CENTRIFUGAL DRIER WITH PURGING DEVICE

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ABSTRACT
A centrifugal drier comprises a non-rotary closure member mounted in the rotary drier basket over the interior chamber thereof, which receives sugar juice. The closure member includes a frusto-conical rim extending parallel to the conical basket wall and defining an annular gap therewith. A flexible annular diaphragm carried by the rim at the upper end thereof closes the upper end of the gap and purging water is sprayed into the gap. A control system displaces the closure member along the basket axis in response to the sugar juice feed rate so as to maintain the flexible diaphragm in contact with the layer of sugar on the basket wall during operation of the drier.

9 Claims, 4 Drawing Figures
CENTRIFUGAL DRIER WITH PURGING DEVICE

The present invention relates to improvements in a centrifugal drier with a rotary basket having a conical wall and defining an interior chamber, which comprises means in the basket chamber for purging the centrifuged solid material forming a film on the basket wall during operation of the drier. Such driers are particularly useful in the sugar refining industry.

In sugar refining, the purging of the sugar layer on the basket screen in the interior basket chamber is effectuated by spraying a suitable fluid, such as very hot water, on the layer of sugar to eliminate by vigorous washing the film of sirup remaining on the sugar crystals after the first drying phase.

When this purging operation is carried out in a continuously rotating conical drying basket, the purging liquid is entrained towards the upper rim of the basket by the layer of air which is swirled upwards by the rotating basket. This results in a dispersion of the purging liquid, which is damaging to the washing of the sugar crystals and the subsequent drying thereof. Furthermore, a portion of the purging liquid is projected into the sugar receiving chamber where it tends to form undesirable sugar agglomerates.

Purging of the solid sugar layer must be effectuated in the rotary basket at a level determined by the structure thereof between a first zone where initial drying is effected by the elimination of the largest part of the mother liquor, which constitutes the "poor sirup", and a second zone where the sirup resulting from the purging, i.e. the "rich sirup", is eliminated.

Good drying will be obtained when the output of massiccute corresponds to the drying capacity of the first zone of the basket. However, this capacity may be modified by variations in the viscosity of the solid-liquid mixture, i.e. the sugar juice, its granular characteristics and the crystallization of the massiccute. Therefore, a control of the drying efficiency is necessary to assure optimum utilization of the drier and the highest sugar quality by holding the remelting of the dried sugar due to purging to a minimum.

This object is attained by this invention in a centrifugal drier wherein drying and purging are controlled, the flow of the massiccute and of the purging liquid being automatically regulated so that these operations proceed under optimal conditions.

The above and other objects are accomplished by the invention with a centrifugal drier of the indicated type wherein a non-rotary closure member is mounted in the rotary basket over the interior chamber thereof which receives the solid-liquid mixture, the solid phase of the mixture being centrifugally deposited on the conical basket wall upon rotation of the basket and forming a layer of solid material on the wall. The closure member includes a frusto-conical rim extending substantially parallel to the conical basket wall and defining there-with an annular gap. A flexible annular diaphragm is carried by the rim at the upper end thereof for closing the upper end of the gap, means being provided for introducing a purging fluid into the gap. A control system displaces the closure member along the axis of the basket in response to the feed rate of the solid-liquid mixture so as to maintain the flexible diaphragm in contact with the layer of solid material on the basket wall during the operation of the drier.

The liquid tightness of the interior chamber and annular gap in communication therewith may be improved by providing a series of flexible annular diaphragms at the upper end of the closure member rim to seal off the gap from the outside.

The closure member is axially displaceable along the axis of rotation of the drier basket to regulate the width of the gap between the closure member rim and the basket wall. For this purpose, the closure member may be glidingly mounted on a central post, which may be a hollow feed column for the sugar juice, the axial displacement being effected by a control lever linked to the closure member.

The axial position of the closure member is automatically controlled as a function of, and in response to, the feed rate so that the spacing between basket wall and closure member rim increases and decreases proportionally to the feed rate.

According to one feature of the present invention, a safety device prevents axial displacement of the closure member against the bottom of the basket when the spacing attains a set minimal value.

