METHOD AND APPARATUS FOR MANUFACTURING MICROFIBRILLATED CELLULOSE FIBER

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ABSTRACT
The invention provides a regulating apparatus (10) for regulating the movement of spherical elements from one location, typically from a container (14), to another. The apparatus (10) includes a cylindrical tubular member (18) and a feed head (20) mounted in the spherical tubular member (18) so that it is rotatable relative thereto about an axis of rotation (22). A feed passage (32) opens upwardly out of a radially outer edge portion of the feed head (20). As the feed head (20) rotates, spherical elements enter the feed passage (32) and are discharged therefrom.
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[0001] THE INVENTION relates to a method of controlling the movement of spherical elements and to apparatus for regulating the movement of spherical elements.

[0002] The Inventors are aware of situations where it is desirable to control the movement of elements from one location to another.

[0003] One such situation is in a nuclear power plant making use of a high temperature gas cooled reactor of the pebble bed type. Pebble bed reactors make use of spherical fuel elements and spherical moderator elements and it is extremely important that the movement of the spherical elements through the reactor and around the plant be carefully controlled.

[0004] According to one aspect of the invention there is provided a method of controlling the movement of spherical elements which includes the steps of

[0005] feeding the spherical elements into a downwardly directed feed path; and

[0006] rotating a feed head in the feed path to regulate the movement of the spherical elements through a feed passage which leads from the feed path.

[0007] The method may include feeding the spherical elements from a container in which the elements are contained into the feed path. Hence the method may be particularly well suited to the dispensing of spherical elements from a container containing the elements.

[0008] The method may include regulating the rate at which the spherical elements enter the feed passage.

[0009] Regulating the rate at which spherical elements enter the feed passage may include permitting the spherical elements to enter the feed passage only at one or more predetermined positions of the head.

[0010] According to another aspect of the invention there is provided regulating apparatus for regulating the movement of spherical elements from one location to another, which apparatus includes

[0011] a feed path defining means defining a downwardly extending feed path within which spherical elements are receivable;

[0012] at least one feed passage leading from the feed path; and

[0013] a feed head mounted for rotation in the feed path to regulate the flow of spherical elements from the feed path into the feed passage.

[0014] The invention may find application particularly in the dispensing of spherical elements from a container containing the elements the feed path then typically extends downwardly from an outlet of the container containing the spherical elements.

[0015] The feed passage may be dimensioned to permit the passage of spherical elements in single file therethrough.

[0016] In one embodiment of the invention the feed passage may have an upper end which opens upwardly out of the feed head.

[0017] The feed head may have an upper surface which is inclined so as to feed the spherical elements in the feed path towards the upper end of the feed passage. In a preferred embodiment of the invention, the upper surface of the feed head may taper upwardly inwardly from a radially outer edge thereof, the upper end of the passage opening out of the feed head at a radially outer edge region thereof.

[0018] It will be appreciated that with the arrangement described above, the spherical elements can enter and pass through the feed passage one at a time providing a degree of control of the discharge of the elements from the container. However, it may be desirable to regulate the rate at which the spherical elements are discharged more closely.

[0019] To this end, the regulating apparatus may include regulating means for regulating the rate at which spherical elements pass through the feed passage. This may be achieved by regulating the rate at which the spherical elements enter the feed passage.

[0020] Hence, the method may include permitting the spherical elements to enter the feed passage only at one or more predetermined positions of the feed head. In this way the number of spheres entering the feed passage per revolution of the feed head can be closely controlled.

[0021] The regulating means may include a discontinuous barrier which covers the upper end of the feed passage and inhibits the entry of spheres into the feed passage for part of the rotation of the feed head.

[0022] The barrier may be formed by a circumferential shoulder which is positioned adjacent the upper surface of the radially outer edge region of the feed head, the shoulder having at least one radially inwardly and downwardly open recess within which recess a spherical element is receivable. Hence under the influence of gravity a spherical element will enter the recess. As the feed head rotates, each time the upper end of the feed passage comes into register with the recess a spherical element will enter the passage. Preferably, a plurality of circumferentially spaced recesses is provided in the shoulder. Hence, the number of spherical elements being discharged per revolution of the feed head will correspond to the number of recesses.

