

Method and apparatus for the blending of granular materials

The present invention relates to a method and apparatus for blending freely-flowing granular materials contained within a hoppers bin. Operation may be in either a continuous mode with the simultaneous loading and discharge of material (with a predetermined material volume maintained in the bin) or in a batch mode with consecutive loading and discharge.

In US—A—4068828 a blending method is described in which particulate materials are blended in a vessel which has a plurality of vertically extending conduits therein. The conduits are provided with a plurality of openings within the vessel, and terminate in a common collection zone. Certain of the openings are provided with baffle means to permit particles to enter the tubes when there is flow of particles through the tubes from higher elevations. The locations of the openings and the baffle sizes are selected such that the total flow of particles through the conduits at progressively lower elevations in the vessel increases substantially as a linear function with respect to vertical distance measured downwardly. An inverted cone can be employed in the bottom of the vessel to provide more uniform mixing of materials that do not flow through the conduits.

In US—A—3268215 a similar blending method is described in which means are provided for maintaining a substantially equal flow rate of material downwardly through its conduits and in an amount such that the materials passing downwardly through said conduits is less than the free-fall rate of the materials and such that only the uppermost of the apertures in each said conduit disposed below the level of the materials in said tank is operative to withdraw materials from the vessel.

By contrast, the blending operation of the present invention is accomplished by withdrawing material by gravity flow from a multitude of locations distributed essentially uniformly within the designated blending region of the bin in the particular manner hereinbefore described. The blending region may be whole or merely part of the total bin volume depending on the application.

In accordance with the present invention there is provided a method for the high efficiency blending of solid particulate materials which comprises introducing the materials to be mixed into a bin and withdrawing one portion of said solid particulate materials by gravity through a downwardly-extending blending tube having positioned, through the walls thereof, a plurality of material inlet passages, characterised in that the said passages are positioned and dimensioned to provide unblocked flow characteristics (as defined) therethrough, and in that the method further comprises withdrawing

another portion of said solid particulate materials by gravity through a plurality of downwardly extending auxiliary blending tubes having positioned, through the walls thereof, a plurality of material inlet passages positioned and dimensioned to provide blocked flow characteristics (as defined) therethrough; joining the portions of material in an enlarged section below the main tube and near the downstream ends of all of said main blending tube and auxiliary blending tubes which joined portions of material are passed therefrom as a blended stream; and maintaining unblocked flow characteristics as defined in said main blending tube while maintaining blocked flow characteristics (as defined) in said plurality of auxiliary blending tubes.

The invention also provides an apparatus for the high efficiency blending of solid particulate materials which comprises an outer hoppers bin having means for the introduction therein of materials to be mixed and a downwardly-extending blending tube positioned therein and having passing through the walls thereof a plurality of material inlet passages, characterised in that the said passages are positioned and dimensioned to provide unblocked flow characteristics (as defined) therethrough, and in that the apparatus further comprises a plurality of downwardly-extending auxiliary blending tubes positioned therein and having passing through the walls thereof a plurality of material inlet passages positioned and dimensioned to provide blocked flow characteristics (as defined) therethrough; said main and said auxiliary blending tubes joining in an enlarged section below the main tube and near their downstream ends to pass a blended stream of material flow therethrough while maintaining unblocked flow characteristics as defined in said main blending tube and blocked flow characteristics (as defined) in said plurality of auxiliary blending tubes.

By the term "blocked flow" as used herein is meant a condition of flow of material under gravity through a substantially vertical tube in which the flow rate of material entering the tube at its upper end is at least as great as the flow rate of material leaving the tube at its lower end, so that there is some degree of packing between the particles within the tube.

By the term "unblocked flow" as used herein is meant a condition of flow of material under gravity through a substantially vertical tube in which the flow rate of material entering the tube at its upper end is less than the maximum flow rate that the material could experience in leaving the lower end of the tube, so that there is essentially no packing between the particles within the tube.

