This invention relates to treating fluids and more particularly relates to reducing undesirable thermal decomposition in processes where a relatively large volume of liquid is retained as a surge volume ahead of the pump.

This invention may be applied to a number of industrial processes but more specifically it is especially adapted for use in the distillation of petroleum. It is usual practice to maintain a liquid body of oil in the bottom of a crude distillation tower, or separator or the like to maintain a surge volume ahead of the bottoms pump. In continuous operations of this type where fluctuations in flow of the liquid being discharged from the system are apt to occur, it is essential that a liquid seal be maintained in the draw-off line ahead of the draw-off pump in order to maintain substantially constant pressure in the system and thereby avoid upsetting equilibrium conditions. The most satisfactory method of maintaining the desired liquid seal on the draw-off pump is to employ a large volume of liquid as surge ahead of the pump.

As a result, this relatively large volume of liquid is held at high temperatures for a sufficiently long period of time to undergo some thermal decomposition. This results in loss of yield where the residuum or bottoms constitutes a charge stock for a subsequent process for recovering valuable products therefrom, as lubricating oil in a vacuum distillation process. Also, holding up this relatively large volume of liquid results in decomposition of certain organic compounds to yield corrosive or otherwise undesirable substances, such as organic sulfur compounds yielding hydrogen sulfide which is corrosive to the equipment and which must be removed by subsequent treatment to obtain a satisfactory product. In tar separators or other vessels where a relatively large volume of bottoms is maintained, thermal decomposition of the bottoms takes place and coke formation results.

A preferred modification of our invention which is applicable to any reservoir of material in which a controlled liquid level is maintained, comprises

1. separating the reservoir into two different sized sections, one section having a minimum volume and the other section having a sufficient volume to provide the necessary surge volume or capacity, the two sections being under equalized pressure and being sealed one from the other by the material being handled;
2. delivery of the liquid material from both sections simultaneously to a common outlet flow line, thereby maintaining substantially the same level in each section;
3. cooling the liquid mixture in the common flow line;
4. and pumping back a portion of the cooled liquid mixture to the large section to maintain a controlled temperature therein, lower than that of the liquid material originally entering the reservoir.

The material entering the reservoir enters the section of minimum volume. The desirable and advantageous feature of the preferred modification of our invention is the convenient and efficient means of cooling and controlling the temperature of the surge liquid in the reservoir which is provided in the recycling of a small portion of the liquid being withdrawn from a tower or the like to the reservoir after it has been cooled.

More specifically, according to the preferred form of our invention, the treated liquid product such as a heavy oil flows from the bottom plate of a distillation tower into a seal cup having a weir sufficiently high to prevent overflow of the liquid into the bottom of the vessel or tower during normal operation. The liquid from the seal cup is continually withdrawn and passed through a product cooler. A part of the cooled product is returned to the bottom of the tower to cool the retained body of liquid, the amount returned to the bottom of the tower being controlled to maintain a substantially constant temperature in the bottom of the tower. The temperature of the body of liquid in the bottom of the tower is much lower than that of the liquid in the seal cup.

Cooled liquid from the body of the liquid in the bottom of the vessel is withdrawn and mixed with the hot liquid from the seal cup by means of an equalizing line connecting the bottom of the vessel with the withdrawal line from the seal cup. A controlled liquid level is maintained in the seal cup and the bottom of the vessel by a liquid level control device actuating a valve in the discharge line for discharging bottoms from the vessel.

According to modifications of our invention the undesirable effects of the thermal decomposition in the retained body of liquid are greatly reduced without sacrificing the necessary surge volume. In its broader aspects, the invention comprises

1. a product draw-off line containing a discharge pump followed by a control valve, the line being in communication with a distillation tower, or separator, etc., and serving as a means of withdrawing liquid product therefrom;
2. a reservoir in which a liquid level is maintained and which is interconnected at or near
its bottom with the product draw-off line at a point ahead of the discharge pump, the reservoir being maintained under a pressure equalized with that in the product draw-off line and below in a suitable position so that the liquid level carried in the reservoir will correspond to the level of liquid desired to be carried in the product draw-off line; and (3) means for maintaining the liquid in the reservoir at a temperature below the temperature of the liquid being discharged through the product draw-off line, and preferably below the temperature at which incipient decomposition occurs.

