APPARATUS FOR DENSIFYING BULKY POWDERS

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3,034,421

APARATUS FOR DENSIFYING BULKY POWDERS

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Filed Nov. 24, 1959, Ser. No. 855,123

8 Claims. (Cl. 190—43)

The present invention relates to the densifying of bulky, finely divided materials and, more particularly, to apparatus for converting a bulky, finely divided material of varying, low apparent density into a product of uniform, controlled higher density.

A major difficulty encountered in the packaging of bulky, finely divided materials into containers, such as bags, is the resistance of such material to the packaging procedures due to its fluffy aerated nature. It will be understood that the term 'gas' as used in the description refers to the presence of any absorbed gases upon the minute particles of the material and also to the presence of those gases that may be termed merely interstitial. Packing rates of these bulky materials in terms of the weight unit of the product per unit of time with the present conventional methods tend to be low, making packing costs consequently high. Furthermore, apparent densities of these materials tend to vary, causing process upset and lack of finished product uniformity.

One object of this invention is to produce apparatus capable of converting a bulky, finely divided material of varying, low apparent density into a product of uniform, controlled higher density.

The nature of the present invention may be stated in general terms as relating to an apparatus for densifying a bulky, finely divided material comprising a cylindrical passage having an inlet and an outlet, a first conveyor for transferring the material along the passage toward the outlet, a second conveyor between the output end of the first conveyor and the outlet of the passage for conveying the material to the outlet of the passage, separate motor means for effecting movement of the first and second conveyors, variable speed control means for one of the motor means, means for sensing the power consumption by the other of the motor means, and means responsive to the sensing means connected to the variable speed control means whereby the speed of one of the motor means and its associated conveyor is proportional to the power consumed by the other of the motor means and its associated conveyor.

Now referring to the drawings in which like reference numerals denote similar parts throughout the several views:

FIG. 1 is a fragmentary sectional view of one form of the apparatus of the invention with a diagrammatic illustration of the energizing system;

FIG. 2 is a sectional view of the cutter conveyor illustrated in FIG. 1 taken along line 2—2;

FIG. 3 is a fragmentary sectional view of the cutter conveyor taken along line 3—3 of FIG. 2;

FIG. 4 is a fragmentary sectional view of a modification of the conveyor showing means for expelling gases from the material being treated;

FIG. 5 is a sectional view of the conveyor illustrated in FIG. 4 taken along line 5—5;

FIG. 6 is a fragmentary sectional view of another modification of the apparatus wherein the gases from the material being treated are removed at the inlet end thereof;

FIG. 7 is a fragmentary sectional view of still another modification of the apparatus wherein the gases from the material being treated are removed in the region of the outlet end thereof; and

FIG. 8 is an enlarged fragmentary sectional view of the modification illustrated in FIG. 7 taken along line 8—8 thereof.

Referring to FIG. 1, there is shown a generally elongate cylindrical housing 10 having an inlet opening 12 at one end of the housing and an outlet 14 at the other end thereof. A conveyor screw 16 carried by a hollow shaft 18 is rotatably mounted within the housing 10. The end of the conveyor screw 16 is connected to one end of a shaft 18 which extends through the end wall of the housing 10 and is journaled within a bearing assembly 20 secured to the outer end wall of the housing 10. The opposite end of the shaft 18 is provided with a sprocket wheel 22 which is keyed or otherwise suitably secured thereto.

The outlet end of the conveyor screw 16 is connected to one end of a shaft 24, the other end of which is journaled within a bearing assembly 26 secured to the inner wall of the housing 10.

At the outlet end of the housing 10, there is a second conveyor or cutting screw 28 mounted for rotation therein on a shaft 30. The shaft 30 is journaled within spaced bearing assemblies 32 and 34 located outside the outlet end of the housing 10. The inwardly extending end of the shaft 30 is provided with a pressure plate 36 having a V-shaped notched edge which is adapted to carry a cutter blade 40. The pressure plate 36 and the cutter blade 40 are clearly illustrated in FIGS. 2 and 3 and the function thereof will be described in greater detail hereinafter.

A sprocket wheel 42 is keyed or otherwise suitably secured to the shaft 30 between the bearing assemblies 32 and 34.

In order to drive the conveyor screw 16, there is provided a constant speed electric drive motor 46 having a sprocket wheel 48 keyed to the armature shaft thereof. A chain 50 is employed to couple the rotary movement of the sprocket wheel 48 of the electric motor 46 to the sprocket wheel 22 of the conveyor screw 16 and to thereby impart rotational movement to the conveyor.

