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METHOD

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ABSTRACT

Apparatus and method for handling particulate materials by causing the same to move along a generally continuous path by the action of vibratory motion of the body containing the materials. The body is mounted for oscillatory movement about an axis spaced from the path. The apparatus can be used as a materials dryer for directing hot gases across the path of travel of the materials and through the same to dry the materials as the body vibrates. The apparatus can be used as a materials grinder for placing discrete grinding elements in the body for movement relative to the materials to reduce the latter to a predetermined particle size as a function of the vibration of the body.

9 Claims, 8 Drawing Figures
MATERIALS HANDLING APPARATUS AND METHOD

This invention relates to improvements in the handling of particulate materials, and more particularly, to apparatus and a method for moving materials along a predetermined path as a function of the vibration of the container holding the materials.

The present invention is directed to apparatus and a method for moving a mass of particulate materials along a generally continuous path in a manner which permits the materials to be processed as they are being moved. In one embodiment of the invention, the materials can be dried as the same traverse the continuous path. This is accomplished by directing hot gases across the path and through the materials to eliminate the moisture therein. Following the drying operation, the materials can be collected and either stored or further processed.

In another embodiment of the invention, the particulate materials can be ground until the particles thereof are of a predetermined size so that they will be capable of passing through an opening which allows the materials to be directed to a collection region. This is accomplished by the use of discrete grinding elements which move relation to the materials and reduce the size of the particles thereof by the grinding action on materials between adjacent elements. This grinding action can be carried out continuously until substantially all the particles are reduced to a particular particle size.

The materials handling capabilities of the present invention are realized by providing a body for holding such materials and vibrating the body at a frequency and at an amplitude sufficient to cause the materials to physically move along a generally continuous path. This path is preferably in a vertical plane so that the materials will progressively move past a given region as the body oscillates or vibrates about a generally horizontal axis. Thus, by moving the materials over the path, the materials can be processed, such as by the use of gases to dry the materials or by the use of metal, ball-like grinding elements for grinding the materials, either of which is accomplished as the body vibrates. Other process steps can be performed on the materials as they move along the continuous path in the body.

The primary object of this invention is, therefore, to provide materials handling apparatus and method wherein a mass of particulate materials are moved along a generally continuous path by vibrating the container for the materials so that the materials can be further processed as they are being moved and the processing step or steps can be carried out substantially automatically without operator attention.

Another object of this invention is to provide an apparatus and method for drying particulate materials wherein hot gases are directed through the materials as the same move about a continuous path due to the vibration of the container which holds the materials so that the materials are progressively dried automatically and one mass of dried materials can be collected at a region remote from the drying area as another mass of materials yet to be dried can continue to be subjected to the hot gases.

Another object of this invention is to provide apparatus and a method for grinding particulate materials by moving the materials along a continuous path between a number of grinding elements which are set into motion by the vibration of the container holding the elements and the materials so that the elements grind the materials therebetween and thereby reduce the particle size of the same sufficiently to allow the materials to pass through a separator and be collected in a region spaced from the grinding region.

Other objects of this invention will become apparent as the following specification progresses, reference being had to the accompanying drawings for illustrations of several embodiments of the invention.

In the drawings:

FIG. 1 is a perspective view of one embodiment of the materials handling apparatus of this invention, showing its use as a dryer;

FIG. 2 is a cross-sectional view of the apparatus of FIG. 1;

FIG. 3 is an exploded, perspective view of a particular heating system for the apparatus of FIG. 1;

FIG. 4 is a view similar to FIG. 2, but showing the heating system of FIG. 3 with the apparatus of FIG. 1;

FIG. 5 is a view similar to FIG. 1, but showing a second embodiment of the apparatus when used as a dryer;

FIG. 6 is a cross-sectional view of a third embodiment of the apparatus, showing its use as a grinding means;

FIG. 6a is an enlarged fragmentary view of a portion of the interior of a dryer, showing a plurality of metal balls in the particulate material to be dried thereby; and

FIG. 7 is an exploded, perspective view of another type of heating system for use with the apparatus of FIGS. 1 and 5.

