

A METHOD AND DEVICE FOR CLEANING NON-FIXED MEDIA FILTERS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to the field of liquid filtration using unfixed filter media, and more specifically to a method and system for removing filtered contaminants from these type filter beds during periodic cleaning cycles.

2. The Prior Art

Various types of methods and systems have been used in the prior art to remove accumulated contaminants from a bed of granular filter medium. The methods utilized to date generally have these common processing steps: 1) providing an agitation means to break-up agglomerations of filter media and contaminants typically formed during the filtration process, 2) flowing a carrier medium through the agitated granules to mobilize the contaminants away from the filter media, 3) retaining the filter media within the filter while allowing contaminants to flow out, and 4) returning the cleaned filter media back to its normal state. These four steps can be condensed to the following: 1) agitation, 2) washing, 3) separating, and 4) reforming.

With regard to common Step 1, various means are disclosed to agitate the filter media such as rotary blades and high-velocity liquid jets (See U.S. Patent Nos. 2,521,396 and 3,992,291 / 3,953,333). However, both of these methods create at least two significant problems. First, rotary blade systems often have mechanical seals that require frequent maintenance. Second, the high-velocity liquid jets produce large volumes of dirty backwash water that must be stored and recycled through the process. What is needed in the art is an agitating means that does not require rotating internal baffles or impellers and minimizes liquid usage.

With regard to common step 2, the carrier medium used to flush the filter media is most commonly the clean filtrate fluid. In many systems, large volume storage of clean filtrate is required to provide surge capacity when the backwash cycle draws a high-volume rate to flush the media during this step. Some methods utilize the high-volume water jets to both agitate and back flush, which is a combination of common steps 1 and 2. However, such systems still generate large volumes of backwash liquid that must be stored and recycled back through the process. Also, it would be preferred to utilize contaminated process fluid for backwashing instead of clean filtrate. This would avoid having to have clean filtrate storage vessels and pumps specifically for periodic backwashing cycles.

With regard to common step 3, separation of the contaminants from the filter media is typically done by flowing the slurry in a continuous flow path over a cleaning element, located external to the filter housing, where interspersed larger particulates are removed from the slurry, and returning the withdrawn filter material back to the filter housing (See U.S. Patent Nos. 3,992,291 and 3,953,333). This method adds significant cost and size to the filter since it requires various external conduits, vessels, valves and equipment. U.S. Patent No. 4,787,987 discloses an in-situ method of separating the contaminants from the filter media by a screen, of size slightly smaller than the filter media size, contained within the vessel below the filter media. That method agitates and slurries the media and contaminants by action of a high-volume liquid pump. During this agitation step, make-up liquid is added to the vessel at substantially the same rate that the concentrated contaminated liquid is removed through the screen means while the filter media is retained within the filter housing.

The present invention is directed in part, to a novel means of in-situ agitation and fluidization of filter media granules to sufficiently liberate collected contaminants as rapidly as possible and flushing those contaminants from the filter housing using the least amount of liquid necessary. Other advantages that are inherent in the disclosed and claimed invention will be apparent of those of ordinary skill in the art.

SUMMARY OF THE INVENTION

The inventors present a novel method of in-situ cleaning of agglomerated contaminants from granular filter media. This method combines a low rate of contaminated liquid with a gas, such as air or natural gas, to create a jetting stream. This jetting stream is dispersed into the filter media through one or more radial nozzles disposed within the filter media. The gas exits the radial nozzles as a bubble dispersion within the liquid. As the jetting stream rises up through the filter media, it expands the bed to break large contaminant agglomerations and fluidizes the individual filter media granules to dislodge and mobilize smaller contaminant agglomerations within the interstitial spaces of the filter media. This fluidizing action provides the requisite degree of agitation of the media to loosen and mobilize contaminant agglomerations without the need for high liquid space velocities common to other filter cleaning methods.

This method provides the benefit of allowing use of contaminated process liquid in the jetting stream, which eliminates the need for storing clean filtrate for use during backwash cycles.

This method provides the further benefit of minimizing the volume of contaminant-laden liquid water that must be reprocessed. Other filter cleaning methods require large liquid volume rates, up to 1.5 times the incoming liquid rate during normal operation, to provide sufficient interstitial velocity to mobilize contaminants away from the filter media. Lower backwash volumes reduce ancillary equipment costs and reprocessing costs.

