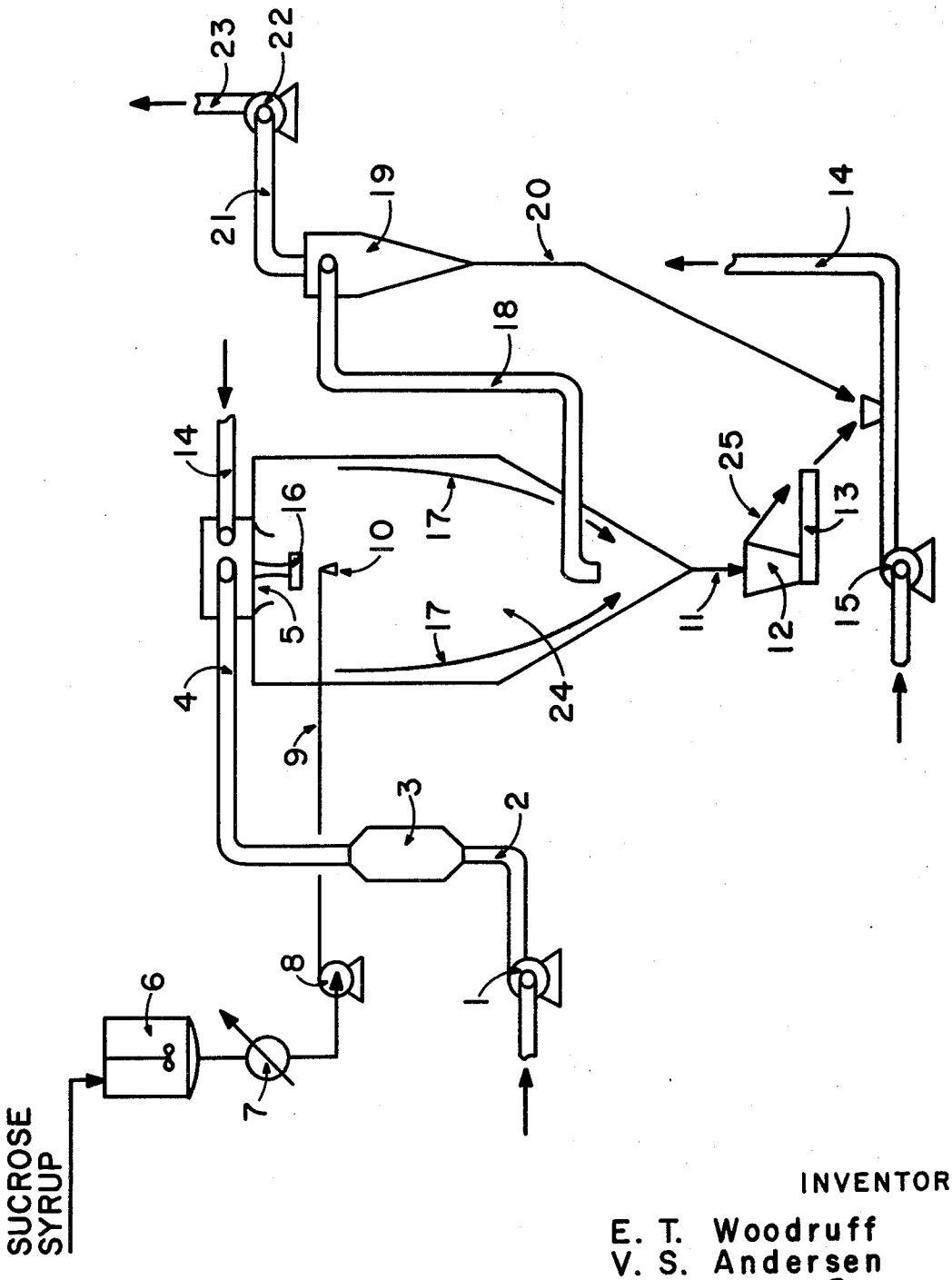
10 Claims, 2 Drawing Figures



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SHEET 1 OF 2

Fig. 1

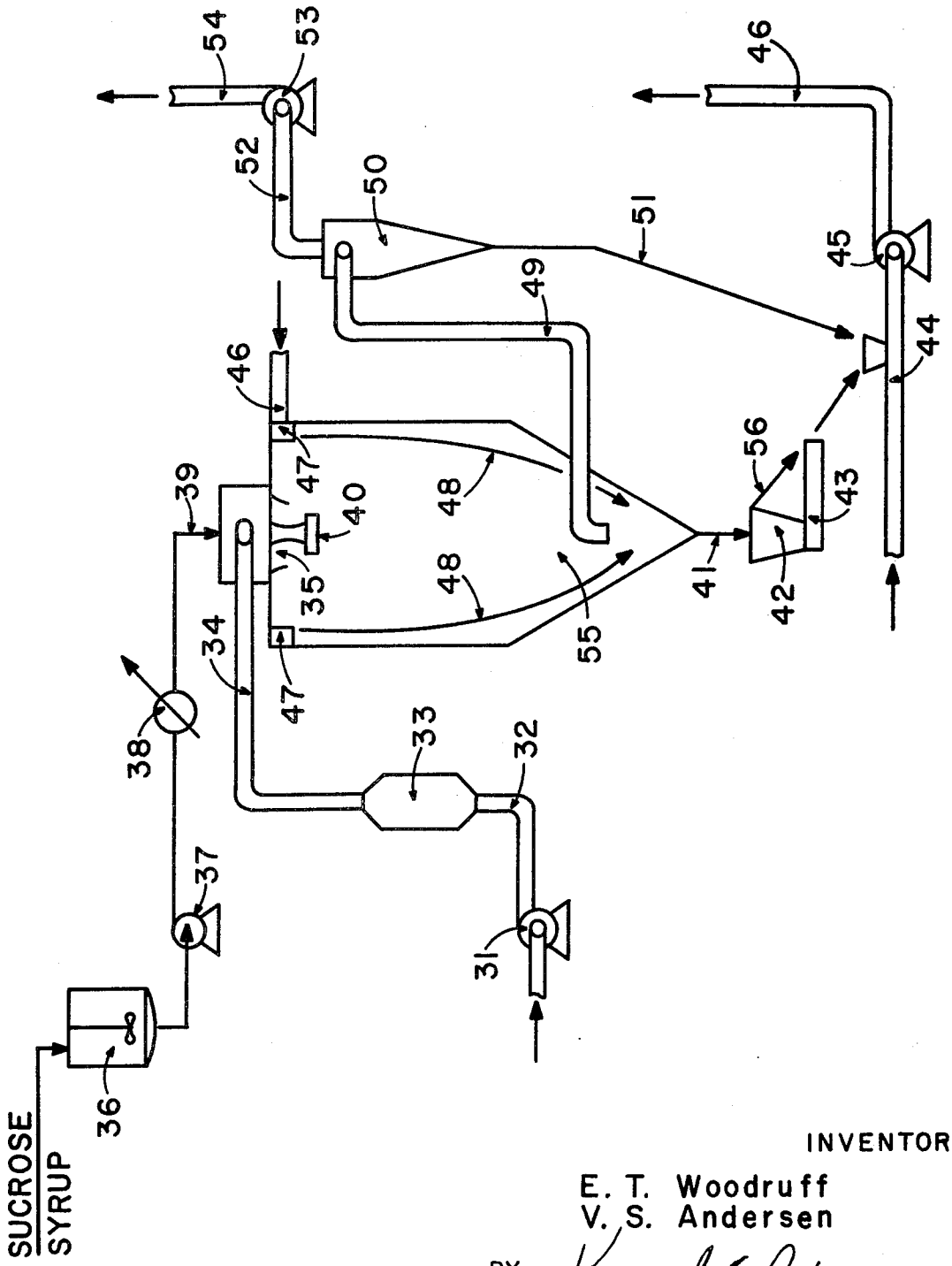


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Fig. 2



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SUGAR DRYING METHOD

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 ensuring continuous operation of a process for spray drying sucrose-containing solutions in the presence of recycled product solids; and at the same time eliminating the need for any post crystallization treatment of product solids between recovery from the dryer outlet and recycle to the dryer solids feed inlet.

