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2,375,558

MIXING APPARATUS

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Fig. 1.

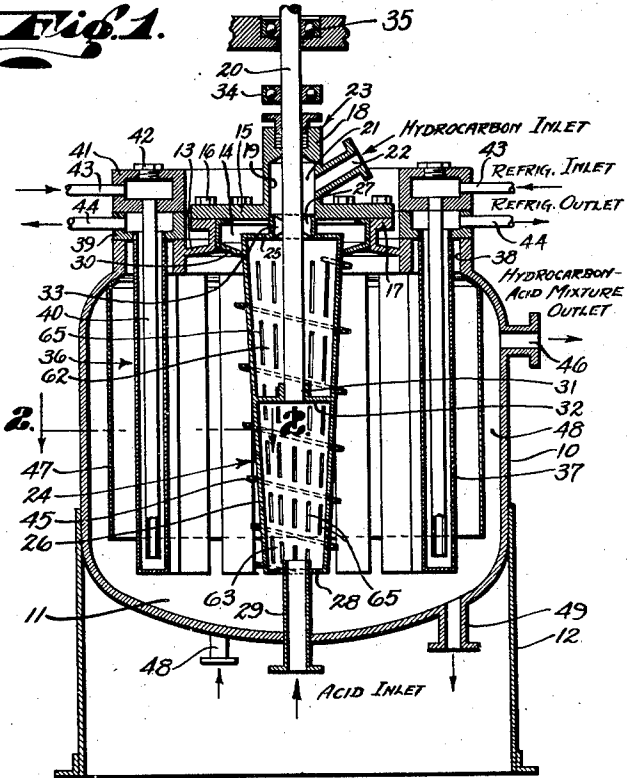


Fig. 2.

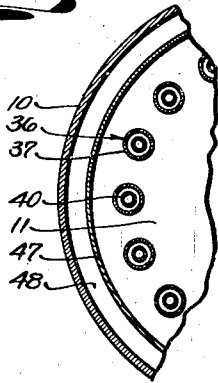


Fig. 3.

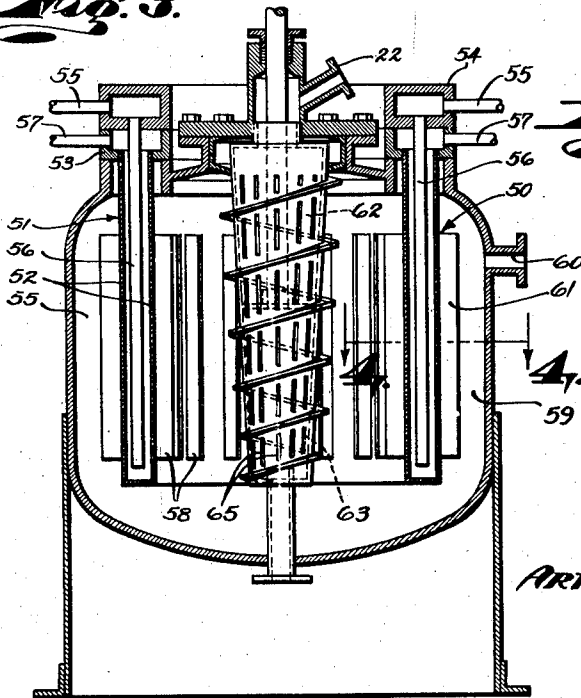
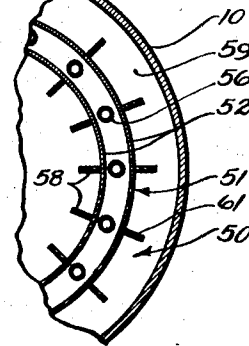


Fig. 4.



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MIXING APPARATUS

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5 Claims. (Cl. 259—23)

This invention deals generally with mixing apparatus of the type in which fluid is introduced to a revolving agitator or rotor, and is ejected in finely divided condition through apertures in the rotor into a surrounding body of liquid. In certain of its more particular aspects the invention is directed to the use of such rotor type mixers, for intimately contacting chemically reactive materials and meeting the thermal requirements of the mixing operation by heating or cooling, as the case may be, the reacting mixture.

It is contemplated that the invention may be employed for mixing or contacting any materials for which the apparatus is adaptable, and that such materials may include liquid or gaseous fluids, with or without solids being included in the mixture. The invention has been designed particularly for use as a catalyst contactor in oil refining processes, especially for alkylation of hydrocarbons in the presence of an acid catalyst, and will therefore be described typically in connection with such uses.

