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METHOD FOR DISTILLING MIXTURES OF SUBSTANCES AND

A DEVICE FOR CARRYING SAME INTO EFFECT

Field of Invention

This invention relates to distilling mixtures of substances in a liquid or liquefied state in, e.g., alcohol processing industry for purifying alcohol from impurities, for preparing purified liquids in microbiology, medicine, farming practice, for treating liquid waste products and sewage, as well as in petrochemistry, and so on.

Background of Invention

The distillation process proceeding in industrial columns on special contact devices of, e.g., the tray, packed, or film type, on which mass-transfer of the substances being fractionated, i.e., interaction between the vapor and boiling liquid coexisting on said contact devices. The starting mixture of substances is preheated and fed as a feed mixture onto one of the contact devices of the distillation apparatus. The resultant vapors ascend to the top of the apparatus, while the liquid runs down to the bottom portion thereof.

While passing consecutively through said contact devices the vapors get rich in volatiles and are depleted in heavier substances (as to volatility thereof), whereas the case with the liquid is quite the reverse. Hence two principal processes are to be carried out, that is, consecutive motion (as a rule, countercurrent as for height) motion of a required number of flows, and an efficient mass-transfer on the contact devices. With an adequately prolonged period of contact between the phases coexisting on the contact devices a maximum possible enrichment and depletion of substances occurs which

is termed thermodynamic phase equilibrium and characterized by a equality of chemical potentials of substances in the vapor and liquid phases. Under practical conditions the time of contact between the coexisting phases is limited, whereby the flows leaving the contact devices differ from the equilibrium ones. In a majority of practically used contact devices it is the stay time of the vapor phase is especially limited, which time depends on the time of vapor bubbles emergence. That is why a single contact between the phases coexisting on the contact devices fails to provide an adequate degree of mass-transfer. The phase contact time can be extended by recycling the liquid and vapor flows that have left the contact devices, thus extending the mass-transfer between the phases. Part of the condensate of vapors that have left the topmost (as along the vapor flow) contact device is recycled into the column refining section located upstream of the feed inlet, whereupon said part of vapor condensate is fed again to the topmost contact device as a volatiles-enriched reflux. Returned back to the column stripping section located downstream of the feed inlet are the vapors of the liquid that has left the bottommost contact device (as along its flow to said column section. Thus, a countercurrent motion of the liquid and vapor flows is carried out in the distillation apparatus.

It is with the aid of said vapor and liquid recycles that the problem of a maximum extension of the time of contact between the liquid and vapor phases coexisting on the contact devices is solved, thus providing an efficient mass-transfer between the substances on the contact devices.

The stripping section of the column is intended for fractionating the still product enriched with heavy substances with which are also enriched the vapors returned back as evaporation of part of the still liquor.

While consecutively passing through the contact devices the vapors get depleted in heavy substances and enriched with volatile substances. Thus, part of the product enriched with volatiles is recycled in the top of the column refining section and part of the product enriched with heavy substances is recycled in the bottom of the column stripping section. The mass-transfer between the phases occurs in two concurrent processes, i.e., partial evaporation of the liquid and partial condensation of the vapors.

The pathway of the liquid is much longer than the pathway of the vapor. Hence the stay time of the vapors on the contact devices is to be increased which as a rule is effected due to revaporization of the reflux (the liquid fed to all the contact devices).

The number of vapor and liquid flows required for their countercurrent motion is determined by the ratio between the volatile and heavy components in a starting mixture and by technological conditions of fractionation of the distillation products.

In the heretofore known methods the starting feed mixture is preheated in a heat exchanger to a boiling temperature (usually a few degrees below the boiling points), whereupon the preheated liquid is fed to the topmost tray of the column stripping section.

A required amount of liquid in the column refining section corresponds to the amount of reflux fed to the column top tray, while a feed liquid is added thereto in the column stripping section. The

processes of mass-transfer between the phases proceed adiabatically which is also dictated by the conditions of thermodynamic phase equilibrium. The amount of vapor in both column sections is virtually constant (a little reduction of said amount is due to deviation from adiabatic conditions, and that in the column stripping section results from underheating of the feed). Constancy of the liquid and vapor flows in the column sections place limitation on further search for their optimum recycles on some of the contact devices, insofar as a necessity arises for setting a maximum recycle value called forth by a more complicated mass-transfer conditions on even a single one of all the contact devices of a column section.