In a liquid product draw-off system of this type, the reservoir serves as a receiver or dispenser for surge liquid when the rate of flow of liquid into the product discharge line is subject to fluctuations above or below the average, which usually is equivalent to the rate at which the liquid is discharged through the discharge pump and control valve. Where the rate of flow of the liquid in the product draw-off line is not subject to fluctuations, the control valve may be set so that the rate of discharge therethrough is the same as the rate of entry of liquid in the line, in which case there will be substantially no flow of liquid into or out of the reservoir and the reservoir becomes in effect a potential source of surge which is used only in case of emergency.

In the drawings:
Fig. 1 represents an elevational view partly in section of a distillation tower including the preferred form of our invention; and
Figs. 2 to 5 inclusive, represent modified forms of our invention applied to a distillation tower or the like.

Referring now to Fig. 1 of the drawings, the reference character 10 designates a fractionating tower including plates 12 and 14. Only two plates are shown. The tower is provided with a feed inlet 16. The plate 14 has a downspout 16 and the plate 12 has a downspout 18. The fractionating plates and downspouts are parts of well known fractionating equipment. The tower 10 is provided with a vapor outlet 22 for removing the product in vapor form.

The downspout 16 on the lowest plate 14 projects a seal cup 24 having a weir 26. The seal cup forms the reservoir section of minimum volume. The downspout 16 is provided with a baffle 28 sealed in the liquid in the seal cup 24 to insure disengagement of vapor from the liquid being withdrawn from the seal cup. The bottom of the tower or vessel 10 forms the reservoir section of larger volume and contains a body of liquid or bottoms 32 having a level shown at 34 and forming the surge volume. The level in the seal cup 24 designated 35 is normally at the same height as the level 34 in the bottom of the tower 10 and the base seal 26 separates mixing of liquid in the two sections. Hot liquid from the bottom plate 14 flows through spout 16 into the seal cup 24 from which it is withdrawn as will be presently described.

The level of the bottoms in tower 10 is maintained substantially constant by means of a float 36. The float is associated controlling the discharge line from the tower later to be described. The hot liquid is withdrawn from seal cup 24 through line 38 by means of pump 42 and passed through a cooler 44 having an inlet 46 and an outlet 48 for a cooling medium. The cooled liquid is passed through line 52 and a portion thereof returned to the bottom of tower 10 through line 54. The amount of liquid being returned through line 54 is controlled by valve 58 which in turn is controlled by a temperature responsive device 62 connected to the control valve 58 by mechanism diagrammatically shown at 64. Conventional control means are used. The temperature responsive device 62 is positioned in the bottom central portion of the bottoms 33 and may be a pyrometer or the like. The temperature responsive device 62 is used to maintain the temperature of the bottoms substantially constant at a temperature below that of the liquid in seal cup 24.

The line 55 containing cooled liquid communicates with discharge line 66 having a diaphragm valve 68 which is controlled through diagrammatically shown mechanism 66 by the float 35 for maintaining the level 34 in the tower substantially constant. Conventional control means are used.

An equalizing line 72 is provided which communicates with the bottom of the tower 10 and under certain conditions carries liquid from the bottom of the tower 10 to line 78 ahead of pump 42 where it is mixed with the hot liquid withdrawn from the seal cup 24. In normal operation the level is at 34 in the bottom of the vessel or tower 10 and at the same level 35 in the seal cup 24 and liquid flows in the direction of arrow 74 through line 72 from the bottom of the tower 10. If for any reason the level of the bottoms in tower 10 should fall to about the level indicated at 75 and with the level in the seal cup at 33, liquid will flow in the opposite direction in the equalizing line 72 to equalize the levels in the bottom of the tower and in the seal cup. It will be apparent that, as there is no valve in the equalizing line 72 and with the levels 75 and 33 as above described, hot liquid from line 36 will flow through line 72 in the direction of arrow 76 into the bottom of the tower or vessel 10 until the level in the bottom of the vessel and the seal cup are the same. When the levels are the same the flow through line 72 will again be in the direction of arrow 74 in line 72.

