Tool For Loading Reactor Tubes

Background of the invention:

The present invention relates to chemical reactors, and, in particular, to a device for loading the tubes of chemical reactors with catalyst.

In the past, many different types of devices have been used to assist in loading catalyst into reactor tubes. For example, various sleeves, templates, and vibrating machines have been used. The catalyst typically is in a pellet form and may have various shapes and sizes. Then, once the catalyst has been loaded, a stick is inserted into each tube to measure the distance from the top of the catalyst to the top of the reactor tube (the outage) to see whether that space or outage is within the desired range. If the outage is too large, additional catalyst is loaded and the outage is measured again. If the outage is too small, catalyst is removed, typically by vacuuming it out of the top of the tube, and the outage is measured again.

Summary of the invention:

The present invention provides a loading sleeve for loading catalyst into a reactor tube. The loading sleeve has an upper flange, which rests on the upper tube sheet of the reactor, and a tube projecting downwardly from the flange into the reactor tube. Since the tube portion of the loading sleeve has a smaller diameter than the reactor tube, when the loading sleeve is filled with catalyst and is then removed from the reactor tube, it leaves a gap or outage at the top of the reactor tube.

In a preferred embodiment of the present invention, the loading sleeve also has some type of marking which can be used for checking the outage. After the loading sleeve has been removed from the reactor tube, and the catalyst has settled into the reactor tube, the loading sleeve is again inserted into the reactor tube until it rests on the catalyst in the reactor tube, with a portion of the loading sleeve projecting upwardly, out of the reactor tube. By checking the markings on the portion of the loading sleeve projecting out of the reactor tube, a person can see whether the tube has been loaded to a height that is within the desired specifications. This eliminates the need for a separate testing tool.

Also in a preferred embodiment of the present invention, the flanges of the loading sleeves may be made large enough that they overlap each other. This helps prevent dust and fines from collecting between the loading sleeves.

Brief Description of the Drawings:

Figure 1 is a broken-away section view through the upper portion of a chemical reactor, with loading sleeves of the present invention inserted into the reactor tubes;

Figure 2 is a top view of a portion of the reactor of Figure 2;

Figure 3 is an enlarged top view of one of the reactor tubes of Figure 1;

Figure 4 is a section view through an alternative embodiment of a loading sleeve;

Figure 5 is a schematic view showing catalyst being loaded into the reactor tube through the loading sleeve of Figure 1;

Figure 6 is a side view of the loading sleeve of Figure 4;

Figure 7 is a side view of the loading sleeve of Figure 5;

Figure 8 is a side view of another alternative embodiment of a loading sleeve;

Figure 9 is an enlarged view of the upper portion of the loading sleeve of Figure 8;

Figure 10 is a top view of the loading sleeve of Figure 8;

Figure 11 is a top view of a reactor using another alternative embodiment of a loading sleeve; and

Figure 12 is a top view of a reactor using the same loading sleeve as Figure 11 but with the loading sleeves arranged in a different way.

Description of the Preferred Embodiments:

Figure 1 is a section view through a portion of a chemical reactor. The reactor includes an upper tube sheet 10 and a lower tube sheet (not shown), which is parallel to the upper tube sheet 10. A plurality of reactor tubes 12 extends downwardly from the upper tube sheet 10 to the lower tube sheet. The upper and lower tube sheets have openings 14 aligned with the tubes 12. In this view, loading sleeves 16 have been inserted into the reactor tubes 12. Each of the loading sleeves 16 includes an upper flange portion 18, which

rests on the upper tube sheet 10, and a downwardly-extending tubular sleeve portion 20, which extends into its respective reactor tube 12. The flange 18 defines a central opening 22, which opens into the inside of the tubular sleeve portion 20. In this embodiment, the tubular sleeve 20 has a constant diameter, and the opening 22 has a constant diameter that is smaller than the inside diameter of the tubular sleeve 20. The size of the opening 22 depends upon the size and shape of catalyst to be used. It may be from just a bit larger than the catalyst to about three times the diameter of the catalyst, in order to minimize the opportunity for bridging.