Thus, a maximum possible amount of reflux is fed to the top contact device of a given section, and accordingly a maximum amount of vapor required for revaporization of the volatiles from the reflux is fed to the bottom contact device of the column.

Known in the present state of the art is dividing a distilling column into a number of refining or stripping sections due to the provision of additional feed inlets or outlets for discharging extra fractionation products. In this case the top portion of each of said sections receives its constant reflux for all the contact devices of each section.

It follows from all stated before that said problems are solved in the heretofore-known methods by a single way, that is, recycling part of the distillate product in the form of reflux and recycling part of the still product in the form of vapor.

The known methods suffer from high energy consumption of the distillation process concerned with phase transformations of the

substances under fractionation occurring during liquid-vapor transition, and vice versa, and from a necessity for effecting said recycles, that is, the top product reflux and vapors of the bottom product of the distillation process in amounts determined by its maximum value of all the contact devices of the column section.

Furthermore, a rigid linkage between the sections as to vapor and liquid flows causes overloading of the column stripping section as to liquid and that of the column refining section as to vapor. This in turn involves additional expenses for making equipment and sophisticates control of the process.

Known in the art presently is a method for and a system of distilling volatiles from an aqueous medium in a distilling column equipped with contact devices (cf US Patent # 4,783,242, IPC B 01 D, 1988).

Liquid leaving the bottom contact device is directed to a separator which communicates with a thermocompressor to which a heating steam is fed. It is due to a pressure drop in the separator established by virtue of thermal compression of the heating steam that the liquid evaporates. The resultant vapors enriched with volatile components are brought together with the heating steam in the thermocompressor and returned to the bottom contact device. The remainder liquid is divided into two parts of which one is forwarded to a condenser and after its having been warmed up with the vapors leaving the top contact device, is returned to the separator, that is, said liquid is used as a refrigerant in the condenser, thus recovering the heat of vapors. The other part of the liquid appearing

as purified water is discharged from the separator as a still product.

Thus, there is effected recycle of the heavy components to the bottom contact device and part of heat is saved due to thermal compression for their recycle in the form of vapors.

A disadvantage inherent in said method resides in use of a commonly adopted establishing recycles of the main flows in the column, i.e., by feeding a standard amount of reflux to the top contact device and a standard amount of vapors to the bottom contact device, using a standard pattern of phase transformations of the flows leaving the last (as along the direction of their motion) contact devices of the column, which results in high energy consumption.

The closes to the one proposed herein is a method of arranging flows in mass-transfer apparatus used for fractionating liquids in the chemical, petroleum-refining, and food industries (cf. RF Patent # 2,016,617, IPC B 01 D 3/00, 1994).

According to said method, a countercurrent contacting of vapor and liquid occurs on contact devices. One part of the vapor flow is by-passed one or more contact devices and then intermixed with the main flow as along the direction of motion of the vapor flow. The process of dividing and intermixing the flows is repeated several times as for height of the apparatus. As a rule, such procedures make it possible to reduce column overloading as to vapor by controlling the required vapor flows as along the direction of motion of the main flow, and to select optimum cross-sectional areas of the column sections.

However, realization of said method involves much energy which is due to the fact that while recycling vapor directed for a variety of mass-transfer devices arranged across its pathway, it is necessary to return the reflux in usual amounts and then to vaporize it in order to remove volatile components.

One prior-art mass-transfer device is known to comprise contact devices of any heretofore-known type (cf. USSR Inventor's Certificate # 1,777,921, IPC B01 D 3/22, 1992).

To intensify the heat-and-mass transfer process on the contact device the gas flow is divided and then brought in contact with an integral liquid flow on a contact device provided with crossover pipes through which a lesser portion of vapor is fed. Said crossover pipes are interconnected in pairs through a chamber provided with a slit nozzle and ensuring better contact between the liquid and vapor on the contact device.

Though such a construction arrangement renders the heat-and-mass transfer process more intense, it fails to substantially reduce energy consumption of the process since it also involves returning a usual amount of reflux to the column for its revaporization.

Disclosure of Invention

The present invention is aimed at the provision of a distilling method and device which operates with a minimum energy demand. In addition, the invention makes possible reducing the overall dimensions of the device due to selection of optimum cross-sectional areas of the various column sections so as to establish optimum liquid and vapor flows therein.

