

METHOD AND APPARATUS FOR LOADING CATALYST

BACKGROUND OF THE INVENTION

Field of the Invention

5 [0001] Embodiments of the present invention generally relate to methods and apparatus for filling particulate material into a tube. More particularly embodiments of the present invention generally relate to methods and apparatus for filling a catalyst into a tube of a primary reformer furnace.

Description of the Related Art

10 [0002] Primary reformer furnaces such as those used in the production of ammonia, hydrogen and methanol typically utilize tens or hundreds of heat transfer tubes that are filled with catalyst particles. These tubes must initially be filled with catalyst, and used catalyst must be replaced with fresh catalyst periodically. Voids in the catalyst fill can easily form if catalyst particles are introduced to the tubes too quickly or non-uniformly during the filling of the tubes. Also, catalyst particles can fracture or crush if they are
15 allowed to free-fall too far during filling of the tubes. Voids or crushed catalyst create local density variations as well as a catalyst density that is less than optimal. Local density variations differ from tube to tube and cause variations in the pressure drop over the tubes. This results in distortions of gas distribution in a multi-tube reactor and causes uneven temperature distribution over the tubes during operation of the reactor. The
20 resultant thermal and mechanical stress in the tube can reduce its useful life. To reduce voids the tube can be vibrated by such methods as tapping or vibrating the upper part of the tube. However, this is laborious and delays the filling operation. Additionally, tapping or vibration can expose the tube to extra mechanical stress. If excessive crushing or fracturing of catalyst particles occurs during filling, the only remedy is to remove all
25 catalyst from the tube and refill it properly. This adds substantial labor and results in the loss of expensive catalyst

[0003] One method for reducing density variations utilizes a short sock or sock-like member made of a material such as a soft plastic that is first filled with the catalyst. The catalyst can be delivered from the manufacturer already in the socks. When filling the

tubes, a sock filled with catalyst is fastened onto a line and lowered towards the bottom of each tube. By jerking the line, the sock opens at its bottom and the catalyst flows into the tube with a minimum of free fall. However, there are several disadvantages with this method. Filling one tube with this method usually requires a number of the socks
5 thereby making the method laborious. Sometimes, the sock will open prematurely, allowing the catalyst particles to fall a great distance and achieve enough gravimetrically induced velocity to crush or fracture when they hit the bottom of a tube. If the sock contains voids among the particles of catalyst, then corresponding voids will typically form in the tube when the sock is emptied. Consequently, the tubes must be exposed to
10 tapping or vibrating to secure reasonably even gas distribution over the tubes.

[0004] Another method for attaining good and even packing of catalyst into a tube includes filling the tube with water and then pouring in the catalyst. However, this method requires that the water subsequently be completely removed. Removal of the water and necessary subsequent drying takes a long time. Additionally, used water
15 requires special treatment, adding time and cost.

[0005] RD Patent Application RD-253040-A describes a method for filling a tube with a catalyst by adding the catalyst to the upper part of the tube by means of a transporter comprising a slowly rotating arrangement. The catalyst is transported from a container through a duct in which there is a rod with oblique/transverse propeller wings or brushes.
20 The catalyst particles are then transported to the upper end of the catalyst tube and fall smoothly into the tube. However, the particles must be added slowly in order to get even filling of the tube. Further, the catalyst drops a significant length especially during the first part of the filling operation thereby permitting the catalyst to be crushed or broken during the fall. Therefore, the particles can pack unevenly over the vertical length of the
25 tube and the filling time can be long.

[0006] Therefore, there exists a need for a catalyst loading tool that is cost effective to manufacture and is easily configurable to accommodate particular loading requirements for a given reactor. There exists a further need for a catalyst loading tool that permits filling of reactor tubes evenly without breaking the catalyst particles.