[0023] In another embodiment of the invention the feed passage has an upper end which opens upwardly into the feed path, a lower end which is angularly offset from the upper end and an intermediate portion extending between the upper and lower ends.

[0024] The intermediate portion may extend circumferentially adjacent to a radially outer surface of the feed head for at least part of its length. Hence, the lower end may be angularly offset from the upper end in the direction of rotation of the feed head.

[0025] A plurality of circumferentially spaced feed passages may be provided.

[0026] The invention extends to a nuclear power plant which includes a spherical element handling system including at least one regulating apparatus of the type described above.

[0027] The invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings.
In the drawings:
FIG. 1 shows a schematic sectional elevation of regulating apparatus in accordance with the invention;
FIG. 2 shows a schematic sectional elevation, similar to FIG. 1, of another regulating apparatus in accordance with the invention;
FIG. 3 shows a side elevation taken at III-III in FIG. 2;
FIG. 4 shows a schematic sectional elevation, similar to FIGS. 1 and 2, of another regulating apparatus in accordance with the invention;
FIG. 5 shows a sectional elevation of the apparatus of FIG. 4 taken at 90° relative to the elevation of FIG. 4;
FIG. 6 shows a plan view of the apparatus of FIGS. 4 and 5;
FIG. 7 shows a three-dimensional fragmentary view of the apparatus of FIGS. 4 to 6; and
FIG. 8 shows a plan view, similar to FIG. 6, of yet another regulating apparatus in accordance with the invention.

In FIG. 1 of the drawings, reference numeral 10 refers generally to regulating apparatus in accordance with the invention.

The regulating apparatus 10 is intended for dispensing spherical elements 12, particularly fuel spheres and/or moderator spheres from a container 14 in which the spherical elements 12 are contained. The container 14 includes a downwardly directed outlet 16 which opens out of a bottom of the container 14. The bottom of the container 14 is inclined downwardly towards the outlet 16 so as to feed the spherical elements 12 contained therein towards the outlet 16.

The regulating apparatus 10 includes a cylindrical tubular member 18 extending downwardly from the outlet 16 of the container 14. A feed head 20 is mounted in the cylindrical tubular member 18 such that it is rotatable relative thereto about an axis of rotation 22. The feed head 20 is dimensioned such that the clearance between the feed head 20 and the inner surface of the tubular member 18 is too small to permit a spherical element 12 to enter therebetween.

The feed head 20 comprises a circular cylindrical centre portion 24, a generally conical upper portion 26 and a tubular stem 28, the upper portion 26 and stem 28 being provided on opposite sides of the centre portion 24. The stem 28 typically functions as a drive shaft.

The upper portion 26 has an upper surface or crown 30 which slopes downwardly outwardly from the centre thereof towards the radially outer edge thereof.

A feed passage 32 extends downwardly through the feed head 20. More particularly, the feed passage 32 has an upper end 32.1 which opens upwardly out of the crown 30 in a radially outer edge portion thereof. Initially, the feed passage 32 extends vertically downwardly from its upper end 32.1 whereafter it extends downwardly and radially inwardly towards the centre of the feed head 20 and then downwardly through the stem or drive shaft 28. A drive mechanism (not shown) will typically be drivingly connected to the drive shaft 28 whereby the shaft and hence the feed head 20 is rotatable about the axis 22.

In the embodiment described above, the tubular member 18 defines a feed path 34.

In use, the spherical elements 12 are fed under the influence of gravity through the outlet 16 and down the feed path 34 where they accumulate on top of the feed head 20. In addition, by virtue of the inclination of the crown 30, the spherical elements 12 are urged radially outwardly and downwardly. As the feed head 20 rotates about the axis 22, the spherical elements will be arranged in a circular row of spherical elements along the radially outer edge portion of the crown 30. As the spherical elements 12 line up with the upper end 32.1 of the feed passage 32 they fall downwardly into the feed passage, under the influence of gravity. In this way, the discharge of the spherical elements can be controlled. However, the possibility does exist that strings of spherical elements may be discharged and it may be desirable to control the rate at which the spherical elements are discharged more closely.

