

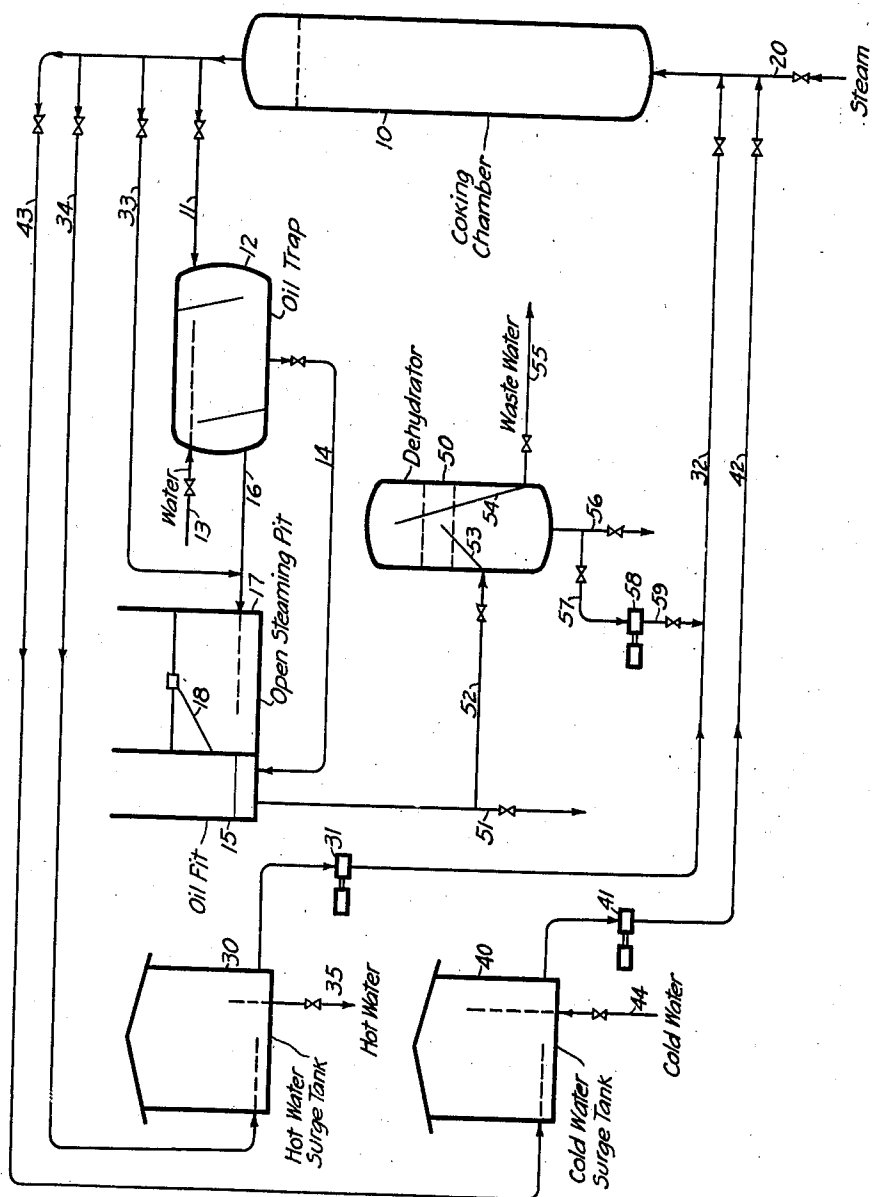
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PROCESS FOR RECOVERY OF TAR OILS

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PROCESS FOR RECOVERY OF TAR OILS

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This invention relates to a new and improved process for depressuring, steaming, and cooling a petroleum oil coking chamber immediately after discontinuance of the coking operation of said chamber and prior to the removal of the coke therein. More particularly, it deals with the economical recovery of the residual oils which are present in the chamber after the coking operation and which are removed as vapors during the depressuring and steaming (commonly referred to as "blow-down") of said coking chamber. Further, this invention deals more particularly with an economical process for the gradual cooling of the coke in the chamber, after said blow-down with steam, by the recirculation of a large volume of water at decreasing temperatures through said coke in said chamber.