SUMMARY OF THE INVENTION

[0007] Embodiments of the present invention generally relate to methods and apparatus that prevent breakage of a catalyst particle and evenly fill the catalyst into tubes to an optimum density. The loading tool comprises a plurality of damper members extending
5 from a centerline of the tube in at least one radial direction but in every case, having a diameter smaller than the inner diameter of the tube. For example, in one embodiment the damper members are shaped in a "Z"-like formation with each having a different rotational orientation than the adjacent one above or below it. The Z formations can be horizontally arranged along a central member or can be formed vertically in a unitary
10 fashion from a single, stiffened member. In another embodiment, the dampers are formed into spiral or helical shapes that increase or decrease in diameter along the length of the tube.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] So that the manner in which the above recited features of the present invention
15 can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective
20 embodiments.

[0009] Figure 1 shows one embodiment of a damper member that is formed horizontally relative to a filler tube.

[0010] Figure 2 shows the dampers of Figure 1 arranged along a central member.

[0011] Figure 3 is a top view of the embodiment of Figure 2 in a tube.

25 [0012] Figure 4 is a section view showing the tool of Figure 2 in a loading tube being filled with particles.

[0013] Figure 5 is a top view of another embodiment of a tool where the dampers are

spiral-shaped.

[0014] Figure 6 is a side view showing the spiral-shaped dampers in a tube being filled with pellets.

[0015] Figure 7 is a top view of another embodiment of the invention wherein the damper members are vertically arranged and rotated relative to each other.

[0016] Figure 8 is a side view showing the embodiment of Figure 7 in a tube being filled with pellets.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0017] The present invention is used with a catalyst filling process where pellets of catalyst are placed in a tube with the help of a loading tool. The loading tool comprises dampers that are formed into repeating shapes from material such as a wire or the like in a manner whereby at least a portion of the dampers are substantially transverse and axially arranged to provide substantially circumferential coverage along a longitudinal length of the tube. The distance between damper members can be substantially equal or can vary. The plurality of damper members reduces the falling velocity of the particles and diverts the particles from falling in straight downward paths.

[0018] In the embodiment shown in Figures 1-4, dampers 10 are arranged in a horizontal manner along a central member 30. Each damper is symmetrically shaped and includes a central portion 12 and arms 15 extending outwards from each side of the portion 12 in a single plane that is perpendicular to the longitudinal axis of the central member 30. In the embodiment shown, a cross arm 20 extends at an angle of less than ninety degrees from an end of each arm 15. As shown in Figures 2 and 4, the dampers 10 are arranged along the central member 30 in a manner wherein each damper is rotationally distinct from the adjacent damper and whereby the arms 15 and cross arms 20 extend into an annular area 65 formed between the central member 30 and an inside wall 55 of a tube 60. The result of the rotational differences are evident in Figure 3. While there is no contact between the damper 10 and the wall 55, the arms extend outwards far enough that pellets 70 are interrupted by the arms 15, 20 from free falling to

the bottom of the tube 60. Depending on the job and the needs of an operator, the arms 15 can extend outwards at a 90 degree angle from the central member and the cross arms 20 can likewise extend at a 90 degree angle from the arms. Figure 4 illustrates the loading tool in use. The tool is lowered into tube the 60 in a coaxial manner with an annular space between the tool and an inner wall 55 of the tube. Thereafter, pellets 70 are dropped into the tube 60 and contact various dampers as they fall towards the bottom of the tube. The tool can either remain stationary in the tube the pellets approach the bottom of the tool, at which point the tool can be periodically raised until the tube is full, or the tool can be gradually and continuously pulled upwards as the tube fills. Either of these two methods can be accomplished manually or automatically with an appropriate mechanical device.