Hence, in another embodiment of the invention, shown in FIGS. 2 and 3 of the drawings, in which unless otherwise indicated, the same reference numerals are used to designate similar parts, a tubular insert 40 is positioned within the member 18.

Typically, the wall thickness of the insert 40 will be slightly larger than the diameter of a spherical element 12. A plurality of inwardly and downwardly opening recesses 42 is provided in a lower edge of the insert 40, the recesses 42 being separated by circumferentially extending lands 44. Each recess 42 will typically be dimensioned such that a single spherical element 12 is receivable therein.

Hence, in use, in this embodiment of the invention, the spherical elements 12 will be urged under the influence of gravity downwardly so that a spherical element 12 will enter each of the recesses 42. When the upper end 32.1 of the feed passage 32 is in register with one of the lands 44 then the feed path 34 is essentially blocked off inhibiting the entry of a spherical element therein. However, when the upper end 32.1 comes into register with one of the recesses 42, the spherical element positioned in the recess falls into the feed path 34 and can be discharged at a desired location in the usual manner. In this way, the number of spherical elements discharged per revolution of the feed head 20 can be closely controlled.

Naturally, dimensions of the components of the regulating apparatus could vary. However, the Inventors believe that the feed path 34 will typically have an internal diameter which is at least six times the diameter of the spherical elements with which the regulating apparatus is intended for use.

The Inventors believe that regulating apparatus in accordance with the invention will permit a controlled discharge of spherical elements. In addition, the Inventors believe that the apparatus will inhibit the formation of blockages as a result of bridge building. Further, the apparatus will permit the unloading of spheres to be interrupted, e.g. by stopping the feed head in a position in which the upper end 32.1 of the feed passage 32 is in register with one of the lands 44. The apparatus will also permit the discharge of spherical elements in a manner which reduces the risk of
damage to the spherical elements. In addition, by virtue of the relative simplicity of the apparatus, the Inventors believe that it will be reliable in operation.

[0050] Reference is now made to FIGS. 4 to 7 of the drawings, in which reference numeral 50 refers generally to part of another regulating apparatus in accordance with the invention and, unless otherwise indicated, the same reference numerals used above are used to designate similar parts.

[0051] In this embodiment of the invention, the feed passage 32 does not extend through the drive shaft 28. Accordingly, the drive shaft need not necessarily be hollow although this possibility is not excluded.

[0052] Further, the tubular member 18 has a portion of generally increased wall thickness, generally indicated by reference numeral 52. The wall thickness increases downwardly such that a portion 18.1 of a radially inner surface of the tubular member 18 tapers inwardly downwardly.

[0053] The feed passage 32 has an upper end 54 which opens upwardly out of the surface 18.1. The feed passage 32 further has a lower end 56 which is inclined downwardly and spaced angularly from the upper end 54 and an intermediate portion 58 extending between the upper end portion 54 and the lower end portion 56. The upper end portion 54 and intermediate portion 58 are defined by a recess in the tubular member 18 and a surface of the feed head 20.

[0054] The dimensions of the feed passage 34 are selected such that the spherical elements 12 can enter and pass along the feed passage 32 one at a time.

[0055] In use, the feed head 20 is rotated in the direction of arrow 60. This serves to agitate the spherical elements 12 within the tubular member 18 so that they become aligned with and enter the upper end 54 of the feed passage 32. The spherical elements move downwardly, under the influence of gravity, into the intermediate portion 58 of the feed passage 32 and are transported therealong as a result of the rotation of the head 20. The spherical elements 12 then come into register with the lower end 56 of the feed passage 32 and are discharged, under the influence of gravity, therethrough.

[0056] Reference is now made to FIG. 8 of the drawings, in which reference numeral 70 refers generally to part of yet another regulating apparatus in accordance with the invention and, unless otherwise indicated, the same reference numerals used above are used to designate similar parts.