The electric motor 46 is coupled to a source of energizing potential through three power leads 52.

Drive for the cutter or conveyor screw 28 is provided by a variable speed electric drive motor 54 which is coupled to a source of energizing potential through a power lead 56. The motor 54 is provided with a sprocket wheel 58 keyed to the armature shaft thereof, and a chain 57 is employed to couple the rotary movement of the sprocket wheel 55 to the sprocket wheel 42 of the cutter screw 28.

The motor assembly 54 may typically be of the type manufactured and sold by The Cleveland Worm and Gear Company and identified as a Cleveland Variator size 6K.6 rated 3 H.P. at 870 r.p.m. This assembly is equipped with 115 volt single phase pilot motor. The motor assembly 54 is a simple drive that provides infinitely variable output speed over a range up to typically 6:1 from a constant speed power source.

To achieve the desired objectives of the invention, that is, to control the speed of the drive motor 54 in relation to the power consumed by the constant speed motor 46, there is provided an interconnecting circuit arrangement 58. The circuit arrangement 58 is effective to receive reduced alternating current from power leads 52, to rectify the current and supply a D.C. voltage output. The circuit arrangement comprises a current transformer 60 which is connected across a suitable full-wave rectifier 62 through leads 64 and 66 which are suitably fused. The rectified output of the rectifier 62 is fed through filter network comprised of resistors 68, 70 and a condenser 72. The rectified filtered output of the circuit is sensed across a potentiometer 74. A control device 76 for regulating the speed or r.p.m. of the variable
speed drive motor 54 is connected to the circuit arrangement 58 through leads 78 and 80. The output of the control device 76 is connected to the variable speed drive motor 54 through a lead 82. The control device 76 may typically be an indicating recorder-controller of the type manufactured and sold by the Leeds & Northrup Company and identified as Leeds & Northrup Model 2-30-12-045-6-25-3 Speedomax Type H, Model R measuring circuit D.C. potentiometer single point indicating-recording controller and is effective to energize suitable means in the motor assembly 54 to vary the speed thereof in proportion to an electrical signal received from the control device 76.

In general terms the apparatus thus far described functions in such a manner that the speed with which the cutter conveyor screw 28 is driven is in direct proportion to power consumed by the suitable threaded fastener which drives the conveyor screw 16. More specifically, the conveyor screw 16 is caused to rotate upon the energization of the constant speed motor 46, the speed of which is adjusted to the desired level determined by the production demand placed upon the equipment from the standpoint of the density of the final product and the rate of product output. Therefore, the speed of the conveyor screw 16 is maintained constant irrespective of the load imposed on it by the material fed into the inlet opening 12 of the housing 10. As the conveyor screw 16 is rotated, the material is fed toward the outlet end of the housing 10 and enters a "dead space" area indicated D and defined by the outlet end of the conveyor screw 16 and the inlet end of the conveyor screw 28. The material being treated tends to pack up against the pressure plate 36 of the cutter screw 28 which provides a resistance to material flow, thereby effecting the densification of the process material. Manifestly, the densification occurs within the "dead space" D. The cutter blade 40 which is affixed to the pressure plate 36 partially covers the product exit slot 38 formed in the pressure plate 36 and may be set to any desired degree of coverage by a suitable threaded fastener much like. It will be appreciated that as the cutter screw 28 and its associated pressure plate 36 are revolved, the cutter blade 40 removes the densified product formed within the "dead space" D. The extent of the cutter blade protrusion into the dead space area and the size of the opening of the product exit slot behind the cutter blades determine the "bite," or amount of densified product removed by the cutter, in one revolution thereof. The setting of the cutter blade 40 over the product exit slot 38 is determined by the initial density of the process material; the rate of material of the same being densified desired. The best density control is considered to be achieved with the smallest cutter blade which will accordingly readily enable the r.p.m. of the cutter conveyor 25 to increase and decrease over a narrow mildscale range.

To facilitate the description of the automatic operation of the system and interrelationship between the conveyor screw 16 and the cutter screw 28, it is convenient to refer to a "null point" in the cutter screw operation. The "null point": is the equilibrium condition of the process and is determined by the amount of power consumed by the constant speed drive motor 46 that is necessary to prevent a change in the r.p.m. of the cutter conveyor when the cutter conveyor r.p.m. is between arbitrary high and low limits.

