Apparatus for wetting discrete particles of dry powder material such as polyelectrolites, carbon and other hard to wet material, is disclosed in this application. The apparatus comprises a wetting tank which is provided with liquid supply and discharge mechanisms and a rotary drum which is only partially immersed in the liquid contained in the wetting tank. As the drum rotates it carries a thin layer of liquid on the surface portions not immersed in the liquid and also agitates the liquid in the tank. The powder is carried in a feeding hopper and discrete particles are discharged to the layer of liquid carried by the drum and thereafter the individually wetted particles are discharged into the liquid in the wetting tank where it starts to form a solution. The solution flows through the discharge mechanism and into a separate aging tank where the solution is finally formed. In one preferred embodiment of the invention a special spreader nozzle is used to spread the particles along a straight line on the drum.

10 Claims, 4 Drawing Figures
PARTICLE WETTING APPARATUS

Various dry chemical powders must be changed to a liquid solution for their most efficient use. Some of these powders, however, are extremely difficult to disperse into a solution because unless the discrete particles are separated from each other they are not completely wetted and have a tendency to adhere to each other along their dry surfaces forming globules which are practically undissolvable. Accordingly, it is desirable to wet each individual particle of powder so that the time required to form the liquid solution is kept to a minimum and so that the desired concentration of solution is obtained.

Presently, various methods are utilized to wet individual particles of powder, but have not proven entirely satisfactory. For example, one such technique involves the use of a special wetting eductor which is hydraulically operated and which utilizes suction and a special funnel for feeding the particles to the liquid. Another technique involves the use of a water spray into which the particles are fed prior to being discharged into a tank of liquid. Both of these techniques are generally satisfactory at low feeding rates, but neither assures the complete wetting of each particle at high feed rates.

It should be obvious that if the feed rate is limited, then the quantity of solution which can be produced in an economical and efficient manner is also limited. However, the economical and efficient production of large quantities of some solutions is now a necessary requirement of the intended applications of various solutions. For example, in the treatment of waste water, various solutions including polyelectrolytes or polymers are used as coagulant aids for facilitating the separation of the solids from the water. Large quantities of polymer solution are, of course, required in waste water applications and the solution must be economically and efficiently produced.

This invention is, therefore, directed to a system and apparatus for economically and efficiently producing liquid solutions from particles of dry powder and, particularly, from particles of dry powder that must be individually wetted. Briefly, this is accomplished in accordance with this invention by providing a wetting tank, including a liquid supply and discharge mechanism and a rotary drum which is only partially immersed in the liquid contained in the wetting tank. Rotation of the drum causes it to carry a thin layer of the liquid on any surface portion not immersed in the liquid. The dry powder to be mixed with the liquid is carried in a feeding hopper and particles of the powder are fed to the layer of liquid carried on the drum where they are individually wetted and thereafter, discharged into the liquid in the wetting tank. The drum also causes agitation of the liquid which further facilitates the dissolution of the particles in the liquid. Eventually, the liquid and particles are fed to the aging tank until they form the solution desired.

Another aspect of this invention is directed toward a novel spreader nozzle which can be used in any feeding system, but which is particularly useful in conjunction with the system described above for evenly distributing the particles on the rotary drum. The nozzle includes a receiving surface on which the particles are deposited and an inclined spreader surface over which the particles are distributed from the receiving surface. Diverging side edges extend along the spreader surface from the receiving surface toward a guide surface which determines the configuration in which the particles are deposited on the drum or other surface on which they are to be deposited. While the configuration of the guide surface can vary, the preferred embodiment utilizes a straight edge so that the particles fall on the drum in a straight line covering substantially the entire length of the drum.

For a better understanding of the invention reference is made to the following description of a preferred embodiment, taken in conjunction with the figures of the accompanying drawings, in which:

FIG. 1 is a perspective view illustrating a system in accordance with this invention;

FIG. 2 is a perspective view with portions omitted for the sake of clarity of a spreader nozzle which can be used in the system illustrated in FIG. 1;

FIG. 3 is a front view of the spreader nozzle illustrated in FIG. 2; and,

FIG. 4 is a side view of the spreader nozzle illustrated in FIG. 2.

