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SEPARATION OF HYDROCARBONS AND WATER FROM MIXTURES THEREOFTechnical Field

This invention relates to the separation of hydrocarbons and water from emulsified mixtures thereof, and more particularly the separation of oil and other hydrocarbon fuels from emulsified mixtures with water. For the simplicity of description, hereinafter the invention will be described with reference to the separation of mixtures of oil and water, although it should be appreciated that it is also applicable to the separation of mixtures of other hydrocarbon fuels and water.

Background Art

The advent of increasingly stricter environmental regulations with respect to the treatment of oil and water mixtures to separate the components of the mixture both at sea and on land, whereby to dispose of the unwanted oil component of the mixture and recovery of the water component, has required a reassessment of existing separation methods and apparatus. At present it has been internationally agreed that the treatment of such mixtures be such as to reduce the oil component of the mixture to a level less than 15 parts per million. Known separation methods and apparatus using principles of gravity, coalescence and various membrane based equipment, have been unable to, or at the best unable to consistently, separate the oil component from such mixtures to achieve water discharges with the low oil level required, whilst it is anticipated that ultimately regulations, including international regulations, will require significantly less, if not no, levels of oil in water after treatment.

The problem has become exacerbated with vessels at sea where the increased use of detergents combined with the advent of fuel types that are composed of a greater proportion of the lighter hydrocarbon fractions, has

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resulted in bilge waters that contain oil which is emulsified with the bilge water, and as such vessels are subject to increasingly stricter international regulations which known treatment methods and apparatus cannot-
5 consistently meet, there is a need for better methods and apparatus. It is anticipated that on-land installations will ultimately be subject to the same stricter regulations.

Disclosure of the Invention

10 We have found that using activated polymer materials, such as ground rubber, and in the form of filter devices into which mixtures of oil and water are passed, achieves very significant improvements in capturing the oil component of the mixture whereby the water discharge from the filter
15 device contains far less than the required 15 parts per million of oil and with the capacity ultimately to achieve close to no, if not any, oil component.

Fine ground rubber, or other polymer materials, ground to in the range of 30 - 60 mesh, and activated, and placed in
20 oil, has the ability to retain oil on its surface. In normal circumstances fine ground polymer materials, such as rubber, are hydrophobic and will float on the surface of a body of water and not mix with the water, whereby the water will not wet the surfaces of the rubber granules, and as a
25 consequence oil in an emulsified mixture with water will not contact the surfaces of the rubber granules. However, if the ground rubber or other polymer material is, what is hereinafter referred to as "activated", by being washed with certain substance, such as, alcohol or an alcohol
30 based substance, the granulated material becomes hydrophilic allowing full contact therewith by the water of the mixture and therefore also by the oil emulsified in the mixture, and is such that the oil will be retained on the surfaces of the granulated material, and as a result
35 separated from the water component of the mixture.

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The invention therefore envisages a method of separating the hydrocarbon and water components of a mixture thereof, in which the mixture is passed through at least one filter mass including granules of a polymer material which have been activated by exposure to a substance rendering said granules hydrophilic, and whereby a large proportion of the hydrocarbon content of the mixture is retained by said granules to be separated from the water content of the mixture as it passes through said filter mass.

The invention also envisages an apparatus for separating the hydrocarbon and water components of a mixture thereof, comprising at least one housing containing at least one filter mass including granules of a polymer material which have been activated by exposure to a substance rendering said granules hydrophilic, and whereby to retain a large proportion of the hydrocarbon content of the mixture and separate it from the water content of the mixture as it passes through said filter mass, means to introduce said mixture into said housing, and means through which separated water may be discharged from said housing.