[0019] Figures 5 and 6 illustrate another embodiment of the loading tool 150. As shown, the dampers 105 making up the tool consist of a plurality of spiral or helix-shaped members, each of which has a slightly increased or reduced outer diameter than the adjacent spiral and all preferably formed of the same wire or stiffened member. Figure 5 is a top view showing how the spiral shapes of the dampers 105 substantially cover the interior of a tube to stop the freefall of pellets being loaded into the tube. Considering Figure 6, it can be appreciated for example, that spiral 106 is larger in diameter than the spiral 107 thereabove but is smaller than the next lower spiral 108. In the embodiment shown in Figure 6, the spirals increase in diameter along a first longitudinal length of the tool and then decrease along a second length. In this manner, the loading tool has a consistent center line and the stiffened member from which it is formed can traverse a portion of the tube prior to forming another group of dampers. In each case, an annular area remains between the outer diameter of each damper and an inside wall 55 of the tube 60. Shaping of the damper members and changes to length, stiffness, number, axial spacing of the spirals along the length of the wire, etc., can be adapted to the material to be filled into the tube and the size of the tube. These changes can be accomplished since the damper is relatively inexpensive and can be adjusted easily. As shown in Figure 6, multiple dampers can be used along a tube's length and the distance between them can be varied.

[0020] In another embodiment shown in Figures 7 and 8, each damper 200 of the loading tool is formed in the shape of a partial "Z" and each is connected in a rotationally fixed and distinct manner relative to dampers above and below it. Each Z shape includes an upper horizontal leg 210, a diagonal connecting leg 215 and a lower horizontal leg 220. Upper and lower legs 210 and 220 are foreshortened and connected to a leg of the next Z at a mid point 221 such that a constant center line of the damper is maintained relative to the longitudinal axis of the tube 60. Due to the unitary design, the dampers 200 can be formed of stiff material and in a manner whereby they remain rotationally distinct from each other while sharing the same center line.

[0021] Figure 7 is a top view of one arrangement as it would appear in a tube 60. The Z-shaped dampers 200 are arranged whereby they cover essentially the entire radial area of the inner portion of the tube (only the upper leg 200 of each Z shape is visible). In the embodiment of Figure 7, the dampers 200 are each rotated 30 degrees counterclockwise from the damper thereabove and the relative angle of each from the horizontal is labeled. The result is a stair-stepped appearance that is illustrated in a side view in Figure 8 where two complete tools A, B are connected together to form one longer tool that extends the length of the tube 60.

[0022] In addition to the clocked arrangement of Figures 7 and 8, the shapes can be alternately rotated between clockwise and counterclockwise. By "clocking" the shapes in this manner, the pellets 70 are never permitted to fall very far in the tube 60 without hitting a damper. In other words, the vertical distance between dampers along any straight vertical path in the tube is minimized by the design. For example, a first Z could be rotated 30 degrees clockwise from the Z thereabove. A second Z below the first could then be rotated 30 degrees counterclockwise from the first Z. The arrangement creates a loading tool wherein legs of the various Zs are more likely to contact a falling pellet at more equal intervals along the length of the tube 60.

[0023] Since the damper members do not occupy a substantial portion of the cross section of the tube at any particular axial location they can be rigid or flexible and still permit the particles to fall. The loading tool can be moved or jerked primarily in both directions axially and is pulled gradually out of the tube as the tube is filled, or it can

remain stationary while a predetermined amount of catalyst is being added and then pulled upwards in the tube between catalyst filling sequences. As the loading tool is removed from the tube, it can be broken into sections at weakened locations along its length. Therefore, the amount of the loading tool that has to be handled outside of the tube is limited to the length between weakened portions. The particles can pour down into the tube through a funnel that is removed after filling is completed. However, the particles can be added to the tube through other methods known in the art. While the examples shown include "Z" shapes, it will be understood that the dampeners could be of a variety of shapes, which can all be substantially identical along the center member. For example, the shapes can be symmetrical or uniformly asymmetrical in geometry and can provide a balanced, limited coverage of the annulus formed between a centerline of the tube and a wall of the tube.

[0024] Periodic adjustments of the height of the lowest extremity of the center member can be made manually. This is accomplished by physically feeling the wire member change from tension to slackness as the lowest extremity of the center member contacts the catalyst interface, similar to the sensation from a weighted fishing line contacting the bottom of a body of water. In one embodiment of the present invention, periodic adjustments also can be assisted by the addition of a sensor member at the lowest extremity of the center member. This sensor member can communicate with the top of the center member to provide visual or auditory indication of contact with the catalyst interface.