The liquids passing through the basket screen along the wall of the basket in the drying and purging or washing zones are separately collected in a conventional manner. The drying efficiency may be controlled by measuring the quality or the flow of the liquid collected in the purging zone. More particularly, in the case of white sugar, the coloring of the rich sirup may be measured and the flow of the massiccute may be controlled as a function of the measured color parameter to obtain a product of the desired quality. When brown sugar is treated, the flow of poor sirup, which is collected on the other side of the drying zone, may be controlled, and the flow of massiccute is regulated as a function of this parameter to obtain optimum drying. It is also possible to control the flow of the purging liquid as a function of these measured parameters.

The above objects, advantages and features of the present invention will become more apparent from the following detailed description of a now preferred embodiment thereof, taken in conjunction with the accompanying drawing wherein.

FIG. 1 is a schematic side elevational view, partly in vertical section, of one half of a centrifugal drier according to this invention, the other half being symmetrical and identical with the illustrated half;

FIG. 2 is a horizontal section of the drier of FIG. 1, taken just above one set of the spraying means for the purging liquid;

FIG. 3 is an enlarged detailed view, partly in section, of one spraying nozzle of such means; and

FIG. 4 is a diagram of the control system for operating the drier.

Referring now to the drawing, the generally conventional centrifugal drier is shown to comprise a rotary basket 11 mounted for rotation about vertical axis of rotation 12 in the interior of a closed vessel or casing 72. The basket has a conical wall and defines an interior chamber delimited by filter screen 13 which covers the basket wall to permit liquid to pass therethrough and through ports in the basket wall into liquid collecting chambers 49 and 51 in closed casing 72.

The interior basket chamber is liquid-tightly closed by closure member 14 according to this invention. The closure member is non-rotary and includes a hub 15 glidingly mounted on hollow feed column 10 for axial
displacement within the basket. The feed column extends coaxially into the interior basket chamber for feeding the massecuite, or any other solid-liquid mixture, into the interior basket chamber through its axial bore which is connected at its upper end outside the closed casing 72 to a supply of massecuite (not shown).

The solid phase of the mixture, i.e. the sugar, is centrifugally deposited on the conical basket wall screen 13 upon rotation of the basket about its axis 12 and forms a layer of the solid material, i.e. sugar crystals, on the screen while the motor liquid passes therethrough and into collecting chamber 49, 51. A gasket 16 held on annular support plate 17 maintains a liquid-tight joint between the feed column 10 and closure member hub 15 while permitting axial displacement thereof along the column.

The closure member hub 15 is fixed to, or integral with, a crossbeam or carrier 18 attached to, or hanging on, two tie rods 19 which are diametrically disposed and pass through the bores of two diametrically disposed bosses 21 in cover 20 of casing 72 so that the tie rods may move vertically in the bores. The upper ends of the tie rods are affixed to a cross beam 22 which is attached to one arm of a control lever 24 by two links 23, 23 which pivots on axle 25 mounted on a bracket supported by casing cover 20. The other arm of control lever 24 is connected by two links 26, 26 to a gliding guide block 27 which is guided for vertical movement on two vertical posts 28, 28 and may vertically displaced by threaded spindle 29 whose rotation is controlled and actuated by reduction motor 30. A displacement sensor 31 senses the axial position of guide block 27 and produces a control signal which is a function of the control lever position. This control signal is transmitted to the control system to be described hereinafter.

The non-rotary closure member 14, which is mounted in the drier basket over the interior chamber receiving the solid-liquid mixture from feed column 10, has a frusto-conical rim 32 extending upwardly towards the upper edge of basket 11 substantially parallel to the conical basket wall and defining therewith an annular gap in communication with the interior basket chamber and forming a part with the upper edge of the basket wall. The rim 32 is spaced from the basket screen 13 a distance extending the thickness of the layer of sugar deposited thereon during the continuation operation of the drier so as to leave an annular gap over the sugar layer. A plurality of flexible annular diaphragms 33 are carried by rim 32 at the upper end thereof for closing the upper end of the gap, the gap being divided in a plurality of annular zones by the respective diaphragms which are attached to the rim by any suitable means, such as clamping or bonding. The axial position of the closure member 14 determines the very small distance maintained between the layer of sugar on screen 13 and the edges of the diaphragms.

The diaphragms 33 may be made of any suitable flexible or elastic material, such as rubber, so as to permit an agglomerate of sugar crystals to pass without damage along the screen and to avoid accidental contact with the sugar layer, which may have grave consequences for the operation of the drier. However, the diaphragm material is sufficiently rigid to maintain the pressure differential between adjacent zones on respective sides of each diaphragm during operation. The number of diaphragms used in the drier depends on the type of solid-liquid mixtures being dried and the conditions of operation of the drier, and will readily be established without undue experimentation by those skilled in the art.