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The herein-proposed method for distilling a mixture of substances comprises feeding said mixture to a distilling column provided with contact devices for liquid and vapor to interact. Vapors of volatiles are drawn off from the column top, while the high-boiling substances are boiled in a still, and the resultant vapor is directed to the column bottom. Simultaneously part of the vapor drawn off from one of the contact devices is returned to the vapor or liquid flow on at least one of the contact devices located upstream in the direction of the main vapor flow and/or is returned to the liquid flow below the level thereof onto the same contact device at the place located upstream of the point of drawing-off said part of vapor in the direction of the main vapor flow. Returning of a part of vapor flow to the column is carried out without complete vapor condensing, i.e., without its complete phase transformation into liquid.

The amount V^1 of the vapor returned to the "nth" contact device as referred to a total amount V_n of the vapor on the "nth" contact device equals substantially from 0.40 to 0.95. Said ratio is obtained experimentally and depends on a difference between the liquid temperature on the "nth" contact device and the temperature of the vapor in the state of equilibrium with the liquid on the "nth" contact device.

The vapor emerging from the contact device or at least that part thereof which is returned to the contact devices located upstream with respect to the direction of the vapor flow is subjected to partial condensation, whereas the condensate may be returned to the

contact devices located with respect to the direction of the vapor flow.

In some instances the starting mixture is boiled in a boiler prior to being fed to the distilling column, whereupon the vapor and liquid flows are fed thereto separately.

Part of the liquid emerging from the contact device may be returned to the contact devices located upstream with respect to the direction of the liquid flow.

According to the present invention, the problem of establishing a required number of countercurrent liquid and vapor flows is solved individually for each contact device regardless of the problem of providing an intense mass transfer on the other contact devices. To solve the above problem and provide for a required fractionation of substances due to repeated contacts between the coexisting phases in the present invention, use is made in the present invention of recycles, that is, returns of liquid and vapor flows without considerable phase transformations of their component substances, accompanied by a reduced reflux return, thus solving the problem with minimized energy consumption.

The temperature of the vapor in a state of equilibrium with the liquid on the contact device is found from the tabular data on the state of equilibrium (cf. the textbook "Equilibrium between liquid and vapor" by V.B.Kogan, V.M.Fridman, and V.V.Kafarov, Nauka PH, 1964 (in Russian)).

The temperature of the vapor on the contact device is measured using conventional techniques with the column operating.

In the instance of wide-boiling mixtures or whenever the temperature of the vapor returned on the contact device is substantially lower than the boiling point of the liquid, the latter is afterheated to its boiling point.

Carrying out recycles of flows on the contact devices without changing the states of aggregation of said flows involves no considerable amount of energy to be consumed. Said energy is estimated as mechanical work spent for pumping over the respective vapor or liquid flows.

Thus, a total energy consumption according to the proposed method is essentially lower than the amount of heat consumed for boiling additional reflux provided according to conventional methods.

In addition, the proposed method is capable of controlling any recycle ratio of flows at any cross-section of the column so as to provide a maximum recycle ratio in the distilling regions featuring most complicated conditions and a minimum one in the simple distilling regions. According to the heretofore-known methods, recycles of the reflux and vapors are constant as for the entire height of the column section and are as a rule determined by the most complicated distilling conditions on any of the contact device of the column section.

Partial condensation of the vapor leaving the contact devices is carried out in a conventional way adopted in rectification practice, e.g., with the aid of a cooling unit; however, according to our invention, there is attained more efficient mass-transfer on the contact device to which the returned vapor is fed, this being due to return of the vapor enriched with the substance being isolated.

Vapors may also be condensed in special condensing devices wherein an optimum degree of condensation is set up.

With partial condensation of recycled vapor such special condensing devices are dispensed with because said condensation is carried out due to a differential pressure immediately in the vapor conveying device. In some instances with a view to enhancing mass transfer of some admixtures, part of the liquid is returned to the contact device to the contact devices located upstream with respect to the direction of motion thereof.