[0025] With embodiments of the present invention, a novel, reproducible, and quick filling method is disclosed. The method is gentle to the particles such that crushing of particles during the filling operation is avoided. An even filling of the tube is also obtained, and thus one result has been avoidance of uneven temperature distribution when a tube filled with catalyst is in operation. Further, an even density of particles in the tubes is attained without exposing them to tapping/vibration, which is both time-consuming and damaging to the tubes. Consequently, time is saved both during filling and also since the tubes do not have to be tapped. The method is simple, cost efficient, and can be modified both quickly and easily. Additionally, it is to only a very small

degree dependent upon whoever is the particular operator during the filling process. Furthermore, errors connected with filling of particles into socks are avoided. A substantial degree of freedom regarding packaging and the form of transport for the particles also is obtained.

- 5 [0026] While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

Claims:

1. A loading tool for distributing solid particles into a tube, comprising:
a center member; and
5 a plurality of substantially identical damper members disposed along the center member, each damper member including at least two rigid and opposing arms extending outwards at substantially ninety degrees from the center member in at least two opposing directions and each damper member rotationally distinct from adjacent damper members.
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2. The loading tool of claim 1, wherein each arm further includes a cross arm extending from a distal end thereof at an angle of up to ninety degrees.
3. A method of distributing solid particles into a tube, comprising:
15 positioning a loading tool in an interior of the tube, the loading tool having a center member and a plurality of substantially identical damper members connected to the center member, wherein each damper member includes at least two rigid arms extending outwards at substantially ninety degrees from the center member in at least two opposing directions and each damper member is rotationally distinct from adjacent
20 damper members;
filling the tube with the solid particles, wherein the solid particles contact at least some of the plurality of damper members; and
removing the loading tool from the tube.
- 25 4. The method of claim 3, wherein the loading tool is removed as the solid particles fill the tube.
5. A loading tool for filling a tube with particles comprising:
a stiffened central member;
30 a plurality of spiral shapes formed from the stiffened member, each spiral shape having a different outer diameter than the shape adjacent thereto, and the loading tool

having a centerline substantially coaxial with a centerline of the tube.

6. The loading tool of claim 5, wherein the plurality of spiral shapes increase and decrease in diameter over the length of the plurality of spiral shapes.

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7. The loading tool of claim 6, wherein multiple pluralities of spiral shapes are formed from and connected by the stiffened member, the pluralities extending between an upper and lower end of the tube.

10 8. A method for distributing solid particles into a tube, comprising:

positioning a loading tool in an interior of the tube, the loading tool having a central member and a plurality of spirals of varying diameters formed from the central member, the spirals for providing coverage of distinct radial portions of the tube;

15 filling the tube with the solid particles, wherein the solid particles contact at least some of the plurality of spirals;

removing the loading tool from the tube as the solid particles fill the tube; and

utilizing a sensor to communicate the position of a second portion of the center member to a first portion of the center member.

20 9. The method of claim 8, wherein the second portion of the center member is located at a lowest extremity of the center member.

10. The method of claim 9, wherein the first portion of the center member is located at an upper portion of the center member.

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11. A loading device for insertion into a catalyst tube to facilitate the loading of the tube with pellets, comprising:

30 a unitary member extending vertically from an upper end towards a lower end of the tube, the unitary member formed into repeating shapes, each of which includes a uniform centerline and each of which have a dimension in a radial direction, the radial directions rotationally distinct from adjacent shapes.

12. The device of claim 11, wherein the repeating shapes are formed in the shape of a "Z".
13. The device of claim 12, wherein the repeating shapes are formed of a single,
5 stiffened member.
14. A loading tool for filling a tube with pellets, comprising:
a central member; and
dampers disposed along the central member, the dampers including at least two
10 opposing, radially extending portions extending outwardly in a single plane perpendicular to a longitudinal axis of the tube.