APPARATUS FOR EFFECTING FLUID-FLUID CONTACT
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This invention relates to an apparatus for effecting fluid-fluid contact. More particularly, this invention relates to an apparatus for effecting fluid-fluid contact between two immiscible fluids. Still more particularly, this invention relates to an apparatus for effecting liquid-liquid contact, such as countercurrent liquid-liquid contact, between two, at least partially immiscible, liquids.

In U.S. Patent 2,601,674 there is disclosed an apparatus described as a rotating disc contactor which is particularly suitable for effecting fluid-fluid, specifically liquid-liquid, contact between two immiscible fluids. As described in the above-identified patent a rotating disc contactor comprises a stationary tube or shell of which the part forming the actual contacting zone is divided into a plurality of compartments, preferably substantially identical in size and shape, by stationary annular baffles or rings having circular openings. Further, there are rotors or rotor discs, one in each compartment, fixed on a rotor shaft co-axial with the stationary tube, the rotors or discs being removed approximately half-way between the stationary baffles and having a diameter smaller than the diameter of the central openings in the stator baffles.

The liquids to be contacted are fed into the contactor to traverse these several compartments successively, either in countercurrent flow or in countercurrent flow with respect to each other. When used for countercurrent flow of liquids, the tube or contacting zone portion thereof is at least partly upright, and the liquids are of different densities; this results in the formation of two liquid phases of different densities which traverse the successive compartments in opposite directions. The rotation of the rotor discs imparts further movement to the liquids, leading to more intimate contact therebetween.

As further disclosed in U.S. Patent 2,601,674, the disclosures of which are herein incorporated and made part of this disclosure, the rotating disc contactor or contacting zone portion thereof comprises an outer shell which should, when countercurrent extraction between two immiscible liquids is carried out, be at least partially upright. Preferably the rotating disc contactor or outer shell or contacting zone portion thereof is circular in cross section.

This shell in the contacting zone portion has fitted within it a series of annular, stationary, transverse stator baffles extending from the shell wall radially inwardly toward a circular opening, thereby dividing the shell into a series of compartments in communication with one another. The stator baffles are preferably imperforate, except for the aforementioned central opening, and are flat or substantially so, whereby each baffle has its substantially planar surfaces perpendicular to the vertical axis of the contactor. The use of stator baffles of other outlines or shapes, e.g., frusto-conical surfaces of revolution, is possible. These may be permanently fixed to the shell wall or removable mounted in any desired manner, and spaced with respect to the wall of the shell. The interval between the baffles, i.e., the depth of the compartments, may be uniform or may be varied. These stator baffles are provided throughout the part of the shell that is to serve as the contacting zone or extraction zone portion thereof. Liquid inlet and discharge ports are provided at suitable points, e.g., at the ends of the shell and, if desired, intermediate the ends thereof.

A rotor shaft is rotatably mounted substantially coaxially within the contacting zone and is provided with a suitable drive means outside of the shell itself for rotating the rotor shaft at a relatively high speed, such as a speed in the range of 10—2,000 r.p.m. more or less depending upon the size of the contactor, the fluids being contacted and the extent of mixing or contacting desired.

The rotor shaft extends through the openings in the stator baffles and carries a plurality of rotors or rotor discs thereon arranged so that there is one rotor or rotor baffle thereon arranged so that there is one rotor or rotor baffle within each compartment, approximately midway between the adjacent set of stator baffles. The rotors may have any shape found to be desirable or suitable. When, as in the embodiment of this invention illustrated in the accompanying drawing, a cylindrical shell is used and the stator baffles are of equal dimensions, including the compartments therebetween, the rotors are all of a lesser diameter than the diameter of the openings through the stator baffles. When the stators are not all of the same size they may be arranged with openings becoming progressively larger toward one end, thereby permitting free movement of the shaft and the rotors through these openings despite the fact the rotors, like the baffles, may not all be the same size.

Other features of a rotating disc contactor employed to improve fluid-fluid contact include the relative dimensions of the shell and the rotors therein. Best results are usually obtainable when the ratio of the internal diameter of the shell to the axial interval between adjacent stator baffles or between adjacent rotors is in the range 2—8. Still another feature of a rotating disc contactor is the improvement of the liquid-liquid contact is the condition of the surfaces of the stators and rotors. It is generally preferred that the surfaces of these parts be smooth, without irregularities, vanes, ribs, flanges and the like thereon.

Hereinafter in commercial scale operations a rotating disc contactor has generally been employed to effect countercurrent contact between two flowing immiscible liquids. For example, rotating disc contactors have been employed in the solvent refining of lubricating oils employing furfural as the selective solvent. When a rotating disc contactor is employed under conditions involving a relatively high pressure, e.g., a pressure in the range of 100—1,000 p.s.i.g., or more or less, and a relatively high temperature, e.g., a temperature in the range 150—600° F., difficulty would like be experienced in operations under these conditions because of leakage from the rotating disc contactor at that portion thereof where the rotor shaft enters the shell. An effective seal between the rotor shaft and the shell body would be difficult to obtain under conditions of high temperature and pressure thereby creating a hazard and militating against the employment of a rotating disc contactor under such conditions.