Further advantages of the invention are attained when the starting (feed) mixture is preboiled and the resultant vapor and the liquid are fed separately to the column. According to conventional methods, the operation of the column sections is closely interconnected in terms of one of the flows fed thereto. Thus, the amount of vapors in the refining section depends unambiguously on and is equal to the amount of vapors leaving the last tray of the stripping section. The amount of liquid in the stripping section is uniquely defined as the sum of the feed and the liquid leaving the bottom tray of the refining section. This makes it impossible to independently control the operation of the column sections; but a possibility of an independent control appears when the vapors, liquid, and feed are fed to the column separately.

The starting mixture is boiled in an additional reboiler and the resultant vapor and the liquid are fed separately to the contact devices.

With the additional reboiler operating, the still-liquor reboiler accounts for the steam consumption required to evaporate th

equilibrium vapor on the top contact device of the stripping section, while the additional reboiler accounts for the steam consumption necessary to evaporate the feed vapor. In addition, energy is spent also for establishing an impetus of the process (overcoming the column resistance, etc.).

Both vapor portions are integrated in the column refining section where the vapor serves as a source of heat for the volatile components to release.

In the known methods the separate use of two boilers instead of a single one gives no advantages as far as the heat consumption is concerned. As mentioned above, according to the proposed invention, use of the boilers makes it possible to reduce the contribution to the total power consumption of the portion that accounts for the phase transitions of the flows. Thus, the amount of heavy substances on the bottom contact device of the refining section is used to determine the amount of reflux returned from the condenser, and the amount of volatile substances on the top contact device of the stripping section is used to determine the amount of heating steam in the still-liquor reboiler.

A device for carrying into effect the proposed method for distilling a mixture of substances comprises a the distilling column provided with contact devices and equipped with means for extracting part of the vapor, while at least one of the contact devices further comprises at least one means for feeding the extracted vapor, said means being located downstream of the vapor extraction point as along the main flow motion. The column also has a conveying device for said vapor.

The vapor extraction means and the means for feeding the vapor to the contact devices may appear as branch pipes interconnected through a piping inside the vapor conveying means is accommodated, said means providing the motion of the vapor from a lower-pressure zone to a higher pressure zone.

The vapor feeding branch pipe may be located either in the vapor area of the contact device or in the liquid layer below its level on the contact device.

Both the vapor extraction means and vapor feeding means may appear as a vapor conduit, wherein the vapor conveying means is accommodated above the vapor conduit inside the column intended for extracting the vapor from the contact device.

The vapor feeding branch pipes may be arranged tangentially to the cross-sectional periphery of the distillation column.

The contact devices may be provided with vertical partitions having their bottom portion immersed in the liquid so as to establish individual liquid communication chambers, while the vapor extraction and feeding pipes are located in different chambers defined by said vertical partitions.

The vapor conveying means may be followed by a device for separating the vapor from the liquid entrained by it, said device communicating through piping with the contact device located upstream as along the vapor flow path.

The vapors not completely condensed are returned by some transferring devices (such as fans, gas blowers, piston or ejector devices, etc.)

In some instances sections of a column or chambers operating at different pressures are used for vapor conveying. Part of the vapors is returned from the higher-pressure zone to the lower-pressure zone. In particular, the vapors under a higher pressure are formed in the column stripping section at the expense of a part of the still-liquor vapors which are reheated in an additional preheater at a pressure higher than that of the remainder part thereof. Part of the still-liquor vapors under a higher pressure is used as a working or pressure fluid for returning part of the vapors from the contact devices of the column stripping section by ejectors. Used as the working fluid in the ejectors of the column refining section bottom section is part of the vapors which is reheated in the additional preheater. The flow-rate of the working fluid fed to the ejectors is controlled in direct proportion to a ratio or difference between the values of an actual and equilibrium temperatures on the contact devices. Used as the working fluid in the column refining section ejectors is part of the vapors from the top contact device of the section, said vapors being directed onto the ejectors of a number of the bottom contact devices by a gas blower.

The the distilling column may be equipped with the contact devices of the tray, film, or other types.

The the distilling column may also be furnished with packing shells, packed grids, or other types of packings. Interposed between the shells are vapor conduits for the vapors to pass from the top shells to the bottom ones. Part of the vapors leaving the column top shell and part of the vapors from the vapor conduits running between other shells are returned by gas blowers to the shall points locatin

upstream of the point of vapor extraction as along the main vapor flow path. The vapor returning branch pipes are disposed at different levels as for the shell height, which shell may have a variable cross-section so that its upper section is larger than the lower one thereof. The ratio between the vapors is controlled in a direct proportion to a difference between the temperature of the liquid at the level of the vapor return branch pipe and an equilibrium value of said temperature on the contact devices.