Previously, it has been impractical to completely recover the residual oils removed during blow-down of a cracking coking chamber because of the large quantity of vapors which would have to be condensed to obtain such a complete recovery. Since the temperature of the coke in such a chamber is lowered from about 800–1000° F. to about 100–200° F. in as short a time as possible by water, it is obvious that an enormous quantity of water is necessary and that enormous amounts of oil and water vapors are produced. Usually the vapors from such blow-down are vented in a blow-off pit in a field at a distance far enough away from the coking chamber that these vapors will not affect or hinder the efficient operation of the units of the refinery. Such procedure is obviously purely a waste of these oil vapors, heat and water, all of which represent a total loss so far as the operation of the cracking unit is concerned. Further, since a large portion of the residual oils removed from the coking chamber are substantially as dense as or denser than water, they are not readily removed from refinery effluents, and accordingly the drain from said blow-off pits constitutes a bad contaminant for such effluents.

Also, previously there was little or no effort made to conserve the water used in cooling such chambers from about 310° F. to a temperature sufficiently low to permit opening of the chamber for removal of the coke therein. Here again, the water is usually run into the refinery effluent system or sewer without recirculation through the chamber or without any regard to controlling its temperature. Although water may be cheap, the amounts needed in such blow-down and cooling processes are very large over short periods

of time and may not be available in sufficient quantities at the moment needed. Also, since the water is used during a comparatively short period of time, and through a restricted path, it may be necessary to pump at a relatively high pressure from the water source. Accordingly, the conservation of water is not an immaterial factor in the cost of operation of such a coking unit.

It is the purpose of this invention to substantially completely, efficiently, and economically recover the residual oils present in the vapors produced by the depressuring and steaming of a petroleum oil coking chamber. Another purpose is to reduce the oil contamination of the oil refinery water effluent by the removal of said residual oils and thereby simplify the oil recovery from said effluent. Another purpose is to reduce the oil fog nuisance at the blow-off pits. Still another purpose is to conserve and thereby reduce the consumption of the water for cooling such coking chambers.

The process of this invention is an improvement in one portion of the cycle of operation of a cracking coking chamber—more particularly, that portion of the cycle between the time the coking chamber is full immediately after shutting off the hot oil feed, and the opening of the chamber for removing the coke therein. In other words, it deals with the depressuring, steaming and cooling of the coke in the chamber so it can be opened to the air and the coke removed therefrom.

Generally, the process of this invention consists of five main steps; namely, (1) depressuring; (2) steaming; (3) hot water cooling; (4) cold water cooling, and (5) oil dehydration.

Depressuring (1) comprises release of the coking pressure in the chamber and recovering the oil in the vapors removed thereby. The heavier oils in the released vapors are first condensed by a water spray in a trap. Then the lighter oils are condensed by bubbling the remaining uncondensed vapors into an open steaming pit. Depressuring is followed by passing live steam (2) through the hot coking chamber to strip the oils and tars still remaining in the coke. These oil vapors are condensed in the same two stages as mentioned in the depressuring step. After the steam has stripped out the bulk of these oils from the coke and assured sufficient porosity in the coke for subsequent operations, hot water (3) is introduced into the chamber from a hot water surge tank. As soon as the hot water contacts the coke in the chamber it is turned to steam which strips out more oils, producing vapors which

are condensed as previously described above in steps (1) and (2) until the temperature of these vapors from the chamber is about $310^{\circ}\text{F.} \pm 25^{\circ}\text{F.}$ At this time cold water (4) is introduced into the chamber from a cold water surge tank and the vapors and water coming from the chamber are passed into the hot water surge tank mentioned above until they reach a temperature of about 130°F. , at which time they are passed into the cold water surge tank. The introduction of cold water is continued until the temperature of the chamber has been lowered sufficiently to permit the safe opening of the chamber so that the coke therein may be easily removed. The oil condensed and recovered in the pit above mentioned may be dehydrated (5) in any suitable manner, preferably by phase separation, to produce a dry oil final product.