Referring now specifically to FIG. 1, there is illustrated a system for feeding and wetting particles of dry powder to a liquid to form a solution. The system includes a feeding device 10, a wetting tank 12 and an aging tank 13. Feeding device 10 may be any of a variety of conveyor type mechanisms, but the preferred embodiment includes a hopper 11 in which the powder is stored and could also include a conventional type of vibratory mechanism (not shown) for keeping the particles from packing together in the hopper. Use of a vibratory mechanism depends, of course, on the cohesive tendencies of the particles. Located at the bottom of and communicating with hopper 11 is a discharge pipe 14 having a discharge spout 15 extending outside the hopper. Inside discharge pipe 14 is a suitable conveyor (not shown) such as a helical feeder or screw feeder for conveying the particles from hopper 12 to discharge spout 15. Adjacent discharge spout 15 is a spreader nozzle 16, the details of which will be fully explained hereafter. At this point it should merely be noted that nozzle 16 distributes the particles evenly along a straight line, is not necessary for the invention but allows for a material increase in the feeding rate of the powder.

Wetting tank 12 is in the form of a receptacle adapted to contain the liquid, generally water, with which the powder is to be mixed. Accordingly, wetting tank 12 is provided with a liquid conduit 18 connected to a suitable source of the liquid and having branches 18a and 18b extending into the tank. Conduit 18 includes a rotameter 20 which measures the flow rate of the liquid in a conventional manner. While rotameter 20 is not required, it should be noted that some type of flow rate indicator should be provided so that the delivery rate of the liquid can be adjusted. Branch conduit 18a is located adjacent one wall of wetting tank 12, extends across the width of the tank and includes a series of holes which uniformly distribute the liquid as a spray inside the tank; branch conduit 18b is spaced lengthwise from branch 18a, also extends across the width of the tank and also includes a series of holes (not shown) which distribute the liquid as a spray inside the tank. Only a single branch conduit could be utilized, but as will become clearer hereinafter, use of the two branches will minimize the effects of the duct formed by the particles fed to the tank.
At the end of the tank opposite branch conduit 18a there is provided a discharge conduit 22 that communicates at one of its ends with the interior of the wetting tank and at its other end with a jet type pump or ejector 24. As clearly shown in the drawing conduit 22 is coupled to the bottom wall of a projecting portion 19 extending from the main portion of wetting tank 12, but having a depth substantially less than that of the main portion. Accordingly, a predetermined level of liquid is maintained in the wetting tank. As is known in the art, ejectors discharge a jet of liquid across a suction chamber through a diffuser along with the liquid. Accordingly, ejector 24 is connected to conduit 18 through a conduit 23 including a control valve 25. When the control valve is open, liquid is discharged through ejector 24 sucking the solution in the wetting tank through the diffuser and into aging tank 13. It should be understood that various other types of discharge mechanisms could be utilized, for example, an overflow spout.

Extending across the tank 12 adjacent and below branch conduit 18b is an imperfect cylindrical drum 26 which is rotated by a drive motor 28 located outside the tank. As illustrated in the drawing a portion of drum 26 is located below the surface of the liquid maintained in the tank and the remaining portion is located above that surface. Rotation of the drum by drive motor 28 agitates the liquid in the tank and also causes a thin uninterrupted layer of liquid to adhere to the portion of the drum not immersed in the liquid during the rotation, that is, any small segment extending along the length of the drum will, as it first emerges from below the surface of the liquid, pick up and carry a thin layer of liquid. As the segment continues along its path of travel, the layer of liquid is carried along until just before the segment re-enters the liquid where it will be hurled from the drum and into the liquid. A preferred driving speed for the drum is approximately 400 revolutions per minute.