Figure 2 is a top view showing a plurality of the loading sleeves 16 inserted into a plurality of adjacent reactor tubes 12. In this view, it can be seen that the tubular sleeves 20 and flanges 18 have a circular cross-sectional shape, which is preferred. However, other shapes could also be used. Figure 3 is an enlarged top view of one of the loading sleeves 16 in its respective tube 12. The outside diameter of the downwardly-projecting tubular sleeve 20 is small enough to fit easily into the reactor tube 12, and the flange 18 is large enough to prevent the loading sleeve 16 from falling through the opening 14 into the reactor tube 12.

Figure 5 is a schematic view showing the loading sleeve 16 being used to load catalyst into the reactor tube 12. In this view, the catalyst 30 is shown as being spherical, but it could be of various shapes. Catalyst frequently has a cylindrical shape, for example. The loading sleeve 16 is inserted into the reactor tube 12 until the flange 18 rests on the upper tube sheet 10. Then catalyst 30 is inserted through the opening 22 in the flange 18. Typically the catalyst 30 is inserted by hand or broom massage, but other methods may also be used. The catalyst 30 falls through the loading sleeve 16 and into the reactor tube 12, filling the reactor tube 12 from the bottom up. Eventually, the catalyst 30 also fills the interior of the loading sleeve 16, as shown in this view.

Once several of the loading sleeves 16 are filled to the top with catalyst 30, they are then completely removed from the reactor tube 12. The loading sleeves 16 may have to be tapped in order to ensure that all of the catalyst 30 falls out of the sleeve 16 and remains in its respective reactor tube 12. Since the volume inside the loading sleeve 16 is less than the volume of the

surrounding portion of the reactor tube 12, when the loading sleeve 16 is removed, the catalyst 30 that was in the loading sleeve 12 falls downwardly to fill the larger diameter reactor tube 12, leaving a gap or outage 32 from the top of the catalyst 30 to the top of the tube sheet 10, as shown in Figure 7. The relative inside diameters of the loading sleeve and the reactor tube may be selected to achieve the desired outage 32 when the loading sleeve is removed from the reactor tube.

After the loading sleeve 16 has been removed from the reactor tube and the catalyst 30 has settled to form the outage 32, the loading sleeve 16 is again inserted into the reactor tube 12, as shown in Figure 7. This time, the catalyst 30 prevents the loading sleeve from being inserted all the way into the reactor tube 12. Instead, the loading sleeve 16 can only be inserted the distance of the outage 32, at which point it is prevented by the catalyst 30 from being inserted any further.

There are graduated markings 34 on the sleeve 16, which are then used to determine whether the catalyst 30 has been loaded to the correct outage. The markings 34 preferably are on the outer surface of the sleeve 16. The markings may be of various types. There may be a plurality of graduated markings at various heights, as shown in Figure 7, which may indicate the distance of the marking above the bottom of the sleeve 16, or the bottommost marking may indicate a height of "0" and the other markings indicate their height above the "0" mark, for example. Or there may be a group of markings that say "In spec" and markings above and below those that say "out of spec", or one section of the sleeve may be marked in green or another preferred color, indicating the correct outage range, and sections above and below that section may be marked in another color, such as red, to indicate that they are outside of the specified outage range. Other similar indicators may be used so that a person inserting the loading sleeve back into the reactor tube can determine the dimension of the outage 32, or whether the outage 32 is within a predetermined, specified range.

Thus, with a single tool, a worker may both install the catalyst and then check the catalyst height to be sure the gap 32 above the catalyst is within a desired range. If the gap 32 is too large, the worker may insert additional catalyst and check again. If the gap 32 is too small, the worker may vacuum

out some catalyst, check again, and add catalyst as needed. By providing both the loading function and the measuring function in a single tool, the worker does not have to carry two separate tools for performing these two functions.