Brief Description of Drawings

FIGS.1(a), (b), (c) schematically represent distillation columns M provided with contact devices K, showing different embodiments of recycling a part of the vapor flows, according to the present invention, wherein the liquid level I on the contact devices is indicated with a dotted line.

FIG.1(a) presents one of the embodiments of arranging liquid and vapor flows, wherein part of the vapors extracted from the contact device is returned to those areas of the contact devices which are located upstream as along the direction of vapor motion.

The starting mixture is fed to a column M as a feed F. The top of the column is equipped with a condenser C2. The main flow of vapors V, as it moves up along the column, passes successively through contact devices K and reaches the condenser C2, wherein the vapors are condensed and discharged from the column as a distillate product D. A Liquid L moves down countercurrently to the bottom of the column and is received by a column still C1. The vapors generate in the still are returned to the bottom contact device. The resultant bottoms product W is withdrawn from the column.

A mass-transfer between the coexisting boiling-liquid and vapor phases occurs on the contact devices. On completing the mass-transfer process, part of the vapor V1 is extracted from each of the contact devices and directed, in countercurrent, to the preceding contact device, returning it to the vapor flow V lying above the level 1 of the liquid on the contact device.

FIG.1(b) illustrates an embodiment of arranging liquid and vapor flows, wherein part of the vapors extracted from the contact device is returned to a number of the contact devices which are located upstream as along the direction of the main flow of vapor V.

The distilling tower M represented in FIG.1(b) is further provided with a reboiler C3 receiving the feed F which is boiled, and then the flows of liquid F1 and vapor F2 are fed to the column separately.

Extraction of part of the vapor V1 and its return to the vapor flow V is made to several contact devices located upstream as along the direction of its motion.

Extraction of part of the liquid L' and its return to the main flow L is carried out on two contact devices, part of the liquid on the contact devices being extracted as a liquid side-cut distillate P.

FIG.1(3) shows an embodiment of arranging the flows, where part of the vapor V1 extracted from the contact device K is fed to the same contact device, but to the liquid stream L lying below its level 1 in the device.

FIG.2(a) shows schematically a device for carrying out the method of distillation, according to the invention, indicating the

direction of vapor flow V (solid line) and liquid flow L (dotted line) in the column, as well as the direction of flow of the vapor extracted from and feed to the contact devices.

The device comprises a distilling column 1 provided with tray-type contact devices 2, 2', 2". The means for vapor extraction and its feeding to the contact devices appear as branch pipes 4 and 5 respectively. A piping 3 communicates the vapor extraction pipes 4 with the vapor feeding pipes 5. A separator 7 for separating the vapor from the liquid is located behind the fan 6 and communicates with the contact device 2' by a piping 8.

At its top, the column 1 is equipped with a reflux condenser 9, and at its bottom, with a still 10. The contact devices are provided with partitions 11, the bottom part thereof lying below the level of liquid indicated with a dotted line. The partitions define liquid-communicating chambers K1 and K2, while the vapor extraction pipes 4 and the vapor feeding pipes 5 are situated in different chambers of the same contact device.

FIG.2(b) is a schematic fragmentary view of the column with the contact devices 2 and 2'. The vapor extraction and feeding means appear as a vapor conduit 12 with its inlet portion 13 shaped as a cone and located in the vapor area of the contact device 2', and with the outlet portion of the piping 12 located in the vapor area of the contact device 2 upstream as along the direction of the main flow of vapor V. The vapor conveying means 6 is located above the inlet portion 13 of the vapor conduit 12 and is provided with a baffle 14 separating the flow of the extracted vapor from the main vapor flow.

FIG.2(c) schematically shows a fragment of the column with the contact devices 2 and 2'. The vapor extraction and vapor feeding means appear as the branch pipes 4 and 5 intercommunicating through the piping 3 which accommodates the vapor conveying means 6. The vapor feeding branch pipe 5 is of the nozzle-type configuration for a better mass-transfer process.

The branch pipes 4 and 5 are located on the same contact device, the vapor feeding pipe 5 lying below the liquid level on the contact device.