The accompanying drawing shows a flow diagram of the improved coking chamber blow-down recovery and cooling system of this invention. Referring to the drawing, the following is detailed description of this improved process.

(1) *Depressuring.*—After the coking cycle in the coking chamber 10 has been cut off there exists a pressure of about 175–200 pounds p. s. i. and normally a temperature of about $800\text{--}1000^{\circ}\text{F.}$ in the chamber, which conditions must be lowered so that the chamber may be opened and the coke removed. The first step toward this end consists of slowly opening the valve in vapor line 11 at the top of the chamber so that the pressure and oil vapors in the chamber may be released. These released oil vapors pass through line 11 into the oil trap 12 wherein they are cooled by a spray of water introduced into the trap through valved line 13. The heavier and relatively higher boiling oils in the vapor are therein condensed and collected in the bottom of the trap, from which they are withdrawn through the valved line 14 into the oil pit 15 continuously or from time to time, as desired. The uncondensed vapors, comprising the lighter lower boiling oils and steam generated from the water spray for condensing the heavier oils in the trap, are then passed through line 16 into the bottom of an open steaming pit 17 partially filled with water. The vapors entering said trap vary in temperature during the process from about 800 to 215°F. , and the vapors leaving said trap vary in temperature during the process from about 320 to 215°F. The direct contact of these latter vapors with the water condenses the lighter oils which float on the surface of the water in the pit. Whatever steam is not condensed by the water will pass into the atmosphere above the pit substantially free from oil. As the lighter oils have an A. P. I. gravity ranging between about 12.0 and 35.0, they accumulate on the surface of the water in pit 17 and are skimmed off by the gooseneck 18 into oil pit 15.

The heavier oils, which comprise about 95% by volume of the oil recovered and which are collected in trap 12, are denser than water (1.0). Since the temperature in the trap varies from a maximum of about $700\text{--}800^{\circ}\text{F.}$ to a minimum of about $215\text{--}235^{\circ}\text{F.}$, and the pressure varies from a maximum of 30–50 pounds p. s. i. to about 0–2 pounds p. s. i. gauge, it can readily be seen that substantially all of the water introduced into the trap will be vaporized and pass out as steam through line 16 and into the open steaming pit 17. The vapors passing from trap 12 range in temperature from about 215 to 320°F. when they enter steaming pit 17 and are under a pressure

varying from 0 to about 30 pounds p. s. i. gauge. It is to be expected that some of the water vapor will not condense in open pit 17, but will boil up and out through the surface of the water and oil film in the pit. Accordingly, pit 17 should have sufficiently high walls to prevent bubbling over of the oil on the surface of the pit. In congested areas a tall stack (not shown) of suitable dimensions may be mounted over the pit 17 to disperse the vapors at a high elevation. Since the amount of lighter oils carried over into the pit is only about 5% of the total oil recovered, passage through the water in the pit is normally sufficient to condense most of the lighter oils as well as to condense enough water vapor to keep the amount of water in the pit approximately constant.

2. *Steaming.*—After the pressure in chamber 10 has been released as described above, raw steam under pressure, say about 150 pounds p. s. i., is introduced into the bottom of the chamber through the valved line 20 to cool the chamber, to remove any residual oils remaining on the coke therein which were not previously removed by depressuring and to assure sufficient porosity of the coke for subsequent operations. The resulting steam and oil vapors are again passed through vapor line 11 into trap 12 and pit 17, as described above, until the temperature of the vapors coming from chamber 10 has been reduced from a maximum of about $800\text{--}1000^{\circ}\text{F.}$ to a minimum of about $600\text{--}700^{\circ}\text{F.}$, at which time the steam entering through valved line 20 is cut off.