Figures 4 and 6 show an alternative embodiment of a loading sleeve 116. In this embodiment, the opening 122 through the upper flange is tapered, having a smaller diameter at the top and a larger diameter at the bottom. The top surface of the flange is also dished, tapering from a higher elevation at its outer edge to a lower elevation adjacent the opening 122, in order to allow the catalyst to flow more easily toward the center opening during loading. This embodiment also differs from the first embodiment in that, instead of having a plurality of graduations on the tube, this embodiment has a single wide band indicating positions of the loading sleeve 116 at which the outage 32 would be within the desired range. If the entire band 134 is below the upper tube sheet 10 and cannot be seen, then the person measuring the outage knows that the outage 32 is too large and more catalyst should be added. If the person can see the entire band 134, including its bottom edge, extending above the upper tube sheet 10, then he knows that the outage 32 is too small, and some catalyst should be removed. If only a portion of the band 134 projects above the upper tube sheet 10, the person knows that the outage 32 is within the desired specified range.

Figures 8-10 show a second alternative embodiment of a loading sleeve 216. In this embodiment, the downwardly projecting tubular sleeve portion 220 does not have a constant diameter. Instead, its upper portion is tapered, like a funnel, having a larger diameter at the top and tapering to a smaller diameter. Then, the rest of the tubular portion 220 has a constant diameter which is slightly larger than the smaller diameter of the tapered portion. This loading sleeve 216 has a plurality of graduations 234, which indicate the height of the graduation above the bottom of the tubular sleeve 216. With this device, the person will obtain an actual reading of the outage dimension 32 rather than just an indication of whether it is in or out of a pre-specified range.

Figures 11 and 12 show another alternative embodiment of a loading sleeve 316 made in accordance with the present invention. This loading

sleeve 316 is identical to the sleeve 16 of Figures 1-3, except that the flange portion 318 has a larger diameter, so that the flange portions 318 of adjacent loading sleeves 316 overlap each other. The flange portions 318 have a diameter that is large enough to ensure a complete overlap of the adjacent flanges, so that none of the upper tube sheet 10 between the loading sleeves 316 is exposed, and yet small enough that the flanges 318 do not cover the adjacent openings 322.

Figure 11 shows one arrangement of these large-flanged loading sleeves 316, in which the person begins inserting the sleeves 316 at one end of the reactor and then just overlaps subsequent rows of flanges 318 over the previous rows similar to the scales on a fish. It should be noted that the sleeves 316 are made of a somewhat flexible material, such as plastic, so all the flanges 318 are close to the surface of the upper tube sheet 10.

Figure 12 shows the same large-flanged loading sleeves 316 as in Figure 11, except they have been inserted in a different order, with the flanges of a first set of rows (say the odd-numbered rows) down, in contact with the upper tube sheet 10 and the flanges of a second set of rows (say the even-numbered rows) resting on the flanges 318 of the first set of rows. In both the arrangement of Figure 11 and the arrangement of Figure 12, the flanges 318 overlap to prevent dust from settling down into positions on the upper tube sheet 10 between the loading sleeves. With these arrangements, the dust may be swept off or vacuumed off very readily.

It is preferred that the loading sleeves 16 be made of a hard material, such as ABS plastic, rather than a soft material such as polyethylene, in order to prevent the material from abrading and contaminating the reactor tube 12. While a metal may be used, hard plastic is preferred. It is also preferred that the flange portion 18 and tubular portion 20 be permanently connected together to function as a single piece, so the tubular portion 20 cannot become detached during use and fall down into the reactor tube 12. This may be accomplished by fabricating or molding the flange 18 and tubular portion 20 together so they are a single piece, by gluing or welding them together to form a single piece, or by other known means. Injection molding a single piece, including the flange 18 and tubular portion 20, is preferred. In the case of welding or gluing, it would be desirable to inspect and test the assembly to

ensure that the flange 18 and tubular portion 20 will remain together. Other secure attachment arrangements, such as pinning or riveting, may also be used. It may alternatively be desirable to use a tubular portion 20 with threads that thread into the flange head 18, with several revolutions of the tubular portion 20 being used to mate the two parts together.