The first embodiment of the materials handling apparatus of this invention is denoted by the numeral 10 and is illustrated in FIGS. 1 and 2. Apparatus 10 is adapted for use as a dryer for particulate materials and includes an open top, trough-like body 12 formed by a pair of side walls 14 and 16, a bottom wall 18, and a pair of opposed end walls 20 and 22. Bottom wall 18 is curved and is integral with side walls 14 and 16 as shown in FIG. 2. End wall 20 has an opening 24 therethrough which communicates with a pipe 26, the latter extending outwardly from end wall 20 and adapted to be coupled to a source of hot air (not shown). A perforated, metal tube 28 within body 12 also communicates with opening 24 and extends between end walls 20 and 22 as shown in FIG. 1. Tube 28 is spaced above bottom 18 and inwardly from side walls 14 and 16 and defines a generally continuous materials passage or path along which materials to be dried can move as body 12 is vibrated in a manner to be described.

Body 12 is pivotally mounted by a pair of axially aligned pins 30 and 32 on the upper ends of a pair of upright members 34 and 36, respectively, members 34 and 36 forming parts of a support 38 which is positioned on a suitable supporting surface or floor. Side wall 16 has two sets of spaced, laterally extending ears 40 for connection with respective pins 30 and 32.

The portion of body 12 remote from ears 40 has a number of blocks 42 which rest on soft rubber mounts 44, the latter being disposed on the flat, upper surface 46 of a platform 48 extending laterally from upright members 34 and 36 and forming a part of support 38. Soft rubber pads 50 are used to support platform 48 on
a surface therebelow, such as the floor of a building in which drying operations are to be carried out.

Each block 42 has a bearing 52 thereon for rotatably mounting a shaft 54 extending through the bearings. The shaft has a pulley 56 thereon to which is coupled an endless, flexible belt 58, the belt being coupled by a second pulley 60 to the drive shaft 62 of a variable speed motor 64 supported on an extension 66 projecting laterally from platform 48. A pair of weights 68 are eccentrically mounted on shaft 64 to impart oscillation of body 12 about the axis through pins 30 and 32 when shaft 54 rotates under the influence of motor 64. The resilient character of mounts 44 permits this vibration since the mounts can expand and be compressed alternately at the frequency of vibration of the body.

Apparatus 10 is adapted to dry particulate materials such as grains, ores, minerals and the like. Materials to be dried are placed in a hopper 70 and fed by an auger 72 through a tube 74 into body 12 through the open top thereof. Auger 72 may be provided with a pulley 76 at its outer end, whereby the auger can be driven by a motor at a controlled speed thereby meter the rate at which the materials are directed into body 12.

Body 12 is provided with a materials exit in the form of a tube 78 connected with an outlet opening 80 in end wall 22. Materials directed toward opening 80 will pass through the same, through tube 78, out of the latter and into a suitable container (not shown). A pair of vanes 82 are secured to the inner surface of side wall 16, and are inclined toward opening 24 to cause advancement of a portion of the materials in body 12 toward opening 80 as the materials move about tube 28 due to the vibration of body 12.

In operation, materials to be dried are directed into body 12 through the open top thereof. The materials will generally be of a volume such that the upper level of the materials will be above tube 28. Thus, the materials can move along the path extending about tube 28 in response to the vibration of body 12. After the materials have been directed into body 12, motor 64 is energized to cause rotation of shaft 54 and thereby rotation of weights 68. The speed of rotation of the shaft will be progressively increased until the materials in body 12 commence to move along the path surrounding tube 28. For purposes of illustration, materials movement will occur at a rotational speed of shaft 54 of 1,600 to 2,000 rpm. Such movement is caused by the vibration of the materials in the vicinity of side wall 14 and the junction of this side wall with bottom 18. The materials vibration is most pronounced in this region as distinguished from the region near side wall 16 because the latter region is much closer to the axis of vibration. The effect of the vibration is to cause a net upward movement of the materials between side wall 14 and tube 28. This, in turn, tends to cause spaces or voids to be formed above bottom 18, and these spaces are immediately filled with materials which gravitate toward bottom 18 from the region between side wall 18 and tube 28. The result of these materials movements is to cause the materials in body 12 to circulate along the aforesaid path in the direction of arrows 83 (FIG. 2).