FIG.2(a) illustrates that the starting mixture of substances F is fed to the top tray of the stripping section. The flow of liquid L moves down along the column 1, while the flow of vapor V moves up countercurrently along the column 1. A mass-transfer process occurs on the contact devices 2, 2', 2" between the phases of the boiling liquid and the vapor coexisting thereon. The dotted line indicates the level of the liquid layer on the contact device.

The liquid leaving the bottom tray of the stripping section is received by the still 10. The vapors generated in the still are returned to the bottom tray of the stripping section. The vapors as they successively pass through the trays reach the reflux condenser 9, wherein they are condensed and removed from the column as the distillate product D, whereas the bottoms product W is removed from the column still 10.

It is in this manner that there are arranged the flows of the required minimum amounts of vapor and liquid, not related to phase transitions and necessary to release the volatile matter from the

refining section and release the heavy substances from the stripping section.

Apart from the minimum vapor and liquid flows required, additional vapor and liquid recycles are set up on the contact devices.

By the way of the pipe 4, using the fan 6 located inside the piping 3, Part of the vapor is extracted from the contact device 2" through the pipe 4, using the fan 6 located inside the piping 3, whereupon said part of vapor is transferred along the piping 3 and fed through the pipe 5 to the contact device 2' upstream as along the direction of motion of the main flow of vapor V, i.e., downstream of the contact device 2".

In the separator 7 the liquid entrained along with the vapor is separated therefrom and transferred through the piping 8 to the contact device located upstream as along the direction of motion of the flow vapor V.

FIG.2(b) shows that part of the vapor flow is transferred from the vapor area of the contact device 2' by the fan 6 and is directed to the vapor conduit 12 through its cone-shaped inlet portion 13. The baffle 14 serves as an auxiliary means for separating the extracted vapor flow from its main flow. The extracted vapor flow is fed through the outlet portion 15 of the vapor conduit 12 into the vapor area of the contact device 2.

FIG.2(c) shows that part of the vapor flow is extracted through the branch pipe 4 and fed to the same contact device below the level of the liquid through the nozzle-type branch pipe 5.

FIG.3(a) demonstrates that part of the flow of vapor V' is returned, with the aid of the ejectors 6' and the gas blower 6", to the contact devices K located upstream as along the direction of vapor motion. Used as the working fluid in the ejectors are the vapors generated in the additional preheaters C and C' operating under elevated pressure.

Used as the working fluid in the ejectors of the top portion of the column refining section is part of the vapors of the top contact device which are fed to the ejectors by the gas blower 6". The vapors are returned to some of the contact devices with the aid of the fans 6.

FIG.3(b) is a schematic fragmentary view of the device, wherein the vapors are turned by the gas blower 6" between the sections of the packing column M at the different places of a section as for height.

Additional recycles ensure a high intensity of mass transfer of substances between phases coexisting on the trays due to such a contacting factor that provides for the required degree of enrichment of the vapors leaving the trays with volatile components and their depletion in heavy components, as well as the reverse processes in the liquid leaving the trays.

Preferred Embodiment of Invention

Example 1

A water-alcohol mixture containing 10 percent (by weight) alcohol is fractionated in a distilling apparatus. The apparatus is equipped with a column, a condenser, and a reboiler. The column includes 70 convex trays serving to carry out the mass-transfer of

the boiling liquid and the vapor bubbling therethrough. The column operates at atmospheric pressure. The alcohol vapors leaving the top tray are fed to the condenser. The resultant condensate is split into two flows: one of them being extracted as a float fraction of the distillate product containing alcohol and light additives. The remainder part of the condensate is returned to the top tray as a reflux. The distillate product containing more than 94 percent alcohol is extracted from the 68th tray (counting from below) as a liquid fraction.

Prior to feeding to the column the starting mixture is fed to the additional reboiler and the resulting vapor is directed to the 20th tray, while the remaining liquid is supplied to the 18th tray. The liquid leaving the first tray is introduced into the reboiler, the resultant vapor is returned to the first tray of the column, and the remainder liquid containing water and less than 0.02 percent of alcohol is discharged as a bottoms product. The column is provided with means for extracting vapor and feeding its extracted part to the contact devices, which are made in the form of branch pipes interconnected by pipings to fans fitted therein. The vapor feeding branch pipes are located, as shown in FIG.2(a), below the extraction branch pipes. Part of the vapor leaving the trays 60 through 68 is directed by the fan to the vapor area of the trays 59 through 67. The ratio between the returned portion of the vapor V' and its total amount V_n on the contact devices 60 through 68 is 0.0 to 0.95. Returning the vapor from the trays 1 through 59 to the subjacent trays, the V'/V_n ratio being 0.8 to 0.85.