If the level in tower 10 is as shown at 34 and the level in the seal cup should fall to a lower level such as indicated at 78 the liquid will flow through equalizing line 72 in the direction of arrow 74 than through line 36 to cause equalization of the levels in the bottom of the tower and in the seal cup.

A draw-off line 82 is shown for withdrawing a desired fraction from the side of the tower. Any number of withdrawal lines may be provided.

In a process of the character described it is necessary to maintain a controlled surge volume ahead of the bottoms pump to absorb abnormal fluctuations. From the above it will be seen that the weir 26 is sufficiently high to prevent overflow of the liquid from the seal cup to the bottom of the vessel or tower 10. The liquid in the seal cup is at a relatively high temperature and is withdrawn from the seal cup through line 38. The relatively large volume of liquid or bottoms 32 is at a much lower temperature and comprises a surge with means for such lower temperature so that undesirable thermal decomposition of the surge volume does not take place.

The temperature of the bottoms is maintained substantially constant by the temperature responsive device 62. If the bottoms temperature rises, the temperature responsive device 62 operates control valve 58 to flow more of the cooled
product into the bottom of the tower through line 54. If the temperature of the bottoms in vessel 10 falls, the temperature control device 62 actuates control valve 53 to move it toward closing position so that less cool oil is returned to the bottom of the tower 10 through line 54. A rise in the level 34 will actuate the float 35 to operate discharge control valve 56 to permit a discharge of a greater volume of bottoms liquid. Any fall in the level 34 below level 35 in the seal cup will be compensated for by means of the equalizing line 72 and hot liquid from line 38 will pass through line 72 in the direction of arrow 73 or pulsative, control valve 68 to the tower 10 to be mixed with the bottoms therein.

The opening of control valve 55 in line 54 to permit the recycling of a greater volume of bottoms liquid to the reservoir in the bottom of tower 10 does not necessarily cause a rise in the liquid level 34 since any increase in the rate at which liquid is recycled to the reservoir is accompanied by a corresponding increase in the rate at which liquid is withdrawn from the reservoir through line 72. Hence, the manipulation of control valve 55 in recycle line 54 has a negligible, if any, effect on the level 34 in the tower 10.

Although the preferred modification of this invention has been described as a process in which cooled liquid product is continuously recycled or passed from the discharge line to the reservoir of surge liquid for purpose of controlling the temperature of the latter, it is to be understood that the passing of the cooled liquid product to the reservoir may be carried out intermittently rather than continuously if desired.

Referring now to Fig. 2, numeral 100 denotes a conventional fractional tower which is provided with a charge line 102, a vapor product draw-off line 104, and a liquid product draw-off line 105 which contains a discharge pump 108 and a control valve 112. Tower 100 is also provided with conventional bubble plates in which only the bottom plate 114 is shown in the drawings. Bubble plate 114 is provided with conventional bell-capped vapor flues 116 and a conventional liquid overflow line 118 by means of which liquid discharged from plate 114 is conducted into the conventional seal cup 119 from whence it is discharged over weir 122 into the bottom of tower 100 and then flowed into line 106. Line 106 is in communication with reservoir 124 through line 126. By means of line 128, the pressure in reservoir 124 is equalized with the pressure in tower 100 and vapors are conducted from reservoir 124 to tower 100. In Fig. 2 reservoir 124 is located at a lower level and outside of tower 100 as a separate unit.