Apparatus suitable for use in carrying out the

method aspect of the invention is as set forth in the embodiment of the drawings in which:

Figure 1 is a vertical cross-sectional view of the hoppers bin apparatus;

Figure 2 is an enlarged fragmentary view of the hoppers bin of Figure 1 showing, in greater internal sectional detail, the lower end thereof;

Figure 3 is a perspective view of a closed hoppers bin apparatus of the embodiment of Figures 1 and 2;

Figure 4 is a schematic top sectional view of the hoppers bin apparatus showing the internal relationship of the main and auxiliary blending tubes;

Figure 5 is a partial elevational view of the main blending tube of the hoppers bin apparatus, showing the orientation of holes through the tube walls;

Figure 6 is an exploded schematic view of the six auxiliary blending tubes laid out so as to show the relative orientation of holes in the tube walls; and

Figure 7 is an exploded schematic view of the three blending tube support assemblies positioned at different levels within the hoppers bin, as shown in Figure 1 hereof.

As shown in the embodiment of Figures 1 and 2 of the drawings, the apparatus comprises a hoppers bin 10 having a main blending tube 12 and a plurality of auxiliary blending tubes 14 which join into an enlarged section 16 below the main tube 12. Holes of passages 18a and 18b respectively pass through the tube walls of the main and auxiliary blending tubes 12 and 14. The blending tubes are positioned to allow the granular material to flow into the tube interiors wherein it flows downward toward the discharge outlet at the lower section of the hoppers bin or blender 10. The material outlet flow rate is controlled by setting of valve means positioned at the downstream end of the blender.

The passages or holes 18a of the main tube are typically distributed uniformly over its length and are sized so that, for the minimum discharge rate and the fastest flowing granular material to be blended, these holes can provide only, for example, 75 percent of the discharge rate. That is, the main blending tube 12 should always be unblocked. The additional material required is provided by the combination of "hopper flow" of material through the annular space 20 around the blending skirt 22 and flow of material through passages or holes 18b of and through the auxiliary blending tubes 14.

Open or closed blender embodiments may be alternatively employed within the scope of the present invention depending upon the use to which the blender is to be put. Continuous operation would favor an open blender (open at the top to the atmosphere and enabling continuous filling), but closed continuous operation blenders, as described hereinbelow, may also be employed. It has been found that the closed embodiment is the most preferred embodiment

for all operations of the blender of the present invention. Such a closed top blender provides shelter from the admission of foreign matter into the hopper blender bin as well as a means for providing additional structural support for the internal blending tube assembly.

The flow rate of material into the enlarged section 16 below the main tube 12 from the auxiliary tube 14 is self-regulated so that, for a larger than minimum discharge rate, the additional material required is automatically provided.

It has been found that "blocked" auxiliary blending tubes provide for the self-regulation of material flow rates at auxiliary tubes. In order to obtain "blocked-flow characteristics" in the auxiliary tubes of the blenders of the invention this self-regulation effect is needed. It has been found that the enlarged section inner cross-sectional area at the discharge section of the tubes should be substantially equal to or larger than the combined auxiliary blending tube areas at the points of junction with the enlarged section. The self-regulation effect, described above, is provided by satisfying the ratio of 1 and above between the enlarged section cross-sectional area and the combined auxiliary blending tube areas at the points of junction with the enlarged section.

If the discharge rate is less than the maximum combined flow rates of the hopper and the main and auxiliary blending tubes, then a densely-packed but flowing region will build up in the enlarged section until the auxiliary tube openings are almost completely blocked. This densely-packed region acts as a throttle for the auxiliary tube flow, preventing the tubes from flowing at their maximum rates. It is in this context that the auxiliary tube is said to be exhibiting "blocked flow characteristics". If the discharge rate were to increase, then the height of the densely-packed region would drop and the auxiliary tube flowrate would increase. (The opposite applies for a decrease in discharge rate).

Employing a blender having an unblocked main blending tube and a plurality of blocked auxiliary blending tubes communicating with the outlet of the main tubes in the manner shown in Figure 2 of the drawings, it has been found that, for operation with bin material level above the metering holes of all the auxiliary tubes, each auxiliary tube provides a generally equal contribution to the total material passed through all the auxiliary tubes.

