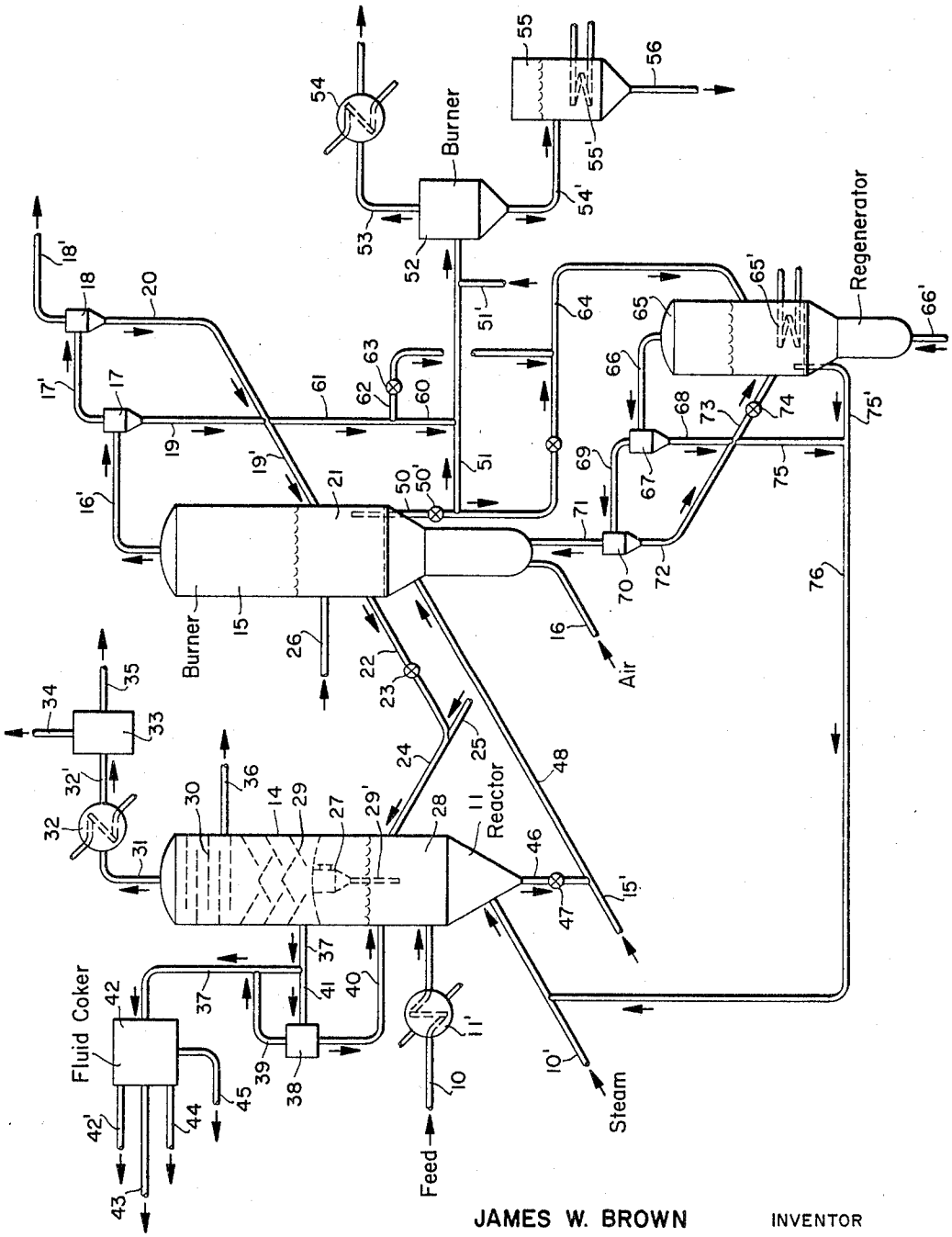
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MODIFIED FLUID COKING PROCESS

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MODIFIED FLUID COKING PROCESS

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This invention relates to an improved process for the recovery of hydrocarbon oil from bituminous or tar sands or the like in which the oil is in admixture with mineral solids and water. More particularly, this invention relates to a modified system of fluid coking in which viscous crude petroleum oil is separated and cracked from a mixture with sand, clay and water.

