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3,117,027

APPARATUS FOR COATING PARTICLES
IN A FLUIDIZED BED

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The present invention relates to the coating art and more specifically to improvements in the air suspension coating process. This process and illustrative apparatus for carrying out the process are described in Wurster Patent 2,648,609 and also in the copending Wurster application Serial No. 810,128, filed April 30, 1959. As shown in these disclosures, the particles to be coated, e.g. tablets, crystals, powders and the like, are suspended in a coating tower in a moving gas stream, e.g. an air stream, and the coating composition in atomized or like form is introduced into the gas stream prior to its contact with the suspended particles to be coated.

In practice it has been found when coating relatively small particles, e.g. small crystals or powders, in the air suspension coating process that a considerable amount of material being coated does not settle out in the enlarged bell or settling section of the tower but tends to pass on out of the system through the exhaust connection or stack at the top of the tower. While this material can be recovered by conventional means such as by the use of a standard cyclone separator or the like, this procedure is objectionable as it interrupts the coating operation making controlled or uniform coating difficult. It also poses special problems involving the return of the recovered material to the coating section of the tower. Also, while the losses from the system can be kept to the minimum by reducing the air flow to the minimum required to suspend the particles and dry the coating, this is objectionable as it necessarily results in a substantial decrease in the coating rate.

We have discovered that these problems can be readily solved by the placing of a cyclonic inducer, described below, between the coating and settling sections of the tower. The cyclonic inducer directs the particles leaving the coating section in such a manner that their momentum is reduced by being thrown against the outside of the settling section. In doing so they also impinge against returning particles causing a further substantial reduction of the upward or escape momentum.

The location of the cyclonic inducer is such that it acts to support part of the material in the settling section and automatically feeds it back into the coating section at a uniform rate. This aids in maintaining an optimum quantity of material to be coated within the coating section and also in maintaining a constant pressure drop across the bed throughout the coating process. With the location of the cyclone inducer as noted above and described in detail below, losses are reduced so significantly that air flows and hence coating rates can be increased two to three times above that considered possible heretofore when using fine powders in the air suspension coating process. As static electricity bleeds off where velocity is high or changing, the operation of the cyclonic inducer also functions to some extent as a discharge point for static electricity which tends to build up on small particles.

The electrostatic charge, referred to above, may seriously interfere with the coating process when relatively small particles such as small vitamin A crystals, powders and the like are being coated. The charged particles, for example, may cling to the sides of the tower, build up and close the column completely and, if the pressure is allowed to build up, result in most of the particles finally being blown out of the exhaust stack. The charge as

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noted above may be dissipated by the cyclonic inducer which, if made of metal, can also be grounded. We have also found that the static charge can be controlled and kept down by humidifying the gas used to aerate and suspend the particles being coated. This can be done manually by controlled steam injection when needed; but can also be provided for automatically as described below.

For a more complete understanding of the practical application of the principles of our invention reference is made to the appended drawings and following examples. In the drawings:

FIGURE 1 is a vertical sectional view of an apparatus in accordance with our invention and suitable for carrying out the process of our invention;

FIGURE 2 is a fragmentary isometric view of a portion of the apparatus shown in FIGURE 1; and

FIGURE 3 is a schematic wiring diagram of an electrical control circuit utilized in the apparatus shown in FIGURES 1 and 2.

Referring more particularly to FIGURE 1, the illustrated apparatus which is similar to that shown in the above-noted copending application Serial No. 810,128, basically includes a tower 10, an auxiliary air supply system and an auxiliary coating material feed system.

Tower 10 is a vertically elongated hollow shell, constructed of rigid, hard, transparent synthetic resin (e.g. Lucite), or similar material and includes a centrally cylindrical bell 12 provided with a lateral charge port 16. At its lower end bell 12 includes a frustoconical lower end section 18, sharply reducing the diameter of the opening into bell 12 at its lower end. Similarly, the upper end of bell 12 is reduced to a much smaller diameter by a frustoconical upper end section 20. Thus bell 12 including its lower and upper sections 18 and 20 encloses a chamber or settling section which is accessible at its upper and lower ends through openings of substantially smaller diameter than the main portion of bell 12 and which is further accessible by means of a lateral opening in the form of a charge port 16 which can be closed by a suitable cap 24 during operation.