Since the auxiliary blending tubes 14 are required to feed material over a wide range of flow rates, these tubes do not operate in an "unblocked" manner. If a blending tube is discharging material at a lower rate than is possible with the given number of material inlet metering passages or holes, then a region of densely-packed but flowing material will build up in the tube so that the appropriate number of lower holes are closed by the presence of the

densely-packed region and, therefore, are not feeding. Holes located above the upper level of densely-packed material can feed freely.

As shown in the embodiment of the drawing, each auxiliary blending tube 14 has a multitude of passages or holes which are distributed over only a part of the vertical expanse of the blending region. The combination of upper feeding holes of all the auxiliary tubes are intended to be essentially uniformly distributed over the blending region regardless of the total discharge rate. Whereas, for purposes of illustration in connection with the description of the continuous mode of operation, metering holes have been shown at only specific portions of the auxiliary tubes of the embodiment of blender shown in Figure 1 of the drawings. It is to be understood that for both continuous and batch operation modes such holes may extend up to substantially the entire length of such auxiliary tubes.

A multiplicity of auxiliary tubes (three or more) is used in the embodiment of the drawings so that the upper flow from all of the auxiliary tubes combined will approximate the desired uniform withdrawal from the blending region. The greater the number of auxiliary tubes, the closer the approximation to the ideal case of perfecting uniform withdrawal. However, because a number of holes in each auxiliary blending tube will be feeding material for even the minimum discharge rate, a relatively small number of tubes are needed to match the performance of previously known gravity blending systems with many more blending tubes. This naturally effects a considerable cost reduction.

A small amount of material flow from around the blending skirt 22 into the discharge outlet is most preferably maintained at all times to prevent a non-flowing condition in the lower section of the bin. As shown in Figure 2, the bottom of the main blending tube 12 consists of the conical-shaped blending skirt 22, the bottom of which partially spans the cylindrical section 24 of the outlet hopper. This hopper is designed to provide a "mass flow" with approximately constant material flow velocity across its cross-section. Flow into the outlet hopper will come from both the combined blending tubes and the annular gap 20 between the blending skirt and the inner hopper walls. The ratio of the two flow rates has been found to be approximately equal to the ratio of the annular gap area to that of the blending skirt. The provision of such a lower section ensures that a constant fraction (typically about 12 percent) of the total material flow represents material discharge from the bottom of the main hopper for all discharge rates. The cross-sectional area of the downstream outlet hopper region is greater than that of the enlarged section 16.

During a batch mode of discharge operation, the material level in the blender will be decreasing. Material metering holes or passages

located above the material level become inoperative and it is necessary to provide additional feeding holes which become active only when the material level is lowered. These holes are distributed on the auxiliary blending tubes in such a way that, regardless of the level, material is withdrawn in an approximately uniform manner from the region of the bin containing material. During a continuous mode of operation a constant, predetermined volume of material is in the blender and the additional holes are prevented from feeding by the densely-packed material in the auxiliary blending tubes.

The blender described herein can also be employed with a purging operation as shown in Figure 1 and 2 of the drawing. Such an operation is required if flammable gases tend to evolve from the granular material (e.g., low density polyethylene pellets). By maintaining an air flow through the blender, these gases can be expelled, preventing a combustible mixture from accumulating in the hopper bin.

As shown, the purging gas, such as air, is introduced through inlet conduit 26 and, in turn, the purge inlet line 28 to the purge gas distributor 30 positioned within the hopper bin 10. An additional purge gas line 32 is positioned in the material outlet line 34 immediately upstream of the material outlet sliding gate valve 36. A purge gas valve 38 is positioned in the additional purge gas line 32 and is preferentially maintained open for initial filling only while material outlet valve 36 is closed.

The entire blending apparatus of the invention is shown schematically in Figure 3 of the drawings. The embodiment there shown is a closed blender having a top cover 40 and tube access port closures 42 positioned therein. A dust collector outlet port member 44 is also secured to the top closure 40 as is the entry of resin inlet through resin inlet tube 46. The main blending tube 12 and the six auxiliary blending tubes 14 are also shown as positioned in the interior of the blender body 10. All blending tubes terminate in the enlarged section 16 at the base of the blender. Purge air entering through inlet line 48 passes to both the purge air distributor 50 within the blender body 10 and the lower section of the outlet of the blender. Also positioned as shown in Figure 3 are the outlet slide valve 36 and outlet blender resin line 52.