This method provides the further benefit of reducing the cleaning cycle time. Other filter cleaning methods flow the gas separately through the filter media to break contaminant agglomerations followed by liquid flow through the media to flush contaminants away. By combining the agitation step with the flushing step, cleaning cycle times can be significantly reduced. Shorter cleaning cycle times will provide improved overall performance of the filter system.

This method provides the further benefit of allowing optimization of media cleaning cycle for a variety of filtering process. By adjusting the ratio of gas to liquid in the jetting stream and; if necessary, the size and location of the radial jetting

nozzles, the cleaning cycle can accommodate a broader variety of contaminate loading rates, agglomeration tendencies, and physical characteristics.

In a preferred embodiment of the invention, a granular media filter is described that is comprised of a filter housing in which the media is contained and settled by gravity onto the bottom of the filter housing to form a bed. The filter housing bottom has an outlet port to which is attached a mechanical sieve, such as wedge-wire or slotted pipe. The mechanical sieve slots are smaller than the filter media granules so that as the process liquid flows through the filter, the clean filtrate exits the outlet port while the filter granules are retained within the filter housing. During normal filter operation, contaminated liquid flows from an inlet port connected to distributor and mechanical sieve and flows through the filter media bed, depositing contaminants on top of, within the interstitial spaces of and the surface of the filter media.

When sufficient levels of contaminants are trapped within the filter housing, normal flow to the filter housing is stopped and a cleaning cycle is initiated. The embodiment filter housing has a single radial nozzle, or a plurality of evenly spaced radial nozzles depending on the filter housing diameter, placed just above the bottom of the filter bed. A conduit or pipe runs from a nozzle with a connection on the outside of the filter housing to the radial nozzle. During the cleaning cycle, a controlled rate of a jetting stream flows through the radial nozzles, up through the filter media, and up towards the inlet port distributor/mechanical sieve. The jetting stream is comprised of a mixture of gas and liquid formed outside of the filter housing and transported to the radial nozzles via the connecting conduit. The radial nozzle is designed to create an optimum dispersion of the gas and liquid components so that the mixture can simultaneously agitate the filter granules and flush out contaminants from the interstitial spaces of the media.

As the jetting stream, liberated contaminants, and some fluidized filter granules flow towards the inlet port, the mechanical sieve retains the fluidized granules within the filter housing while allowing the jetting stream and contaminants to exit the filter housing. The embodiment further includes a vent port at the top of

the filter housing to allow trapped gas from the jetting stream to escape prior to returning the filter to normal operation.

The rate of gas and liquid mixed to form the jetting stream and used to agitate and flush the contaminants from the filter housing should be selected to account for the following considerations: (1) adequate nozzle exit velocity to produce a uniform gas dispersion within the liquid and substantial coverage of the jetting stream across the media bed cross-section, (2) adequate vertical gas velocity to expand the media bed in order to break large contaminant agglomerations; (3) adequate gas velocity to fluidize and agitate the media granules, and (4) adequate liquid momentum to mobilize and carry liberated contaminants away from the filter bed.

The number and location of the radial nozzles within the filter housing should be selected to account for the following considerations: (1) even distribution of the jetting stream across the filter bed cross-section and minimizing "blind-spots" or the volume of filter media uncontacted by the jetting stream; and (2) close enough to the bottom of the media bed so that the nozzle outflow contacts the bottom outlet port mechanical sieve to clean the sieve of filter media collected thereon;

Although the invention has been summarized as including a method and apparatus for removing contaminants from a bed of granular filter media, other uses within the scope of the invention may become apparent to those in the filtration art.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical sectional view of a non-fixed media housing, which forms a part of the present invention, showing internal members used to carry out the medial cleaning method herein described..

FIG. 2 is horizontal sectional view across the filter housing diameter, which forms part of the present invention, showing one embodiment position of the jetting nozzles in a 45° angle between the filtrate outlet sieve manifold.

FIG. 3 is a three-dimensional sectional view of FIG. 2 embodiment as viewed from the underside of the filter housing vessel. This view provides further detail of the embodiment presented in FIG. 2.