Accordingly it is an object of this invention to provide an improved rotating disc contactor.

Another object of this invention is to provide a more versatile rotating disc contactor.

Another object of this invention is to provide a rotating disc contactor suitable for contacting immiscible liquids under conditions involving a relatively high temperature and/or a relatively high pressure.

Still another object of this invention is to provide a rotating disc contactor suitable not only for the solvent refining of lubricating oils and the like but also suitable for the solvent desphalting and/or solvent fractionation
of petroleum fractions and other mixtures of chemical compounds. How these and other objects of this invention are accomplished will become apparent in the light of the accompanying disclosure made with reference to the drawings wherein FIG. 1 schematically illustrates a rotating disc contactor in accordance with this invention; FIG. 2 is a plan view of a rotor suitable for use therein and FIG. 3 is a vertical cross section of the rotor element of FIG. 2. In accordance with at least one embodiment of the invention at least one of the foregoing objects will be achieved.

In accordance with this invention an improved fluid-fluid contacting device, such as a rotating disc contactor, is obtained by employing one or a portion or all of the fluids to be contacted in such a manner so as to effect actual mechanical agitation of the fluids undergoing contacting. Specifically, in the embodiment of this invention with respect to a rotating disc contactor one of the fluids as it enters the interior of the rotating disc contactor is employed to cause the rotors therein to rotate thereby tending to effect actual mechanical agitation of the fluids within the contactor.

Still further in accordance with this invention as applied for effecting fluid-fluid contact, such as counter-current liquid-liquid contact between two immiscible liquid phases, one of the fluids introduced into the contactor is arranged to flow through at least one of the rotors within the contactor and then into the interior of the contactor, the flow of fluid from the rotor into the interior of the contactor being such that as the fluid emerges from the rotor into the interior of the contactor, the reaction to the fluid flow causes the rotor to rotate or be moved in a suitable fashion to effect mechanical agitation of the liquid within the contactor and to promote mixing and contact between the fluids therein.

The invention is further illustrated in the accompanying drawings. Referring now to the drawings, particularly FIG. 1 thereof which schematically and generally illustrates a fluid-fluid contacting apparatus in accordance with the practice of this invention, there is illustrated a closed vertical column 10 of circular cross section and cylindrical shape provided with a cover 11 at the upper end thereof and a flanged opening 12. The upper end of column 10 is provided with outlets 14 and an inlet 15. Also, the lower end of column 10 is provided with an inlet 16 and an outlet 18.

The interior wall of column 10 is provided with annular horizontal stator rings 17, desirably made of thin, flat sheet metal but having circular central openings therethrough concentric with column 10. Extending through column 10 is tubing or hollow rotor shaft 19. Rotor shaft 19 is rotatably fixed at its upper end in upper bearing 20 fixed and supported on the bottom of cover 11. The lower end of rotor shaft 19 is rotatably mounted in lower bearing 21 which is supported at the upper end of inlet pipe 22 which extends into column 10 from the lower end thereof. The other end of inlet pipe 22 forming inlet 22a. Fixed to rotor shaft 19 are a plurality of concentrically mounted rotors 24.

Referring now in detail to accompanying FIGS. 2 and 3 which are respectively a plan view and vertical cross sectional view of rotors 24 illustrated in FIG. 1, as is apparent from FIG. 3 rotor 24 has a hollow interior and is adapted, such as by means of threads 25, to be fixed and engaged to rotor shaft 19. The interior of rotor 24 accordingly is in direct fluid communication with the interior hollow rotor shaft 19. Rotors 24 are also provided with discharge orifices 26 which are positioned in rotor 24 so that the reaction of fluid as it leaves the interior of rotor 24 through orifices 26 tends to exert a thrust upon rotor 24 so as to cause the same to rotate.

In a liquid-liquid contacting operation such as solvent deasphalting or a furfural solvent refining operation carried out in accordance with this invention wherein relatively more dense liquid furfural is employed to solvent refine relatively less dense lubricating oil so as to derive an improved lubricating oil fraction therefrom, liquid furfural is introduced into contactor or column 10 via inlet 15 and lubricating oil is introduced into contactor or column 10 via inlet 16. Refined, improved oil or raffinate is withdrawn from the upper end of contactor 10 via outlet 14 and extract mix comprising furfural and oil dissolved therein is removed from the lower end of contactor 10 via outlet 18.

Lubricating oil so treated is also introduced into contactor 10 via inlet 22a and inlet pipe 22 and flows upwardly through tubing or rotor shaft 19 into the interior of rotors 24 from which it discharges via orifices 26 into the interior of contactor 10. A blind or seal is provided within tubing or rotor shaft 19 above the uppermost rotor 24 therein.

As oil leaves rotors 24 through orifices 26 therein the rotors 24 are turned due to the reaction or thrust of the oil as it issues from orifices 26. As rotors 24 rotate within-in contactor 10 more intimate liquid-liquid contact between the furfural and oil therein is promoted and brought about.

