CENTRIFUGE FOR THE CONTINUOUS RECOVERY OF SUGAR CRYSTALS

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Our present invention relates to continuously operable centrifuges and, more particularly, to centrifugal devices for the separation of solid material from liquids.

It is common in the process industries to employ a continuously operating centrifuge for the recovery of a solid centrifugate from a mixture thereof with a mother liquor in which the solid is soluble. Centrifuges of this type are conventionally employed in sugar-refining processes for the extraction of sugar crystals from a mother liquor. In this process the molasses is cooled to precipitate crystals of sugar, the resulting slurry or mixture being then fed continuously into the rotating basket of a high-speed centrifuge which centrifugally forces the liquid through the perforations in the basket into the surrounding molasses or liquor compartment while the crystals ascend the basket wall and pass into the sugar compartment. To this end the basket wall is usually of conical configuration with one or more centrifuge stages. The production efficiency of these centrifuges has generally been controlled by regulating the rate of flow of the mixture into the centrifuge basket. This arrangement has, however, the disadvantage that the centrifuge does not always operate under the most efficient conditions since the mother liquor or syrup is highly viscous. It has been proposed, therefore, to heat the basket at axially spaced locations to accelerate the passage of the syrup through the perforated wall. This method has also been found to be unsuitable, for the most part, since the heating results in the establishment of intervening unheated or cool regions which decrease the rate of flow through the centrifuge. Moreover, it should be noted that most earlier constructions made use of an open centrifuge housing whereby free air circulation was permitted into the basket as well as between the latter and the compartments. This also resulted in the formation of cool zones and/or the non-uniform heating of the basket and its layer of crystals. It is, therefore, an object of the present invention to provide an improved method of operating a centrifuge for the separation of a solid from its mother liquor wherein the abovementioned disadvantages are obviated and an optimum separation rate can be achieved.

A more specific object of the invention is to provide an improved method of operating continuous sugar centrifuges which is capable of effects a considerable increase in the operating efficiency thereof.

Another object of the invention is to provide a sugar centrifuge operable at a relatively high rate without the disadvantages inherent in earlier constructions.

These objects are attained, in accordance with the invention, by maintaining the basket of a centrifuge, which is rotatable about a substantially vertical axis and diverges conically upwardsly to communicate with an outer compartment for collecting a solid centrifugate and is surrounded by an inner compartment for collecting the mother liquor in which the solid is increasingly soluble with increasing temperature, at a temperature below that at which substantial amounts of centrifugate dissolve in the mother liquor but sufficiently high to effect a relatively rapid passage of the mother liquor through the basket and the solid layer deposited thereon. It should be noted, in this connection, that the solid centrifugate may be in solution equilibrium with the mother liquor upon its admission to the basket, in which case the viscosity of the mother liquor will be well defined and characteristic of its inlet temperature. The basket of the centrifuge and advantageously, the layer deposited thereon is, according to the invention, raised to a temperature in excess of that of the admitted mixture so that further amounts of the centrifugate are capable of dissolving in the latter. Since, however, the viscosity of the liquor increases with temperature, the latter is so chosen that the liquor is capable of passing through the perforations in the drum or basket of the centrifuge at a much higher rate so that it is in contact with the centrifugate layer for a short time and is thus not able to redissolve substantial amounts of the layer. Inasmuch as dissolution of the solid matter is a rate process and, therefore, time dependent, the reduced contact duration prevents any substantial dissolution of the solid deposited upon the centrifuge basket.

It is essential, for the purposes of the present invention, that the centrifugate should not pass through any cool zones as it travels axially along the wall of the centrifuge basket towards its upper end at which it is transferred to the centrifugate compartment so that undercooling is avoided. In conventional centrifuges the centrifugate (e.g. the mass of sugar crystals) encounters decreasing temperatures as it climbs the basket wall since it is introduced into the basket initially in a warm state and the circulation of air in the region of the upper end of the basket results in a cooling thereof at this end. It is, therefore, another feature of this invention to provide means for heating the basket at its upper end or, at least, to prevent its cooling in this region. We have found that, for optimum operation of a sugar centrifuge, best results are obtained when the basket is maintained, throughout its entire axial height, at a temperature between substantially 52° C. and 80° C. and preferably between 65° C. and 75° C. The considerable amount of heat generated by frictional engagement between the rapidly rotating basket and the surrounding air has also been found to be sufficient to maintain the temperature of the basket within the proper range, especially when the mixture of sugar crystals and syrup is fed into the basket at a temperature just below the lower limit of this range, if baffle means are provided for limiting the circulation of air in the vicinity of the upper end of the basket and between the compartments. Thus we prefer to introduce the sugar slurry at a temperature of the order of 50° C. while maintaining the temperature in the molasses compartment between approximately 60° C. and 110° C.