FIG. 4 is a top cross-sectional view similar to that shown in FIG. 2 but with the radial nozzles located just above and aligned with the outlet sieve manifold members showing an alternate location of the radial nozzles for use in the present invention.

FIG. 5 shows a detailed, three-dimensional view of a radial nozzle and its subcomponents. Dashed lines extend from the annular space of the radial nozzle indicating general motion of the jetting stream from the nozzle and the effect the jetting stream has on the fluids surrounding the nozzle.

FIG. 6 shows vertical cross-sectional view of an alternate embodiment of the radial nozzle where the nozzle plates are modified to enhance uniformity of jetting stream distribution and reduce media plugging of the nozzle when inactive.

FIG. 7 shows three-dimensional, top-side view of a further alternative embodiment of the present invention where the radial nozzles are located underneath the filtrate outlet sieve manifold members in order to provide cleaning of the sieve manifold screen as well as the filter media in the housing during the cleaning method described herein.

FIG. 8 shows an alternate embodiment of the present invention where a plurality of filter housings, each incorporating the internal members required to carry

out the cleaning method herein, is incorporated into one horizontal filter housing separated into individual compartments by internal baffles.

DETAILED DESCRIPTION

Referring to FIG. 1, a filter vessel 10 is illustrated for housing a bed 12 of granular filter medium. The filter housing is a pressure-rated vessel having a 2:1 ellipsoidal upper and lower heads. Other filter vessel shapes and designs may be used and will not effect the principle operation of the invention. The granular filter media 12 may be any of a number of materials chosen based upon the characteristics of the liquid to be filtered and the properties of the contaminants. For filtration of water containing suspended oil droplets and solids contaminants, granulated black walnut shells are commonly used. A space 14 exists above the filter bed 12 to provide room for the bed to expand during the cleaning cycle. It will be understood, of course, that any suitable filter housing may be utilized for confining the bed of granular filter material.

The filter vessel 10 also includes inlet distributors 20 for the introduction of contaminated liquid from an exterior conduit and dispersing the liquid substantially uniformly across the cross-section of the filter vessel. A backwash outlet header 22 is also installed in the top of the filter vessel for receiving flow of jetting stream and liberated contaminants during the cleaning cycle. The outlet header also contains a mechanical sieve means 23, shown here as slotted pipe or wedge-wire where the open slots are of a diameter less than the smallest media granule size and prevent any mobilized filter media from escaping the vessel during the backwash cycle. Although this figure shows separate process fluid inlet and backwash outlet means, many inlet distributor designs combine both process fluid distribution and backwash extraction. The description of the inlet is exemplary of a preferred embodiment and that other feed inlets may be utilized depending on the characteristics of the liquid to be filtered and the contaminants contained therein.

FIG. 1 also shows an outlet header 30 to which attached are mechanical sieve means 33, shown here as slotted pipe or wedge-wire. After passing through the filter bed, the cleaned filtrate exits the filter vessel through the openings in the sieve. The diameter of the sieve openings is smaller than the smallest filter media granule diameter so that the media is retained inside the vessel during operation.

FIGS. 1 and 2 shows a plurality of radial nozzles 40 having outlets just below the bottom tangent of the mechanical sieves. In the embodiment shown in FIG. 2, the mechanical sieves means 33 is comprised of four wedge-wire screens forming a cross-shaped outlet header. In this configuration, four radial nozzles 40 are placed within the spaces between the four mechanical sieves 33 in the outlet header. Of course, it is to be understood to those skilled in the art that the size and shape of the outlet sieve means and the number of radial nozzles employed will be dependent on the diameter of the filter housing.

