Claims

1. An arrangement for vacuuming a vertical chemical reactor tube to a desired outage, comprising: a device including a vacuum conduit having a vacuum conduit inlet and a vacuum conduit outlet and a collection hopper between said vacuum conduit inlet and outlet; said vacuum conduit having a side wall defining a window opening; a collar mounted onto said vacuum conduit, including a portion for covering the window opening, said collar being movable relative to said vacuum conduit for covering and uncovering the window opening; and a biasing spring which biases the collar to a position in which the collar covers the window opening.

2. An arrangement for vacuuming a vertical chemical reactor tube to a desired outage as recited in claim 1, wherein said collar is part of a shuttle mechanism including means for automatically moving the collar in a direction to uncover the window opening when the vacuum conduit inlet has moved a desired distance into the reactor tube.

3. An arrangement for vacuuming a vertical chemical reactor tube to a desired outage as recited in claim 1, wherein said device defines a second conduit adjacent to the vacuum conduit, said second conduit including means for supplying external gas through the top of the chemical reactor tube as the vacuum conduit inlet is inserted into the top of the reactor tube.

4. An arrangement for vacuuming a vertical chemical reactor tube to a desired outage as recited in claim 1, wherein the cross-sectional area at said vacuum conduit inlet is smaller than the cross-sectional area of the remainder of said vacuum conduit up to the collection hopper.

5. An arrangement for vacuuming a vertical chemical reactor tube to a desired outage as recited in claim 3, wherein the cross-sectional area at said vacuum conduit inlet is smaller than the cross-sectional area of the remainder of said vacuum conduit up to the collection hopper.

~~6. An arrangement for vacuuming solid particles and gas from a vertical chemical reactor tube, comprising: a vacuum conduit having a vacuum conduit inlet~~

and a vacuum conduit outlet and a collection hopper between said vacuum conduit inlet and outlet; a second conduit having a second conduit inlet and a second conduit outlet, wherein at least a portion of said second conduit is fixed relative to said vacuum conduit so that the second conduit outlet is adjacent said vacuum conduit inlet; a vacuum source in fluid communication with said vacuum conduit outlet; and a pressurized gas source in fluid communication with said second conduit inlet.

7. An arrangement for vacuuming solid particles and gas from a vertical chemical reactor tube as recited in claim 6, wherein said vacuum conduit has a side wall defining a window opening; and further comprising: a collar mounted onto said vacuum conduit, including a portion for covering the window opening, said collar being movable relative to said vacuum conduit for covering and uncovering the window opening; and a biasing spring which biases the collar to a position in which the collar covers the window opening.

8. An arrangement for vacuuming solid particles and gas from a vertical chemical reactor tube as recited in claim 7, including means by which relative motion between the vacuum conduit and the collar opens and closes the window opening.

9. An arrangement for vacuuming solid particles and gas from a vertical chemical reactor tube as recited in claim 8, wherein the cross-sectional area at the vacuum conduit inlet is smaller than the cross-sectional area of the remainder of the vacuum conduit up to the collection hopper.

10. An arrangement for vacuuming solid particles and gas from a vertical chemical reactor tube as recited in claim 6, and further comprising a nozzle at said second conduit outlet, said nozzle defining at least one downwardly directed through opening and a plurality of angled through openings in fluid communication with said second conduit, said angled through openings being directed at an upward angle.

11. A method for vacuuming solid particles and gas from a vertical chemical reactor tube, comprising the steps of:

inserting the inlet end of a vacuum conduit and the outlet end of a second conduit into the top of the chemical reactor tube, applying a vacuum to the outlet end of the vacuum conduit remote from its respective inlet end, pulling solid particles from the chemical reactor tube into the vacuum conduit inlet and through the vacuum conduit to a collection hopper, and pulling gas from the chemical reactor tube through the vacuum conduit to the vacuum conduit outlet, wherein at least some of said gas enters the reactor tube through the second conduit.

12. A method for vacuuming solid particles and gas from a vertical chemical reactor tube as recited in claim 11, and further comprising the step of substantially reducing the vacuum level being applied at the vacuum conduit inlet when the vacuum conduit inlet reaches a desired depth within the reactor tube.

13. A method for vacuuming solid particles and gas from a vertical chemical reactor tube as recited in claim 11, and further comprising the step of injecting pressurized fluid into the inlet of said second conduit.

14. A method for vacuuming solid particles and gas from a vertical chemical reactor tube, comprising the steps of: mounting a vacuum conduit on a fixture, including at least two downwardly-projecting locating pins; setting the fixture down on the tube sheet of a chemical reactor, with said locating pins projecting into two respective openings in the tube sheet; activating an automatic control, which drives the inlet of the vacuum conduit into one of the chemical reactor tubes at a controlled rate to a desired depth, holds the vacuum conduit inlet at that depth for a controlled dwell time, and then retracts the vacuum conduit from the chemical reactor tube; and applying a vacuum to the vacuum conduit outlet in order to vacuum particles out of the chemical reactor tube.

15. A method for vacuuming solid particles and gas from a vertical chemical reactor tube as recited in claim 14, and further comprising the step of substantially reducing the vacuum level being applied at the vacuum conduit inlet when the vacuum conduit inlet has reached the desired depth.

16. A method for vacuuming solid particles and gas from a vertical chemical reactor tube as recited in claim 14, and further comprising the step of injecting gas

at a pressure higher than ambient pressure into the top of the chemical reactor tube through a second conduit as the vacuum conduit is vacuuming particles out of the chemical reactor tube.

17. A method for vacuuming solid particles and gas from a vertical chemical reactor tube, comprising the steps of: injecting pressurized gas into the tube to fluidize at least some of the particles in the tube; providing a vacuum conduit at the top of the reactor tube; drawing a vacuum through the vacuum conduit to pull particles from the reactor tube at the same time that the pressurized gas is being injected to fluidize the particles; and positioning the inlet of the vacuum conduit in close enough proximity to the reactor tube and providing sufficient flow through the vacuum conduit to prevent the solid particles from leaking out into the reactor as they are being vacuumed.

18. A method for vacuuming solid particles and gas from a vertical chemical reactor tube, as recited in claim 17, wherein the pressurized gas is injected into the bottom of the reactor tube.

19. A method for vacuuming solid particles and gas from a vertical chemical reactor tube as recited in claim 17, wherein the pressurized gas is injected into the top of the reactor tube.

20. A method for vacuuming solid particles and gas from a vertical chemical reactor tube as recited in claim 18, including using an injector tube to inject the pressurized gas into the bottom of the reactor tube and sealing between the injector tube and the inner surface of the reactor tube.

21. A method for vacuuming solid particles and gas from a vertical chemical reactor tube as recited in claim 20, including the step of inflating a seal between the injector tube and the inner surface of the reactor tube.