This completes the "blow-down" recovery steps of the process.

3. *Hot water cooling.*—After the temperature in coking chamber 10 has been reduced gradually as far as practical by steaming, hot water from surge tank 30 at an average temperature of about 175°F. and not lower than about 130°F. is pumped by pump 31 into the bottom of chamber 10 through valved line 32. The water is pumped at a pressure sufficient to overcome the resistance of its flow through the coke in the chamber. The first hot water introduced into the chamber is immediately converted into steam since the temperature of the coke therein is at least above about 310°F. and probably much higher, viz., between 600 and 700°F. The steam vapors thus produced further strip the coke and are passed off as described above through valved line 11 into trap 12 and pit 17 as before. However, if substantially no heavy oil is present in the vapor, it may pass directly into pit 17 through valved line 33, bypassing trap 12.

When cooling has progressed to the point where the outlet vapors from the top of the chamber are at a temperature of about $310^{\circ}\text{F.} \pm 25^{\circ}\text{F.}$, the valved line 11 (or 33, whichever is open) is closed and valved line 34 is opened so that the vapors and hot water rising to the top of chamber 10 are passed back into the hot water surge tank 30. By making this change at about 310°F. and at a pressure of about 50# per sq. in. it can be assured that very little, if any, hot water will enter the trap 12 and emulsify the oil therein. If this oil in the trap did emulsify it would pass on through line 16 and overflow pit 17, thereby necessitating the pumping of large volumes of water containing oil into the water effluent system, and defeat one important purpose of this invention.

Simultaneously with the opening of valved line 34, pump 31 is stopped and valved line 32 is closed to prevent any further hot water from

being introduced into chamber 10. The water lost from the hot water surge tank 30 as steam is made up from water from cold water surge tank 40 after passing it through the coke in the chamber 10 whereby it is heated. Ordinarily, an excess of hot water is available in the surge tank 30 and must be continuously or intermittently withdrawn through valved line 35 in the bottom of tank 30 to the sewer, or it may be passed over a cooling water tower (not shown) and returned to the cold water surge tank 40. This hot water is substantially free of oil, i. e., less than .002% oil, and accordingly would not contaminate the sewer or cold water in surge tank 40. However, if sufficient hot water is not available in the hot water surge tank 30 to prevent further steaming in chamber 10, cold water also may be introduced into the bottom of the chamber through valved line 42 and pump 41 from cold water surge tank 40.

4. *Cold water cooling.*—When the vapors and steam stop coming from chamber 1 and valved lines 11 (or 33) and 32 are closed as noted above, pump 41 is started and cold water from cold water surge tank 40 is introduced through valved line 42 into the bottom of chamber 10. When the water coming from the top of chamber 10 through valved line 34 has reached a temperature not higher than about 130° F., valved line 34 is closed and valved line 43 is opened. This cuts off hot water return to the hot water surge tank 30 and opens the return line to the cold water surge tank 40. When the water from the chamber 10 has been reduced to a temperature of about 100–130° F. or sufficiently low so that chamber 10 can be opened and coke therein removed, pump 41 is stopped and valved lines 42 and 43 are closed. The cold water passed from cold water surge tank 40 to the hot water surge tank 13 is made up continuously at a low rate through the cold water makeup valved line 44 into the cold water surge tank 40. The cold water in surge tank 40 normally has an average temperature of about 90° F., depending on atmospheric temperature, and a maximum temperature of not over about 130° F. In some cases recirculation of the cold water may not be necessary; however, the more the water is recirculated the smaller is the amount needed for cooling.

A modification of this process not shown on the drawing comprises running water from cold water surge tank 40 into trap 12 through valved line 13; however, the water introduced into trap 12 through line 13 should be as cold as possible, and preferably as low as about 60° F.

This completes the water cooling steps.

