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REFINING OF EFFLUENT FROM IN SITU COMBUSTION OPERATION

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ABSTRACT OF THE DISCLOSURE

A hot, high pressure vapor-liquid mixture from an in situ combustion operation is charged to a sand trap and vapor-liquid separator to remove sand and recover a vapor stream of N_2 , H_2O , and hydrocarbons boiling in the gas oil range and lower at relatively high pressure and temperature and a liquid stream of water and higher boiling hydrocarbons. The latter stream is flashed to separate an overhead vapor stream and a bottoms liquid stream of high boiling hydrocarbons and water in the form of an emulsion. This emulsion is broken into an overhead vapor stream, a bottoms stream of water, and a side stream of hydrocarbons boiling above the gas oil range. The overhead vapor stream from the sand trap and liquid-vapor separator is reduced substantially in pressure and cooled and thereafter passed to a low temperature and low pressure zone to recover an overhead vapor stream of H_2O , N_2 , CO , and CO_2 , a bottoms water stream, and a side stream of hydrocarbons ranging from gas oil to normally gaseous hydrocarbons. The liquid side stream is fractionated to recover a normally gaseous hydrocarbon stream, a gasoline stream, a distillate stream, and a gas oil bottoms stream. Apparatus for effecting the process is provided.

This invention relates to a process and apparatus for refining the high temperature and high pressure effluent from a production well of an in situ combustion operation.

The production of oil from subterranean oil-bearing strata by in situ combustion is an established commercial operation. The produced effluent from such an operation conducted by direct drive of the combustion front is at an elevated temperature and pressure during that phase of the operation when the combustion zone is approaching the production well. During the entire period of a reverse burning operation, the produced effluent is at a relatively high temperature and pressure due to the fact that the fire front is initiated at the production well and, as the front moves radially outwardly therefrom, the hot combustion products and hydrocarbons pass thru only the hot sand or rock intermediate the fire front and the production well.

The hot effluent from an in situ combustion process contains substantial concentrations of H_2O , N_2 , CO , and CO_2 in addition to hydrocarbons ranging from normally gaseous to heavy residual hydrocarbons. To illustrate, when producing in-place oil of about 8 to 10 API gravity by reverse burning, the oil is upgraded underground to about 26–27 API at 60° F.

The hot effluent from the production well in an in situ combustion operation contains such high concentrations of water and nitrogen that refining of the effluent near the wellhead or in the field being produced has numerous advantages over transporting the effluent thru pipeline or other means to a distant refinery for processing.

This invention is concerned with an arrangement of apparatus and process for the refining of the hot high pressure effluent from an in situ combustion process near the wellhead.

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Accordingly, it is an object of the invention to provide an improved process and arrangement of apparatus for refining the high temperature, high pressure effluent from an in situ combustion process effected in a subterranean deposit of oil. Another object is to provide a process and apparatus which removes water, nitrogen, and other non-hydrocarbon materials from an in situ combustion effluent. A further object is to reduce the cost and time required for recovering hydrocarbons from an in situ combustion operation and to transport the hydrocarbon phase of such an operation to market. Other objects of the invention will become apparent to one skilled in the art upon consideration of the accompanying disclosure.

In accordance with the invention the hot vapor-liquid mixture from a production well in an in situ combustion operation is charged to a sand trap and liquid-vapor separator to remove sand and other solids from the stream and to recover a separate vapor stream comprising N_2 , H_2O , and hydrocarbons boiling in the gas oil range and lower at relatively high pressure and temperature and a separate liquid stream comprising water and hydrocarbons boiling above the gas oil range. The liquid stream comprising water and high boiling hydrocarbons is flashed in a flashing zone or flash vessel to separate an overhead vapor stream and a bottoms liquid stream comprising principally high boiling hydrocarbons and water. This liquid stream in the form of an emulsion is then passed to an emulsion breaker to effect separation of same into an overhead vapor stream, a bottom water stream, and a side stream of residual hydrocarbons boiling above the gas oil range. The overhead vapor stream from the sand trap and liquid-vapor separator, containing principally H_2O , N_2 , CO_2 , CO , and hydrocarbons ranging from gas oil to normally gaseous hydrocarbons, is substantially reduced in pressure and cooled before passing into a low temperature and low pressure separator to separate same into an overhead vapor stream comprising principally H_2O , N_2 , CO , and CO_2 , a bottom water stream, and a side stream comprising principally hydrocarbons ranging from gas oil to normally gaseous hydrocarbons. This liquid side stream is fractionated in a conventional distillation column or fractionator to recover an overhead normally gaseous hydrocarbon stream, a stream of gasoline, a distillate side stream, and a bottoms gas oil stream.