In reservoir 124 a liquid level 132 is maintained by float mechanism 134 which indirectly actuates control valve 112 in line 106 through conventional means 136. A liquid level 139 in line 106 is maintained at substantially the same height as the liquid level 132 in the bottom of tower 100, since line 106 and reservoir 124 are under substantially the same pressure. By means of cooling coil 142 or the equivalent thereof, the volume of liquid surge maintained in reservoir 124 is kept at a temperature below the temperature of a liquid entering line 139 in the reservoir 124, since line 106 and reservoir 124 are under substantially the same pressure. By means of cooling coil 142 or the equivalent thereof, the volume of liquid surge maintained in reservoir 124 is kept at a temperature below which appreciable decomposition of the reservoir liquid occurs. It is essential that the surge liquid in reservoir 124 be maintained at a temperature above that at which crystallization or solidification occurs. Hence, in some cases, particularly where heat is lost from the reservoir at a rate faster than it is gained, it may be desirable to heat rather than to cool the surge liquid by means of coil 142 or the equivalent thereof.

Where the rate of flow of liquid from plate 114 through overflow line 118 is constant, control valve 112 may be set to discharge liquid at the same rate at which the liquid enters line 106 from tower 100 and, under these circumstances substantially no liquid will flow into or out of reservoir 124 through line 126. In cases where the rate of flow of liquid from plate 114 through line 118 into the bottom of tower 100 is irregular or pulsative, control valve 68 may be set to discharge liquid from line 106 at the average rate of the entry of liquid into that from tower 100. Under these conditions of operation, when a surge of liquid flows enters line 106 from tower 100, a portion of the liquid will back up into reservoir 124 through line 126; whereas during the ebb or cease of flow of liquid into line 106 from tower 100, a portion of liquid in reservoir 124 will flow into line 106 through line 126.

The quantity of liquid flowing into or out of reservoir 124 at any one time will usually not be sufficiently large to raise or lower the height of the liquid level 132 any appreciable extent unless the surge or decline of flow of liquid into line 106 last a considerable length of time. In the latter case, the float mechanism 134 would be raised or lowered and would open or close control valve 112 to the extent that the rate of discharge of liquid therethrough will again equal the average rate of entry of liquid into line 106 from tower 100.

Fig. 3 shows an arrangement substantially the same as that shown in Fig. 2 with the exception that reservoir 152 (similar to reservoir 124 in Fig. 2) is in the bottom of tower 154, below the bottom bubble plate 156, and it is an integral part of the tower instead of being a separate drum external to the tower as shown in Fig. 2. Line 158 is connected with the bottom of seal cup 152, which is inside and near the bottom of tower 154, instead of being connected directly to the bottom of tower 100 as shown in Fig. 2. Since the bottom of tower 154 constitutes reservoir 152 in this form of our invention, line 156 connects with the bottom of tower 154 in the same manner that line 126 connects with the bottom of reservoir 124 in Fig. 2.

In the operation of the apparatus shown in Fig. 3, the liquid level 166, which is carried in line 166 of Fig. 3, is carried in seal cup 162 and is at substantially the same height as the liquid level 158 in reservoir 152 in the bottom of tower 154.

Weir 172 of seal cup 162 is sufficiently high to prevent overflow of liquid from seal cup 162 into reservoir 152 or vice versa during normal operations. Under equilibrium conditions, the normal direction of flow of liquid from plate 156 is first through overflow line 174 into seal cup 162, then from seal cup 162, through line 150 to pump 176 and control valve 178. Any fluctuation in the rate of flow of liquid into seal cup 162 would cause liquid to flow into or out of reservoir 152 through line 158 as has previously been described. Fig. 3 also has charge line 139, bell-capped vapor flues 144, float control mechanism 168 and 167, cooling coil 188 and vapor outlet 192.

In the modification shown in Fig. 4 a portion 201 of the draw-off line 202 extends inside reservoir 204 forming the lower portion of tower 206. Portion 201 of draw-off line 202 is in communica-
tion with the bottom portion of seal cup 208 for withdrawing liquid therefrom. Level of liquid in seal cup is shown at 209. Portion of the draw-off line 238 as at 244 in Figs. 1, 2 and 3. The operation of the apparatus shown in Fig. 4 is substantially the same as that described in connection with Fig. 3.