Suitable stops (not shown) prevent axial displacement of the closure member 14 beyond predetermined axial end positions and safety means protect the flexible diaphragms in case of untimely movements of the closure member, one form of such safety means being illustrated by way of example.

This safety means (see FIG. 2) comprises feeler or sensor 43 mounted on axle 44 and a lever 45 keyed to the axle and normally biased by spring 46 against electrical contact 47. The assembly is controlled by a slight rotation of the feeler when it comes into contact with the sugar layer on basket screen 13 to open or close an electric control circuit including contact 47. This control circuit may, for example, close a valve in the feed means of the massecuite delivered into the basket interior so that no more massecuite is supplied thereto when the feeler 43 contacts the sugar layer. Operation of the control circuit may also, if desired, product an alarm signal. Obviously, the illustrated feeler may be replaced by any suitable proximity detector for operation of the safety means which will cut off further massecuite supply when the sugar layer on the basket wall is built up beyond a predetermined thickness.

Purging of the sugar layer on the basket wall is effected in the gap between the closure member rim 32 and the basket wall by means of a series of spray nozzles 34 disposed at regular intervals about the circumference of the rim in a plurality of nozzle sets at superposed levels. In the embodiment shown in FIG. 2, each set of nozzles comprises four spray nozzles disposed 90° apart from each other but, if desired, a larger number of spray nozzles may be used at each level or some levels.

FIG. 3 illustrates a preferred mounting of the spray nozzles. Each nozzle carrier comprises a cylindrical head 35 mounted in a countersunk bore 42 in the closure member rim 32 and attached to a threaded body 36 having an axial bore 37. The threaded body 36 extends through a radial bore in rim 32 and is mounted therein by means of nut 38 tightened to engage the inner wall of the rim. A connector 39 connects the threaded body 36 to a purging liquid feed conduit 40 to deliver the purging liquid from conduit 40 into bore 37 which communicates with a central bore in nozzle 34. The nozzle is screwed into a tap in the cylindrical head 35 which communicates with bore 37, the nozzle having a shoulder engaging a machined wall portion of head 35. This mounting permits each nozzle to be positioned and oriented precisely so that no unevenness of the sprays perturbs the circumferential air circulation between the closure member rim and the sugar layer.

The purging liquid, i.e. hot water, is delivered to the feed conduit 40 for each nozzle from annular mains 52, 53, 54, 55, one main being provided for each set of nozzles and the mains being carried by suitable means (not shown) on hub 15 of the closure member. Each purging liquid main is, in turn, fed by respective hoses 56 passing through cover 20 outside the closed casing 72 to a supply of purging liquid (not shown).

The hereinbefore described purging system makes it possible to reduce the radial movement of air to a very small value so as not to interfere with the purging oper-
ation. In effect, since the interior chamber of the basket receiving the solid-liquid mixture is tightly closed, a low pressure is established under the closure member in this chamber, which is subdivided in the purging zone by the superposed diaphragms 33, so as to oppose the escape of air.

In contrast, the circumferential circulation of air in the annular gap between the closure member rim and the sugar layer is very active because it is completely unimpeded. This circulation is favorable because the purging liquid, i.e. water, atomized by the spray nozzles 34 is entrained into rapid rotation and adheres rapidly to the sugar layer.

The sirups filtered through screen 13 are collected in channels 50 in the basket wall at a plurality of superposed levels, each of the channels communicating with ports 75 in the basket wall to remove the separated sirups from the drying basket. A frusto-conical skirt 48 is affixed to the outer wall of basket 11 to divide the sirups into two portions, one of the sirup portions being collected in chamber 51 and the other sirup portion being collected in chamber 49 in close-casing 72, the two collecting chambers being separated by tubular wall 71 concentrically arranged about the drying basket 11.

In the manufacture of white sugar, all four mains 52, 53, 54 and 55 are fed with purging water. The nozzles receiving water from main 52 at a suitable level along the drying basket wall assure a pre-purging of the sugar deposited on the wall. In the pre-purging zone, a large part of the impurities is removed from the sugar without any appreciable remelting thereof. The superposed sets of spray nozzles fed with hot water from mains 53, 54 and 55 produce the complete purging of the sugar from impurities, which is inevitably accompanied by some melting. This can only be reduced by holding the supply of purging water to a minimum compatible with a desired degree of impurity removal.