5. *Oil dehydration.*—The oils recovered from the above process and accumulated in the oil pit 15 still contain from about 5 to 35% by volume of water, which should be removed if the oil is to be put to an efficient use. This may be done in a dehydrator 50 or by other conventional dehydrating means not shown. Thus the wet recovered oil may be withdrawn from pit 15 through valved line 51 as a final wet oil product, or it may be passed into dehydrator 50 through valved line 52 for the separation of some of the water in the oil. Recovered oil having the same or greater density than water is introduced into dehydrator 50 through gooseneck 53 between the lower oil phase and the upper water phase so as to aid in its separation. Often an intermediate oil-water emulsion phase forms at the end of

gooseneck 53 in the dehydrator. The upper or water phase is withdrawn from dehydrator 50 through the gooseneck 54 and valved line 55, and discarded to the sewer. The lower oil phase is withdrawn from the bottom of the dehydrator through valved line 56 and may be further dehydrated or used as it is, whichever is desired.

It is important to maintain the contents of dehydrator 50 at a temperature not in excess of 160° F. because the gravity of water changes with changes in temperature at a different rate from the gravity of the oil recovered, both gravities being normally about the same at about 160° F. If the temperature in dehydrator 50 is maintained between about 140 and 150° F. the water phase withdrawn from dehydrator 50 through lines 54 and 55 is clear and the oil phase contains only from about 1 to 5% water.

If the oil-water emulsion layer in the dehydrator 50 becomes too large and substantially no separation is obtained, it may be withdrawn from dehydrator 50 through valved line 57 and pumped by pump 58 through valved lines 59 and 32 into coking chamber 10 right after the depressing step (1) when the coke and chamber are hot enough to vaporize the oil in the emulsion and thereby break it, producing oil vapors which may again be condensed as described above in trap 12 and pit 17.

The heavy oil recovered by the process of this invention is highly aromatic in nature and has an A. P. I. gravity ranging from about 0.0 to 8.0. Normally it has a pour point ranging from about 5 to 75° F., a Saybolt Universal viscosity at 100° F. of between 120 and 400 seconds, and a Saybolt Universal viscosity at 210° F. of between 30 and 500 seconds. Such an oil has many uses; for example, it is a good blending stock for fuel oils, as well as prolific source of by-products of polycyclic type.

The several pieces of apparatus employed in carrying out the process of this invention may be of any convenient or conventional design provided it will withstand the conditions involved in carrying out the process.

The following specific example of actual plant operation will clearly illustrate the many advantages and economy of the above process.

Example.—A 500 barrel capacity Dubbs coking chamber, at a temperature of 900° F., was depressured and steamed for 45 minutes with approximately 40,000 pounds of steam introduced at a pressure of about 160 pounds p. s. i. At the end of this time the steam was cut off and the temperature of the vapors from the chamber was found to be about 700° F. Hot water at a temperature of about 175° F. was pumped under a pressure of 300 pounds p. s. i. into the bottom of the chamber, slowly at first and then more rapidly, as the chamber cooled, up to a rate of about 600 gallons per minute, at which time the outlet vapors had decreased to a temperature of about 310° F. and were free of oil. The vapors were then switched to the hot water surge tank, and the hot water was turned off and cold water turned on under a pressure of about 200 pounds p. s. i. and a rate of about 750–1400 gallons per minute. Water was continuously withdrawn from the hot water surge tank at a rate of about 100 gallons per minute to the sewer to prevent its overflow. As the water came out of the top of the chamber it was reduced in pressure to about 85 pounds p. s. i. due to the resistance of the coke in the chamber. The amount of hot water used varied between about 40,000

and 60,000 gallons, with a loss to sewer and the formation of steam of between about 5,000 and 20,000 gallons. The amount of cold water consumed was between about 15,000 and 30,000 gallons, most of which went to replace the hot water lost from the hot water surge tank. The cold water makeup was introduced into the cold water surge tank during cold water circulation at a rate of from 150 to 350 gallons per minute. As many as 5 chambers, each of 500 barrels capacity, may be handled within a period of 24 hours, and 2 or 3 may be cooled simultaneously with the indicated amount of cold water makeup.