In Fig. 4 the charge line is designated 214, vapor outlet line 216, bell-capped vapor flues 218, bottom plate 222, level of surge liquid 223, overflow pipe 224, cooling coil 225, float control mechanism 226 and 228, pump 224 and control valve 236.

In the modification shown in Fig. 5 the draw-off line 238 communicates directly with the side of plate overflow line 242 and the seal cup is eliminated. The operation of the charge line, overflow line 242 opens into the surge liquid in reservoir 244 as at 245. In this modification a liquid level 248 is carried inside overflow line 242 instead of being carried in a seal cup such as 208 in Fig. 4. The operation of the apparatus shown in Fig. 5 is substantially the same as described in connection with Figs. 2, 3, and 4.

In Fig. 5 a tower 252 is provided having charge line 254, vapor outlet line 256, bottom plate 258, bell-capped flues 260, liquid level 259 of surge liquid, cooling coil 264 and float control mechanism 266 and 268. Line 238 has a pump 270 and an outlet control valve 272. As similar elements are used in the forms of the invention shown in Figs. 2 to 5 inclusive, detailed description in all forms except Fig. 3 has been omitted.

In the aforesaid modifications of our invention the surge liquid maintained in the reservoir is assumed to be of the same type as the liquid being withdrawn from the tower since this is the usual and preferred procedure. However, where it is not objectionable for the liquid being withdrawn from the tower to become contaminated with a diluted liquid, the reservoir may be filled and provided with a suitable and more stable diluent liquid by means not shown in the drawings if desired.

While our invention may be used generally in processes where surge volumes are necessary and where the surge volume is maintained at relatively high temperatures which may cause thermal decomposition of the liquid comprising a surge volume, the invention may be used in connection with tar separators of thermal cracking equipment, or similar equipment. The invention is especially adapted for use with distillation of crude oil in a crude vacuum distillation unit. In such processes products lighter than the residuum are removed as overhead vapor or liquid side streams and the bottoms are frequently further treated to separate lubricating oil fractions. The valuable stock containing the lubricating oil fractions forms the body of the surge volume in the bottom or base of the column and if this stock is maintained at the usual high temperatures, thermal decomposition of the stock results and causes a loss of yield of the recoverable lubricating fractions in subsequent processes. In addition, if the surge liquid is maintained at relatively high temperatures, thermal decomposition of organic sulfur compounds contained therein will occur with the formation of hydrogen sulfide which is corrosive to the present and subsequent processing equipment. With our process corrosion of the equipment is noticeably lowered.

The vacuum distillation of crude oil is preferably carried out under a pressure of about 2 inches of mercury absolute. In distilling a crude oil under this pressure the bottoms oil passing down through spout 16 will be at a temperature of about 550° F. to 650° F. In the normal operation of the preferred modification of our invention, the temperature of the body of oil or bottoms in the tower 10 will be about 200° to 400° F. In the normal preferred operation with bottoms being withdrawn from the seal cup 24 and through the equalizing line 72, the oil mixture passing through the pump 42 will usually be about 650° F. (but may be higher or lower) and the oil or bottoms being discharged through line 65 will be at about 200° F. The amount of cooled bottoms normally being returned through line 84 forms about 1% to 3% of the amount of hot oil being withdrawn from seal cup 24 through line 31.

The temperature responsive device 62 of the preferred modification is also useful in preventing too low temperatures in the body of the oil 32 in the tower 10. If too low temperatures were used the equalizing line 72 might become plugged with residuum solidifying at the lower temperatures.

While we have shown several forms of apparatus which may be used in practicing our invention and have given an example of carrying out our invention in connection with vacuum distillation of crude oil, it is to be understood that these are by way of illustration only and various changes and modifications may be made without departing from the spirit of the invention.