The radial nozzles 40 shown in FIGS. 1 and 2 are comprised of two horizontal circular discs spaced-apart to create a void through which the jetting stream flows into the filter media bed during the cleaning cycle. The elevation of the radial nozzle outlet void is shown approximately even with the bottom tangent of the mechanical sieve pipes 33. In many filter vessels, the bottom vessel head is filled with a solid material, such as grout or concrete, up to the bottom of the mechanical sieve pipes. This solid material acts as a support base for the filter media granules during normal filter operations since filter media below the mechanical sieve pipes is essentially of no effective use. Normally, the radial nozzle outlet voids are placed near the bottom tangent of the sieves pipes 33 so that filter media near the base of the tank can be contacted by the jetting stream. The placement of nozzles near the base of the filter media bed also allows the jetting stream to clear the openings of the sieve slots of possible media or contaminant obstructions. For applications where contact with the media near the base or jetting of the sieve is not required or desired, the height of the outlet voids of the radial nozzles may be elevated above the outlet manifold so that the jetting dispersion can penetrate to the full extremities of the vessel without interference from the outlet manifold or sieve screens.

The jetting stream, comprised of a mixture of liquid and gas premixed outside of the filter housing, is carried to the radial nozzle via a conduit **35**. This conduit is shown in the drawing as a straight pipe segment collected to a pipe 90° elbow turning down and connected to the top circular disc of radial nozzle.

For most filter vessel sizes shown in FIG. 2, four radial nozzles placed in the proximate center of each quadrant formed by the cross-shaped outlet manifold and sieve pipes will provide adequate coverage of the jetting stream throughout the filter bed cross-section. The lateral extent to which the radial nozzles disperse the jetting stream is predominantly set by the rate of water and gas premixed outside of the filter housing by the filter operator. Therefore, the balance between increasing the water/gas flow rate to each radial nozzle or increasing the number of radial nozzles across the vessel cross-section is largely a question of economics. The inventors have found satisfactory economics by designing each jetting nozzle to clear a region of approximately 1.5 to 3 feet lateral radius from the nozzle centerline. The number of nozzles is increased as needed to substantially cover the cross-section of the filter vessel, while the placement of the nozzles is largely dictated by cross-sectional symmetry.

FIG. 2 shows the placement of the plurality of nozzles across the vessel cross section in relation to a vessel/nozzle centerline radius **R**. This vessel nozzle radius **R** will vary with filter media type, filter vessel diameter, contaminant loading, and contaminant physical properties. The inventors have found that for water filtration of oil and solids using black walnut shells, an **R** value in the range of 25% to 36% of the vessel diameter **D** will provide adequate coverage of the jetting stream for effective media agitation cleaning.

FIG. 4 shows an alternate location of the four nozzles shown on dotted radius “**R**”, each rotated 45° from the positions shown in FIG. 2 and located just above the mechanical sieve screens **33**. By rotating the radial nozzles in line with the mechanical sieve screens and elevating them just above the top tangent of the circular

size screens, the jetting stream will have the least degree of interference with from the sieve screens. This location may, for example, be more desirable for filter applications where the majority of the contaminants collect in the first few feet of filter media depth and the filter media does not tend to plug the openings of the sieve screens. The benefit of this arrangement is that "blind-spots" are minimized since the vertical movement of the jetting stream is not impeded by contact with the sieve screen members as may occur in other embodiments shown.

Alternatively, as shown in FIG. 7, the radial nozzles may be placed below and aligned with the outlet sieve screens so that the jetting stream comes in direct contact with the sieve screens to flush and clean filter media and contaminants away from the sieve openings. This nozzle orientation may be preferred in some applications where jetting of the sieve screens is required to agitate media around the sieve screens for contaminant removal and to flush away any media that may have become lodged within the sieve screen openings.

FIG. 5 shows a single radial nozzle element contemplated by the inventors for dispersing the jetting stream. The radial nozzle is comprised of a top circular plate **50** and a bottom circular plate **51** into which an opening (not shown) is placed for connection to conduits **38, 37, 36, & 35** to transport the jetting stream to the nozzle. Each circular plate is of diameter **D**. The nozzle plates **50, 51** are spaced apart by a gap '**h**', which can be of variable dimension based on the size of the vessel, the filter media being cleaned, and the jetting radius desired. The inventors have found satisfactory performance for a nozzle gap '**h**' within the range of 2 mm for small filter systems to 30 mm for large industrial filter applications. In general, the gap diameter '**h**' should be smaller-than the smallest sized filter media granule in order to prevent said granules from plugging the gap when the nozzle is not in operation. The diameter **D** of the circular plates **50, 51** typically ranges from 100 mm for small filter systems to 400 mm for large industrial filter systems.