As shown in Figure 4 of the drawings, the six auxiliary blending tubes 14 are positioned around the main blending tube 12 within blender body 10.

Figure 5 of the drawings shows the main blending tube 12 and the orientation of the main blending tube holes 18a, successively positioned at 90° from each other along the length of the main blending tube. An exploded view showing of the six auxiliary blending tubes 14 appears in Figure 6 of the drawings, together

with a preferred relative positioning arrangement for the auxiliary blending tube holes 18b.

The blender of the embodiment of the figures of the drawings is such that the preferred manner of suspension of the main and auxiliary blending tubes is shown as a triple level assembly of supporting members designated as 54a, 54b and 54c in Figures 1 and 7. As shown in greater detail in Figure 7, levels 1, 2 and 3 show these assemblies within the outer blender wall 10. Level 1 and level 3 are substantially identical, with level 2 providing the alternate of pair support for levels 1 and 3. Each level support assembly encloses the main blending tube 12 and the auxiliary blending tubes 14 by respective supporting enclosure within outer sleeve members 60 and 62, respectively. These outer sleeve members are, in turn, connected through support members 64 to either of the sleeve members or the blender walls as shown in the three levels of Figure 7.

The method and apparatus of the invention can be employed to effect the blending of any solid granular materials. They are particularly well suited to the blending of materials of thermoplastic resin (such as low density polyethylene, high density polyethylene and the like). Blenders of this type exhibit high blending efficiency and high throughput capacity (i.e. greater than 1.814×10^4 kg (40,000 pounds) per hour) in the handling of polyethylene granular materials.

In an example of the practice of the invention, blending apparatus was constructed capable of providing adjustable material transfer rates (throughput capacity) of between 6.804×10^3 and 1.814×10^4 kg/hr (15,000 and 40,000 pounds/hour) of granular polyethylene material. This blending apparatus was of the general design as shown in the embodiment of the figures of the drawings. This blender is capable of handling a wide variety of granular materials, such as both low and high density granular polyethylene resins.

The total volume of the blender was 3.679×10^2 m³ (13,000 cubic feet) which provided a 1.981×10^2 m³ (7,000 cubic foot) blending volume (the predetermined minimum material volume maintained during continuous mode blending). The outer bin shell of the blender was constructed of 5052-H32 aluminum alloy of 4.88 m (16 feet) inside diameter and approximately 18.29 m (60 feet) in height of the cylindrical section with a bottom hopper angle of 60° from the horizontal.

The outlet hopper insert below the main hopper was constructed of similar aluminum alloy, had a 0.99 m (39 inch) inside diameter, 0.76 m (30 inch) height of the cylindrical section and a hopper angle of 70° from the horizontal. The outlet of the hopper was 0.305 m (12 inches) in inside diameter.

The main blending tube comprises 0.203 m (8-inch) 6061-T6 aluminum alloy pipe of length sufficient to extend to the top of the bin

Thirty-four main blending tube holes, each having a diameter of 34.9 mm (1-3/8 inches) and distributed uniformly over the blending region, were provided. The holes were drilled perpendicular to the tube centre line and deburred. Two holes were positioned in each elevation spaced 180° apart. The hole pairs were positioned with a 90° rotation from those of the preceding elevation position.

The auxiliary blending tubes were six in number, each composed of 6061-T6 aluminum alloy pipes having a 0.152 m (6-inch) diameter and of length sufficient to extend to the top of the bin. Each of the auxiliary blending tubes had a group of from 16 to 48 holes of 34.9 mm (1-3/8 inch) diameter which were relatively positioned in a hole pattern similar to that employed in the main blending tube.

The purge air flow rate of 7.075 m³/min (250 SCFM) is provided to be maintained at all times.

The minimum discharge rate for the operation of the blender employing high density polyethylene material is 6.804×10^3 kg (15,000 pounds) per hour, with a calculated 4.781×10^3 kg (10,540 pounds) per hour flowing through the main tube, 1.104×10^3 (2435 pounds) per hour flowing through the combined auxiliary tubes and 9.185×10^2 kg (2025 pounds) per hour flowing through the annular gap 20 between the blending skirt and the hopper bin walls.