In operation, particles discharged from feeding device 10 are directed downwardly as a stream toward the surface of the drum so that they contact the layer of liquid which, of course, wets each particle. Relative movement between the particles and the drum assures that particles are not deposited on top of each other but are always fed to a different portion of the drum. As the drum continues its rotation, an individual particle which has been wetted is then hurled from the surface of the drum as the drum approaches the liquid and continues its movement in the liquid due to the agitation of the liquid caused by the drum. It is desirable to rotate the drum in a counterclockwise direction as illustrated by arrow A in FIG. 1 so that the particles travel from the supply end of the tank toward the discharge end of the tank assuring that the particles will not form a lagoon in the tank but will be discharged to aging tank 14. Thus, it can be seen that individual particles of powder are wetted and the agitation of the liquid in the tank facilitates the dissolving of the particles.

Aging tank 13 could be of any construction capable of receiving and holding a solution until the particles are completely dissolved. In the preferred embodiment disclosed herein, tank 13 comprises a receptacle having a volume so as to hold the solution for a predetermined time, usually one to two hours, and having an open top located below the open end of conduit 23 on the discharge side of ejector 24 so that the solution is discharged from wetting tank 12 into the aging tank. To facilitate the complete dissolving of the particles in the liquid, a mixer 32 is provided and operates at relatively low speeds, for example, less than about 400 revolutions per minute. Of course, a suitable discharge mechanism is provided for removing the solution from aging tank 13 and in the preferred embodiment described herein, includes a conduit 30 communicating with the inside of the tank adjacent its bottom surface and a suitable transfer pump 31 including a drive motor 33. Thus, the solution is pumped from the bottom of the tank. Other types of discharge mechanisms could also be used, for example, a suitable overflow spout could be provided adjacent the top of the tank.

It should be clear from a reading of the description of a preferred embodiment of the system in accordance with the invention, that the system is virtually maintenance free and effectively and economically wets each distinct particle of powder. It should also be clear, that a simple and economical wetting tank has been provided for use in the above described system.

Referring now to FIGS. 2 through 4, there is disclosed a spreader nozzle 16 capable of being used in the above described or other particle feeding systems.

While it was noted previously that nozzle 16 is not necessary for the operation of the system described above, it has been found that a nozzle of this type allows for significantly increasing the feed rate of particles through a discharge spout by distributing the particles along a straight line rather than in a narrow stream.

Before describing the spreader nozzle in detail, the characteristic of particle flow on which the configuration is based will be explained. As particles of powder are discharged onto a relatively flat surface from a pipe or spout having a relatively small diameter, a cone of powder is formed. In any cross-section through the longitudinal axis of the cone, the sides of the cone will define a predetermined included angle which is generally called the angle of repose and which varies for different powders. Once a cone having the predetermined angle of repose has been formed, additional particles falling on the cone will slide down the cone and be deposited on the flat surface forming a circular pile of material around the cone.

Referring now to FIGS. 2-4, it can be seen that spreader nozzle 16 includes a flat particle receiving surface 34, a generally inclined spreader surface 36 and a guide surface 38. Spread surface 36 actually is a segment of an imaginary frusto-cone C, as best seen in FIG. 2, so that it is generally arcuate in cross section and has a pair of edges 40 and 42 diverging from receiving surface 34 to guide surface 38. Thus the shortest width of spreader surface 36 is adjacent receiving surface 34 and its longest width is adjacent guide surface 38. The included angle between edges 40 and 42 should be equal to or just slightly smaller than the angle of repose of the powder being distributed. Obviously, however, this angle varies slightly for different powders and, thus the angle is selected to be just equal to or slightly smaller than the smallest angle of repose for the materials anticipated to be distributed.

Receiving surface 34 can be generally perpendicular to the longitudinal axis of frusto-cone C, but in the preferred embodiment is slightly inclined so that it forms a small angle with a plane perpendicular to the longitudinal axis of the frusto-cone. Accordingly, as best seen in FIG. 2, receiving surface 34 intersects spreader surface 36 along an arcuate edge. In the particular em-
bodiment enclosed herein guide surface 38 is a substantially flat surface extending generally parallel to the longitudinal axis of frusto-cone C. It should be understood, however, that its configuration can vary depending on the distribution pattern desired for the particles being discharged. Finally, it should be noted that side walls 44 and 46 are formed along edges 40 and 42, respectively, and function to confine the particles to spreader surface 36, as will be fully explained hereinafter. Walls 44 and 46 also extend along the sides of receiving surface 34.