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, carmelization being reduced as much as possible by the use of vacuum to reduce the evaporation temperature. Fractional crystallization is essential since, during processing, inversion of the cane sugar takes place, usually to the extent of about 15 percent by weight of the original sucrose content by the time processing is completed. This invert sugar, which is substantially uncrystallizable, is discarded together with up to about 20 percent 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 (Reimers et al. - U.S. Pat. No. 3,140,201) drying intimate blends of sugar solids and sugar solutions (Oikawa - U.S. Pat. No. 3,271,194 and British Pat. No. 1,099,723) and simultaneous centrifugal distribution and spray drying of sugar solids and a sugar solution (Japanese Pat. publication No. 20384/69). Agglomeration of pulverized sugar using a liquid sugar syrup binder and drying of the agglomerated product is taught in Harding et al. - U.S. Pat. No. 3,518,095. A similar agglomeration process is disclosed in Gidlow et al. - U.S. Pat. No. 3,506,457. A process and apparatus for spray-drying liquid substances in the presence of small amounts of dust-like particles (e.g., recycled fines) is taught by Bishop - U.S. Pat. No. 2,698,815. Molasses is one liquid product suggested as suitably dried in this manner. Spray drying of high D.E. glucose solutions in the presence of recycled solids is disclosed by Repsdorph et al. in U.S. Pat. No. 3,477,874 and corresponding British Pat. No. 1,075,161. A process and apparatus for spray drying a foamed lactose syrup is disclosed in Nava et al. - U.S. Pat. No. 3,533,805. Process and apparatus for preparing a spray dried topping mix containing sucrose, some of which is added in the dry state to the dryer, is disclosed in Nezbed - U.S. Pat. No. 3,414,980.

Belgian Pat. No. 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. In a preferred embodiment of the disclosed process a portion of the dried product is recycled as the solids dispersed in the drying zone. In the process of the Belgian patent the use of sucrose particles, e.g., recycled dry product, is necessary to the process of drying the sucrose-containing solution. Attempts to directly spray dry the solution in the absence of such solid particles results in caramelization and degradation of the sugars in the solution and irreversible adhesion and sticking of the freshly formed, incompletely crystallized solids to the walls of the dryer.

The presence of recycle solids provides a practicable process for spray drying sucrose-containing solutions. However, some problems still remain in attempting to practice this process on a commercial, high production rate, continuous basis. For example, in pilot plant runs of the process described in the aforementioned Belgian Pat. No. 742,249, the product coming from the dryer is typically a plastic-like mass of incompletely crystallized material. In a short period of time (e.g., 5 to 10 minutes) crystallization of the product will be complete and a free flowing product results, comprising agglomerates of sucrose microcrystals with agglomerates ranging in size from about 1,000 microns (roughly the size of the individual crystals of commercial white household sugar) to as low as about 150 microns and made up of individual microspheres ranging in size from about 25 to about 150 microns. Average agglomerate particle size typically ranges from about 200 to 600 microns (i.e., 50 weight percent of the product will be above and 50 weight percent below a given particle size in the range of about 200 to 600 microns).

When the 200 to 600 micron product particles or agglomerates are recycled to the drying step they tend to promote heavy accumulation of the plastic mass on the dryer walls. Portions of this mass "flake" off the walls and discharge from the dryer in a random intermittent fashion. From time to time the size of the randomly discharged portion is so large that it effectively blocks the dryer outlet, forcing a shut-down and interruption of continuous operation.

It is an object of the present invention to resolve these prior art problems.