Oil was recovered from the vapors in the trap and steaming pit during the operation of the process with the aid of a cold water spray having a temperature of about 60° F., which was injected into the trap to hold a constant outlet temperature to about 350° F. The rate of water sprayed varied from about 30 gallons to about 5 gallons per minute, decreasing gradually as the vapors entering the trap decreased in temperature. The pressure in the trap varied from about 30 to 3 pounds p. s. i. during this time. The heavy oil collected per cycle amounted to about 80 barrels and had a water content of about 20% by volume. This oil after dehydration in a dehydrator of the type disclosed herein had an A. P. I. gravity of below 8.0 and gave a yield of about 65 barrels of heavy oil.

I claim as my invention:

1. In a continuous process for recovering residual tars and oils removed from a petroleum oil coking chamber during blowdown of said chamber, the steps comprising depressuring said chamber substantially at the temperature of said coking to produce oil vapors, passing steam through said chamber until its temperature has been lowered from said coking temperature to between about 600° F. and 700° F. to strip the oils therefrom and produce mixed steam and oil vapors, introducing hot water into said chamber to cool the vapors to a temperature of between about 285° F. and 335° F. and to produce more steam and oil vapors, contacting said steam and oil vapors thus produced in a trap to a temperature above about 215° F. with a spray of cold water to condense relatively high boiling oils heavier than water in said vapors, passing the uncondensed lower boiling oil vapors into an open steaming pit to condense at least a major portion of the remaining oils in said vapors, collecting the condensed oils, and introducing cold water into said chamber to cool said chamber to below about 130° F.

2. The process of claim 1 wherein the hot water introduced into said chamber is at a temperature above about 130° F.

3. The process of claim 1 wherein the hot water introduced into said chamber has an average temperature of about 175° F. and is introduced under a pressure of about 300 pounds per square inch.

4. The process of claim 1 wherein the vapors entering said trap have a temperature ranging between about 215° F. and 800° F.

5. The process of claim 1 wherein the vapors leaving said trap have a temperature ranging between 215° F. and 320° F. and a pressure of less than 50 pounds per square inch.

6. The process of claim 1 wherein the cold water introduced in said chamber has an average temperature of about 90° F. and is introduced under a pressure of about 200 pounds per square inch.

7. In a process for recovering residual tars and oils removed from a petroleum oil coking chamber at the end of the coking cycle, the steps comprising depressuring said chamber substantially at the temperature of said coking to produce oil vapors, passing steam through said chamber until its temperature is lowered from said coking temperature to between about 600° F. and 700° F. to strip oils therefrom and to produce mixed steam and oil vapors, introducing hot water into said chamber to cool the vapors to a temperature of between about 285° F. and 335° F. and to produce more steam and oil vapors, contacting said steam and oil vapors in a trap maintained at a temperature between about 215° F. and 800° F. with a spray of cold water to condense relatively high boiling oils heavier than water in said vapors, passing the uncondensed lower boiling oil vapors into an open steaming pit to condense at least a major portion of the remaining lighter oils in said vapors, skimming the lighter oils from said pit, combining the oils thus condensed in said trap and pit in a separate receiver and then dehydrating them in a dehydrator maintained at a temperature below about 160° F. to produce an oil phase and a water phase, separating said phases, and finally introducing cold water into said chamber when the temperatures of said vapors have reached about 310° F. to produce hot water and water vapors and to cool said chamber to below about 130° F.