In various areas of the world, tar sands exist which contain various types of hydrocarbons as, for example, the large deposits of Athabasca tar sands existing in Canada. These sands contain tremendous reserves of hydrocarbon constituents. For example, the oil in the sands may vary from about 5% to 21% by volume, generally in the range of about 12% by volume. The gravity of the oil ranges from about 6° to 10° API, generally about 8° API. These sands may lie from about 200 to 300 feet below an overburden and the beds may range from about 100 to 400 feet thick. A typical oil recovered from the sands has an initial boiling point of about 300° F., 1.0% distilled to 430° F., 20.0% distilled to 650° F. and 50.0% distilled to 980° F. However, the recovery and processing of hydrocarbons in the past has not been effective to any great extent due to the deficiencies in operating techniques for the recovery of these hydrocarbons. For example, relatively small amounts of fine clay and sand (from about 0% to 30%, usually about 5%) may result in formations of a stable emulsion containing sand, clay, water and bitumen which is apparently stabilized by the fine solids. This makes further processing by conventional techniques exceedingly difficult.

Numerous attempts have been made in the past to recover bitumen from the Athabasca tar sands in various manners. For example, it has been suggested that a solvent be added in order to reduce the viscosity of the bitumen, and in conjunction with water, to float the bitumen solvent mixture away from the sand. Although this technique achieves a good separation of clean sand, the addition of water results in problems with the formation of stable emulsions and sludges which have been very difficult to separate. Thus, extensive supplementary processing has been required in order to avoid large losses of oil and solvent.

It has also been suggested in the past that tar sands as they are mined be handled by a thermal process in order to recover the bitumen therefrom. However, this process has been uneconomical due to the large amount of heat which is lost due to the fact that the heat is imparted to the sand and cannot be effectively and efficiently recovered therefrom. It has been suggested for example that tar sands be handled in a direct fluid coking operation. However, as pointed out, this process is uneconomical for the reasons given above. Also, any process that will effectively handle tar sands must have the ability to handle a very wide range of tar sand and compositions which occur even in an immediate location. Underground extraction with hot water is currently being carried on but this has met with limited success.

Further problems have been encountered from fine clay and sand in the tar sands when attempting to separate oil by means of a fluid coking process. Fine clay particles may be carried to the scrubber by entrainment in the vaporous hydrocarbon product and once there either completely clog the scrubber or greatly reduce its efficiency.

Alternatively, fine material and other solids may be released through the stack in the burner. With large scale operations such as would be undertaken in the Athabasca region this would amount to several tons of material per day and have a most unsatisfactory effect on the surrounding area.

Tar sands contain between about 3 and 20 wt. percent crude oil and between about 1 and 10 wt. percent of water. Sand and other mineral matter, i.e. clay, form about 80 to 90 wt. percent of the tar sands. About 1–20% of this mineral material is fine material.

According to a preferred embodiment of this invention, a tar sand which may be an Athabasca tar sand is subjected to a froth flotation. That is to say, hot water is mixed with the tar sand; several phases are formed including an aqueous phase, a sand phase, and a froth. The froth forms because gas is liberated from the bitumen, the gas being predominantly ethane, methane and trapped air. The froth may contain up to 40 vol. percent of gas. The water phase and the sand phase are withdrawn and discarded.

This froth is then subjected to a fluid coking process to remove oil and water and to form coke and lower boiling hydrocarbons from the oil within the froth. Extraneous hot gas or fuel may be added to the burner of the coking unit and this combined with the low coking temperature utilized prevents the coke from being entirely burned to provide heat for the coking process. The lighter overhead hydrocarbon products are separated from the heavier products and removed or may further be put to use, as will subsequently be explained. The heavier, 900° F.+ fraction, is subjected to conventional process such as fluid coking in which gas and liquid product are produced along with a high value coke. However, the heavier fraction may be subjected to other processes such as visbreaking, for example.