It is a specific object of the invention to provide a procedure for inhibiting or preventing large build-ups of uncrystallized plastic materials on the dryer walls, thus ensuring continuous operation for a long period of time.

Still another object of the invention is the provision of a drying procedure and apparatus which eliminates the need for any post-crystallization steps or equipment.

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

In accordance with the present invention, build-up of solids on the dryer walls during the drying of sucrose-containing solutions in the presence of recycled product solids is inhibited or prevented, and crystalline free flowing product is obtained directly from the dryer outlet (i.e., without the need for any post-crystallization externally of the dryer) by maintaining the average particle size (i.e., the size where 50 weight percent of the particles are large and 50 weight percent are smaller), of the recycled solid product at about 200 microns or less, preferably about 150 microns or less and most preferably between about 50 microns and 100 or 150 microns and by dispersing the recycled fine-sized product solids at the outer periphery of the drying zone as an enveloping solids-bearing atmosphere around the solution droplets. In this way wall accumu-

lation in the dryer is negligible and post-crystallization is eliminated.

In a particular embodiment the invention is applied to the sucrose solution spray drying process which has been described in the aforementioned Belgian Pat. No. 742,249. In general, the process 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 pre-heated, e.g., to a temperature of 50° to 100° C. 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 drying temperature (i.e., the ambient temperature in the dryer after substantially steady state conditions have been established for continuous operation) will vary with other process conditions and the particular sucrose-containing solution to be dried but typically ranges from about 50° to about 130° C., preferably about 80° to about 100° C. Temperature can be controlled by controlling the temperature or feed rate of the incoming sugar syrup or the recycled solids or the temperature of the incoming hot air, or the average residence time in the dryer.

The particle size of the recycled solids is maintained in the desired range by size reduction prior to the recycle. This can be accomplished by an intermediate grinding step, by appropriately designing the recycle system so that the product solids are deagglomerated by attrition or impact in the course of being returned to the dryer solids feed inlet, or in any other suitable manner. In any event it is essential that the average particle size of the recycled product solids be reduced to not greater than about 200 microns and preferably not greater than about 150 microns prior to reintroduction into the dryer. For reasons of overall process economy, dusting losses and the like, it is generally undesirable to reduce the average particle size of the recycle product lower than about 25 microns, particularly since no substantial further improvement in results will be observed. In the presently preferred embodiment of the present invention the product solids are deagglomerated in the solids recycle system to an average particle size within the range of from about 50 to about 100 or 150 microns.

Size reduction of recycle product solids particles as an improvement, standing alone, is the subject of commonly owned, concurrently filed U.S. Application Ser. No. 139,852.

In accordance with the present application still further improvements are achieved by recycling the reduced size product solids at the outer periphery of the drying zone as an enveloping solids-bearing atmosphere around the atomized sucrose-containing solution to be dried. This not only further inhibits accumulations on the dryer walls but results in the further unexpected advantage of providing directly from the dryer a dry, free-flowing product.

There are several ways of introducing the recycled product in accordance with the present invention. In one embodiment, the recycled product is introduced into the dryer by means of a centrally located centrifugal "powder" atomizer and is carried by drying air currents to the dryer walls. In another, presently preferred, embodiment the recycled product solids are recycled in a current of conveying gas (e.g., in a pneumatic conveyor) and introduced tangentially along the dryer walls at a plurality (preferably from two to eight) of points spaced about the dryer periphery. It is not necessary and may not be desirable for the plural tangential inlets to be equally spaced about the dryer periphery. In any event the sucrose-containing solution is separately atomized in any suitable manner (e.g., centrifugally or in a single or multiple fluid sprayer) centrally of the drying zone and within the enveloping solids-bearing atmosphere.

The drawings schematically illustrate apparatus suitable for practicing the present invention. In the drawings:

FIG. **1** is a schematic illustration of apparatus incorporating a centrifugal "powder" atomizer.

FIG. **2** is a schematic illustration of apparatus in which recycle solids are tangentially introduced at the dryer walls.