In instances where the residual oil from the emulsion breaker is of high enough quality, a portion of this stream is admixed with the liquid hydrocarbon stream passing into the fractionator to recover valuable lighter constituents therefrom, the heavier portions of this residual oil being recovered in the gas oil.

A more complete understanding of the invention may be had by reference to the drawing which is a process flow illustrating a preferred arrangement of apparatus in accordance with the invention.

Referring to the drawing, a production line 10 connects with the wellhead of a production well 12 of an in situ combustion field operation. Line 10 leads into sand trap and liquid-vapor separator 14. Pressure in line 10 can be controlled within limits by means of vent line 16 containing a motor valve 18 under the control of a pressure controller 20 which is sensitive to pressure in line 10 downstream of line 16. Vessel 14 is an upright elongated vessel having overhead vapor line 22, a bottom outlet line 24 for sand, and line 26 for withdrawing a liquid side stream comprising principally water and hydrocarbons. Line 26 leads in flash vessel 28 and is provided with a motor valve 30 which is operated by liquid level controller 32 to maintain a suitable liquid level in vessel 14.

Vessel 28 has an overhead vapor line 34 and a bottom liquid line 36 which leads into an emulsion breaker

38 comprising an upright elongated vessel which is provided with a pair of liquid level controllers 40 and 42 for maintaining suitable levels of residual hydrocarbon and water, respectively. An overhead vapor line 44 connects with line 34 and vents thru line 46 under pressure controller 48 which operates motor valve 50. Level controller 42, which is sensitive to the interface level of the water and oil, operates motor valve 52 in effluent water line 54 to maintain a suitable water level in the lower section of vessel 38. Level controller 40 manipulates a motor valve 56 in effluent residual oil line 58 to maintain a suitable selected hydrocarbon level in vessel 38. Line 58 conducts recovered residual oil to storage or further refining, as desired.

Overhead vapor line 22 leads into line 60 which contains a pressure controller 62 operatively connected with a motor valve 64 for reducing pressure in said line to a predetermined level. Line 60 also contains a condenser or heat exchanger 66. Separator 68 is positioned at the downstream end of line 60 to receive overhead feed from vessel 14, which contains a wide distribution of hydrocarbons in accordance with their boiling range from gas oil to normally gaseous hydrocarbons. Vessel 68 is provided with an overhead vapor line 70 in which is positioned a motor valve 72 which is operated by a pressure controller 74 to maintain suitable backpressure on vessel 68. Water line 76 leads from the bottom of vessel 68 and liquid hydrocarbon line 78 conducts a side stream of liquid hydrocarbon into fractionator 80 as feed thereto. A suitable liquid level of water is maintained in the lower section of vessel 68 by means of interface level controller 82 which is in control of motor valve 84 in line 76. In a similar manner a suitable hydrocarbon level is maintained in vessel 68 by means of level controller 86 which is in operative control of motor valve 88 in line 78.

Fractionator 80, which is a conventional fractional distillation column, is provided with an overhead vapor line 90 containing a condenser 92 and leading into an accumulator 94. Line 96, leading from the bottom of accumulator 94, is provided with a pump 98 which forces gasoline as reflux back to the upper section of fractionator 80 thru line 100 and also passes gasoline thru line 102 to storage under the control of level controller 104 which operatively controls valve 106 in line 102. Line 108 vents normally gaseous materials from accumulator 94 under the control of pressure controller 110 and motor valve 112.

Distillate line 114 leads into accumulator 116 which is provided with an overhead vapor line 118 and a liquid outlet line 120 containing pump 122. Reflux line 124 leads from line 120 into column 80 and is provided with a motor valve 126 which is operated by level controller 128 on accumulator 116. Distillate recovery line 130 leads to storage and is provided with a suitable backpressure valve 132, when necessary, or pumping into a storage tank provides the necessary backpressure.

A reboiler 134 in reboil line 136 provides reboil heat for column 80. Gas oil product line 138 connects with reboil line 136 intermediate reboiler 134 and a pump 140 therein and passes thru a heat exchanger 142 in line 78 to recover heat from the gas oil and preheat the feed in line 78. A by-pass line 144 around heat exchanger 142 provides for by-passing all or any desired proportion of the gas oil around the exchanger.

Line 146 connects oil residue line 58 with line 78 to permit passing any desired amount of the residual oil into the hydrocarbon feed in line 78 passing into fractionator 80. Auxiliary line 148 connects line 10 with line 60 to provide for by-passing vapor from line 10 to line 60 around vessel 14 when desired.

In order to further illustrate the invention the following example is presented. The data therein are not to be construed as unnecessarily limiting the invention.