Depending from lower section 18 of bell 12, tower 10 is further provided with an elongated throat or coating section 26 which communicates at its upper end with the opening into lower bell section 18 and which at its lower end is tapered to still a further reduced diameter. Near its lower end throat 26 is provided with a downwardly inclined lateral discharge port 28 which is provided with a removable cap 30. The lower end of throat section 26 terminates in a short cylindrical nozzle section 32 into which the air supply system and coating material feed system are connected. A fine mesh grid 33 is mounted in the upper end of nozzle section 32 extending completely across the interior of such section.

Above upper bell section 20 tower 10 is further provided with a short vertical cylindrical disengaging section 34 which can be interiorly provided with transversely positioned screens or the like to facilitate disengagement of entrained fines. Above disengaging section 34 tower 10 is further provided with a frustoconical exhaust connection 36 reducing the diameter of tower 10 at its outlet end suitably for connection to a stack or fine or solvent recovery system.

The air supply system is conventional in nature and includes suitable provision for controlling humidity of and for heating air which is blown into the lower end of nozzle section 32 at the lower end of tower 10 through an air conduit 62 which is connected directly to nozzle section 32.

The coating feed material system which is more completely described in the above-noted copending application basically is arranged to introduce the coating materials under suitable pressure through an inlet connection

106 of an atomizing nozzle 108 extending into the lower end of nozzle section 32 of tower 10. The coating material feed system further includes a second air inlet connection 120 leading into nozzle 108 for admitting compressed air to assist in atomizing the coating materials. It will be noted that compressed air inlet 120 and coating material inlet 106 enter nozzle section 32 and are directed at acute angles toward each other at their outlet ends to form atomizing nozzle 108.

In accordance with this invention the apparatus described in the aforementioned copending application is further provided with a device 40 for imparting a cyclonic movement to upwardly rising gas in tower 10 as it passes from throat section 26 into bell section 12. Specifically referring more particularly to FIGURE 2, device 40 consists of a central hub 42 from which a number of vanes 44 radiate; in the illustrated apparatus six such vanes are shown. Each vane 44 is a flat blade of uniform cross-sectional area and at its inner end is attached to hub 42 at a substantial angle to the axis of hub 42. Each such vane 44, moreover, is affixed to hub 42 at the same angle as each other such that the cyclone inducer device 40 resembles a propeller. Cyclone inducer device 40 is positioned in tower 10 at the upper end of the coating or throat section 26 with the outer ends of vanes 44 securely affixed to the inner wall of throat section 26 and with the axis of hub 42 coinciding on the vertical axis of tower 10 (see FIGURE 1).

Tower 10 is further provided with devices to eliminate adherence of the materials being coated to the walls of tower 10 by reason of static electricity build up on the particles. These devices include a ground connection 46 for cyclone inducer device 40, which is of metal construction, and an inlet pipe 48 connected into air inlet 62 for introducing steam into the warm air entering throat section 26. Steam inlet 48 is provided with a solenoid operated valve 50 having a solenoid operator 52 capable of opening valve 50 when energized. At the upper end of tower 10 specifically in exhaust connection 36, tower 10 is provided with an ionization gap 54 which consists of a pair of vertical plates 56a and 56b which are spaced a short distance apart. Plates 56a and 56b are supported in exhaust connection 36, respectively, by metal posts 57a and 57b which extend through opposite sides of exhaust connection 36 and are affixed in the walls of exhaust connection 36.

Referring more specifically to FIGURE 3, ionization gap 54 is electrically connected in series with the energizing coil 58a of a relay 58 across the terminals of a power supply 59. Physically the electrical connections to gap 54 are conveniently made by attaching such electrical connections to posts 57a and 57b which support plates 56a and 56b constituting ionization gap 54. Gap 54 is also provided with a shunt connection including a normally open push button switch 60 which is physically located at a convenient place for the operator of the apparatus. Relay 58 is provided with a pair of normally open switches 58b and 58c which are connected in the power circuit for solenoid 52. Thus actuation of push button 60 can be employed manually to drop relay 58 closing switches 58b and 58c, thereby opening valve 50 to introduce steam into the air stream in inlet connection 62. It will be apparent that the presence of ionized gas between plates 56a and 56b will automatically produce the same actuation of valve 50.

In operation the charge of finely divided seed or powder on which the coating growth is to occur is introduced into tower 10 through lateral inlet port 16. Cap 24 is then placed in position to close port 16 and warm air is blown into tower 10 through inlet connection 62. As the warm air rises upwardly in tower 10 it carries the seed particles upwardly with it in a suspended state, generally forming an expanded fluidized bed B which is located partly in the upper end of throat 26 and partly in the lower end of bell 12.

For convenience bed B has been designated B₁ where it exists in throat section 26 and B₂ where it exists in bell section 12. It must be appreciated, however, that only a single bed is present.