The maximum discharge rate is 1.814×10^4 kg (40,000 pounds) per hour with a calculated 4.781×10^3 kg (10,540 pounds) per hour passing through the main tube, 1.091×10^4 kg (24,060 pounds) per hour through the combined auxiliary tubes and 2.449×10^3 kg (5400 pounds) per hour passing through the annular gap. The annular gap flow is always a fixed percentage of the total output, but the main blending tube flows a constant rate of material and the aggregate auxiliary blending tubes flow a self-regulated output to provide the additional material required.

In this embodiment, four holes of 38.1 mm (1-1/2 inch) diameter were positioned near the top of all seven blending tubes, below the blender roof and well above the maximum resin level, to provide for equalization of pressure within the tubes.

It is, of course, well understood to those skilled in the solid material blending art that the parameters of the elements of apparatus of the invention are to be dimensioned to effect most preferred results for various materials, including the volume to be handled and flow rates most preferred from the standpoint of the blending operation.

Claims

1. A method for the high efficiency blending of solid particulate materials which comprises introducing the materials to be mixed into a bin and withdrawing one portion of said solid par-

with a preferred relative positioning arrangement for the auxiliary blending tube holes 18b.

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Claims

1. A method for the high efficiency blending of solid particulate materials which comprises introducing the materials to be mixed into a bin and withdrawing one portion of said solid par-



ticulate materials by gravity through a downwardly-extending blending tube having positioned, through the walls thereof, a plurality of material inlet passages, characterised in that the said passages are positioned and dimensioned to provide unblocked flow characteristics (which means a condition of material under gravity through a substantially vertical tube in which the flow rate of material entering the tube at its upper end is less than the maximum flow rate that the material could experience in leaving the lower end of the tube, so that there is essentially no packing between the particles within the tube) therethrough, and in that the method further comprises withdrawing another portion of said solid particulate materials by gravity through a plurality of downwardly extending auxiliary blending tubes having positioned, through the walls thereof, a plurality of material inlet passages positioned and dimensioned to provide blocked flow characteristics (which means a condition of flow of material under gravity through a substantially vertical tube in which the flow rate of material entering the tube at its upper end is at least as great as the flow rate of material leaving the tube at its lower end, so that there is some degree of packing between the particles within the tube) therethrough; joining the portions of material in an enlarged section below the main tube and near the downstream ends of all of said main blending tube and auxiliary blending tubes which joined portions of material are passed therefrom as a blended stream; and maintaining unblocked flow characteristics in said main blending tube while maintaining blocked flow characteristics in said plurality of auxiliary blending tubes.

2. A method as claimed in claim 1 wherein a portion of said materials is passed by gravity as an outer annular stream between said enlarged section and the walls of said bin to a downstream region where it further blends with said blended stream.

3. An apparatus for the high efficiency blending of solid particulate materials which comprises an outer hoppered bin having means for the introduction thereinto of materials to be mixed and a downwardly-extending blending tube positioned therein and having passing through the walls thereof a plurality of material inlet passages, characterised in that the said passages are positioned and dimensioned to provide unblocked flow characteristics therethrough, and in that the apparatus further comprises a plurality of downwardly-extending auxiliary blending tubes positioned therein and having passing through the walls thereof a plurality of material inlet passages positioned and dimensioned to provide blocked flow characteristics therethrough; said main and said auxiliary blending tubes joining in an enlarged section below the main tube and near their downstream ends to pass a blended stream of material flow therethrough while maintaining

unblocked flow characteristics in said main blending tube and blocked flow characteristics in said plurality of auxiliary blending tubes.

4. An apparatus as claimed in claim 3 wherein said hoppered bin provides an outer annular passage of hoppered material flow around said enlarged section and means for joining the hoppered material flow with said blended stream of flow at a downstream region of final blending in a zone having a larger cross-sectional area than said enlarged section.