Brief Description of the Drawings

Several preferred embodiments of the invention will now be described with reference to the accompanying drawings, in which,

Figure 1, is a schematic vertical cross-sectional view through an apparatus in accordance with a first preferred embodiment of the invention, and for carrying out the method of the invention,

Figure 2, is a schematic view of a plurality of the apparatus of Figure 1 connected in series to form a second embodiment of the invention,

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Figure 3, is a schematic view of a plurality of the apparatus of Figure 1 connected in parallel to form a third embodiment of the invention,

Figure 4, is a top plan view of an apparatus in accordance with a fourth embodiment of the invention,

Figure 5, is a cross-sectional view taken along line 5 - 5 of Figure 4, and

Figure 6, is a plan view from beneath of the apparatus of Figures 4 and 5.

10 Best Modes for carrying out the Invention

Referring to Figure 1 of the drawings, the apparatus of this first preferred embodiment of the invention comprises a vertically elongate cylindrical housing 10 having an upper end wall 11 and a lower end wall 12, and divided into three chambers 13, 14 and 15 by upper and lower sieves or screens 16a and 16b respectively, and through which fluid can pass from chamber 13 to chamber 14 and thereafter from chamber 14 to chamber 15. The upper and lower sieves or screens prevent solid rubber, or other polymer, granules 17 in the chamber 14 from passing out of that chamber into either chamber 13 and/or 15. In this preferred embodiment the material in chamber 14 is granulated rubber ground from old motor vehicle tyres to within a range of 30 - 60 mesh, by means of a grinding mechanism which cuts or saws the tread, side walls, or both, of the tyre into granules. Other polymer materials may also be used, including natural rubber. The rubber granules after being washed with alcohol, or an alcohol based substance, to thereby become "activated" as discussed previously, are suspended in a body of water in chamber 14 to form a fluidised bed 20 in the chamber.

At the top of the housing 10, and through the upper end

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wall 11 thereof, is provided an inlet conduit 18 for admitting an emulsified mixture of oil and water into chamber 13, and incorporating an inlet valve 19 for controlling flow of mixture to the chamber 13. The mixture accumulating in chamber 13 disperses evenly laterally of the housing 10 and then through the upper sieve or screen 16 to the fluidised bed 20. The activated rubber granules 17 in the fluidised bed are contacted by the mixture to capture the oil component of the mixture, whilst the water component of the mixture passes freely through the fluidised bed to a mineral layer 21 in the bottom of chamber 14. The mineral layer may be formed from quartz, calcite or any other suitable filtering medium. The separated water passes through the mineral layer and then through the lower sieve or screen 16b into chamber 15 from which it flows to a vertically extending discharge conduit 22 and then out of the apparatus via an outlet valve 22a which controls water discharge from the apparatus.

The reaction of the oil with the activated rubber granules 17 in chamber 14, tends to cause the granules to rise within the chamber to the top thereof where they are retarded against further upward movement by the upper sieve of screen 16a, whilst the oil and water mixture passing through the upper sieve or screen 16a tends to agitate the activated fluidised rubber bed 20 to expose the rubber granules 17 to the oil component of the mixture to increase contact and retention of the oil on the granules.

The quality of water discharged from the apparatus may be monitored by equipment, already available, to detect when the oil content reaches the maximum level allowable and to shut down the apparatus and switch the flow of oil/water mixture to an alternative filtering apparatus, whereafter the granulated oil/rubber mass is removed from the previously used apparatus for treatment to recover the oil or the mass is disposed of.

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In the embodiment of Figure 2, a plurality, in this case six, of the filtering apparatus units of Figure 1 are connected in series by connecting conduits 23 between the discharge conduits 22 of one unit and inlet conduits 18 of a following unit to increase the overall oil separation efficiency of the apparatus.

In the embodiment of Figure 3 a plurality, once again six, of the filtering apparatus units of Figure 1 are connected in parallel by a common supply conduit 24 feeding directly the inlet conduits 18 of each housing 10 with a common main discharge conduit 25 being provided for each of the discharge conduits 22 from the housings. Once again the quality of the water discharge from each unit may be monitored to detect when the oil content reaches the maximum level allowable to shut down the particular unit leaving the remaining units to continue their separating functions.