In further reference to FIG. 5, as the jetting stream flows through the void between the plates **50, 51** and exits the outer boundary of plates **50,51** the jetting stream

pressure suddenly drops to that of the filter vessel. The gas within the liquid portion of the jetting stream forms a continuous high-velocity bubble dispersion extending away from the nozzle shown in FIG. 5 as the dashed straight lines. As this jetting stream moves away from the nozzle and into the filter media, it causes liquid within the area around the nozzle to circulate, shown in FIG. 5 as the curved dashed lines with arrows on the end. By causing circulation of the internal liquid, the amount of liquid added to the jetting stream can be reduced, thereby reducing the overall volume of backwash liquid requiring disposal or reprocessing.

For applications involving high-pressure filter housing, there may be a tendency of filter media to pack into the void space between the plates of the radial nozzle and into the jetting stream conduit. FIG. 6 shows a modified nozzle embodiment that includes a top plate 64 that has diameter slightly larger than the bottom plate 65 to reduce granule packing into the nozzle outlet caused by weight pressure of the media on top of the nozzle. This nozzle also has a tapered plate spacing that is comprised of a narrowing section H1 that is smaller than the outlet height H2. The tapered and non-parallel faces of the top plate 64 and bottom plate 65 also aid in the jetting stream clearing the radial void between the plates when jetting cycle is initiated. The embodiment shown in FIG. 6 also shows a dividing cone 66 that is comprised of a cone extending away from the underside of the bottom plate and into the conduit opening of the top plate. The axial center of the cone is aligned with the axial center of the conduit opening to provide more even distribution of the jetting stream throughout the radial void space between the nozzle plates.

In reference to FIG. 8, an embodiment is presented wherein several filter housings, containing the internal members described herein for carrying out the cleaning method and shown in the previous Figures, are placed inside a singular horizontal vessel 80 and separated by a plurality of dividing baffles 84. Note that for clarification purposes, the component numbers of the embodiment in the figure is shown for one chamber and it is to be understood that each chamber has identical components. Each filter chamber contains a process inlet nozzle 82 and a process outlet nozzle 81. A plurality of piping conduits may be connected to these inlet and

outlet connections so that the process fluid may flow into each chamber in parallel. In such a filter, a large fluid processing volume is allowed without requiring a large number of radial nozzles to be installed to ensure adequate jetting coverage as might be required if the filtration were carried out in a single large filter vessel.

Alternatively, the piping conduits connecting the chambers may be done so that the fluid to be filtered flows through each chamber in a series manner. Such a flow pattern may be advantageous where each chamber contains a different media type that has a unique affinity for a particular fluid contaminant or particle size. In this type of filter arrangement, the amount of jetting stream required to break-up and mobilize the contaminants during the cleaning cycle may be varied independently to each chamber to optimize the cleaning cycle.

In the present invention, the jetting stream flowing to the radial nozzles inside the filter housing is comprised of a pre-mixed stream of a compressed gas and liquid flowing to each nozzle from a common header. Connected to this common header is a source of a pressurized gas and pressurized liquid. Each of these stream flows into the common distribution header through a control element and metering means such that the filter operator can adjust the rate of gas and liquid flowing to the nozzles. Typical gas sources are compressed air or natural gas. However, any inert gas would be applicable. For economic reasons, the liquid source typically used by the inventors is the incoming contaminated process fluid.

The amount of liquid and gas flowing into the common header is largely dependent on the overall size of the filter housing. The inventors have determined that approximately 9 gpm (gallons per minute) of water per square foot of bed area and 0.7 SCFM (standard cubic feet per minute) of gas per cubic foot of bed provide adequate performance for cleaning black walnut shells filtering oil and solids from produced water. Converting these values to a common volumetric units gives a typical value of 1.7 cubic feet of liquid per square feet of bed area per standard cubic feet of gas per cubic feet of filter media inside the housing. This ratio will vary to some extent based on the size of the vessel, the number of radial nozzles used, the size and volume of filter media being cleaned, and the physical characteristics of the contaminants.

Therefore, it is understood that part of the operation of this type of filter is adjusting the liquid and gas stream rates to optimize the media cleaning cycle performance while maintaining the amount of contaminated liquid remaining for disposal or recycling.