Patentansprüche

1. Verfahren zum hochwirksamen Vermischen von festen teilchenförmigen Materialien, bei dem man die zu vermischenden Materialien in einen Behälter einführt und einen Teil der festen teilchenförmigen Materialien durch die Schwerkraft über ein sich nach unten erstreckendes Mischrohr abzieht, das durch seine Wände hindurch mehrere Materialeinlässe aufweist, dadurch gekennzeichnet, daß die Einlässe derart angeordnet und dimensioniert sind, daß sie eine nicht blockierende Strömungscharakteristik ergeben (d.h. eine Materialströmung unter dem Einfluß der Schwerkraft durch ein im wesentlichen vertikales Rohr, bei der die Strömungsgeschwindigkeit des Materials, das in das Rohr an seinem oberen Ende eintritt, niedriger ist als die maximale Strömungsgeschwindigkeit, die das Material beim Verlassen des unteren Endes des Rohres erfahren kann, so daß im wesentlichen keine Verdichtung zwischen den Teilchen im Inneren des Rohres stattfindet), und daß ein weiterer Teil der festen teilchenförmigen Materialien durch die Schwerkraft über mehrere sich nach unten erstreckende Hilfsmischrohre abgezogen wird, die durch ihre Wände hindurch mehrere Materialeinlässe aufweisen, die derart angeordnet und dimensioniert sind, daß sie eine blockierende Strömungscharakteristik ergeben (d.h. eine Materialströmung unter dem Einfluß der Schwerkraft durch ein im wesentlichen vertikales Rohr, bei der die Strömungsgeschwindigkeit des Materials, das in das Rohr an seinem oberen Ende eintritt, zumindest genauso groß ist wie die Strömungsgeschwindigkeit des Materials, das das Rohr an seinem unteren Ende verläßt, so daß eine gewisse Verdichtung zwischen den Teilchen im Inneren des Rohres stattfindet), daß man die Anteile des Materials in einem vergrößerten Abschnitt unterhalb des Hauptrohres und nahe den stromabseitigen Enden des Hauptmischrohres und der Hilfsmischrohre vereinigt, von wo aus die vereinigten Materialanteile als Mischstrom geführt werden, und eine nicht blockierende Strömungscharakteristik in dem Hauptmischrohr sowie eine blockierende Strömungscharakteristik in dem mehreren Hilfsmischrohren aufrechterhält.

2. Verfahren nach Anspruch 1, worin ein Teil



des Materials durch die Schwerkraft als äußerer Ringstrom zwischen dem vergrößerten Abschnitt und den Wänden des Behälters zu einem stromabseitigen Bereich geführt wird, wo er weiter mit dem Mischstrom vermischt wird.

3. Vorrichtung zum hochwirksamen Vermischen von festen teilchenförmigen Materialien mit einem äußeren, mit einem Trichter versehenen Behälter, der eine Einrichtung zum Einführen der zu vermischenden Materialien und eine sich nach unten erstreckendes Mischrohr darin angeordnet aufweist, welches durch seine Wände hindurch mehrere Materialeinlässe aufweist, dadurch gekennzeichnet, daß die Einlässe derart angeordnet und dimensioniert sind, daß sie eine nicht blockierende Strömungscharakteristik ergeben, und daß die Vorrichtung ferner mehrere, sich nach unten erstreckende Hilfsmischrohre darin angeordnet aufweist, die durch ihre Wände hindurch mehrere Materialeinlässe aufweisen, welche derart angeordnet und dimensioniert sind, daß sie eine blockierende Strömungscharakteristik ergeben, wobei sich die Haupt- und Hilfsmischrohre in einem vergrößerten Abschnitt unterhalb des Hauptrohres und nahe ihrer stromabseitigen Enden vereinigen, so daß ein gemischter Materialstrom hindurchtritt, während in dem Hauptmischrohr eine nicht blockierende Strömungscharakteristik und in den mehreren Hilfsmischrohren eine blockierende Strömungscharakteristik aufrechterhalten wird.