In the embodiment of Figures 4 to 6, which has proved to be particularly successful in trials conducted in a Royal Australian Navy vessel, and which has become especially effective when installed in series with conventional separators, such as to become a polishing or enhancing filter, comprises of vertically elongate cylindrical main housing 26, with lower supporting legs 26a. In the housing three superimposed filter cartridges 27 having outer housings 27a, formed from hardened rubber or metallic materials, are received and located relative to each other by a male member 28 on the base of one cartridge locating within a female member 29 on the top of the underlying cartridge, and through which cartridges emulsified oil and water mixture successively filters from the top to the bottom of the main housing 26.

In this case, the housings 27a of each of the cartridges 27 have contained therein rubber, or like polymer, granules

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which prior to "activation" are immobilised by application to a thin layer of polymer bond material whilst that material is in a liquid state, and thereafter the combination is allowed to cure into a sheet from the surface of which the rubber granules protrude in an immobilised condition. A plurality of such sheets with open weave spacer sheets therebetween, such as plastic fly wire screen type material, are then wound into the form of a cylinder to form a filter structure the circumference of which is sealed by a plastic sleeve leaving the ends thereof open to allow fluid flow axially through each cartridge via the open weave spacer sheets after the filter structures are placed in the respective housing 27a. Layers of glass fibre wool or similar materials are positioned within the tops and bottoms of the cartridges to prevent migration out of the cartridges of rubber granules which may become detached from the polymer bond materials. The immobilised rubber granules within the cartridge are activated by exposure to alcohol, or an alcohol based substance, prior to, or whilst, being positioned within the housings 27a.

In order to allow access to the interior of the main housing 26 an upper closure plate 28 is provided which closes the upper end of the housing with a plurality of circumferentially spaced apart clamping devices 29 having clamping bolts 29a carrying nuts 29b being provided. The clamping bolts 29a are received within radially extending slots 31 in the perimeter of the closure plate whereby, when the closure plate is positioned on the upper end of the housing, the nuts 29b may be tightened to clamp the closure plate to the end of the housing, with a handle and clamping lever arrangement 37 being provided to complete the clamping action.

In this embodiment of the invention an inlet 32 for emulsified oil and water mixture is provided extending

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radially through the wall of the housing into a cavity 33 above the uppermost of the cartridges 27, and which allows a supply of emulsified oil and water mixture to spread evenly over the top of the uppermost of the cartridges 27 before filtering down through the cartridge assembly. A spring assembly generally indicated as 34, and including force transmitting pillars 34a, a spacer plate 34b, and conical coil springs 34c, provides a downward biasing force on the assembly of the cartridges 27, whilst the cavity 33 is defined between the spacer plate 34b and the top of the uppermost of the cartridges 27.

The bottom of the housing 26 is closed by an end wall 35 through the middle of which an outlet 36 is provided for the discharge of separated water.

As the emulsified oil and water mixture passes successively through the cartridges 27, the oil content thereof contacts and is retained by the "activated" rubber granules within the cartridges. Once the effectiveness of the "activated" rubber granules is reduced to the extent that monitored oil content of the water discharging from the apparatus reaches the allowable maximum parts per million the cartridges 27 are removed after opening the upper closure plate 28 and are thereafter replaced with new cartridges. The used cartridges are then disposed of by burial in land fillings or as fuel for furnaces or kilns. In this embodiment of the invention a pressure gauge may be provided and associated with a gauge port 50 through the upper closure plate 28, whilst a drain port 51 is provided through the lower end wall 35 of the housing and closed by a removable closure plug 52.

Once again, as with the embodiments of Figures 2 and 3, a plurality of the apparatus of Figures 4 to 6 may be coupled in series or in parallel to increase the capacity of the system, or in the case of parallel coupling, allow the

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closing down of one unit when the oil content of the water discharging therefrom reaches the allowable limit.