The solids, including sand and other mineral matter such as clay, are coated with coke in the first stage, low severity or low temperature coking reactor during the coking step, and the coated solids are then trapped within the coking reactor. By trapped it is meant that the coke coating serves as a glue. Therefore, the smaller solids become stuck to larger particles and this serves to keep the smaller solids within the reactor rather than allowing them to escape through the stack. This is particularly true of very fine solid material within the 1 to 5 micron range; the cohesive force of the coke tends to keep them stuck to larger particles and, therefore, they tend to remain within the coking unit. As much as 50% of the coke formed during coking is maintained on the solids.

Fines from the cyclones of the low temperature burner together with some of the coarser solids from the burner are regenerated in a fluid bed and used as cracking catalyst in the reactor. The clay in these particles becomes activated and acts as a cracking catalyst. Some of the stack solids from the high temperature burner may also be used for this purpose.

The net carbon or coke coated solids are removed from the burner of the fluid coker and are introduced into a relatively high temperature burner. Because of the high temperature in this burner, and the fact that all the coke is burned, the coke coating is burned to CO_2 thereby producing a large amount of heat. This heat in the form of hot gas is passed into a boiler where it may be utilized for the production of steam. Alternately, part of this hot gas may be passed through the coker burner to supply heat.

The extreme heat causes some of the sand and clay to become sintered, that is to say agglomerated in large masses which are, therefore, easier to remove than smaller pieces. Alternately, the solids may be removed as slag where ash melting point is low.

Solid particles are removed from the high temperature burner and introduced into a cooler. The heat liberated during this cooling process is captured in a boiler and may be used for production of steam.

The advantages of this invention in relation to conventional fluid coking may be summarized as follows:

The mineral solids from the tar sands are coated with coke in the first stage coking reactor. In the case of a froth from an Athabasca sand, this protective coke covering on the solid particles eliminates problems of erosion of apparatus and entrainment of fine solid particles, which would otherwise be encountered if all the carbon were burned off the solids in a conventional fluid coker burner. The principle of operation of the burner is that at least 5% and preferably 50% of coke is maintained on the solids to produce a protective covering during burning in the burner. If necessary, in cases where the heat load is unusually high in the reactor, supplementary fuel such as torch oil is burned in the burner in preference to the coke covering to maintain this protective coating.

The first coking reactor operates at low severity without recycle of oil except as slurry recycled to return solids to the reactor. Presence of water in the feed makes it possible to reduce cracking time. This maximizes the liquid oil product yields, particularly where the feed stock contains a large amount of low boiling hydrocarbons.

Catalytic fines are regenerated and used as a catalyst in the cracking reactor. The presence of these fines will increase the dry gas and naphtha yield and decrease the gas oil within the reactor.

The second stage coker operates on the unconverted residuum or residual oil from the first stage. As mentioned previously, this residuum may be subjected to a great variety of treatment as for example visbreaking. This coker is of the conventional type and employs recycle of unconverted residuum. Recycle rates would be undesirably high if recycle were attempted in the first stage coker. This is because of the high steam dilution rate caused by the water in the feed. Also, the second stage coker makes high quality coke since the oil feed is relatively free of solids such as sand, clay, etc. In fact, where there is excessive entrainment of solids in the vaporous product from the first stage coker reaction, it is possible to employ a solids settling step with recycle of solids to the first stage reactor and the passing of a solids-free oil feed to the second stage coking reactor.

Since it is desirable to recover the heating value of the protective coke layer on the sand or other solids, this is done more efficiently than with a conventional fluid coker burner. The solids leaving the first stage burner are completely burned at high temperature and high velocity in a subsequent high temperature transfer line or cyclone-type burner where carbon or coke is burned almost entirely to carbon dioxide. This also permits complete removal of the carbon rather than the incomplete removal which would be experienced in a conventional fluid burner. The heat in the flue gas containing carbon dioxide and the solids from the high temperature burner is recovered by producing steam in boilers. In the process of removing carbon, some of the fine particles of clay are activated and regenerated to form catalyst for use in this first stage coker.

