AGGLOMERATING WITH INDEPENDENTLY ROTATABLE SCREEN AND DRUM

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ABSTRACT

A ball agglomerating apparatus comprises a rotatable ball agglomerating, tumbling drum having an agglomerate ball classifying screen rotatably mounted therein and scrolled to spiral outwardly from the drum centre to adjacent the drum curved inner surface. The drum rotates at a faster speed than the screen so that agglomerate balls are formed in the drum by feeding particulate material, liquid suspendant, and an agglomerating liquid immiscible, with the suspendant into the rotating drum, the agglomerate balls are then scooped up by the screen and classified as they are conveyed inwardly along the spiral to finally emerge from a drum outlet.

5 Claims, 4 Drawing Figures
AGGLOMERATING WITH INDEPENDENTLY ROTATABLE SCREEN AND DRUM

This invention relates to a method and apparatus for ball agglomerating particulate material.

A process for the spherical agglomeration of finely divided solids is described in U.S. Pat. No. 3,268,071, dated Aug. 23, 1966, by Ira E. Puddington et al. In this prior process, finely divided solids in liquid suspending agent are, if necessary, rendered liophobic to the suspending liquid. A finding or agglomerating liquid immiscible with the liquid suspending agent is added to the suspension, which is then agitated to form the agglomerates.

The agitating vessel may be a reciprocating shaker or the like, and generally is only capable of performing a batch operation.

Furthermore, in the conventional formation of granules or pellets, and the like, considerable difficulty is frequently experienced as a result of powders sticking to the walls of the treating vessel or dish. Thus, it is often difficult to develop desired tumbling and compacting motion in the vessel, more especially with light, sticky powders. Moreover, size control is sometimes lacking as a result of "snowballing" which may occur when the binding liquid is not evenly distributed in the powdered mass.

To overcome these problems, a spherical agglomeration process which is continuous has been proposed in U.S. Pat. No. 3,471,267, dated Oct. 7, 1969, by Charles E. Capes et al. In this process a finely divided single solid material, as distinguished from complexes such as ores, is continuously added along with a liquid suspending agent, and an agglomerating liquid which is immiscible with the liquid suspending agent, into a body of these substances in an inclined, open topped, tumbling cylinder rotating about its axis. Agglomerates of the fine solid particles are continuously removed over the lower edge of the open topped tumbling cylinder.

Whilst this process has proved successful it has been necessary to screen the agglomerate balls and, if desired, recycle undersize balls. The oversize balls may, if desired, be reduced in size by size reduction. The screening operation has been carried out external to the agglomerating apparatus, and this has entailed the additional cost of screening apparatus together with the additional cost of handling and recycling apparatus. Furthermore, size reduction is unduly costly.

It is an object of the invention to provide a method and an apparatus for ball agglomerating particulate material into more uniformly sized agglomerate balls than has hitherto been possible without the addition of screening apparatus external to the agglomerating apparatus.

According to the invention there is provided, apparatus for ball agglomerating particulate material from a mixture of the material, a liquid suspending agent, and an agglomerating liquid immiscible with the liquid suspending agent, comprising a rotatably mounted ball agglomerating drum having mixture inlet means and an agglomerate ball outlet, an agglomerate ball size classifying screen rotatably mounted in the drum and scroiled to spiral inwardly from adjacent to the curved drum inner surface to the agglomerate ball outlet to convey classified agglomerate ball thereto, means for rotating the screen in the outwardly spiralling direction of the screen, and means for rotating the drum at a faster speed than the screen.

Further according to the invention there is provided a method of ball agglomerating particulate material from a mixture of the material, a liquid suspending agent, and an agglomerating liquid immiscible with the liquid suspending agent, comprising feeding the mixture into a rotating ball agglomerating drum to tumble the mixture and produce agglomerate balls from it, lifting the balls in the drum by means of a scroll shaped agglomerate ball classifying screen which is rotating in the outwardly spiralling direction of the screen and at a slower than the speed of the drum, so that agglomerate balls only classified by being of a predetermined minimum size by the screen are conveyed inwardly along the spiral of the screen, and then removing the classified balls from the drum which have been so conveyed by the screen.