[0057] The main difference between the apparatus 70 and the apparatus 50 is that, whereas in the apparatus 50 a single feed passage 32 is provided, in case of the apparatus 70, two angularly spaced feed passages 32 are provided. Naturally, any number of feed passages could be provided.

[0058] A cavity 80 (FIG. 5) is provided below the feed head 20 within which dust and wear products are receivable without influencing the operation of the apparatus.

[0059] The Inventors believe that by not routing the feed passage through the drive shaft 28, the drive arrangement can be simplified. This further leads to a reduction in the radiation hazard to maintenance and operating personnel. The Inventors further believe that the apparatus shown in FIGS. 4 to 8 of the drawings will further reduce the risk of damage to the spherical elements.

1. A method of controlling the movement of spherical elements which includes the steps of
   - feeding the spherical elements into a downwardly directed feed path;
   - rotating a feed head in the feed path to regulate the movement of the spherical elements through a feed passage which leads from the feed path; and
   - regulating the rate at which the spherical elements enter the feed passage.

2. A method as claimed in claim 1, which includes feeding the spherical elements from a container in which the elements are contained into the feed path.

3. A method as claimed in claim 1 or claim 2, in which regulating the rate at which spherical elements enter the feed passage includes permitting the spherical elements to enter the feed passage only at one or more predetermined positions of the feed head.

4. Regulating apparatus for regulating the movement of spherical elements from one location to another, which apparatus includes
   - a feed path defining means defining a downwardly extending feed path within which spherical elements are receivable;
   - at least one feed passage leading from the feed path;
   - a feed head mounted for rotation in the feed path to regulate the flow of spherical elements from the feed path into the feed passage; and
   - regulating means for regulating the rate at which spherical elements pass through the feed passage.

5. Regulating apparatus as claimed in claim 5, in which the feed path extends downwardly from an outlet of a container containing the spherical elements.

6. Regulating apparatus as claimed in claim 4 or claim 5, in which the feed passage is dimensioned to permit the passage of spherical elements in single file therethrough.

7. Regulating apparatus as claimed in any one of claims 4 to 6, inclusive, in which the feed passage has an upper end which opens upwardly out of the feed head.

8. Regulating apparatus as claimed in claim 7, in which the feed head has an upper surface which is inclined so as to feed the spherical elements in the feed path towards the upper end of the feed passage.

9. Regulating apparatus as claimed in claim 8, in which the upper surface of the feed head tapers upwardly inwardly from a radially outer edge thereof, the upper end of the feed passage opening out of the feed head at a radially outer edge region thereof.

10. Regulating apparatus as claimed in claim 9, in which the regulating means includes a discontinuous barrier which covers the upper end of the feed passage and inhibits the entry of spherical elements into the feed passage for part of the rotation of the feed head.

11. Regulating apparatus as claimed in claim 10, in which the barrier is formed by a circumferential shoulder which is positioned adjacent the upper surface of the radially outer edge region of the feed head, the shoulder having at least one radially inwardly and downwardly open recess in which recess a spherical element is receivable.
12. Regulating apparatus as claimed in claim 11, in which a plurality of circumferentially spaced recesses is provided in the shoulder.

13. Regulating apparatus as claimed in any one of claims 4 to 6, inclusive, in which the feed passage has an upper end which opens upwardly into the feed path, a lower end which is angularly offset from the upper end and an intermediate portion extending between the upper and lower ends.

14. Regulating apparatus as claimed in claim 13, in which the lower end is angularly offset from the upper end in the direction of rotation of the feed head.

15. Regulating apparatus as claimed in claim 14, in which the intermediate portion extends circumferentially adjacent to a radially outer surface of the feed head for at least part of its length.

16. Regulating apparatus as claimed in any one of claims 13 to 15, inclusive, in which a plurality of circumferentially spaced feed passages is provided.

17. A nuclear power plant which includes a spherical element handling system including at least one regulating apparatus as claimed in any one of claims 4 to 16, inclusive.

18. A method as claimed in claim 1, substantially as described and illustrated herein.

19. Regulating apparatus as claimed in claim 4 substantially as described herein.

20. A new method, apparatus or power plant substantially as described and illustrated herein.