In the drawing, the figure is a schematic representation of a preferred embodiment of this invention.

The reference numeral **10** designates a line through which a froth, which is obtained from a tar sand and is an admixture of oil, sand, mineral solids such as clay, water and air, is introduced into a fluid coker unit including a reactor **11** and a burner **15**. The froth feed is preheated in heater **11'**.

Reactor **11** is maintained at a temperature between 800° F. and 1200° F. which is the conventional temperature of a fluid coker. The bed contains a sticky bed of fluid coke particles which may range in size between

20–400 microns. Pressure may be maintained between 5 and 15 p.s.i.g. and preferably at about 10 p.s.i.g. Superficial velocity of gas passing up through reactor **11** may be between 1 and 4 feet per second and the solids bed depth, which may vary widely, should be about 30 to 50 feet. The fluidized bed **28** is maintained as such by the upflowing hydrocarbon gases and vapors formed by the coking of the oil feed and by steam added to the process through line **10'**. When using finely divided coke of about 20–400 microns and at a superficial velocity as above mentioned the density of the fluidized bed **28** will be about 35 lbs. per cu. ft. depending on the superficial gas velocity selected and the particular particle size range. Catalytic fines are added to the reactor **11** from catalyst regenerator **65** through lines **75'**, **76** and line **10'**.

Burner **15** is maintained at a temperature of 900° F. to 1200° F. Pressure may vary between 5 and 15 p.s.i.g. with about 10 p.s.i.g. being preferred. Superficial velocity of the gas passing up through burner **15** may be between 1–3 ft./sec. and bed depth should be between 10 and 30 ft. Air to maintain combustion is added to the bottom of the burner **15** through line **16**. Cyclones **17** and **18** are in series and are located outside burner **15** and they serve to separate solid particles from flue gases in which they are entrained. Part of these solid particles is returned to bed **21** through diplegs **19** and **20** and line **19'**. The amount of solids flowing from diplegs **19** and **20** into line **19'** may be independently controlled by providing separate lines and valves (not shown). Part of the particles pass to burner **52** through lines **61**, **60** and **51** where all the carbon is removed and a third portion passes to catalyst regenerator **65** through lines **61**, **62** and **64** from whence fine material passes from regenerator **5** through lines **76** and **10'** to recator **11**. The particles are heated in the regenerator **65** and the carbon is burned off. Thus the catalytic clay particles are regenerated. It should be noted that the catalytic characteristics of clay particles are known. Hot coke particles are removed from the burner **15** through line or standpipe **22**. They pass through slide valve **23** and then re-enter reactor **11** through riser **24**. Particles are mixed with steam introduced through line **25** and the mixture passed through riser **24**. In order not to burn all the coke off the solids and to maintain at least 5 to 50% of the coke on the solids in the burner it may be necessary to add supplementary fuel to the burner; this fuel may be added through line **26**. Many different fuels are acceptable and gas, torch oil or gas oil are among several which may be utilized. Alternatively, hot combustion products from line **53** may be passed through burner **15** to supply heat (by means not shown).

The oil within the froth collects on the coke particles in the bed **28** of reactor **11** and most of the solid materials and especially the fines adhere to the surface of the coke particles. The hydrocarbon oil is cracked and vaporized. The vaporous products move upwardly in the bed and into the space above the bed and pass through cyclone separator **27**. Here some of the solids entrained within the vaporous products are separated and returned to bed **28** through dipleg **29'**. The vapors pass up into scrubber **29**. Scrubber **29** is superimposed on the reactor **11** and includes fractionator **30**. Within the scrubber, dust particles and other impurities are removed; the "clean" vapors then pass up to fractionator **30**. Here they are separated into a multiplicity of hydrocarbon fractions. Heat is removed from scrubber **29** and fractionator **20** by conventional heat exchange (not shown).