We claim:
1. A process for reducing thermal decomposition of a surge volume of liquid which comprises withdrawing hot liquid from a vessel, maintaining a reservoir of cooler liquid as a surge volume, mixing the withdrawn hot liquid with a small portion of cooler liquid withdrawn from said reservoir of cooler liquid, further cooling the mixture, withdrawing at least part of the cooled mixture from the system and returning another portion of the cooled mixture to said reservoir of cooler liquid.
2. A process for reducing thermal decomposition of a surge volume of liquid in the bottom of a vessel which comprises withdrawing hot liquid from a well in said vessel, mixing the withdrawn hot liquid with a small portion of cooler liquid withdrawn from the surge volume in the bottom of said vessel, further cooling the mixture, withdrawing at least part of the cooled mixture from the system and returning the rest of the cooled mixture to the surge volume in the bottom of said vessel.
3. A process according to claim 2 wherein the amount of cooled mixture returned to the bottom of said vessel is controlled to maintain the temperature of the surge volume at a desired temperature.
4. A process for reducing thermal decomposition of a surge volume of liquid in the bottom of a fractionating tower which comprises withdrawing hot residual oil from the bottom fractionating plate and tower, mixing the hot withdrawn residual oil with cooler liquid withdrawn from a surge volume of liquid in the bottom of said tower below said bottom fractionating plate, further cooling the mixture, withdrawing at least
part of the cooled mixture from the system and returning the rest of the cooled mixture to the
surge volume of liquid in the bottom of said fractionating tower.

5. An apparatus for distilling liquids including in combination a fractionating tower provided
with fractionating plates, means for introducing liquid into said tower, a cup below the
bottom fractionating plate for receiving hot residual liquid from said tower, a pipe for
withdrawing hot residual liquid from said cup, said pipe being provided with equalizing means
for connecting said pipe with the bottom portion of said tower for withdrawing cooler liquid from
a surge volume in the bottom of said tower and mixing it with the hot residual liquid, means for
cooling the mixture, means for returning cooled mixture to the surge volume, temperature
responsive means in the bottom portion of said tower for controlling the amount of cooled mix-
ture returned to the surge volume, liquid level control means for maintaining the liquid level
of the surge volume at a predetermined level and a valved outlet line controlled by said liquid level
control means for removing controlled amounts of cooled residual liquid.

6. An apparatus according to claim 5 wherein the cup has a weir extending above the level of
the surge volume in said tower.

7. A process for reducing thermal decomposi-
tion of a surge volume of liquid which comprises withdrawing hot liquid from a vessel through a
line, maintaining a separate reservoir of cooler liquid as a surge volume, maintaining said res-
ervoir and withdrawal line in open communica-
tion so that liquid may flow from the withdrawal
line to the surge volume of liquid or from the
surge volume of liquid to the withdrawal line so as to compensate for fluctuations of flow of liq-
uid withdrawn from the vessel, maintaining said surge volume of liquid at a temperature below
the temperature of the hot liquid and returning regulated amounts of the liquid in the withdrawal
line to said surge volume.

8. In the operation of a system producing a hot liquid and provided with a withdrawal line
for hot liquid product and a surge volume of thermally unstable liquid in open communica-
tion with said withdrawal line to compensate for fluctuations of flow therein, the steps which com-
prise continuously mixing hot liquid product in said withdrawal line with liquid from said surge
volume, withdrawing a portion of said mixture from the system, returning the remainder of said
portion to said surge volume and maintain-
ing the temperature of the liquid in said surge volume below its decomposition temperature.

9. In the operation of a fractionating tower, the steps which comprise withdrawing residual
liquid from a bottom fractionating plate in said tower through a line, maintaining a surge vol-
ume of cooler liquid at the bottom of said tower, maintaining said surge volume and withdrawal
line in open communication so that liquid may flow from the withdrawal line to the surge volume
of liquid or from the surge volume of liquid to
the withdrawal line so as to compensate for fluc-
tuations in flow of liquid withdrawn from said
tower, cooling the withdrawn liquid and return-
ing at least a portion of said cooled liquid to
said surge volume.

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