The general procedure employed in methods of alkylation, involves contacting a mixture of hydrocarbons, e. g., olefins and isoparaffins, with an acid catalyst such as sulphuric acid, which promotes the olefin-isoparaffin reaction to form the so-called alkylate product. By reason of the nature of the materials being mixed, and the requisites and consequences of their forming a chemically reactive mixture, handling and mixing of the materials present difficulties and requirements for most efficient operation, that are not met to best advantage by ordinary mixers. Among the major features to be desired in a mixer of this kind, are such control over the proportions, physical condition and distribution of the reactants as to avoid excessive effects of one on the other, and to favorably promote the desired completeness and time of reactions. Also it is important that proper control be had of the temperature of the mixed reactants, as in the case of an alkylation contactor by providing for the efficient removal of heat from the mixture directly within the mixing zone. From standpoints of equipment expense and operating costs it is desirable that the apparatus be of simple construction, thoroughly practicable for installation, repair and replacement of parts, and that power costs, pressure drops and the like, be minimized to the greatest extent compatible with thorough mixing.

In accordance with the invention, these features are embodied in mixing apparatus which utilizes a motor-driven rotor for obtaining initial division and dispersion of the materials to be mixed, as

well as thorough agitation of the resulting mixture, and provides for efficient transfer of heat between the mixture and a surrounding exchanger unit placed in direct contact with the agitated mixture. For purposes of alkylation, separate streams of the hydrocarbons and acid, or catalyst, are fed into separate chambers in the rotor, thence to be ejected in finely divided condition and intimately dispersed throughout a surrounding body of liquid being agitated by the rotor. By thus having the reactants initially divided and dispersed, deleterious effects resulting from the action of an excess of one upon the other are avoided, and general uniformity of admixture and reaction are assured. Then by providing for direct heat exchange with the agitated mixture, close and efficient control is had upon the thermal conditions of the reaction.

Included among additional objects and features of the invention are such structural improvements as the maintenance of a seal preventing access of corrosive fluids to the motor shaft packing joint, the simplicity of construction and mounting of the heat exchange unit within the mixing chamber, and the provision for baffled flow of the reacted mixture from the mixing zone to its outlet.

More complete understanding of all the features and objects of the invention, as well as the details of certain typical and illustrative embodiments, will be had from the description to follow. Reference is had throughout the description to the accompanying drawing in which:

Fig. 1 is a view showing one form of the mixing apparatus in vertical section;

Fig. 2 is a fragmentary section on line 2—2 of Fig. 1;

Fig. 3 is a view similar to Fig. 1, illustrating a variational form of the invention; and

Fig. 4 is an enlarged fragmentary section on line 4—4 of Fig. 3.

Referring first to Fig. 1, the apparatus comprises a shell 10 containing the mixing chamber 11, the shell being suitably supported as by the cylindric base 12. The top wall 13 of the shell has a central opening 14 closed by cover plate 15 removably secured by bolts 16 to the shell flange 17. The cover has a tubular extension 18 containing a bore 19 spaced about the rotor shaft 20 and forming a fluid passage 21 through which fluid introduced through the inlet 22 is taken into the rotor, as will later appear. The packing joint 23 provides a seal against fluid leakage from passage 21 upwardly along the rotor shaft.

The mixing chamber 11 contains a vertically extending rotor, generally indicated at 24, of

hollow construction and preferably frusto-conical in shape, substantially as illustrated. The top portion 25 of the rotor shell 26 projects into the lower end of the cover plate bore 19 to restrict or largely eliminate the passage of fluid from space 21 downwardly about the rotor, and to confine the fluid delivery to the rotor through space 27 about the shaft 20. The lower end 28 of the rotor may approach more or less closely the stationary inlet 29 through which an independent fluid stream is introduced to the lower section of the rotor. Displacement of fluid from the mixing chamber 11 to the top end of the rotor is restricted and largely prevented by an annular baffle 30 attached to the cover 15 and extending in close proximity to the surface of the rotor. Further upward displacement of acidic mixing chamber fluid that might be injurious to the packing joint 23, is prevented by the close running of the top end 25 of the rotor within bore 19, and the maintenance of the oil seal resulting from the hydrocarbon fed to the rotor through passage 21.