If the tubular portion 20 or a piece of the tubular portion 20 falls into the reactor tube 12, and it is not realized prior to starting up the reactor, the portion may melt and fuse the catalyst together, restricting the flow of gas through the tube 12, so the reactor does not function properly, and perhaps even permanently damaging the tube. This would be very undesirable and should be avoided if possible.

While forming each tube 16 as a single piece or permanently securing the flange portion 18 and tubular portion 20 together such as by welding or adhesive to form a single piece helps alleviate the problem of tubular portions 20 being left in the reactor tubes 12, it also makes the products more difficult to store. Keeping the flange portion 18 and tubular portion 20 as separate pieces has the advantage of making the products easier to store and of permitting one flange portion 18 to be used with various length tubular portions 20, making it adaptable for various desired outages.

Particularly if the flange portion 18 and tubular portion 20 are not permanently secured together, it may be desirable to mark each flange portion 18 and tubular portion 20 with a unique bar code or other mark and log each piece in and out of the work area in order to help ensure that all the flanges 18 and tubular portions 20 are accounted for, with none left in the reactor tubes 12. The tubes 16 may also be marked to indicate that they have been tested and inspected.

It will be obvious to those skilled in the art that modifications may be made to the embodiments described above without departing from the scope of the present invention.

Claims:

1. A device for loading a chemical reactor tube with catalyst and for checking the height of the catalyst within the reactor tube after loading, where the chemical reactor tube is one of a large number of reactor tubes extending from an upper tube sheet to a lower tube sheet, comprising:

an upper flange portion for resting on top of the upper tube sheet, said upper flange portion having an outside diameter and defining an opening that is substantially unrestricted and suitable for receiving whole catalyst particles that are brushed across the top of the upper tube sheet when the flange is resting on top of the upper tube sheet;

a tubular sleeve portion having a top and a bottom, wherein the top is adjoined to said upper flange portion, so that the opening of the flange opens into said tubular sleeve portion, and wherein said tubular sleeve portion projects downwardly from said upper flange portion;

wherein the outside diameter of said tubular sleeve portion is smaller than the largest outside diameter of the upper flange portion for the entire length of the tubular sleeve portion, so that the tubular sleeve portion will extend into the reactor tube when the flange is resting on the upper tube sheet, and

wherein the inside diameter of said tubular sleeve portion is larger than the smallest diameter of the opening in the flange for the entire length of the tubular sleeve portion, to ensure that any particles that can pass through the opening in the flange also will flow freely through the entire tubular sleeve portion; and

at least one marking on said tubular sleeve portion at a height above the bottom of said tubular sleeve portion.

2. A device for loading a chemical reactor tube as recited in claim 1, and further comprising a plurality of graduated markings at various heights on said tubular member.

3. A device for loading a chemical reactor tube as recited in claim 1, and further comprising a wide band marking on said tubular sleeve portion indicating a range of desired outage dimensions.

4. A device for loading a chemical reactor tube as recited in claim 1, wherein the flange and tubular sleeve are separate pieces that are secured together.

5. A device for loading a chemical reactor tube as recited in claim 1, wherein said opening is tapered, having a smaller diameter at the top than at the bottom.

6. A method for loading a chemical reactor tube with catalyst, comprising the steps of:

inserting a loading sleeve into an open top of the reactor tube; then

inserting catalyst through said loading sleeve into said reactor tube; then

removing the loading sleeve from the reactor tube; then

re-inserting the loading sleeve into the reactor tube until the loading sleeve contacts the catalyst; and then

reading a marking on the loading sleeve which is visible above the reactor tube when the loading sleeve has been re-inserted in order to determine whether the outage above the catalyst is within a desired range.