Initially, the drive motor 46 is energized to drive the conveyor screw 16; the drive motor 54 is energized to drive the cutter screw 28; and the control device 76 is adjusted to maintain a desired output level to in turn maintain a fixed output speed of the drive motor 54. Now, we will assume that an increased load is imposed on the conveyor screw 16 which therefore calls for more power consumption by the motor 46. The change in power consumed by the motor 46 is sensed by the current transformer 60. The alternating current induced in the transformer 60 is rectified by the rectifier 52, the rectified current is filtered by the filter arrangement of resistors 68, 70, and the condenser 72. The resultant D.C. voltage is sensed by the potentiometer 74 and fed to the control device 76 through the leads 78 and 80. The change in voltage fed to the control device 76 causes change in the output to the variable speed mechanism of the drive motor assembly 54 through lead 82 which effects an increase in the speed of rotation of the cutter screw 28. As the speed of rotation of the cutter screw 28 increases, more of the densified product is removed from the dead space D and is discharged through the outlet 14 thereby resulting in a decrease in the power necessary to drive the constant speed drive motor 46 at the desired speed. This decrease in the power is sensed by the current transformer 60 and in a manner similar to that described hereinabove, reduces the speed of the cutter screw 28 until the predetermined "null point" of the system is reached. Upon reaching the "null point" the motor assembly 54 will drive the cutter screw 28 at a relatively slower speed than the conveyer screw 16 to thereby effect the desired densification of the process material. This condition of operation will continue indefinitely until the power consumed by the motor assembly 46 varies above or below the predetermined "null point" at which time the motor assembly 56 will be called upon to respectively increase or decrease the speed of the cutter screw 28.

In FIGS. 4, 5 and 6 there are illustrated various modifications of the apparatus illustrated in FIGS. 1-3 wherein means are provided to aid in the removal of adsorbed and interstitial gases from the process material in order to further aid in the densification of the material. It has been found that in the treatment of bulky, finely divided materials such as zinc oxide that there is a presence of adsorbed gases upon the minute particles of the material and also interstitial gases contained within the cavities between the individual particles. Manifestly, to obtain the desired densification of the material, the removal of the adsorbed and interstitial gases therefrom is necessary. While the apparatus illustrated in FIGS. 1-3 is effective to remove the major portion of these gases, the modifications shown in FIGS. 4, 5 and 6 may achieve a greater degree of gas exhaustion.

More specifically, the apparatus shown in FIGS. 4, 5 and 6 is similar to the apparatus of FIG. 1 except a hollow shaft 15' is provided with a plurality of radial openings 90. Each of the openings 90 is provided with a hood arrangement 92 being open at the trailing edge when considering the rotation of the associated conveyor 16' to thereby mitigate against the entrance of the process material into the hollow shaft 15'. The inlet end of the hollow shaft 15' of the conveyor screw 16' is carried for rotation on the shaft 18' in the same manner as is shown in FIG. 1. The shaft 18' differs in that it is provided with a longitudinal bore 95 which is in communication with the hollow shaft 15'. The outer end of the shaft 18' is connected to a vacuum fitting 96 which in turn is connected to a suitable vacuum pump through a line 98. It will be appreciated in operation that as the material being treated becomes compressed or densified the adsorbed and interstitial gases may be readily removed through the openings 90, the hollow shaft 15', and the control bore 94 of the shaft 18'. FIG. 6 shows another modification for aiding in the removal of adsorbed and interstitial gases from the material being treated wherein the vacuum line 98 is equipped with an inverted frusto-conical chamber 100 having a vacuum line 102 leading to a pump or other suitable means for withdrawing gases from the material being treated. The upper end of the chamber 100 is provided with an inlet hopper 104 for containing the supply of material to be treated. The material leaves the hopper 124 and enters the chamber 100 prior
to entering the inlet 12 of the housing 10'. Gases in the material being treated are in a large degree removed through the vacuum line 102 thereby greatly facilitating the densification process.

Still another modified form of gas removal apparatus of the invention is illustrated in FIGS. 7 and 8. The gas removal apparatus of this form is disposed in the region of the outlet 14" of the housing 10' and comprises a chamber 110 suitably secured to the outer surface of the housing 10" over a housing opening 112. A shield element 114 is secured to the inner surface of the housing 10" and opens toward the outlet end of the housing. A vacuum line 116 is connected to the top of the chamber 110 and provides for communication between the chamber and a source of vacuum.

To mitigate against the slot 112 and its associated shield 114 from becoming plugged or blocked by the deposition or build-up of the material being processed, there is provided an oscillating arm 118 having a pin 120 pivotally mounted in the chamber 110. An arm 122 is connected at one end thereof to the extended end of the pin 120 and the other end of the arm is pivotally coupled to a linkage 124. The opposite end of the linkage 124 is eccentrically pivotally mounted on a rotary wheel 126. As the wheel 126 rotates oscillatory movement is imparted to the extended end of the arm 118. The oscillatory movement of the arm 118 causes the removal of any material which does collect in the slot 112 and the shield 114 and thereby maintains proper communication between the inner portion of the housing 10" and the vacuum line 116.