As the materials move about tube 28, heated air is directed into tube 28 from the hot air source connected to pipe 26. The heated air passes upwardly through the tube and across the aforesaid path and into and through the materials passing along the path. The air then moves out of body 12 through the open top thereof. Vanes 82 operate to advance the portions of the materials adjacent thereto toward end wall 22; thus, there is a slow drift of the materials toward end wall 22 so that the dried materials eventually move to opening 80 and pass through the same out of body 12. The dried materials than can be collected in a suitable container and carried to a storage location or to another region for further processing.

In the alternative, tube 28 can itself be heated by steam coils or heated liquid therein to provide a heat source for drying the materials as the latter move about the tube. Also, the drive shaft of motor 64 can be connected axially to shaft 56 to eliminate the need for the belt and pulley drive assembly.

FIG. 3 illustrates a heating system for use with apparatus 10. It includes a tapered, generally imperforate conduit 84 disposed within perforated tube 28 and provided with a number of longitudinally aligned slits 86 therein which are disposed directly beneath the uppermost margin of pipe 28. A burner 88 is carried by pipe 26 adjacent to one end thereof and has a blower for directing heated gases emanating from the burner into conduit 84, whereby the heated gases can pass upwardly through slits 86 and tube 28 and transversely of the path of the materials in body 12.

A second blower 92 at the opposite end of tube 28 is carried by a pipe 94 and is adapted to direct either cold or hot air into the open, opposite end 96 of conduit 84. Pipe 94 will project outwardly from an opening formed in end wall 22, such opening communicating with the proximal end of tube 28. FIG. 4 illustrates the conduit 84 with tube 28.

In FIG. 5, a second embodiment of the invention as a materials dryer is illustrated, the embodiment comprising dryer apparatus 110 having a generally cylindrical body 112 which is closed at the top and provided with a cylindrical, generally continuous wall, spanning the distance between a pair of end walls 120, only one of which is shown. Body 112 is mounted in substantially the same way as body 12 of FIG. 1 and is adapted to be vibrated in the manner described above with respect to body 12. To this end, body 112 is mounted on a support including a platform 148 having a pair of spaced, upstanding members 136 to the upper ends of which body 112 is pivotally secured by a pair of axially aligned pins 130 for rotation about the common axis through the pins, only one of the pins being shown in FIG. 5. A pair of spaced ears 140 is provided on body 112 for mounting the same to each pin 130, respectively.

Body 112 has a number of blocks 142 supported on soft rubber mounts 144, the latter resting on the flat, upper surface 146 of platform 148. Each block 142 carries a bearing 152 which rotatably mounts a shaft 154 to which is coupled a pulley 156. An endless flexible belt 158 connects pulley 156 to a second pulley 160 on the drive shaft 162 of a drive motor 164 supported on an extension 166 of platform 148. Eccentrically mounted weights 168 are carried by shaft 154 and cause the latter body 112 to vibrate or oscillate about pins 130 when motor 164 is energized.

Apparatus 110 is adapted to be used with materials having fines associated therewith, such as certain types of minerals and ores. A cyclone separator 167 is coupled by a conduit 169 to the interior of body 112 to collect the fines and to separate them from the air which draws the fines out of body 112.
To feed materials into body 112, an auger 172 is provided, the auger being housed in a tube 174 communicating with the open bottom of a hopper 170. The materials passing through tube 174 are discharged into a second tube 175 having an auger 178 therein. The second auger also extends into and through body 112 and serves to advance portions of the materials in the body toward exit tube 177 extending outwardly from the opposite end wall of the body. Tube 177 has a discharge pipe 179 through which materials can gravitate, auger 178 extending through 177 also.

For purposes of illustration, a burner 180 is provided in pipe 182 in communication with an opening (not shown) in end wall 120 nearest the materials inlet of body 112. A blower 184 associated with burner 180 in pipe 182 forces hot gases generated by burner 180 into a perforated tube 128 within body 112. Tube 128 can be provided with a tapered conduit of the type shown in FIG. 3, whereupon the heated gases will flow upwardly through tube 128 in several directions.

In operation, materials are directed into body 112 and, as soon as a volume sufficient to center tube 128 has been received in the body, motor 164 is energized. The speed of rotation of shaft 156 is increased until the materials in body 112 commence to move along the path about tube 128. This movement is caused by the net upward travel of materials near the region of maximum amplitude of body 112 and the gravitation of materials near the region of minimum amplitude of the body.