7. A chemical reactor, comprising:

an upper tube sheet;

a plurality of reactor tubes projecting downwardly from said upper tube sheet;

a plurality of loading sleeves inserted into respective reactor tubes, each of said loading sleeves including an upper flange portion and a downwardly projecting tubular sleeve portion suspended from said upper flange portion, wherein adjacent upper flange portions overlap each other.

8. A chemical reactor as recited in claim 7, wherein said upper flange portions overlap sufficiently to completely cover the portion of said upper tube sheet between their respective reactor tubes.

9. A chemical reactor as recited in claim 8, wherein said upper flange portions are arranged in alternating groups, with a first group of upper flange portions resting on the upper tube sheet and a second group of upper flange portions resting on the first group of upper flange portions.

10. A chemical reactor as recited in claim 8, wherein said tubular sleeve portions include markings on their outer surfaces that can be used to measure the outage after the loading sleeves are removed from their respective reactor tubes and then reinserted into their respective reactor tubes.

11. A device for loading a chemical reactor tube with catalyst and for checking the height of the catalyst within the reactor tube after loading, where the chemical reactor tube is one of a large number of reactor tubes extending from an upper tube sheet to a lower tube sheet, comprising:

a loading sleeve, including an upper flange portion that is suitable for resting on top of the upper tube sheet, said upper flange portion having an outside diameter and defining an opening that is substantially unrestricted and suitable for receiving whole catalyst particles that are brushed across the top of the upper tube sheet when the flange is resting on top of the upper tube sheet;

a tubular sleeve portion projecting downwardly from said upper flange portion to a bottom end;

wherein the outside diameter of said tubular sleeve portion is smaller than the largest outside diameter of the upper flange portion for the entire length of the tubular sleeve portion, so that the tubular sleeve portion will extend into the reactor tube when the flange is resting on the upper tube sheet, and

wherein the inside diameter of said tubular sleeve portion is larger than the smallest diameter of the opening in the flange for the entire length of the tubular sleeve portion, to ensure that any particles that can pass through the opening in the flange also will flow freely through the entire tubular sleeve portion;

and at least one marking on said tubular sleeve portion at a height above said bottom end.

12. A device for loading a chemical reactor tube as recited in claim 11, and further comprising a plurality of graduated markings at various heights on said tubular sleeve portion.

13. A device for loading a chemical reactor tube as recited in claim 11, and further comprising a wide band marking on said tubular sleeve portion indicating a range of desired outage dimensions.

14. A device for loading a chemical reactor tube as recited in claim 11, wherein the upper flange portion and tubular sleeve portion are separate pieces that are permanently secured together by welding.

15. A device for loading a chemical reactor tube as recited in claim 11, wherein said opening is tapered, having a smaller diameter at the top than at the bottom.

16. A device for loading a chemical reactor tube as recited in claim 1, wherein the tubular portion has a substantially constant inside diameter.

17. A device for loading a chemical reactor tube as recited in claim 16, wherein the tubular sleeve portion has a substantially constant outside diameter.

18. A device for loading a chemical reactor tube as recited in claim 17, and further comprising a chemical reactor, including an upper tube sheet and a chemical reactor tube projecting downwardly from said upper tube sheet and having an inside diameter, wherein said flange has a larger outside

diameter than the inside diameter of the chemical reactor tube, and said tubular sleeve portion has a smaller outside diameter than said chemical reactor tube and is received in said chemical reactor tube with said flange located above said chemical reactor tube.

19. A device for loading a chemical reactor tube as recited in claim 18, and further comprising catalyst in said chemical reactor tube, wherein said tubular sleeve portion is resting on top of the catalyst, and said marking provides means for determining whether the level of catalyst in the tube is at the desired height.