The limitation of the air flow suffices, for the most part, to prevent the formation of cool zones axially throughout the basket. Since the frictional heat may be insufficient to maintain the basket at the proper temperature when the slurry or mixture is introduced at a temperature substantially below that of the optimum range, we have found it advisable, in such cases, to provide additional thermal control means in the form of heating means capable of raising the basket to the optimum temperature without, however, formation of cool zones. It is necessary, under these circumstances, to avoid most prior-art methods which entail the heating of an open basket at axially spaced locations whereby cool zones can be formed intermediate the heated regions. We prefer to provide either dielectric heating, wherein an electrode is juxtaposed with the layer over substantially the entire height of the basket, or means employing a heating fluid. The latter may be admitted to the molasses or inner compartment and directed against the basket at its lower end so that effec-
tive distribution of the heat upwardly is ensured. It will be noted, at this point, that the layer of sugar crystals traveling upwardly along the basket wall is relatively thin (e.g. having a thickness of only several millimeters) and is exceptionally temperature sensitive. Thus, it is relatively easy to heat this layer but also relatively easy to cool it. Chilling must be avoided, as previously mentioned, to prevent undercooling of the mother liquor and consequent retention of solute. The importance of checking the circulation of air between the compartments and the interior of the basket will, therefore, be self-evident.

When heating means such as the dielectric or heating-fluid methods are employed, we may provide the centrifuge with a removable circular cover 12 which is seated upon an inner flange 71 of the plate and is provided with an inlet funnel 11 for directing a slurry or mixture of sugar crystals with mother liquor into the interior of the basket. This inlet 11 is aligned with an outlet nozzle 10 of a slurry conduit (which may be heated or insulated in the usual manner to prevent refreezing), while a valve 72 controls the rate of flow of the slurry into the centrifuge, and with a further funnel 73 whose extension 74 guides the slurry within the interior 16 of basket 2 into its well 57. A cylindrical extension 15 at funnel 11 forms a baffle for preventing or checking the flow of air through this inlet. An axially extending annular baffle 14 depends from plate 40 and is in close-space relationship with the upper end of the conical wall portion 61 of basket 2 to reduce or prevent the flow of air between the interior 16 thereof and the compartments 4 and 5 while, nevertheless, permitting the thin layer of sugar crystals (e.g. with a thickness on the order of several millimeters) to pass into compartment 5. A bottom plate 13 forms with cover 12, baffle 14, guide plate 66 and partition 3 an enclosure for the basket 2 preventing exposure thereof to cooling effects.

The base or chassis 9 carries a motor 8 whose drive shaft 75 is provided with a V-belt pulley 76 which is connected by belt 77 to the V-pulley 77 of shaft 51. A pump 78 maintains a continuous flow of lubricant from an oil pan 79 through the bearing sleeve 50 as indicated in dot-dash lines. A conduit 80 extends through plate 40 into the interior 16 of the basket to supply a heating or flushing fluid (e.g. air, steam or hot water), a washing agent or an additive if required. As a consequence of the provision of the aforementioned baffles, the frictional heat generated upon rotation of the basket 2 is sufficient to maintain a temperature of the crystal layer 5 between substantially 52° C. and 80° C. and, preferably between 65° C. and 75° C., without the formation of any undesirable end products in the basket. Thus, the slurry 81, which is introduced at a temperature of, say, 50° C., is fed via funnels 11 and 73 into the well 57 whence the liquid is forced centrifugally through the apertures in the basket while the solid material (i.e. sugar crystals) climbs upwardly along the conical portions 59 and 61 of the basket to pass over plate 68 into the sugar chamber. The molasses 46, however, collects within the compartment 4 from which it may be removed via outlet 45. The sugar crystals may be removed through openings 41 and 42 by suction.