Simultaneously with the movements of the materials about tube 128 in clockwise sense (FIG. 5), heated air will be directed into and through tube 128. This heated air will pass upwardly through the tube and into conduit 169 so as to dry the materials which circulate over the top of tube 128. Separator 167 can be operating at the same time as the materials are moving in the body, whereupon fines drawn by suction into separator 167 can be collected in any suitable manner at its lower end.

Auger 178 operates to cause advancement of adjacent portions of the materials toward tube 177. The materials entering this tube eventually move into register with discharge pipe 179 for gravitation therefrom. The discharge materials are then collected in a suitable container for storage or for further processing.

A secondary blower (not shown) can be housed in a pipe 190 at the opposite end of body 112 from burner 180. This blower can be used to direct additional heated air or cold air into the body.

Another heating system suitable for use with apparatus 10 or apparatus 110 includes a tapered conduit 200 (FIG. 7) provided with an elongated slit 202 extending the length thereof. A fuel manifold 204 extends into and through conduit 200 near the uppermost extremity of the tube 28 or 128, manifold 204 has fuel outlet openings 206 in alignment with slit 202. Fuel enters pipe 204 from a suitable source (not shown) and the fuel is ignited at the outlet openings 206, whereby the combustion gases pass upwardly through slit 202 and through the moving materials thereabove. A boiler 208 in a tube 210 connected to one end of conduit 200 can be used to direct cooling air into the conduit and force the air upwardly through slit 202.

FIG. 6 illustrates the use of the invention as a means for grinding particulate materials to comminute the same and thereby reduce the particle size thereof. Chemicals in the form of powders are suitable for use with apparatus 210. Talc is a typical chemical to be comminuted in this manner. The grinding action is accomplished by a plurality of discrete grinding elements in the form of metal balls which, due to the vibration of the apparatus, move independently of each other and grind particulate materials between adjacent balls. The materials are eventually reduced to a particle size sufficient to permit the materials to pass through a screen or other type of separator for movement to a collection region.

The materials gravitating through opening 229 can be collected in any suitable manner in tube 228. For purposes of illustration, a trough 233 is spaced below and aligned with opening 229, trough 233 being secured by braces 235 to the interior of tube 228. An auger 237 in trough 233 carries the particulate materials received therein toward an exit at one end of tube 228 for discharge from apparatus 210.

In operation, motor 264 is energized after a mass of particulate materials has been directed into body 212 and into the spaces between the various balls 230. A suitable feed means, such as the type shown in FIG. 6, can be used to direct the materials into body 212. As shaft 256 rotates, weights 268 cause body 212 to vibrate about pins 231 and the drive shaft of motor 264 is progressively increased in speed until balls 230 commence to move in the direction of arrow 265 about tube 228. As the balls move, they shift relative to each other and thereby grind the particulate materials therebetween to reduce the particle size of the materials until the materials can gravitate through opening 229.

The particulate materials also move in the direction of arrow 265 relative to the balls to further add to the grinding action thereof.

The materials gravitate into trough 233 and are carried laterally through the same by auger 237. The materials are collected in a suitable receptacle communicating with the trough adjacent to one end wall of apparatus 210. The grinding action of the balls can continue until substantially all of the particulate materials have been reduced to the desired particle size.

To illustrate this use, the invention is in the form of grinding apparatus 210 having a construction similar to apparatus 110 except for the cyclone separator and its connecting pipe. A hollow, cylindrical body 212 has an imperforate, generally horizontal, central tube 228 provided with an opening 229 in the top thereof through which particulate materials of a predetermined particle size or less can pass into the tube. A screen can be placed across the opening to assure that only particles having a particular particle size pass into the tube. Thus, particles having a size greater than the size allowed to pass through the opening will remain in body 212 outside of tube 228.

The space between body 212 and tube 228 is substantially filled with a plurality of discrete metal balls 230 between which the particulate materials, denoted by the numeral 232 in FIG. 6a, is disposed. The balls remain in this space and are sufficiently large so that they cannot gravitate through opening 229 into tube 228.

Body 212 is vibrated about a generally horizontal axis by a motor 264 coupled by a belt and pulley assembly to a shaft 256 journaled by a number of bearings 252 on respective blocks 242 carried by one side of body
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7

212. A number of eccentrically mounted weights 268 (only one of which is shown) are carried on and rotate with shaft 256 to cause body 212 to vibrate or oscillate about pin means 231 which connects a number of ears 240 on the opposite side of body 212 to a pair of uprights 236 of a platform 248. Soft rubber mounts 244 support blocks 242 on the flat, upper surface 246 of platform 248.