The scope of the claims should not be limited by the preferred embodiments set forth in the foregoing examples, but should be given the broadest interpretation consistent with the description as a whole, and the claims are not to be limited to the preferred or exemplified embodiments of the invention.

CLAIMS

1. A deep bed filter vessel (10) for filtering contaminants from a contaminated liquid stream, comprising:

said vessel (10) defining an internal space for containing a liquid to be filtered;

a bed (12) of granular filter medium disposed inside the vessel in at least a lower region thereof;

an inlet distributor (20) situated in an upper region of the vessel (10), for receiving a contaminated liquid and distributing that liquid downwardly and substantially uniformly across the vessel cross section during a filtering cycle;

outlet filter means, coupled to an outlet header (30), for withdrawing filtered liquid from the vessel (10) while retaining the granular filter medium (12) within the vessel during said filtering cycle; said outlet filter means being situated in said lower region of said vessel (10) and low in said filter medium (12);

backwash removal means (22, 23), situated in said upper region of said vessel and independent of both said inlet distributor (20) and said outlet filter means, for withdrawing a mixture of gas and liquid from the vessel during a cleaning cycle while retaining the granular filter medium (12) within the vessel during said cleaning cycle;

characterized by further having:

at least one radial nozzle (40) or a plurality of evenly spaced radial nozzles (40) near the base of the filter media bed for dispensing, during said cleaning cycle, and radially outwardly therefrom, a jetting stream of bubbles of gas dispersed within a backwash liquid at a nozzle exit velocity to produce a uniform gas dispersion within the backwash liquid, the nozzle or plurality of nozzles being situated low in the vessel and within said granulated filter medium (12) and located in proximity to a bottom of the bed (12) so that at least a portion of said jetting stream is directed upon said outlet filter means; and

at least one conduit (36) disposed within the vessel (10) for transporting the controlled mixture of gas and liquid to said at least one radial nozzle (40).

2. The deep bed filter vessel (10) as claimed in claim 1, characterized in that the outlet filter means comprises outlet mechanical sieves (33) , and said mixture is dispensed from said one or more radial nozzles (40) during said cleaning cycle directly contacts said mechanical sieves (33) so as to flush and clear any of said granulated medium(12) which may have become lodged in openings in said mechanical sieves (33).

3. The deep bed filter vessel (10) as claimed in any one of claim 1 or 2, characterized in that the outlet filter means contains mechanical sieves (33) having openings smaller than the smallest granules of medium (12) so that the medium (12) is retained within the vessel (10) during both the filtering cycle and during the cleaning cycle .

4. The deep bed filter vessel (10) as claimed in claim 1, characterized in that said at least one radial nozzle (40) comprises a plurality of radial nozzles (40), said outlet filter means comprises a plurality of mechanical sieves (33) substantially corresponding in number to the plurality of radial nozzles (40), and said controlled mixture when respectively dispensed outwardly from said plurality of radial nozzles (40) during said cleaning cycle directly contacts respective of said plurality of outlet mechanical sieves (33) so as to flush and clear any media therefrom which may have become lodged in openings in said outlet mechanical sieves (33) .

5. The deep bed filter vessel (10) as claimed in claim 1, characterized in that both the outlet filter means and the backwash removal means (23) each contain mechanical sieve means (33) having openings smaller than the smallest granules of medium (12) so that the medium (12) is retained within the vessel(10) during both the filtering cycle and during the cleaning cycle .

6. The deep bed filter vessel (10) as claimed in claim 4, characterized in that said mechanical sieves (33) are situated in a substantially horizontal plane within said vessel (10), and said plurality of radial nozzles(40) are respectively interspersed

between and substantially co-planar with said respective outlet mechanical sieves (33).

7. The deep bed filter vessel (10) as claimed in claim 6, characterized in that said jetting stream from said nozzles agitates the medium in the region of each of said mechanical sieves(33) during the cleaning cycle.

8. The deep bed filter vessel (10) as claimed in claim 1, characterized in that said backwash removal means comprises a plurality of backwash mechanical sieves (23) and said inlet distributor comprises a corresponding plurality of inlet distributors (20) situated proximate respective backwash mechanical sieves (23), such that contaminated liquid exiting said inlet distributors directly contacts said backwash mechanical sieves (23) during the non-cleaning cycle.