In FIG. 2 we show a similar arrangement wherein, however, an external source of thermal energy is employed as an annular baffle or jacket. The usual manner a conduit 17 directs a stream of heating fluid into the molasses compartment 4 and, advantageously, against the lower end of the basket 2 so that, upon rotation of the latter, the heat is distributed upwardly substantially uniformly. This conduit 17 is provided with a valve 22 for
regulating the flow of heating fluid into the molasses chamber, the latter being maintained at a temperature between substantially 60 °C and 110 °C, preferably at the upper end of this range. An electrically controlled mixing valve 21 has one input connected to a steam or hot-air line 22a and another input fed with cold air from a line 22b. Lines 22a and 22b are also provided with manually adjustable control valves 82 and 83 for setting the proportions of hot and cold fluid to be passed through conduit 17. In cases where there is little thermal variation in the region of the basket 2, this proportion may be set permanently. Generally, however, a certain degree of temperature variation is unavoidable since the temperature of the incoming slurry may change from time to time. It is, consequently, advisable to provide means for compensatingly adjusting the heat supply to the basket in response to such thermal variations. To this end we provide a temperature-responsive sensing means 19 which is juxtaposed with the basket and, advantageously, may extend into the region between the latter and the partition 53 within molasses compartment 4. The electrical output of sensor 19 serves for the continuous adjustment of mixing valve 21 in order to increase the supply of heat upon a decrease in the temperature in the region of the basket and vice versa. It should be noted, however, that the sensor may also be provided in the interior 16 of the basket while it or another sensor may be disposed at the inlet 11 to detect the temperature of the incoming slurry.

FIG. 3 shows another method of heating the basket 2 and the layer 8 of crystals deposited thereon. In this case a dielectric heating electrode 18 is juxtaposed with the layer 8 and connected to a high-frequency alternating-current source 84 whose other terminal is connected to the housing 7 which in turn is conductively coupled with the metal basket 2, the latter thus forming a counterelectrode. Electrode 18 extends parallel to a generatrix of the basket which rotates at such high speeds that the heat produced between the electrodes as a consequence of the dielectric character of the sugar-crystal layer is substantially uniform throughout. Again, the intensity of heating may be controlled by a sensor 20 which is connected with the source 84 for adjusting the frequency and/or intensity of its output. In the system the temperature in the molasses compartment 4 may be maintained constant to effect a similar maintenance of the temperature of the basket and the layer 8.

The invention as described and illustrated is believed to admit of many modifications and variations within the ability of persons skilled in the art, all such modifications and variations being deemed to be included in the spirit and scope of the appended claims.

We claim:
1. A centrifuge for the continuous recovery of sugar crystals from a mixture thereof with a mother liquor, comprising a substantially closed housing having a substantially continuous cover; a centrifuge basket journaled in said housing for rotation about a substantially vertical axis, said basket being spacedly overlain by said cover and having a perforate wall diverging conically upwardly from a lower end to an upper end thereof; partition means in said housing forming with said perforate wall a first annular compartment surrounding said basket for collecting mother liquor passing therethrough and forming with said housing a second annular compartment outwardly of said first annular compartment communicating with the interior of said basket at said upper end thereof for collecting said crystals; thermal control means in said housing for maintaining the temperature of the inner surface of said basket and a layer of crystals thereon sufficiently high to permit a rapid passage of said mother liquor through said basket; drive means for rotating said basket about a vertical axis; and baffle means within said housing for limiting the circulation of air therein between the interior of said basket and said compartment, said partition means and said housing means forming an enclosure for said basket substantially preventing the escape of ambient air in the region of said basket and the admission to this region of cooling currents of air from the exterior of the centrifuge, said baffle means including a ring depending from said cover and extending coaxially in closely spaced relationship with said upper end from above into the open upper end of said basket with small clearance from the inner surface thereof for permitting the flow of said crystals along said inner surface past said ring into said second compartment while restricting flow of air between said second compartment and the interior of said basket.
2. A centrifuge as defined in claim 1 wherein said thermal control means comprises heating means in said basket; and sensing means in said housing responsive to the temperature of said layer for controlling said heating means to maintain said temperature substantially constant.
3. A centrifuge as defined in claim 2 wherein said heating means comprises conduit means for introducing a heating fluid into the interior of said basket at a location intermediate said lower and upper ends thereof.
4. A centrifuge as defined in claim 2 wherein said heating means includes a dielectric heater juxtaposed with said layer.

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