The sirup portion collected in chamber 49 from the pre-purging zone is the so-called poor sirup while the sirup collected in chamber 51 from the purging zones proper, which is lightly colored, is the so-called rich sirup. The difference in the nature of the two sirups warrants their separation because they will be differently used in the succeeding crystallization process. Therefore, it is undesirable to permit the poor sirup to overflow from chamber 49 into collecting chamber 51 where it would be mixed with the rich sirup. For this reason, the pre-purging and purging zones are separated by one of the flexible diaphragms 33 disposed at the level of skirt 48 so that the two types of sirups are strictly separated and flow into the two separated collecting chambers.

In the manufacture of brown sugar, only the uppermost main 55 receives and delivers purging liquid so that only the uppermost set of spray nozzles 34 is in operation to provide light purging. The flow of massecuite into the drying basket will be greater than in the production of white sugar and only a single sirup will be collected.

The operation of the centrifugal drier will now be described with reference to FIG. 4, the general structure of the drier and its drive being conventional and, therefore, not illustrated or explained in detail.

A variable-speed electric motor 57 is operably connected to rotary basket 11 for rotation of the basket. The power used by the motor is measured by wattmeter 58 connected thereto. Massecuite is delivered from a suitable supply thereof into the axial bore of feed column 10 which opens into the interior chamber of basket 11, the massecuite feed being controlled by valve 59 which meters the massecuite flow under the control of governor 60 which actuates the valve so as to regulate the flow rate. The reduction motor 30 rotates threaded spindle 29 to rock control lever 24 in response to control 61 which is connected to displacement sensor 31 and controls motor 30 whereby the closure member 14 is axially displaced in a controlled manner. The flow of purging water into mains 52 to 55 is measured by flowmeter 62 and is controlled at a desired rate by valve 63 actuated by control 64. Valve 63 is mounted in water supply main 73 and solenoid valves 74 connect the hoses 56 leading to mains 52 to 55 to supply main 73, the solenoid valves being controlled by commutator or switch 76.

Outlet conduit 77 receives the sirup collected in chamber 51 and a pump 65 in the outlet conduit delivers a portion of the collected sirup through a branch conduit to a colorimeter 67 for measuring the color of the sirup. In the illustrated embodiment, cyclone separator 66 is mounted in the branch conduit to remove the emulsion from the sirup, which may introduce an error into the color measurement. The upper portion of the material is returned to the outlet conduit while the lower portion without the emulsion is directed to colorimeter 67. The colorimeter transmits a control signal to control 68, the signal corresponding to the color measurement.

A flowmeter 69 is mounted in the outlet conduit 77 to measure the flow rate of the collected sirup and transmits a control signal corresponding thereto to control 70.

The switch 76 permits the selection of the mode of operation of the drier according to whether white or brown sugar is to be produced.

The automatic control of the drier operation is effected in the following manner.

The feed valve 59 for the massecuite, which is actuated by control 60, regulates the feed or flow rate of the massecuite into the drying basket in such a manner as to maintain the power used by basket driving motor 57 equal to a set value. The control 64 actuates valve 63 so that the flow rate of the purging water is proportional to that of the massecuite, the coefficient of the proportion between massecuite and water flow being variable and different for the production of white and brown sugar.

Motor 30 operated by control 61 regulates the axial position of closure member 14 as a function of the massecuite flow rate, taking into account that the thickness of the sugar layer on the basket screen increases proportionally with the flow rate of the massecuite into the basket.

When the switch 76 is set to “white sugar”, all solenoid valves 74 are open, the control 64 receives the coefficient of proportionality for white sugar, control 70 is deactivated, and control 68 is operative. Control 68 determines the supply of power as a function of the measurements of colorimeter 67, i.e. under the influence of the control signal transmitted from the colorimeter to control 68. This color measurement permits, in effect, the control of the drying efficiency of the poor sirup. If the coloration of the rich sirup increases, this means that the drying of the poor sirup is insufficient
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and, therefore, the power supply must be reduced. On the other hand, if the coloration of the rich sirup diminishes, this means that the full drying capacity for the poor sirup has not been reached, and the power supply must be increased.