Ambient air from supply fan **1** passes through line **2** into indirect heater **3** to raise the air temperature from ambient conditions to proper spray drying temperature. The heated air continues in line **4** and enters the spray dryer **24** via annulus **5**.

The sucrose syrup to be spray dried is received in feed tank **6**. From there it is pumped via pump **7** through heat exchanger **8** and through line **9** entering the dryer through atomizer head **10**.

Spray dried product drops from the chamber of dryer **24** and passes through line **11** and into surge hopper **12**. From there it is fed by a volumetric feeder **13** into a pneumatic conveying system. The pneumatic conveying system constitutes supply fan **15** and transfer line **14** which conveys recycle product back to spray dryer **24**. Recycle product along with its conveying air enters the dryer through centrifugal powder atomizer **16**. From the atomizer **16** the powder particles are carried by the drying air currents to the walls of the dryer where an eveloping solids-bearing atmosphere, generally designated **17**, is formed about the atomized sucrose solution spray droplets, formed by atomizer head **10**. In the course of recycle to the dryer the product particles are passed through a grinder (not shown) or are otherwise suitably reduced to an average particle size of about 150 microns or less prior to introduction into the dryer. Some or all of the size reduction may be accomplished in the powder atomizer **16**. Product not recycled overflows surge hopper **12** and is transferred to storage and packaging via line **25**.

Dryer off gases pass from line **18** into cyclone collector **19**. Separated product fines pass from collector **19** through line **20** where they enter line **14** and mix with product from feeder **13**. Solids-free off gas from collector **19** passes through line **21** and is exhausted to the atmosphere via exhaust fan **22** and vent line **23**.

In the apparatus of FIG. 2 ambient air from supply fan 31 passes through line 32 into indirect heater 33 to raise the air temperature from ambient conditions to proper spray drying temperature. The heated air continues in line 34 and enters the spray dryer 55 via annulus 35.

The sucrose syrup to be spray dried is received in feed tank 36. From there it is pumped via pump 37 through heat exchanger 38 and through line 39 and enters the dryer through centrifugal atomizer 40.

Spray dried crystaline free flowing product falls from drying chamber 55 through line 41 into surge hopper 42. From there it is fed by a volumetric feeder 43 into a pneumatic conveying system via line 44. The material passes through a combination pneumatic conveying and milling fan 45 which reduces the particle size of the product. The material is then conveyed through line 46 and recycled to spray dryer 55.

Recycle product enters dryer chamber 55 through tangential inlets 47. Having been placed in the dryer in such a manner the recycle product flows along the dryer walls and forms a solids-bearing enveloping atmosphere generally designated 48 between the dryer walls and the syrup spray droplets from 40.

Product not recycled to drying chamber 55 overflows surge tank 42 and passes through line 56 to product storage and packaging.

Exhaust gas from drying chamber 55 passes through line 49 to cyclone collector 50. Product fines from 50 are fed into pneumatic recycle line 44 through line 51. Solids-free off gas from collector 50 goes through line 52 to exhaust fan 53 and discharge to the atmosphere via line 54.

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 A

(Comparative Example)

A pilot plant run was conducted utilizing the process and apparatus described in Belgian Pat. No. 742,249. The spray dryer apparatus had a 7½ foot diameter with a 3½ foot high cylindrical section and a 60° conical bottom giving an overall dryer capacity of approximately 240 cubic feet. The liquid atomizer was a high vane centrifugal wheel rotating at 22,900 revolutions per minute.

The sucrose solution feed was affination syrup from a commercial cane sugar refinery. This syrup contained about 70.5 weight percent solids. It was preheated and fed to the dryer at a temperature of about 170° F. and at a rate of 16.2 gallons per hour, providing a syrup solids feed rate of about 128 pounds per hour.