The rotor may be mounted on its drive shaft 20 in any suitable manner, as for example by securing the lower end of the shaft at 31 within the rotor partition 32, and by a spider attachment 33 of the shaft within the upper end 25 of the rotor. The shaft is suitably journaled and supported above the packing joint 23, as by the conventionally illustrated radial bearing 34 and the combined radial and thrust bearing assembly 35, above which the shaft may connect with a motor, not shown, operating to turn the rotor at suitable speed, say in the neighborhood of 300 R. P. M.

The rotor is surrounded by a heat exchange assembly, generally indicated at 36, which, broadly speaking, may be of any suitable form and construction presenting heat transfer surfaces in direct exposure within the mixing chamber to the body of liquid undergoing mixing agitation by the rotor. In the form of the invention shown in Fig. 1, the heat exchange assembly 36 comprises a circular arrangement of depending closed end tubes 37 extending upwardly through openings 38 in the shell 10 and terminating within an annular channel 39. The tubes 36 contain fluid delivery tubes 40 extending upwardly through channel 39 to terminate within the top channel 41, the latter containing plugs 42 which are removable to permit access to the tubes. Cooling fluid or refrigerant introduced to channel 41 through one or more inlets 43, passes downwardly through tubes 40 and thence flows upwardly within tubes 37 to the outlets 44. By this arrangement, the refrigerant is maintained in a condition of flow permitting efficient transfer of heat from the reacting mixture in chamber 11 through large tube surface areas in direct exposure to the liquid mixture being agitated by the rotor. The rotor is provided with suitable outside vanes for purposes of agitation and fluid circulation, the vanes preferably being in the form of a spiral 45 acting to displace the liquid upwardly in the vicinity of the rotor, and to thereby cause fluid circulation at substantial velocity downwardly along the surfaces of the tubes 37.

The reacted mixture is taken from the chamber 11 through an outlet 46 positioned in an upper location in the shell 10 at the outside of an annular baffle 47 spaced at 48 from the wall of the shell. The presence of baffle 47 removes the mixture flowing to the outlet, from the more

violent state of agitation existing within the central portion of the chamber, and permits, where the occasion may require, settling out of emulsions or solids to be retained in the mixing chamber. Auxiliary connections 48 and 49 in the bottom of the chamber may be employed as independent inlets or outlets, as for the introduction or removal of fluid, or of solid catalyst to be included in the mixing.

The form of the invention shown in Fig. 3 differs from the described embodiment with respect to the particular forms of the heat exchanger assembly 50 and associated parts. Here the exchanger comprises an annular, closed bottom shell 51 having spaced walls 52 terminating in the lower channel 53. Refrigerant introduced to the upper channel 54 through inlets 55 is discharged through tubes 56 into the bottom of the shell 51, the refrigerant then flowing upwardly to the outlets 57. Vertically extending vanes 58 may be carried by the inside of the shell 51 to maintain the mixture being circulated by the rotor, in substantially straight line flow along the surface of the exchanger. The vanes thus prevent bodily rotation of the liquid mixture with the rotor (i. e., at any speed approaching that of the rotor), a purpose also served by the exchanger tubes in the form of Fig. 1, by reason of the effect of the individual tubes 37 in baffling circular flow of the agitated body of liquid. The mixture flowing through space 59 to the outlet 60 may be similarly baffled or directed by the outside vanes 61, it being noted that the shell 51 serves both as an exchanger and an annular baffle between the mixing chamber proper and the outlet 60.

In operation, the hydrocarbons, e. g., an olefin-isoparaffin mixture, is fed through inlet 22 into the upper rotor chamber 62 above the partition 32. The acid catalyst, e. g., sulphuric acid, enters the lower rotor chamber 63 through the bottom inlet 29. The two streams are reduced to states of fine division and are intimately dispersed into the liquid mixture being agitated by the rotor in chamber 11, by ejection through slots 65 in the rotor. In this manner, the streams are prevented from co-mingling in advance of their dispersion into the mixture, at which point the materials are so divided and distributed as to obviate any possibility of "over-reaction" resulting from excessive concentrations of the acid in the presence of the hydrocarbons. The reaction of the hydrocarbons being exothermic, it is important that provision be made of constant and efficient removal of heat from the reacting mixture. Heat also is developed by the conversion of the mechanical work energy of the rotor, and it is desirable that such mechanically created heat be removed. Heat removal from the mixture is accomplished by the heat exchanger, by virtue of its surrounding relation to the rotor, and the turbulence and velocity of the fluids inside and outside the exchanger surfaces.