9. The deep bed filter vessel(10) as claimed in claim 8, characterized in that said plurality of downwardly extending inlet distributors (20) are each respectively situated substantially directly above a corresponding respective backwash mechanical sieves (23).

10. The deep bed filter vessel (10) as claimed in claim 1, characterized in that said at least one radial nozzle (40) is/are comprised of a circular top (50) and bottom plate (51) member respectively spaced apart from each other to create a cylindrical void through which said mixture of gas and liquid may exit in a radially-outward manner, with one plate member having a central opening connected to the conduit for permitting passage of the mixture of gas and liquid into said cylindrical void.

11. The deep bed filter vessel (10) as claimed in claim 10, characterized in that the spacing between the top and bottom plate members is equal to or between 2 millimeters and 30 millimeters.

12. The deep bed filter vessel (10) as claimed in claim 10, characterized in that the top (50) and bottom (51) plate members are of equal diameter and between 100 and 400 millimeters in diameter.

13. The deep bed filter vessel (10) as claimed in claim 10, characterized in that the spacing (H) between the top (50) and bottom (51) plate members is substantially equal across a radius of the cylindrical void.

14. The deep bed filter (vessel) as claimed in claim 10, characterized in that the plate members (50,51) are arranged substantially coaxially but spaced apart from each other, and wherein a distance (H) separating top (50) and bottom (51) plate members increases with radial distance away from an axial center of the plate members (50, 51).

15. The deep bed filter vessel(10) as claimed in claim 10, characterized in that the circular top plate (50) member has a diameter (D) slightly larger than the bottom plate member (51) to reduce the tendency of the filter media to lodge within the cylindrical void when the controlled mixture of gas and liquid is not flowing.

16. The deep bed filter vessel (10) as claimed in claim 10, characterized in that said one or more radial nozzles (40) have a flow diverting member (66) adapted to be contacted by the controlled mixture of gas and liquid so as to distribute said mixture more evenly through the cylindrical void .

17. The deep bed filter vessel (10) as claimed in claim 16, characterized in that said flow diverting member (66) has a circular base (65) formed from one of said first and second plate members (50, 51) and an opposite pointed end extending outwardly therefrom and toward an other of said top and bottom plate members (50, 51) and centrally into said cylindrical void, for diverting said mixture radially outwardly and into said cylindrical void.

18. The deep bed filter (vessel) as claimed in claim 16, characterized in that said flow diverting member (66) comprises a dividing cone having a circular base formed of one plate member and connected to the other plate member and a distal point extending away from the surface of the other plate member along a common axis of the plate members (50, 51) for reducing hydraulic pressure low of the controlled mixture exiting through the radial nozzle (40) and distributing such mixture more evenly through the cylindrical void.

19. The deep bed filter vessel (10) as claimed in claim 1, characterized in that said deep bed filter is adapted to use said contaminated liquid stream as said liquid in said controlled mixture of gas and liquid and thereby eliminate a need for storing and/or using a contaminant-free liquid.

20. The deep bed filter vessel (10) of claim 2, 3, or 4, characterized in that said gas bubbles are entrained in said jetting stream outside said vessel, and in a controlled ratio relative to said quantity of backwashing liquid, and said controlled ratio is further variably adjustable to allow optimization during said cleaning cycle of the action of said gas bubbles.

21. The deep bed filter vessel (10) characterized by possessing:

a primary external housing containing a plurality of separate chambers where each chamber defines an internal space for containing a bed of granular filter media and receiving a contaminated liquid to be filtered, each of said plurality of separate chambers containing:

an inlet distributor for receiving during a filtering cycle a contaminated liquid and distributing that liquid uniformly across the chamber cross-section;

an outlet filter means (33) for withdrawing filtered liquid from proximate a bottom region of the chamber while retaining the granular filter media within the chamber, which outlet filter means (33) is not used for backwashing;

at least one radial nozzle (40) or a plurality of evenly spaced radial nozzles (40) located in a region of the chamber proximate the outlet filter