The lightest fraction boiling up to 500° F. is removed through line **31**. It is passed through heat exchanger **32** through line **32'** and is introduced into separator **33** from whence gaseous products are withdrawn overhead through line **34** and liquid products through line **35**.

The middle fraction boiling at 400° F. to 950° F. comprises gas oil and is drawn off through line **36**.

The heaviest fraction, boiling in excess of 950° F., is withdrawn from the bottom of fractionator **30** through line **37**. If desired or necessary, it may be passed to clarifier alternate **38** through line **41** for removal of solid materials. From clarifier **38** the heavy fraction may be returned to line **37** through line **39** or optionally it may be returned to reactor **11** through line **40**. If the heavy fraction is returned to reactor **11** it will contain the heavy metals which are separated within clarifier **38**. This heaviest fraction may be directed into line **26** and used as supplementary fuel for burner **15**.

The heavy fraction is directed through line **37** to a conventional fluid coker **42**. Here ordinary fluid coking conditions are utilized, i.e. 900° F. to 1400° F. in the reactor and 1000° F. to 1600° F. in the burner. The usual products are recovered from coker **42**. Naphtha is recovered through line **43**, a 430° F. to 650° F. heating oil cut is recovered through line **44**, and a gas oil boiling between 650 to 1000° F. is recovered through line **45**.

Furthermore, a high value coke is recovered through line **42'**. Most of the impurities are retained in reactor **11** and consequently this coke from coker **42** is exceptionally good. It contains virtually no nickel and vanadium although some sulfur remains. Consequently, this coke product is suitable for use in electrodes and as metallurgical coke.

Returning to reactor **11** and burner **15**, which comprise the first coking unit, reactor **11** is maintained at a temperature between 800–1100° F., preferably at about 875° F. Pressure may be maintained between 5–15 p.s.i.g. and preferably at about 10 p.s.i.g. Superficial gas velocity within the reactor may be between 1 and 4 feet per second and bed depth should be kept at 30–50 feet. Coke particle size may vary between 20 and 400 microns. The fluidized bed **28** is maintained as such by the upflowing hydrocarbon gases and vapors formed by the coking of the oil feed and by steam added to the process through line **10'**.

When using finely divided coke of about 20 to 400 microns and at a superficial velocity, as above mentioned, the density of the fluidized bed will be about 35 lbs. per cu. ft. but may vary between about 15 and 60 lbs. per cu. ft., depending on the gas velocity selected and the particular particle size range. Particles are removed from reactor **11** and directed to burner **15** through standpipe **46**, slide valve **47** and riser **48**. The particles are passed through line **48** in admixture with air or other gas supplied through line **15'**.

Burner **15** may be maintained at a temperature between 900° and 1200° F., preferably at about 1000° F. Pressure may vary between 5 and 15 p.s.i.g. with about 10 p.s.i.g. being preferred. The upflowing gas velocity in the burner **15** may be between 1–3 ft./sec. and bed depth between 10–30 feet. About 5–50% of the coke deposited on the solids is not burned and remains adhered to the solids in the burner **15**.

Gas entrained coke or carbon covered solids are removed overhead from the burner **15** through line **16'**. These solids first pass through cyclone separator **17** where some of the solids are removed and returned through dipleg **19**. The remaining gas entrained solids pass into cyclone **18** through line **17'**. Here further cyclone separation of solids is made; gases are released to the stack through line **18'**, solids are removed through dipleg **20**. A portion of the fine and coarse solids is passed through line **19'** back into burner **15**. Another portion of the fine and coarse solids is passed into line **61**, material from line **61** may be passed through line **60** into line **51** and then to burner **52**. Fine and coarse material within line **61** may be passed through line **62**, valve **63** and then to line **64** from whence they are passed to the regenerator **65**. Boiler **65'** serves to recover excess heat from regenerator **65**.