From the foregoing description, it will be seen that new improved apparatus for converting a bulky, finely divided material of varying low apparent density into a product of uniform, controlled higher density, has been produced thereby resulting in a uniform product density and the attained high product density.

Although in the preferred embodiment of the invention there is a pressure plate assembly 36 provided with a cutter member 40, in certain applications it may be desired to use the machine without the pressure plate and associated cutter 40. In such an embodiment, the relative difference in the speed of revolution between the conveyor screw 16 and the cutter screw 28 is effective to achieve the desired density and also the cutter screw 28 only may be effective to discharge the densified product through the outlet 14. In such an arrangement for the best results the dead space between the outlet end of the deaserator or conveyor screw 16 and the inlet end of the cutter and conveyor screw 28 would be somewhat longer than in the instance where a pressure plate assembly were employed.

As will be apparent to those skilled in the art, satisfactory densification of the process material may be achieved with certain modifications of the apparatus such as a reversal of the manner in which the conveyors 16 and 28 are coupled to the drive motor means. For example, the variable speed drive motor means 54 could be coupled to the conveyor and deaserator screw 16 and the constant speed drive motor means 46 could be coupled to the cutter and conveyor screw 28. In such an arrangement, the power consumed by the motor means driving the cutter and conveyor screw 28 will be sensed and, in turn, will control the speed of the motor means driving the conveyor and deaserator screw 16.

According to the provisions of the patent statutes, I have explained the principle and mode of operation of my invention and have illustrated and described what I now consider to represent its best embodiments. How-

ever, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. Apparatus for treating a bulky, finely divided material comprising a cylindrical passage having an inlet and an outlet, a first screw conveyor for transferring the material along said passage toward the outlet, a second screw conveyor between said first conveyor and the outlet of said passage for conveying the material to the outlet of said passage, a pressure plate assembly having at least one slot formed therein disposed on the end of said second conveyor adjacent said first conveyor, constant speed electric motor means for effecting movement of said first conveyor, variable speed electric motor means for effecting movement of said second conveyor, and means for continuously sampling the electrical power consumption of said constant speed motor means, said means being effective to vary the speed of said variable electric motor to thereby effect densification of the material between the inlet and the outlet of said cylindrical passage.

2. Apparatus as defined in claim 1 wherein said pressure plate is provided with a cutter element attached thereto adjacent the slot and effectively controls the material passing through the slot.

3. Apparatus as defined in claim 1 wherein said first conveyor screw is carried by an apertured hollow shaft co-extensive with said screw, and a vacuum producing means is connected to one end of said hollow shaft.

4. Apparatus as defined in claim 3 wherein a plurality of hood-like members are carried by said shaft and positioned over the apertures therein.

5. Apparatus as defined in claim 1 wherein the inlet of said housing is provided with an outwardly extending chamber having means for communication with a source of vacuum.

6. Apparatus as defined in claim 1 wherein means are provided between the outlet end of said first conveyor and the inlet end of said second conveyor to create a vacuum within said housing.

7. Apparatus as defined in claim 6 wherein said means includes a chamber mounted on the outer surface of said housing, said chamber having communication with a source of vacuum and with the interior of said housing.

8. Apparatus as defined in claim 7 wherein said chamber is provided with agitating means for maintaining the communication of said chamber with the interior of the housing.

References Cited in the file of this patent

UNITED STATES PATENTS

859,506 Morton ----------------- July 9, 1907
1,334,492 Hindshaw ----------------- Mar. 23, 1920
1,792,216 Fahnstock --------------- Feb. 10, 1931
1,990,632 Bowling ----------------- Feb. 12, 1935
1,999,241 Kiergard ---------------- Apr. 30, 1935
2,078,565 Durst et al. -------------- Apr. 27, 1937
2,178,714 Anderson --------------- Nov. 7, 1939
2,280,880 Anderson --------------- Apr. 28, 1942
2,340,009 Meakin ---------------- Jan. 25, 1944
2,547,336 McDaniel et al. ------ Apr. 3, 1951
2,556,391 Hawk -------------------- June 12, 1951
2,714,490 Prechter ----------------- Aug. 2, 1955

FOREIGN PATENTS

568,094 Great Britain ------------ Mar. 19, 1945
739,509 Great Britain ------------ Nov. 2, 1955