In the accompanying drawings which illustrate, by way of example, embodiments of the invention,

FIG. 1 is a perspective view of an apparatus for ball agglomerating particulate material,

FIG. 2 is a sectional end view along 11—11, FIG. 1 of the ball agglomerating drum,

FIG. 3 is a sectional side view along 111—111, FIG. 2, and

FIG. 4 is a diagrammatic view of a different apparatus for ball agglomerating particulate material.

Referring to FIGS. 1 to 3, there is shown an apparatus for ball agglomerating particulate material from a mixture of the material, a liquid suspending agent and an agglomerating liquid immiscible with the liquid suspending agent, comprising a rotatably mounted ball agglomerating, tumbling drum 1 having a mixture inlet means 2 and an agglomerate ball outlet 4 in the form of a hollow shaft 4, an agglomerate ball size classifying screen 6 rotatably mounted in the drum 1 and scroiled, as shown in FIG. 2, to spiral inwardly from adjacent the curved drum inner surface 8 to the agglomerate ball outlet 4 to convey classified agglomerate thereto, and means in the form of electric motors 10 and 12 for rotating the drum 1 at a faster speed than the screen 6.

The drum 1 is rotatably mounted by bearings 14 and 16 (FIG. 3) in stands 18 and 20 respectively. The stands 18 and 20 are mounted on a base 22 (FIG. 1.) The motors 10 and 12 are mounted on the base 22, and the motor 12 drives the drum 1 by means of sprockets 24 and 26 (FIG. 3) and a chain 28.

The mixture inlet 2 is sealed by a plate 30 about which the inlet 2 may rotate. The plate 30 has a mixture delivery pipe 32 and a recycled suspending delivery pipe 34 extending through it. The pipe 32 has a funnel 36 at its upper end for receiving particles from a pipe 38 and suspending liquid from a pipe 40. It will be noted that the pipe 38 delivers the particles by vertically dropping them into the funnel 36, whilst the liquid suspending agent is delivered by the pipe 40 at an angle into the funnel 36 to swirl the liquid suspending so that it carries the particles from the funnel 36 down into the pipe 32.

The pipe 34 has a number of outlet holes 42 near its outlet end.

The screen 6 is supported by means of plates 44 and 45 on the hollow shaft 4. The hollow shaft 4 has a slot 46 extending the length of the screen 6, and the screen 6 extends over the slot 46 and is secured to the hollow shaft 4 (see FIG. 2). An agglomerate ball conveying helix 48 is secured within the bore of the hollow shaft 4 and extends along its length. The inner end of the hollow shaft 4 is sealed by a plate 49.
The hollow shaft 4 is sealed within a bore 50 of the drum 1, but is rotatably relative to the drum 1 by means of a bearing 52 which mounts the hollow shaft in the bearing stand 58 together with the drum 1.

The open end of the hollow shaft 4 is over an agglomerate ball receiving chute 54 which has its lower end over a filter tray 56 (FIG. 1). The hollow shaft 4 is coupled to the motor by means of pulleys 58 and 60 and vee belt 62.

The chute 54 extends over a ball receiving funnel 64 containing a perforated draining plate 66. The funnel 64 is connected by a pipe 68 to a liquid suspending recirculating pump 70 whose outlet is connected to the pipe 34. An agglomerating liquid supply pipe 72 is connected to the pipe 68. The funnel 64 is also connected by a pipe 69 to a further liquid suspending recirculating pump 71 whose outlet is connected to the pipe 40. An inlet pipe 73 is provided to the pipe 69 for the addition of suspending liquid to replace losses. It should be noted that the pipe 69 withdraws a portion of the suspending liquid for delivery to the pipe 40 prior to the addition of agglomerating liquid to the remainder by pipe 72.