EXAMPLE

	Specific	Ranges
Well Fluid (line 10):		
Quantity, #/hr.....	33,874	-----
Vapor, wt. Percent.....	31.8	-----
Liquid, wt. Percent.....	68.2	-----
Oil, ° API at 60° F.....	26	20-35
Temperature, ° F.....	510	300-650
Pressure, p.s.i.a.....	1,505	500-2,000
Sand Trap and Liquid-Vapor Separator (14):		
Temperature, ° F.....	500	300-650
Pressure, p.s.i.a.....	1,500	500-2,000
Charge, #/hr.....	33,874	-----
Vapor-Gas Yield, #/hr.....	23,120	-----
Liquid Yield, #/hr.....	10,754	-----
Flash Vessel (28) and Emulsion Breaker (38):		
Temperature, ° F.....	270	230-350
Pressure, p.s.i.a.....	50	25-150
Charge, #/hr.....	10,754	-----
Water Liquid Yield, #/hr.....	7,350	-----
Vapor-Steam Yield, #/hr.....	1,950	-----
Residue Oil, Yield, #/hr.....	1,454	-----
° API at 60° F.....	15	10-25
Low Temperature—Low Pressure Water Separator (68):		
Temperature, ° F.....	130	100-150
Pressure, p.s.i.a.....	100	50-150
Charge, #/hr.....	23,120	-----
Vapor, wt. Percent.....	50	-----
Liquid, wt. Percent.....	50	-----
Water Liquid Yield, #/hr.....	8,835	-----
Vapor Yield, #/hr.....	11,810	-----
Liquid Yield, #/hr.....	2,475	-----
Fractionator (80):		
Temperature, Top, ° F.....	340	275-375
Temperature, Bottom, ° F.....	590	540-610
Pressure, p.s.i.a.....	50	20-75
Charge, #/hr.....	2,475	-----
Vent, MCFH.....	2.3	-----
Gasoline Yield, barrels/hr.....	2.2	-----
° API at 60° F.....	49	40-60
Distillate Yield, barrels/hr.....	1.7	-----
° API at 60° F.....	36	30-45
Gas Oil Yield, barrels/hr.....	3.7	-----
° API at 60° F.....	29	25-40

The above data under the "Specific" column illustrate preferred operation when refining the production well effluent from a reverse in situ combustion operation in an oil deposit in which the oil has an API gravity of about 8 to 10. This type has been upgraded by in situ combustion to 26-27 API gravity. Obviously, the invention is applicable to the refining of production well effluent from substantially any in situ combustion operation which upgrades the oil to the range of 20-35 API gravity. Usually the API gravity of the in-place oil will be in the range of about 8-20.

Certain modifications of the invention will become apparent to those skilled in the art and the illustrative details disclosed are not to be construed as imposing unnecessary limitations on the invention.

I claim:

1. A process for refining an effluent stream from a production well of an in situ combustion operation wherein said stream is at a temperature of at least 300° F. and a pressure of at least 500 p.s.i.a, which comprises the steps of:

- passing said stream into a solids-liquid-vapor separating zone and separately recovering therein entrained solids, a vapor stream at a temperature in the range of 300 to 650° F. and a pressure in the range of 500 to 2000 p.s.i.a., and an unvaporized liquid stream at said temperature and pressure;
- flashing the unvaporized liquid stream recovered in step (a) in a flashing zone at a temperature in the range of 230 to 350° F. and a pressure in the range of 25 to 150 p.s.i.a. to recover an overhead vapor stream and a liquid bottoms stream in the form of a liquid-vapor emulsion;
- separating the bottoms stream of step (b) in an emulsion breaking zone at substantially the same temperature and pressure as in step (b) into an overhead vapor stream, a bottom water stream, and a residual hydrocarbon side stream;
- passing the vapor stream of step (a) into a low-temperature separation zone operated at a temperature in the range of 100 to 150° F. and a pressure in

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the range of 50 to 150 p.s.i.a to separate same into an overhead vapor stream comprising principally steam, and a side stream of hydrocarbons ranging from normally gaseous thru gas oil; and

- (e) fractionating the side stream of hydrocarbons of step (c) to recover separate streams of normally gaseous hydrocarbons, gasoline boiling range hydrocarbons, distillate, and gas oil.

2. The process of claim 1 wherein the stream of step (a) is from a reverse burning combustion front in an oil stratum containing a low API gravity oil and the oil in said stream has an API gravity in the range of 20 to 35.

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References Cited

UNITED STATES PATENTS

2,368,497	1/1945	Shipley et al.	208—187
3,310,109	3/1967	Marx et al.	196—98
2,933,447	4/1960	Walker et al.	208—187
3,014,082	12/1961	Woertz	260—676
3,211,643	10/1965	Lenhart	208—187 X

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