means, for dispensing a controlled mixture of gas bubbles and liquid substantially throughout the granular filter media to thereby agitate and fluidize said granular medium particularly in a region of said medium in which said outlet filter means is situated, during a cleaning cycle;

a conduit (35, 36, 37, 38) connected to each radial nozzle (40) and extending outside of each separate chamber, for receiving and transporting said controlled mixture of gas bubbles and a backwashing liquid to each of said radial nozzle(40) for use during said cleaning cycle when said gas bubbles are substantially uniformly entrained and dispersed in said backwashing liquid in a controlled ratio to said backwashing liquid ; and

backwash removal means, independent of said inlet distributor and said outlet filter means, for withdrawing the controlled mixture of gas bubbles and liquid from each chamber during the cleaning cycle while retaining the granular filter medium within the respective chamber during the cleaning cycle.

22. The deep bed filter vessel (10) of claim 21 , characterized by further comprising a plurality of conduits connected to the inlet distributor and outlet filter means of each chamber for allowing the contaminated liquid being filtered to flow through the plurality of chambers within the primary housing either in parallel or in series.

23. The deep bed filter vessel (10) as claimed in claim 21, characterized in that the contaminated fluid is arranged to flow in a series direction through the plurality of chambers.

24. The deep bed filter vessel (10) as claimed in claim 23, characterized in that the average particle size of the granular filter media in each chamber is arranged to decrease in each subsequent chamber in the direction of flow.

25. The deep bed filter vessel (10) as claimed in claim 1 or 21, characterized in that the granular filter medium is granulated black walnut shells.

26. A method of filtering contaminants from a liquid stream using a deep bed filter (10) as claimed in claim 1, which eliminates the need for storing clean filtrate for use during backwash cycles, characterized by:

downwardly filtering the contaminated liquid stream through the deep bed filter vessel (10) during a filtering cycle;

backwashing the granulated filter medium (12) with a controlled mixture of backwashing liquid and gas bubbles during the cleaning cycle via said at least one radial nozzle (40) by directing said jetting fluid from said at least one radial nozzle (40) at an exterior surface of said outlet filter means;

receiving the controlled mixture of gas bubbles and backwashing liquid having entrained contaminants therein within said backwash removal means situated in said upper region of said deep bed filter vessel(10); and

discharging the mixture of gas bubbles and backwashing liquid from the deep bed filter vessel (10) during said cleaning cycle while retaining the granular filter medium (12) within the deep bed filter vessel (10) during said cleaning cycle.

27. The method as claimed in claim 26, characterized by :

using black walnut shells to filter a contaminated liquid stream which comprises water containing suspended oil droplets and solid contaminants.

28. The method as claimed in claim 27, characterized by:

using a filter media (12) comprised of granulated black walnut shells;
and

using a flow rate of water through the deep bed filter of approximately 9 gallons per minute per square foot of bed area .

29. The method as claimed in claim 28 characterized by:
adding gas to the controlled mixture at a rate between approximately
0.7 standard cubic feet per cubic foot of filter medium .

30. The method as claimed in claim 27 , 28, or 29 , characterized by:
using a controlled mixture comprised of a mixture of a gas and water
in the ratio approximately 1.7 cubic feet of water per minute per square foot of bed
area per cubic foot of gas per cubic foot of filter media .

31. A method of filtering contaminants from a liquid stream using a deep bed
filter vessel (10) as claimed in claim 26, characterized in that :

(a) the granular filter medium (12) is granulated black walnut shells;

(b) the liquid component of the controlled mixture of liquid and gas is
water containing suspended oil droplets ;

(c) said vessel (10) is substantially cylindrical , of diameter "D" ;

(d) said outlet filter means comprises a plurality of radially outwardly
extending outlet mechanical sieves (33) uniformly radially spaced from each other
and located in a horizontal plane;

(e) said at least one radial nozzle (40) comprises a plurality of radial
nozzles (40) corresponding in number to the plurality of outlet mechanical sieves
(33), and respectively interspersed between respective outlet mechanical sieves (33)
and co-planar therewith, about a circular arc of radius "R", and

(f) wherein "R" is in the range of 25-35% of diameter "D" of said
vessel(10) .