In operation the drum 1 was rotated in the direction of arrow Y (FIG. 2) at 60 to 100 rpm and the screen 6 was rotated in the same direction at 4 to 6 rpm. In a number of tests using different materials, particles to be agglomerated were fed by pipe 38 into the funnel 36 together with “Varsoil” as the liquid suspending from the pipe 40. Water as the agglomerating liquid immiscible with the “Varsoil” was metered by a hypodermic-type pump (not shown) and fed by the pipe 72 into the drum 1. The total “Varsoil” recirculating rate was about 2,800 cc per minute. Approximately 1,100 cc per minute of “Varsoil” were used to flush the particles down the pipe 32 by means of pump 72, whilst the balance from the funnel 64 (approximately 1,700 cc per movement of the screen 6 and only those balls 74 which were large enough not to fall through the openings in the screen 6 were carried by the screen towards the slot 46 in the hollow shaft 4. Balls 74 which fell through the screen 6 were further subjected to agglomeration to increase their size until they could be carried by the screen 6 to the slot 46.

The balls 74 reaching the slot 46 passed into the hollow shaft 4 and were conveyed by the helix 48 out of the drum 1 to the chute 54. As the hollow shaft 4 rotated some of the liquid within the drum 1 was scooped into the slot 46 and assisted in conveying the balls 74 along the helix 48.

The balls 74 and liquid from the hollow shaft 4 passed down the chute 54 into the funnel 64 where the balls were separated from the liquid by remaining on the plate 66, whilst the liquid was passed back to the drum as previously described.

Experimental results for particles of different materials are listed in the following table. These experiments were performed in an on/off manner over a period of 2 to 3 days or up to 1 to 2 weeks.

In each experiment, however, the apparatus was operated at steady state for at least 2 hours corresponding to about 10 complete changes of the load within the apparatus. Thus, the data in the table may be taken as representative of steady state operation.

It will be noted that in some experiments, nuclei were added to the particles prior to them being fed to the funnel 36, whilst in others, nuclei were not added. In the case of carbonyl iron, no nuclei were added since steady operation was achieved without them. In the case of the other materials, although good product sizing could be achieved without nuclei, the product rate tended to cycle. Hence, nuclei in very small proportion to the particles feed rate were added to give a steady product rate in these instances.

<table>
<thead>
<tr>
<th>Particle characteristics</th>
<th>Operating conditions</th>
<th>Nuclei characteristics</th>
<th>Agglomerate products</th>
<th>Screen opening</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Median size (microns)</td>
<td>10 wt. percent finer than (microns)</td>
<td>10 wt. percent coarser than (microns)</td>
<td>Particle feed rate g/min</td>
</tr>
<tr>
<td>Carbonyl Iron...........</td>
<td>18.0</td>
<td>5.5</td>
<td>23</td>
<td>approx. 20</td>
</tr>
<tr>
<td>Carbonyl Iron...........</td>
<td>18.0</td>
<td>5.5</td>
<td>23</td>
<td>approx. 40</td>
</tr>
<tr>
<td>Sud........... approx. 97</td>
<td>approx. 67 approx. 122</td>
<td>19</td>
<td>4.2</td>
<td>approx. 1</td>
</tr>
<tr>
<td>Iron Ore.................</td>
<td>32u</td>
<td>11</td>
<td>67</td>
<td>approx. 20</td>
</tr>
<tr>
<td>Iron Ore ...............</td>
<td>32u</td>
<td>11</td>
<td>67</td>
<td>21.8</td>
</tr>
</tbody>
</table>

If desired the axis of rotation of the drum 1 may be tilted upwardly at the inlet 2 end by an angle of about 10° to assist the balls carried by the screen 6 to move towards the chute 54 from the drum 1.

In FIG. 4 there is shown a drum 76 with an open end 77, rotatably mounted by a hollow shaft 78 which is minute) was used to carry the water added by pipe 72 along pipe 34 by means of pump 70. The level of the drum 1 was maintained at about x - x, FIG. 2.