As an alternative to inclusion of granules of rubber, or like polymer material, in a fluidised bed as in the case of the embodiments of Figures 1 to 3, or immobilisation on a thin layer of polymer bond material as in the case of the embodiment of Figures 4 to 6, the granules may be retained within a body of a medium of particles such as sand or gravel, either before or after being "activated" by exposure to alcohol or an alcohol based substance. In another alternative, the granules may be retained by applying them to a thread of cotton or similar material utilising a polymer bonding material, and the threads thereafter vertically bunched together within a plastic sleeve to provide a porous filtering mass for use as disposable cartridges in the apparatus of Figures 4 to 6. The granules may then be "activated" by exposure to alcohol, or an alcohol based substance. In a still further alternative a sponge may be created by blowing rubber or polymer granules into a chamber in which, under turbulence, they are mixed with droplets of an aerated polymer bonding material which adhere to the granules, and then drop to the bottom of the chamber to form a sponge-like combination of the granules and the polymer which, when cured, will form a rigid porous filter medium through which an oil and water emulsion mixture can pass and which, if the circumference is contained within a plastic sleeve, can provide disposable cartridges for use in the apparatus of Figures 4 to 6.

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CLAIMS:

1. A method of separating the hydrocarbon and water components of a mixture thereof, in which the mixture is passed through at least one filter mass including granules of a polymer material which have been activated by exposure to a substance rendering said granules hydrophilic, and whereby a large proportion of the hydrocarbon content of the mixture is retained by said granules to be separated from the water content of the mixture as it passes through said filter mass.
2. A method as claimed in Claim 1, wherein the filter mass is a body of liquid in which the said granules are suspended to form a fluidised bed.
3. A method as claimed in Claim 1, wherein the filter mass is one or more cartridges formed from cylindrically wound sheets comprised of said granules retained on a thin layer of polymer bond material, with said sheets alternating with sheets of open weave material.
4. A method as claimed in Claim 1 wherein the filter mass is formed by mixing said granules with a medium of particulate material.
5. A method as claimed in Claim 1, wherein the filter mass is formed from a mass of thread-like elements on which the granules are retained by means of a polymer bonding material.
6. A method as claimed in Claim 1, wherein the filter mass is a porous sponge formed by mixing said granules under turbulence with droplets of an aerated polymer bonding material.
7. A method as claimed in any one of the preceding claims, wherein the granules are rubber granules.

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8. An apparatus for separating the hydrocarbon and water components of a mixture thereof, comprising at least one housing containing at least one filter mass including granules of a polymer material which have been activated by exposure to a substance rendering said granules hydrophilic and whereby to retain a large proportion of the hydrocarbon content of the mixture and separate it from the water content of the mixture as it passes through said filter mass, means to introduce said mixture into said housing, and means through which separated water may be discharged from said housing.
9. An apparatus as claimed Claim 8, wherein the filter mass is a body of liquid in which said granules are suspended to form a fluidised bed.
10. An apparatus as claimed in Claim 8, wherein the filter mass is one or more cartridges formed from cylindrically wound sheets comprised of granules retained on a thin layer of polymer bond material, with said sheets alternating with sheets of open weave material.
11. An apparatus as claimed in Claim 8, wherein the filter mass is formed by mixing said granules in a medium of particulate material.
12. An apparatus as claimed in Claim 8, wherein the filter mass is formed from a mass of thread-like elements on which the granules are retained by means of a polymer bonding material.
13. An apparatus as claimed in Claim 8, wherein the filter mass is a porous sponge formed by mixing said granules under turbulence with droplets of an aerated polymer bonding material.
14. An apparatus as claimed in any one of Claims 8 to

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13, wherein the granules are rubber granules.

15. A method of separating the hydrocarbon and water components of a mixture thereof, substantially as ~~z~~ hereinbefore described.

- 5 16. An apparatus for separating the hydrocarbon and water components of a mixture thereof, substantially as hereinbefore described with reference to Figure 1, Figure 2, Figure 3 or Figures 4 to 6 of the drawings.