Part of the liquid from the trays 12, 14, 18 is pump-extracted and transferred to the trays 13, 15, 19, respectively, the fusel fraction being extracted from trays 12 and 14 as a side draw.

In this embodiment of the method the distillate product contains more than 96 percent alcohol, while the bottoms product contains water and less than 0.02 percent alcohol.

In this method more than 25 percent of the heating steam is saved as compared to the conventional method.

Example 2

A water-alcohol mixture containing 8 wt.% alcohol is fed, as described in Example 1, to a the distilling column provided 70 valve trays.

Part of the vapors leaving the 69th tray and part of the vapors emerging from the 70th tray (the V'/V_n ratio on said trays being 0.9 to 0.95) are fan-returned to the liquid through the branch pipes arranged tangentially to the periphery of the distilling column. Part of the vapors leaving the 68th tray with the V'/V_n of 0.8 to 0.85 is fed by a gas-blower as the working fluid to the ejectors provided on the trays 67 through 42, where they are intermixed with the vapors leaving said trays as shown in FIG.3(a). Then said vapors are returned from the ejectors to the vapor space of the trays. In a similar way are returned the vapors from the ejectors to the trays 41 through 19, said ejectors using as the working fluid the vapors leaving the 42nd tray. In the ejectors of the trays 1 through 18 is mixed part of the vapors leaving the trays with the vapors of a part of the bottoms product, said part of vapors being boiled at a pressure of 1.6 atm in the addition reboiler.

The distillate product contains more than 94 percent alcohol, while the bottoms product contains less than 0.01 percent alcohol. More than 20 percent of the heating steam is saved as compared to the conventional method.

Example 3

A liquefied gaseous mixture is fed into the distillation apparatus constituting a column provided with concave trays for the mass-transfer between the boiling mixture and vapor. The mixture consists of the following substances: 5% methane, 35% ethane, 15% propylene, 20% propane, 10% i-butane, 15% n-butane. A pressure of 27 atm is maintained at the top of the column. The apparatus is equipped with a condenser receiving the vapors that have left the upstream (looking in the flow direction) contact device (concave tray). The resultant condensate is split into two flows one of which is extracted as a distillate product and the other is fed to the top tray as the reflux.

From the lower tray the liquid leaving the last (in the flow direction) tray is sent to the reboiler, where a part of the liquid is evaporated. The vapors produced are returned to the last tray of the apparatus and the remainder liquid is extracted as a bottoms product.

Interposed between all the trays are blower devices allowing the return of part of the vapor leaving the trays to the trays located upstream as along the direction of motion of the main vapor flow. The V'/V_n ratio on the trays 1 through 5 and 20 through 25 (counting from below) is 0.9 to 0.95, and that on the trays 5 through 20 is 0.8 to 0.85.

The distillate product contains methane and ethane, and less than 5 percent of other heavier substances, while the bottoms (still) product contains less than 5 percent methane and ethane, and constitutes the other heavier (in terms of boiling point) substances of the starting mixture.

The total consumption of energy media (i.e., heating steam and coolant) is reduced by 30 percent as compared to the conventional rectification.

Example 4

A liquefied gaseous mixture is fractionated as in Example 3 in the distilling column equipped with 30 valve trays. Part of the vapors are returned from the trays 16 through 30 by means of blower devices provided on each of the trays. Part of the vapors leaving the trays 1 through 15 are returned by the ejectors as shown in FIG.3(a). The ejectors use as the working fluid part of the bottoms product vapors. A pressure of up to 25 atm is maintained in the still. The resultant distillate and bottoms products correspond fully to said products obtained in Example 3. The total consumption of energy media is reduced by 30 percent as compared to the conventional rectification.