As the air introduced through fitting 62 flows upwardly from throat section 26 into bell section 12 it passes cyclone inducer device 40 issuing through the apertures between vanes 44. By reason of the angle of vanes 44 each stream of air passing between each adjacent pair of vanes 44 is given an angular movement which, relative to the vertical axis of tower 10, is the same for each other stream of air passing through each other adjacent pair of vanes 44. Consequently the air entering bell 12 has a swirling cyclonic flow which continues upwardly through bell 12 and into exhaust connection 36. As a result the particles in bed portion B₂ located in bell 12 are thrown by the cyclonic flow of supporting air toward the walls of bell 12, substantially preventing them from being carried entrained in the air stream through exhaust connection 36 in much the same manner as though they had passed through a cyclone separator, with the difference, however, that the particles remain in a fluidized state.

It will be also appreciated that when the fluidized bed B has been established the particles in bed portion B₁ and the particles in bed portion B₂ will be constantly interchanging such that, statistically speaking, if for example half of the particles are in bed portion B₁ and half of the particles are in bed portion B₂, each particle while it is in tower 10 will have half of its residence time in bed portion B₁ and the other half of its residence time in bed portion B₂.

When the desired balance between bed portion B₁ and bed portion B₂ has been determined by establishing the preferred amount of particles in bed portion B₁ for optimum coating conditions, the coating materials are then introduced into nozzle section 32 by pressuring the coating materials to force them through nozzle 108 from inlet connection 106. At the same time a small stream of compressed air is introduced through nozzle 108 and inlet connection 120. The stream of compressed air by impinging on the stream of coating materials issuing from nozzle 108 atomizes these materials such that they are carried suspended in the air stream rising upwardly through nozzle section 32 and into contact with the particles in bed portion B₁ where the coating materials are deposited on the particles in bed portion B₁ and dried by the rising warm air. This process is continued until the desired coating or particle size has been achieved.

As pointed out above, with fine particle sizes a serious problem of the static electricity build-up on the particles frequently occurs, particularly where no humidity can be tolerated. By providing a ground connection 46 for cyclone inducer device 40 a certain amount of this static charge build-up is removed from the particles. Nevertheless and despite the static removal effect of the cyclonic movement of particles in bed portion B₁ a static charge can still develop. In order to obviate this it has been found that injection of steam into the air stream will effectively remove the static charge build-up. Accordingly, when the operator of the apparatus notices the effects of the static charge build-up, which is typically obvious by a noticeable collection of particles on the walls of the apparatus, the operator can by actuating push button 60 open valve 50 to admit the necessary steam injection. The steam injection is continued until the static build-up is completely removed, and then it is terminated. In some instances, however, the operator is otherwise occupied and automatic steam injection is desirable. This is simply accomplished by the ionization gap 54 provided in exhaust connection 36. As a static charge condition occurs in tower 10 the build-up of charge on the particles in bed B is concomitant with ionization of the supporting air or other gas. Consequently a convenient ionization detector circuit such as gap 54 is provided. As the air ionizes in tower 10 and reaches exhaust connection

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36 the ionized air permits current to flow through gap 54 energizing relay 53a. Consequently valve 50 is opened and steam injection occurs. The steam injection continues until ionization of the air ceases when the static charge has been destroyed. Thereby the termination of current flow through gap 54 by reverse procedure cuts off the steam injection. The presence of moisture (water) destroys or removes the static charge and while the invention has been illustrated above by the introduction of the moisture into the air stream in the form of steam, it will be understood and obvious to those skilled in the art that the moisture can be introduced into the air stream by equivalent means such as in water spray form as well as in gas or vapor form. This and like modifications falling within the scope of the invention are intended to be covered by the claim appended hereto.

It is claimed:

An apparatus for coating small particles in a fluidized bed comprising a vertical elongated hollow tower having a lower coating section and an upper settling section having a cross-sectional area substantially greater than the cross-sectional area of the coating section, a gas supply line connected to the lower end of the coating section, means to supply gas to said line, means positioned below

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the fluidized bed for atomizing coating material into the lower end of the coating section to coat said particles, said gas line, coating section and settling section forming a passage for upwardly flowing gas adapted to suspend the particles in said sections, and means in said tower positioned between the said coating and settling sections including a hub, the axis of which coincides with the vertical axis of the tower, and a plurality of blades fixed to said hub and to the inner walls of said tower at an angle with the vertical and radially extending from said hub to the walls of said tower for imparting a swirling cyclonic movement to said upwardly flowing gas as it enters said settling section.

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