It is apparent that depending upon the rate at which oil or other fluid is introduced into the interior of contactor 10 through rotor shaft 24 and orifices 26 the speed of rotation or r.p.m. of rotors 24, other conditions remaining unchanged, will vary. Generally it is desirable to adjust the rate of flow of fluid through rotors 24 and orifices 26 to impart to the rotors that speed found most satisfactory for effecting the desired extent of liquid-liquid contact.

In the embodiment illustrated in FIG. 3 of the drawing the rotors 24 are shown adapted to be threadedly engaged to tubing or rotor shaft 19, any suitable means of effecting a relatively fluid tight seal between rotors 24 and rotor shaft 19 can be employed. For example rotors 24 may be welded to rotor shaft 19 or otherwise mechanically sealed and fixed thereto so that as rotors 24 rotate rotor shaft 19 is rotated therewith. In the embodiment illustrated in FIG. 1 the rotor shaft 19 rotates with rotors 24, i.e., the rotors 24 are fixed with respect to rotor shaft 19. In another embodiment in accordance with this invention the rotors 24 are free to rotate about rotor shaft 19 in which instance the rotors 24 are rotatably mounted along rotor shaft 19 and shaft 19 does not rotate.

In accordance with another embodiment of the practice of this invention, not illustrated in the accompanying drawing, additional rotors may be provided along rotor shaft 19 and fixed to rotate therewith. These rotors, such as rotor 29 in FIG. 1, would be unlike rotors 24 in that there would be no fluid flow therethrough into contactor 10 but would merely serve to impart additional mechanical agitation to the fluids undergoing contacting within contactor 10. Rotors 29, however, may otherwise be like rotors 24 in that rotor 29 may have any suitable size or shape, the same as or different from rotors 24.

As previously indicated the rotors 24 may have any suitable shape and may be provided with smooth or roughened surfaces such as projections, spiral vanes or protuberances thereon so as to influence and to promote upon rotation of the rotors fluid-fluid mixing within contactor 10.

As will be apparent to those skilled in the art many modifications, changes and alterations are possible in the practice of this invention without departing from the spirit or scope thereof.

1. An apparatus for effecting fluid-fluid contact between two immiscible fluid phases comprising a closed container provided with at least one outlet and at least one inlet at one end thereof and at least one outlet and one inlet at the other end thereof, said container being provided with a plurality of annular baffles fixed to the
wall of said container and dividing said container into a plurality of compartments, said container being provided with a plurality of spaced rotatably mounted rotor discs, each rotor disc having a hollow interior and being disposed within a compartment formed by said annular baffles, said rotor discs being provided with discharge orifices in direct fluid communication with the hollow interior of said rotor discs positioned such that the reaction forces of fluid discharged through said orifices exerts rotational thrust upon said rotor discs, said rotor discs being supported on a tubing provided within said container, said tubing being in direct fluid communication with said hollow interior of said rotor discs supported thereon, one end of said tubing being positioned within said container at one end thereof and the other end of said tubing being positioned within said container at the other end thereof, and said other end of said tubing being positioned within said container and in direct fluid communication with said inlet at said other end of said container.

2. An apparatus for effecting fluid-fluid contact between two immiscible fluid phases comprising a closed container provided with at least one outlet and at least one inlet at one end thereof and at least one outlet and one inlet at the other end thereof, said container being provided with a plurality of annular baffles fixed to the wall of said container and dividing said container into a plurality of compartments, said container being provided with a plurality of spaced rotor discs each rotor disc having a hollow interior and being disposed within a compartment formed by said annular baffles, said rotor discs being provided with discharge orifices in direct fluid communication with the hollow interior of said rotor discs positioned such that the reaction forces of fluid discharged through said orifices exerts rotational thrust upon said rotor discs, said rotor discs being rotatably fixed on a tubing provided within said container, said tubing being in direct fluid communication with said hollow interior of said rotor discs rotatably fixed thereon, one end of said tubing being positioned within said container at one end thereof and the other end of said tubing being positioned within said container at the other end thereof, and said other end of said tubing being positioned within said container and in direct fluid communication with said inlet at said other end of said container.

3. An apparatus for effecting fluid-fluid contact between two immiscible fluid phases comprising a closed container provided with at least one outlet and at least one inlet at one end thereof and at least one outlet and one inlet at the other end thereof, said container being provided with a plurality of annular baffles fixed to the wall of said container and dividing said container into a plurality of compartments, said container being provided with a plurality of spaced rotor discs each rotor disc having a hollow interior and being disposed within a compartment formed by said annular baffles, said rotor discs being provided with discharge orifices in direct fluid communication with the hollow interior of said rotor discs positioned such that the reaction forces of fluid discharged through said orifices exerts rotational thrust upon said rotor discs, said rotor discs being rotatably fixed on a tubing provided within said container, said tubing being in direct fluid communication with said hollow interior of said rotor discs rotatably fixed thereon, one end of said tubing being positioned within said container at one end thereof and the other end of said tubing being positioned within said container at the other end thereof, and said other end of said tubing being positioned within said container and in direct fluid communication with said inlet at said other end of said container.

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