Example 5

Water polluted with chemical processing gases and containing up to 0.05% ammonia, hydrogen sulfide and other noxious gases is fed to a the distilling column provided with a total of 40 valve trays. The column is constituted by shells each of which comprises 8 trays, the ejector device (FIG.3(b)) being interposed therebetween. Part of the vapors leaving each tray of the shell save the top tray is ejector-

returned to the same tray. Part of the vapors from the top trays of the shells are returned thereto by means of gas-blowers, while the other part of the vapors from the top trays is fed to the ejectors of the bottom trays as the working fluid. A purified water containing less than 10 ppm noxious gases is obtained in the column still. In the column top there is obtained a fraction of the noxious gases which is forwarded for further processing. Heating steam is fed to the still, its consumption being reduced by more than 25% as compared to the conventional method.

Industrial Applicability

Thus it will be seen from the present specification and illustrative examples that the distillation method and the device for carrying it into effect enable the end products to be obtained while reducing power consumption by at least 20% apart from the possibility to reduce the overall dimensions of the distilling column due to a smaller diameter of individual sections in the central portion of the column by virtue of an independent control of recycles on individual contact devices.

Additional recycles provide for high intensity mass-transfer of the substances between the phases coexisting on the contact devices which is due to such a contact factor that ensures a required degree of enrichment of the vapors leaving the contact devices, with volatile components and depletion in the heavy components, as well as the reverse processes in the liquid leaving the contact devices.

There are established independently for each contact device the vapor recycles directed oppositely to the direction of the main vapor flow, which extends the vapor-to-liquid contact time, intensifies the

mass-transfer process, and minimizes repeated evaporation and reflux return to the distilling column.

As a result of practical use of the proposed method energy consumption is much reduced, while an independent operation of each contact device makes possible decreasing the column overall dimensions.



CLAIMS

1. A method for distilling a mixture of substances, comprising the steps of feeding the mixture into a distilling column provided with contact devices for interaction between liquid and vapor, extracting the vapors from the top of the column, boiling the bottoms product and returning the resultant vapor into the column bottom, extracting part of the vapors leaving the contact devices, following by their return to the column, CHARACTERIZED in that part of the vapor extracted from one of the contact devices is returned to the vapor or liquid flow to at least one of the contact devices located upstream as along the direction of motion of said flow and/or part of the vapor is returned to the flow of liquid below its level to the same contact device, to a spot located upstream of its extraction point as along the direction of motion of the vapor flow, the vapor being recycled without its complete condensation.
2. The method of Claim 1 CHARACTERIZED in that the vapor emerging from the contact device, or at least that part thereof which is returned to the contact device located upstream as along the direction of motion of the vapor is subjected to partial condensing.
3. The method of Claim 1, 3 characterized in that the condensate is returned to the contact devices located upstream as along the direction of motion of the vapor flow.
4. The method of Claim 1 characterized in that part of the liquid emerging from the contact device is returned to the contact devices located upstream as along the direction of its motion.
5. The method of Claim 1 characterized in that the starting mixture is preboiled in the reboiler followed by separately

introducing the vapor and the liquid flows into the distilling column.

6. The device for carrying into effect the method of distilling a mixture of substances as claimed in Claim 1, comprising a distilling column provided with contact devices including an extraction means for part of the vapor CHARACTERIZED in that at least one of the contact devices is further equipped with at least one means for feeding the extracted vapor, the vapor feeding means being located downstream of the vapor extraction point, looking along the direction of the main flow path, the distilling column being provided with a means for conveying the vapor to be fed.

7. The device of Claim 6 characterized in that the vapor extraction and feeding means are formed by branch pipes interconnected by the vapor conveying means, allowing the vapor to flow from a lower-pressure zone to the higher pressure zone.

8. The device of Claim 6 CHARACTERIZED in that both the vapor extraction means and the means for its feeding to the contact device appear as a vapor conduit, the vapor conveying means being accommodated in the distilling column.

9. The device of Claim 6 and 7, CHARACTERIZED in that the vapor feeding branch pipes are located tangentially to the periphery of the distilling column cross-section..

10. The device of Claim 6, 7, CHARACTERIZED in that the contact devices are provided with vertical partitions whose lower portion is immersed in the liquid to form individual chambers communicating through the liquid, the vapor extraction and feeding pipes in the



same contact device being located in different chambers defined by the vertical partitions.

11. The device of Claim 7 characterized in that the conveying means is followed by a means for separating the vapor from the liquid produced, this latter means being connected through a piping with at least one contact device preceding the main vapor flow path.