The regenerator is of the fluid bed variety and is maintained at a temperature of 1100–1500° F. and a superficial gas velocity of 1–4 ft./sec. Air is added to regenerator **65** through line **66'**. Gas entrained solids are removed through line **66**. They pass through cyclone separator **67**, solids are removed through dipleg **68**. The remaining gas entrained solids pass through line **69** into second cyclone separator **70**. Gases are directed from cyclone separator **70** to burner **15** through line **71**. The separated solids from separator **70** pass through dipleg **72** into line **73**, solids from dipleg **68** also pass into line **73**. The solids may pass through valve **74** back to catalyst regenerator **65**. Or, they may pass through line **75** into line **76**. These fine and coarse solids have been subjected to catalyst regeneration and, therefore, have lost their carbon or coke coating. Other fine and coarse material is removed from regenerator **65** through line **75'**. The fine and coarse material is passed from line **76** into line **10'** and from there to reactor **11**. In reactor **11** the fines have a catalytic effect and increase the naphtha yield of the coker. If desired, only fine material may be passed into line **10'**. This may be done in a variety of ways, for example a screen to remove coarse materials may be placed at any point on line **76**.

Carbon or coke coated solids are removed from the dense bed **21** in burner **15** through line **50**, and must pass through valve **50'**. Coarse coated material passes through line **51** into high temperature short-time burner **52**. Air for the burner is supplied through line **51'**. Coated materials from line **50** pass into line **64** from whence they are transported to regenerator **65**.

Burner **52** may be either a fluid bed, a cyclone type or transfer line. The carbon-coated solids are retained in burner **51** for about .1 to 10 seconds at a temperature of between 1500 and 3000° F., preferably about 2500° F.

The temperature in burner **52** is sufficiently high and sufficient air is added through line **51'** to burn all of the coke on the solid particles to carbon dioxide. As a result great amounts of heat are liberated, as much as 5,000 to 10,000 B.t.u. per pound of solids. Sufficient heat is liberated to cause sintering or slagging of the solid particles. Sintered particles may range in size from 20 to 1000 microns. The hot flue gas containing carbon dioxide is removed overhead through line **53** and passed through boiler **54** where the heat is recovered to produce steam; the steam may be utilized for any conventional purpose. The steam may be fed to reactor **11** through line **10'** or into riser **24** through line **25**. Fine particles leaving boiler **54** are collected in a cyclone (not shown) and are electrostatically precipitated to prevent air pollution. Alternatively, they may be recycled to reactor **11** for use as catalytic material.

The mineral solids, some of which are sintered from the high temperature resulting from burning the coke to carbon dioxide in burner **52**, are removed through line **54'** and are introduced into fluid bed cooler **55**. Heat from the solid particles within the cooler is captured within boiler **55'**. Heat in the amount of 100 to 500 B.t.u. per pound of solids is liberated. This heat may also be utilized for process steam by directing it to line **10'**.

Sand and clay representing 70 to 99% of that found in the original feed are removed through line **56** and discarded.

In a specific embodiment of this invention, 10,000 barrels a day (deaerated basis) of froth were utilized. The froth is obtained by a froth flotation process; Athabasca tar sand is contacted with hot water. The aqueous layer is removed; this liquid is in the form of a froth due to trapped air and gases. The froth which is an admixture of 20 wt. percent water, 70 wt. percent crude oil, 5 wt. percent sand, and 5 wt. percent clay, the solids being 50 wt. percent of fine materials (less than 10 microns), and 30 vol. percent gas, is introduced into reactor **11** through line **10**.

Reactor **11** is maintained at a temperature of 900° F. and a pressure of 30 p.s.i.g. Superficial gas velocity is about 3 ft./sec. for maintaining the fluidized bed **28** of

solids. The bed depth is maintained at 40 feet. In the reactor **11** the oil in the tar feed is cracked and forms vaporous products. The vapors pass through cyclone **27** and entrained solids are returned to bed **28** through dipleg **29'**. Vapors pass up through scrubber **29** and uncondensed vapors pass to fractionator **30**. In the scrubber heavy ends are condensed and entrained fines scrubbed out of the vaporous products.