4. Vorrichtung nach Anspruch 3, worin der mit einem Trichter versehene Behälter einen äußeren ringförmigen Durchlaß für eine trichterförmige Materialströmung um den vergrößerten Abschnitt herum und eine Einrichtung zum Vereinigen der trichterförmigen Materialströmung mit dem vermischten Materialstrom in einem stromabseitigen Bereich des endgültigen Vermischens in einer Zone mit größerer Querschnittsfläche als der vergrößerte Abschnitt aufweist.

Revendications

1. Procédé pour le mélange à haute efficacité de matières particulaires solides qui consiste à introduire les matières à mélanger dans un silo et à retirer une partie desdites matières particulaires solides par gravité au moyen d'un tube de mélange s'étendant vers le bas et à travers les parois duquel sont positionnés plusieurs canaux d'entrée de matière, caractérisé en ce que lesdits canaux sont positionnés et dimensionnés pour établir des caractéristiques d'écoulement non bloqué (ce qui signifie une condition d'écoulement de la matière par gravité dans un tube sensiblement vertical dans lequel le débit d'écoulement de la matière entrant dans le tube, à son extrémité supérieure, est inférieure au débit d'écoulement maximal que la matière peut avoir en sortant de l'extrémité inférieure du tube, de manière qu'il

ne se produise pratiquement pas de tassement des particules à l'intérieure du tube), et en ce que le procédé consiste en outre à retirer une autre partie desdites matières particulaires solides par gravité au moyen de plusieurs tubes auxiliaires de mélange s'étendant vers le bas, à travers les parois desquelles sont positionnés plusieurs canaux d'entrée de matières positionnés et dimensionnés pour établir des caractéristiques d'écoulement bloqué, (ce qui signifie une condition d'écoulement de la matière par gravité dans un tube sensiblement vertical dans lequel le débit d'écoulement de la matière entrant dans le tube à son extrémité supérieure est au moins aussi grand que le débit d'écoulement de la matière sortant à son extrémité inférieure, afin qu'il se produise un certain degré de tassement des particules à l'intérieure du tube); à rassembler les parties de matière dans une section élargie au-dessous du tube principal et à proximité des extrémités aval de la totalité dudit tube principal de mélange et desdits tubes auxiliaires de mélange, lesquelles parties rassemblées de matières en sortent en un courant mélangé; et à maintenir des caractéristiques d'écoulement non bloqué dans ledit tube de mélange principal tout en maintenant des caractéristiques d'écoulement bloqué dans lesdits plusieurs tubes de mélange auxiliaires.

2. Procédé selon la revendication 1, dans lequel une partie de ladite matière passe par gravité, sous forme d'un courant annulaire extérieure, entre ladite partie élargie et les parois dudit silo vers une région aval où elle se mélange avantage avec ledit courant mélangé.

3. Appareil pour le mélange à haute efficacité de matières particulaires solides, qui comprend un silo extérieure à trémie ayant des moyens pour y introduire des matières à mélanger et un tube de mélange s'étendant vers le bas, positionné dans ce silo et dont les parois sont traversées par plusieurs canaux d'entrée de matière, caractérisé en ce que lesdits canaux sont positionnés et dimensionnés pour établir des caractéristiques d'écoulement non bloqué, et en ce que l'appareil comprend en outre plusieurs tubes auxiliaires de mélange s'étendant vers le bas, positionnés à l'intérieur et dont les parois sont traversées par plusieurs canaux d'entrée de matière positionnés et dimensionnés pour établir des caractéristiques d'écoulement bloqué; lesdits tubes principal et auxiliaires de mélange se rejoignant en une section élargie au-dessous du tube principal et à proximité de leurs extrémités aval afin d'écouler un courant mélangé de matière tout en maintenant des caractéristiques d'écoulement non bloqué dans ledit tube principal de mélange et des caractéristiques d'écoulement bloqué dans lesdits plusieurs tubes auxiliaires de mélange.

4. Appareil selon la revendication 3, dans lequel ledit silo à trémie délimite un canal annulaire extérieure dans lequel la matière de la trémie s'écoule autour de ladite section élargie, et des moyens destinés à rassembler l'écou-



ment de matière de la trémie avec ledit courant
d'écoulement mélangé en une région aval de

mélange final, dans une zone ayant une aire en
section supérieure à ladite section élargie.

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