1. Apparatus for drying particulate materials comprising: a generally hollow body having a perforated, horizontal tube therein for defining a materials path disposed in generally surrounding relationship to and extending along said tube; means mounting the body for vibration about a generally horizontal axis extending longitudinally of said path and being exterior thereto; means coupled with the body for vibrating the same about said axis at a frequency sufficient to cause a mass of particulate materials within the body to move along said path and about said tube; and means coupled to the tube for directing hot gases therethrough and outwardly thereof across said path to dry the materials flowing along the same.

2. Apparatus as set forth in claim 1, wherein said body has an open top and is provided with means for directing materials thereinto through the open top.

3. Apparatus as set forth in claim 1, wherein said body has a closed top spaced above the tube, and including means coupled with said body for feeding a mass of particulate materials thereinto, a cyclone separator, and means placing the separator in communication with the body at the upper margin thereof.

4. Apparatus as set forth in claim 1, wherein said vibrating means comprises a shaft rotatably mounted on said body and extending longitudinally of said axis, a weight eccentrically mounted on said shaft and rotatable therewith, and means coupled with the shaft for rotating the same at any one of a number of different speeds.

5. Apparatus as set forth in claim 1, wherein said mounting means comprises a platform having a pair of spaced uprights, and pin means pivotally coupling the body to the uprights, and pin means pivotally coupling the body to the uprights, there being a pair of resilient mounts supporting the body on the platform at respective locations spaced from said pin means.

6. Apparatus for handling particulate materials comprising: a generally hollow body adapted to receive a mass of particulate materials to be handled; a perforated tube within the body and spaced inwardly therefrom, the space between the body and the tube presenting at least a portion of a substantially continuous materials path; a tapered conduit within said tube, said conduit having a number of longitudinally aligned slits adjacent to one extremity thereof; a source of hot gases adjacent to one end of the conduit; blower means coupled to the conduit for forcing hot gases thereinto, whereby the gases will flow through said conduit and said tube and across said path for drying materials moving along said path; means mounting the body for vibration about an axis spaced from the path; and means coupled with the body for vibrating the same at a frequency sufficient to cause the materials in the body to move relative to the same along said path.

7. Apparatus for handling particulate materials comprising: a generally hollow body adapted to receive a mass of particulate materials to be handled; a perforated tube within the body and spaced inwardly therefrom, the space between the body and the tube presenting at least a portion of a substantially continuous materials path surrounding the tube; means coupled with the tube for directing hot gases thereinto for flow thereupon and out of the same across said path for drying materials moving along said path; means mounting the body for vibration about an axis spaced from and exteriorly of the path and extending longitudinally of said tube; and means coupled with the body for vibrating the same at a frequency sufficient to cause the materials in the body to move relative to the same along said path.

8. Apparatus for drying particulate materials comprising: a generally hollow body member having a perforated, horizontal tube member therein and spaced therefrom for defining a materials path extending longitudinally of and surrounding said tube; means mounting the body member for vibration about a generally horizontal axis extending longitudinally and exteriorly of said path; means coupled with the body member for vibrating the same about said axis at a frequency sufficient to cause a mass of particulate materials within the body member to move along said path in a predetermined direction; and means coupled with one of said members for drying the materials flowing along said path.

9. Apparatus for handling particulate materials comprising: a generally hollow body adapted to receive a mass of particulate materials to be handled; a perforated tube within the body and spaced inwardly therefrom, the space between the body and the tube presenting at least a portion of a substantially continuous materials path surrounding the tube; a tapered conduit coupled with the tube and having a fuel manifold therein extending along its upper margin, said manifold adapted to be coupled to a source of combustible fuel, said conduit having a slit allowing the gases of combustion caused by the burning of fuel at said manifold to pass upwardly through the conduit, through and out of said tube, and across said path for drying materials moving along said path; means mounting the body for vibration about an axis spaced from and exteriorly of the path and extending longitudinally of said tube; and means coupled with the body for vibrating the same at a frequency sufficient to cause the materials in the body to move relative to the same along said path.* * * * *