When switch 76 is set to "brown sugar", only the solenoid valve feeding the main 55 is open. Control 64 receives the coefficient of proportionality for brown sugar, control 68 is disconnected, and control 70 is operative. In this case, control 70 determines the supply of power as a function of the measured flow of the poor sirup which flows over the level of separation between the two collecting chambers. If this flow is too large, this means that the drying in the upper zone of the basket is too high and the sugar may not be completely dried before it leaves the basket. If, on the other hand, the flow is too low, the drying capacity of the drier has not been fully attained and it is necessary to increase the power supply.

In both instances, the control system adjusts the flow rates of the massecuite and of the purging water and the axial position of the closure member over the interior drying chamber in the basket to bring the power used by the drier to its assigned value.

The illustrated drier can be used for producing brown and white sugar. It may be simplified, of course, if it is used only for making one type of sugar by eliminating the alternative and additional structures selected for either type of sugar.

1 claim:

1. A centrifugal drier comprising

1. a rotary basket having a conical wall and defining an interior chamber,

2. means for feeding a solid-liquid mixture to the basket chamber,

a. the solid phase of the mixture being centrifugally deposited on the conical basket wall upon rotation of the basket and forming a layer of solid material on the wall,

b. a non-rotary closure member mounted in the basket over the interior chamber receiving the solid-liquid mixture,

a. the closure member including a frusto-conical rim extending substantially parallel to the conical basket wall and defining therewith an annular gap,

4. a flexible annular diaphragm carried by the rim at the upper end thereof for closing the upper end of the gap,

5. means for introducing a purging fluid into the gap, and

6. a control system for displacing the closure member along the axis of the basket in response to the feed rate of the solid-liquid mixture so as to maintain the flexible diaphragm in contact with the layer of solid material on the basket wall during the operation of the drier.

2. The centrifugal drier of claim 1, comprising a plurality of said flexible annular diaphragms positioned at superposed levels in planes perpendicular to the axis of rotation of the basket.

3. The centrifugal drier of claim 1, wherein the means for introducing the purging fluid into the gap comprises a plurality of fluid spray devices, respective ones of the spray devices being positioned at superposed levels, and further comprising a flexible annular diaphragm carried by the rim at a level between adjacent superposed levels of said spray devices whereby two separated purging zones are formed in the gap.

4. The centrifugal drier of claim 3, wherein the spray devices are nozzles arrayed in a respective set of nozzles at each of the superposed levels, the nozzles of each set being regularly distributed around the periphery of the rim, and further comprising an annular main connected to the nozzles of each set for delivering the purging fluid to the nozzles.

5. The centrifugal drier of claim 1, wherein the means for feeding the solid-liquid mixture to the basket chamber comprises a hollow column extending along the axis of rotation of the basket into the basket chamber, the non-rotary closure member is glidably mounted on the column for axial displacement in respect thereto, and the control system comprises a control lever linked to the closure member for controllably displacing the same.

6. The centrifugal drier of claim 1, further comprising a casing defining two collecting chambers surrounding the rotary basket and receiving liquid filtered from the interior chamber of the basket through the basket wall, the chambers being separated and one of the liquid collecting chambers being arranged to receive the liquid from an upper zone of the basket chamber and the other liquid collecting chamber being arranged to receive the liquid from a lower zone of the basket chamber, the means for introducing the purging fluid into the gap being positioned in the upper zone, means for measuring the color of the liquid received in the one liquid collecting chamber and for producing a control signal corresponding to the measured color, and means for controlling the feed rate of the solid-liquid mixture to the basket chamber in response to said control signal.

7. The centrifugal drier of claim 6, further comprising a control for maintaining the flow rates of the solid-liquid mixture fed to the basket chamber and the purging fluid at the same proportion to each other.

8. The centrifugal drier of claim 1, further comprising a casing defining two collecting chambers surrounding the rotary basket and receiving liquid filtered from the interior chamber of the basket through the basket wall, the chambers being separated and one of the liquid collecting chambers being arranged to receive the liquid from an upper zone of the basket chambers and the other liquid collecting chamber being arranged to receive the liquid from a lower zone of the basket chamber, the means for introducing the purging fluid into the gap being positioned in the upper zone, means for measuring the flow rate of the liquid received in the one liquid collecting chamber and for producing a control signal corresponding to the measured flow rate, and means for controlling the feed rate of the solid-liquid mixture to the basket chamber in response to the control signal.

9. The centrifugal drier of claim 8, further comprising a control for maintaining the flow rates of the solid-liquid mixture fed to the basket chamber and the purging fluid at the same proportion to each other.

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