Rotation of the drum 1 caused agglomerating of the particulate material into balls 72 (FIG. 2) of different sizes. The balls 74 were scooped up by the rotational...
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5 supported in a bearing stand 80 by a bearing 82. The hollow shaft 78 is coupled to a variable speed electric motor 84 by means of pulleys 86 and 88 and V-belt 90. A spiral screen 92, similar to the screen shown in FIGS. 1 to 3, is mounted by means of a hollow shaft 94 in the drum 76. The hollow shaft 94 is slotted similar to hollow shaft 4 (FIGS. 2 and 3) and is rotatably sealed in a liquid-tight manner within the hollow shaft 78 by bearings 96 and 98. A variable speed electric motor 100 is coupled to the hollow shaft 94 by pulleys 102 and 104 and V-belt 106.

The opening 77 in the drum 76 has a particulate delivery pipe 108 extending into it, and a pipe 110 for recirculating liquid emerging from the hollow shaft 94 together with added agglomerating liquid from pipe 112 by means of a pump 114.

In operation this apparatus functions in the same manner as the apparatus shown in FIGS. 1 to 3. The drum 76 and the spiral screen 92 are rotated at about the same speeds as in the previous embodiment, whilst particulate material is fed into the drum 76 from the pipe 108 together with the liquid suspensant. Agglomerating liquid is fed into the drum by the pipe 110 from pipe 112, which also recirculates liquid flowing out of the hollow shaft 94.

As in the previous embodiment the spiral screen picks up the balls 116 of agglomerate and passes those over a particular size to the hollow shaft 94 from where they pass along the hollow shaft 94 and out of the drum 76 together with a portion of the liquid in the drum 76. The liquid from the hollow shaft 94 is returned to the drum 76 by pipe 110 after removing the ball agglomerates from it.

In a different embodiment the particulate material is fed to the funnel 36 as a slurry using the suspending liquid as a carrier or any liquid immiscible with the suspending liquid and immiscible with the agglomerating liquid as a carrier.

In other embodiments the drum rotates in the opposite direction to the screen, with the screen rotating in the outwardly spiralling direction.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. Apparatus for ball agglomerating particulate material from a mixture of the material, a liquid suspensant, and an agglomerating liquid immiscible with the liquid suspensant, comprising a rotatably mounted ball agglomerating tumbling drum having mixture inlet means and an agglomerate ball outlet, an agglomerate ball size classifying screen rotatably mounted in the drum and scoured to spiral inwardly from adjacent the curved drum inner surface to the agglomerate ball outlet to convey classified agglomerate ball thereto, means for rotating the screen in the outwardly spiralling direction of the screen, and means for rotating the drum at a faster speed and greater number of revolutions per minute than the screen.

2. Apparatus according to claim 1, wherein a rotatably mounted slotted, hollow shaft has the classifying screen mounted on it and extends along the axis of rotation of the drum through the agglomerate ball outlet to an open end of the hollow shaft outside the drum, the slot in the slotted hollow shaft extends along the classifying screen with the spiral of the classifying screen extending over the slot, and closure means sealing the end of the shaft within the drum.

3. Apparatus according to claim 2, wherein an agglomerate ball conveying helix extends along the slotted, shallow shaft.

4. Apparatus according to claim 1, wherein means are provided for recirculating liquid to the drum which overflows out of the agglomerate ball outlet.

5. A method of ball agglomerating particulate material from a mixture of the material, a liquid suspensant, and an agglomerating liquid immiscible with the liquid suspensant, comprising feeding the mixture into a rotating ball agglomerating drum to tumble the mixture and produce agglomerate balls from it, lifting the balls in the drum by means of a scroll shaped agglomerate ball classifying screen which is rotating in the outwardly spiralling direction of the screen and at a slower speed than and smaller number of revolutions per minute than the drum, so that the agglomerate balls only classified by being of a predetermined minimum size by the screen are conveyed inwardly along the spiral of the screen, and then removing the classified balls from the drum which have been so conveyed by the screen.