In operation, spreader nozzle 16 is secured, by any suitable bracket, to the end of discharge pipe 14 so that receiving surface 34 is adjacent to and below the axis of discharge spout 15. Now, the particles discharged through the open end fall on receiving surface 34 where they form a conical pile of powder until the included angle between any two sides of the cone in longitudinal cross-section is equal to the angle of repose for the particles. As additional particles fall on the pile, they slide over the sides of the pile and are uniformly distributed down along spreader surface 36 which conforms generally to the configuration of the pile except that its sides have an included angle slightly smaller than the angle of repose. As the particles fall from spreader surface 36 they are guided by guide surface 38 and, therefore, assume its configuration when they strike drum 26 or other surface on which they are deposited. Since guide surface 38 is flat, a straight line configuration of particles is formed on the portion of the drum on which they are deposited. If surface 38 has another configuration, the particles would assume it when they struck the surface of drum 26. For example, if surface 38 were convex, an arcuate convex configuration would be formed on drum 26 by the particles. As noted previously, walls 41 and 46 confine the particles to spreader surface 36.

It should be noted that due to the slight angle formed between receiving surface 34 and the plane perpendicular to the longitudinal axis of frusto-cone C, where the feeding mechanism stops, most of the particles remaining on the receiving surface will slide onto the spreader surface. It should be further noted that if the particles being fed are generally cohesive, a vibrator could be attached to the nozzle to facilitate their movement.

When spreader nozzle 16 is used with the wetting apparatus of FIG. 1, the particles fall along a generally straight line extending substantially the length of drum 26. Accordingly, the feed rate of the particles can be increased and more of the drum surface is utilized which adds to the efficiency and economy of the system.

While in the foregoing a preferred embodiment of the invention has been described, various modifications may become apparent to those skilled in the art to which this invention relates. Accordingly, all such modifications are included within the intended scope of the invention as recited in the following claims.

What is claimed is:

1. A system for wetting discrete chemical particles including a wetting tank in which the particles are to be wetted, means for feeding the particles to said wetting tank and an aging tank for receiving solution from said wetting tank, the improvement comprising:

a rotating drum located in said wetting tank and being partially immersed in a liquid which adheres to the surface of said drum as it rotates and which agitates the liquid in said tank, said drum being located below said feeding means so that the particles are fed to the layer of liquid on the drum whereby each particle is wetted and thereafter mixed into the liquid in said tank.

2. In a system according to claim 1 wherein said wetting tank includes liquid supply means and discharge means whereby liquid is supplied to said tank and a solution including said liquid and said particles is discharged to said aging tank.

3. In a system according to claim 2 wherein said liquid supply means includes a conduit extending into the interior of said tank and which is formed with a series of openings for allowing the passage of liquid into the tank at points spaced along the interior of said tank.

4. In a system according to claim 2 wherein said liquid supply means includes a plurality of conduits extending into the interior of said tank, one of said conduits being located adjacent to and above said drum.

5. In a system according to claim 2 wherein said discharge means includes a conduit communicating with the interior of said wetting tank and an ejector means for discharging said solution to said aging tank.

6. In a system according to claim 2 wherein said feeding means includes a nozzle for distributing the particles along an elongated line extending substantially throughout the length of said drum.

7. In a system according to claim 6 wherein said nozzle includes an inclined spreader surface over which said particles slide, said spreader surface having side edges that diverge from a smaller width to a larger width closer to said wetting tank.

8. In a system according to claim 7 wherein said side edges are bordered by side walls which confine said particles to said spreader surface.

9. In a system according to claim 7 wherein said nozzle includes a particle receiving surface adjacent said smaller width of said spreader surface and further includes a guide surface adjacent said larger width of said spreader surface.

10. In a system according to claim 7 wherein said spreader surface is a segment of an imaginary frusto-cone and wherein said particle receiving surface forms a slight angle with the plane generally perpendicular to the longitudinal axis of said cone.

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