8. The process of claim 7 wherein the temperature in the dehydrator is maintained between about 140° F. and 150° F.

9. The process of claim 7 wherein the combined oils have an A. P. I. gravity of less than about 8.

10. In a continuous process for recovering residual tars and oils removed from a petroleum oil coking chamber at the end of the coking cycle, the steps comprising depressuring said chamber substantially at the temperature of said coking to produce oil vapors, passing steam through said chamber until its temperature has been lowered from said coking temperature to between about 600° F. and 700° F. to strip the oils therefrom and to produce mixed steam and oil vapors, introducing hot water into said chamber to cool the vapors to a temperature of between about 285° F. and 335° F. and to produce more steam and oil vapors, contacting said steam and oil vapors thus produced in a trap at a temperature between about 215° F. and 800° F. with a spray of cold water to condense relatively high boiling oils heavier than water in said vapors, passing the uncondensed lower boiling oil vapors into an open steaming pit to condense at least a major portion of the remaining lighter oils in said vapors, skimming the lighter oils from said pit, combining the oils thus condensed and dehydrating them in a dehydrator maintained at a temperature below about 160° F. to produce an oil phase, a water phase and an intermediate oil-water emulsion phase, separating said phases, returning said emulsion to said chamber while it is at a temperature above about 600° F. whereby the emulsion is revaporized, and finally introducing cold water into said chamber when the temperature of the vapors therefrom has reached about 310° F. to produce hot water and water vapors and to cool said chamber to below about 130° F.

11. In a continuous process for recovering residual tars and oils removed from a petroleum oil coking chamber during blowdown of said cham-

ber, the steps comprising depressuring said chamber substantially at the temperature of said coking to produce oil vapors, steaming said chamber until its temperature has been lowered from said coking temperature to between about 600° F. and 700° F. to strip oils therefrom and to produce mixed steam and oil vapors, cooling said chamber with water from a hot water surge tank until the vapors have a temperature of between about 285° F. and 335° F. and to produce more steam and oil vapors, condensing said steam and oil vapors thus produced, and collecting the condensed oil therefrom, further cooling said chamber with cold water from a cold water surge tank to produce hot water and water vapors which are substantially free from oil and are collected in said hot water surge tank until said water from said chamber has a temperature of not below about 130° F., at which temperature the water is returned again to said cold water surge tank, thereby cooling said chamber to a temperature about 130° F., and continually adding fresh water to said cold water surge tank.

12. The process of claim 11 wherein the average temperature of the hot water in the hot water surge tank is about 175° F. and is introduced into said chamber under a pressure of about 300 pounds per square inch.

13. The process of claim 11 wherein the cold water in the cold water surge tank has an average temperature of below 130° F. and is introduced into said chamber under a pressure of about 200 pounds per square inch.

14. The process of claim 11 wherein the fresh water fed into said cold water surge tank is fed at a rate of between about 150 and 350 gallons per minute.

15. In a continuous process for recovering residual tars and oils removed from a petroleum oil coking chamber at the end of the coking cycle, the steps comprising depressuring said chamber substantially at the temperature of said coking to produce oil vapors, passing steam through said chamber until its temperature has been lowered from said coking temperature to between about 600° F. and 700° F. to strip the oils therefrom and to produce mixed steam and oil vapors, cooling said chamber with hot water at a temperature above about 130° F. from a hot water surge tank until the vapors have a temperature of between about 285° F. and 335° F. to produce more steam and oil vapors, contacting said steam and oil vapors thus produced in a trap at a temperature above about 215° F. with a spray of cold water to condense relatively high boiling oils heavier than water in said vapors, passing the uncondensed lower boiling oil vapor into an open steaming pit to condense at least a portion of the remaining lighter oils in said vapors, skimming the lighter oils from said pit, combining the oils thus condensed and dehydrating them, the combined oils having an A. P. I. gravity of less than 8, and finally further cooling said chamber with cold water from a cold water surge tank, said cold water having an average temperature of below 130° F., to produce hot water and water vapors which are substantially free from oil and are collected in said hot water surge tank until they have cooled to a temperature of not below about 130° F. at which time they are returned to said cold water surge tank, said cold water cooling said chamber to a temperature below about 130° F.

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