As previously indicated, the mixing apparatus 65 may be employed for blending or mixing fluids, one of which may be a gas. In such instances, a gas or vapor may be introduced through one of the inlets 22 or 29, and a liquid through the other inlet. Solid pulverulent material such as a catalyst, may be introduced with the fluid, or independently as through one of the connections 48 or 49. As a specific example of a purpose for which a liquid or liquid mixture may be contacted with a gas, the apparatus may be used 75 for the conversion of such low molecular weight

gases as methane, ethane and propane, to their solid hydrates by contacting the gas with water under controlled temperature and pressure conditions. The hydrocarbon gas may be introduced through one of the inlets 22 or 29, and water or a mixture or emulsion of water and a non-aqueous liquid such as a mineral oil fraction, e. g., kerosene, introduced through the other inlet. By maintaining the chamber under the pressures and temperatures at which the hydrates are known to form, the hydrocarbons are converted to solid hydrates which may be removed with any excess water, or in the carrier oil, through the outlet 46. The water, or water and carrier oil, may be precooled to the conversion temperature before introduction to the mixing chamber, and refrigerant circulated through the exchanger 36 to remove the heat of hydrate formation, or the entire cooling of the fluids and removal of the heat of hydrate formation may be effected within the mixing chamber by transfer of heat to the exchanger.

The described apparatus may serve also as an efficient contactor for cold acid treatment of hydrocarbons, mixing of the oil and acid, and cooling of the mixture to maintain low temperature conditions, occurring in a manner similar to alkylating treatment of hydrocarbons, as previously described.

I claim:

1. Mixing apparatus comprising a mixing chamber, a vertically extending rotor within the chamber, means for rotating said rotor, means for feeding into the rotor a stream of fluid that is ejected through apertures in the rotor and dispersed in finely divided form into an agitated body of liquid in said chamber, heat exchange means contacted by said agitated body of liquid at the outside of the rotor and passing heat conductive fluid in indirect heat exchange relation with said liquid, a baffle at the outside of said heat exchange means and spaced from the chamber wall, and an outlet to which liquid flows upwardly from said body of liquid at the outside of the baffle.

2. Mixing apparatus comprising a shell forming a mixing chamber, a rotor within said chamber rotatable about a vertical axis, a rotor shaft extending through the top wall of said chamber, means for rotating said shaft and rotor, a packing joint for preventing fluid leakage from the chamber upwardly along the shaft, means introducing fluid at a location below said packing joint into the top of the rotor, the fluid thence being ejected through apertures in the

rotor into a body of liquid in said chamber, means for introducing fluid into the bottom of the rotor, means for ejecting the last mentioned fluid into said liquid body through apertures in the rotor separately from the first mentioned fluid, heat exchange means supported by said top wall of the chamber and surrounding said rotor for passing heat conductive fluid in indirect heat transferring relation with said body of liquid, a baffle surrounding said heat exchange means and spaced from said shell, and an outlet to which liquid flows upwardly from said body at the outside of the baffle.

3. Mixing apparatus comprising a mixing chamber, a rotor within the chamber, means for rotating said rotor, means for feeding into the rotor a fluid stream that is thence ejected through one set of apertures in the rotor to disperse the fluid into an agitated body of liquid in said chamber, means for introducing a second fluid stream into the rotor and thence through a second set of apertures in the rotor into said chamber for admixture with said body of liquid, means for maintaining said body of liquid in direct contact with the rotor and at a level above the location at which said fluid is ejected from the rotor into the liquid, heat exchange means for passing heat conductive fluid in indirect heat transferring relation with said agitated body of the mixed fluids, and substantially spirally shaped agitator means carried by the rotor and operating to circulate said body of mixed fluids along said rotor and heat exchange means.

4. Mixing apparatus comprising a mixing chamber, a rotor within the chamber, means for rotating said rotor, means for feeding separate fluid streams into opposite ends of the rotor, the fluids thence being separately ejected through separate apertures in the rotor into an agitated body of liquid in said chamber, and a substantially spiral agitator vane carried by the outside of the rotor above and below said apertures.

5. Mixing apparatus comprising a shell forming a mixing zone, a vertically extending rotor within said zone and containing separate upper and lower chambers, means for introducing fluid into the upper rotor chamber, the fluid thence being ejected through upper apertures in the rotor into a body of liquid in said zone, means for introducing fluid into the lower rotor chamber to be ejected separately from the first mentioned fluid through lower apertures in the rotor into said body of liquid, and agitator vanes carried by the outside of said rotor.

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