Dried, solid sucrose product from an earlier run was used for the initial "recycle." This product had an average particle size of about 300 microns. Thereafter product solids from the run, with an average particle size of 300 to 400 microns, was used. The recycled solids were fed via four 1-inch diameter tubes evenly spaced about the outside of the centrifugal atomizer at a rate of 512 pounds per hour (recycle weight ratio of 4).

Hot air was introduced into the dryer at about 1,000 cubic feet per minute and a temperature of 336° F. The temperature of the outlet air was 161° F. and the temperature of the product exiting from the dryer was 138° F.

While operating under the foregoing conditions a rapid build-up of accumulated solids on the dryer walls was observed. Within an hour the total wall accumulation amounted to 219 pounds and the accumulated material had built up to a depth as high as 10 inches at some locations on the dryer walls. There was a large mass of flaked-off solids over the dryer solids product outlet. Conditions were judged to be so poor that the run could no longer be continued.

The following example illustrates the practice of the present invention.

EXAMPLE 1

A subsequent run was conducted in the same equipment and under similar conditions as those described in comparative Example A. 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. All recycle 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 introducing them to the dryer through a centrally located centrifugal powder atomizer located above the syrup atomizer. The inlet air temperature was 445° F. and the outlet air temperature was 194° F.

The recovered product was highly agglomerated microspheres having agglomerate particle size ranging up to 1/32 inch to one-sixteenth inch.

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. Furthermore, all product recovered from the dryer was dry and free-flowing and could be directly recycled without requiring any storage or other further post-crystallization treatment.

What is claimed is:

1. In a process for continuously preparing dried, solid sucrose-containing product from a sucrose-containing solution by continuously 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 and continu-

ously introduced recycled product solids per part by weight solids in the solution to be dried, the improvement which comprises inhibiting or preventing accumulations on the dryer walls and continuously providing crystalline, free-flowing product directly from the dryer outlet and without any post dryer crystallization treatment by continuously maintaining the average particle size of the recycle solids at about 200 microns or less and distributing the said separately introduced recycled product solids at the outer periphery of the drying zone as an enveloping solids-bearing atmosphere about the solution droplets.

2. Improvement as defined in claim 1 in which the size of the recycle solids is maintained within the range of about 50 to about 150 microns.

3. Improvement as defined in claim 2 in which the size of the recycle solids is maintained within the desired range by deagglomeration of the product in the dryer recycle system.

4. Improvement as defined in claim 2 in which the said recycled product solids are tangentially fed through plural distribution inlets at the outer periphery of the drying zone.

5. Continuous process for preparing dry sucrose containing products comprising:

a. continuously dispersing in a current of heated air and at the outer periphery of a drying zone as an enveloping solids-bearing atmosphere sucrose particles having an average particle size of about 200 microns or less;

b. continuously and separately dispersing in the heated air, and within the said enveloping solids-bearing atmosphere, spray droplets of a sucrose-containing solution containing from about 0.25 to about 2 parts by weight of solids per part by weight of said particles;

c. evaporating the water from the solution droplets;

d. continuously separating the resulting dry crystalline, free-flowing product from the hot air stream;

e. reducing the average particle size of at least the necessary amounts of said resulting dry product from step (d) to provide the particles used in step (a) to about 200 microns or less;

f. continuously recycling the necessary amounts of reduced size material from step (e) to the dispersion step (a); and

g. recovering, without any post dryer crystallization treatment, the remainder of the dry product.

6. Process as defined in claim 5 wherein the size reduction in step (e) is accomplished by deagglomeration of the dry product from step (d) in the course of the recycle step (f).

7. Process as defined in Claim 5 wherein the size reduction in step (e) is sufficient to provide an average particle size within the range of from about 50 to about 150 microns.

8. Process as defined in Claim 7 wherein the sucrose-containing solution is an affination syrup.

9. Process of Claim 7 wherein the sucrose-containing solution is a last-strike liquor from conventional sugar refinery crystallization.

10. Process as defined in claim 7 wherein the solids are dispersed in step (a) by tangentially feeding through plural, spaced distribution inlets at the outer periphery of the drying zone.

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