The vapors are separated into three fractions in the scrubber and fractionator **30**. The heaviest, or 950° F. fraction, is drawn off through line **37** and comprises about 1500 b./d. This fraction is directed into conventional fluid coker **42**; about 60 tons a day of high value coke are recovered through line **42'**. The coke contains:

(1) Vanadium—less than 100 parts per million
(2) Nickel—less than 50 parts per million
(3) Sulfur—4%

A middle fraction boiling at 500–950° F. is recovered through line **36** as gas oil. This fraction accounts for about 2000 b./d. of product.

The light fractions boiling at up to 500° F. are drawn off through line **31**; this constitutes about 2500 b./d. This fraction passes through heat exchanger **32** and into separator **33** from whence it is separated into gas and liquid product.

The solids in bed **28** are coated with coke during coking in reactor **11** and the solids are drawn off through standpipe **46**, pass through valve **47** and through line **48** into burner **15**. The burner is maintained at a temperature of 1000° F. and a pressure of 10 p.s.i.g. Coke coats the solid material and, about 5–50% of the coke is not burned. Flue gases pass through cyclones **17** and **18** outside of burner **15**; solid material entrained within the gases is returned to bed **21** from diplegs **19** and **20** and line **19'**. Alternatively, the solids may pass through line **61**, line **62**, valve **63** and line **64** thereby entering catalyst regenerator **65**. Additional coke coated solids leave burner **15**, pass through line **50**, valve **50'** then into line **64** and finally pass to regenerator **65**. To prevent all of the coke coating from being burned off the particles, torch oil in the amount of 300 b./d. is added to burner **15** through line **26**.

Catalyst regenerator **65** operates at a temperature of about 1200° F. and a superficial gas velocity of 2 ft./sec. It is a fluid regenerator; hot gases from the regenerator pass through cyclones **67** and **70** whereby entrained fines are separated. The clean gas is then passed through line **71** into burner **15** thereby supplying heat for the burner. About 150 tons a day of solids from regenerator **65** pass through lines **75'**, **76** and into line **10'** from whence they are passed to reactor **11**.

Coarse carbon-coated solids are withdrawn from burner **15** through lines **50** and **51** and are introduced into cyclone type burner **52**. This burner is maintained at a temperature of about 2500° F. The solids are kept there for about 1 second at which time approximately 95% of the coke is burned to carbon dioxide thereby generating about 100 million B.t.u./hour of heat. Simultaneously, about 80% of the solid material is sintered into particles of about 20 to 1000 microns diameter.

The hot flue gases are withdrawn through line **53** and pass to boiler **54**. Boiler **54** contains a polution control device such as a fly ash separator (not shown).

Hot solid particles are withdrawn from burner **52** through line **54'** and directed to cooler **55**. After cooling to a temperature of about 500° F., the sand and clay particles are withdrawn through line **56**. About 120 tons/day of solid material are withdrawn; this represents about 80% of the solid material found in the original tar mixture introduced into reactor **11** and includes about 75% of the fine material. About 5 million B.t.u./hour of heat are captured within boiler **55'**. This is heat liberated by the cooling solids.

It should be noted that this invention may also be utilized for recovery of oil from shale as well as the underground recovery of bitumen.

What is claimed is:

1. A process for recovering oil from a froth obtained from tar sand and containing oil, mineral solid particles and water which comprises introducing said froth into a low severity coking zone maintained at a temperature between about 800° F. and 900° F. wherein it is contacted with a fluidized dense turbulent bed of hot coke-containing mineral solid particles to remove oil and water and to convert oil to vapors and coke is deposited on the solid mineral particles to form a protective coke covering on said solid mineral particles, removing converted vapors from said coking zone, removing a portion of the said coke-containing solid particles to a first burning zone maintained at a temperature between about 900° F. and 1200° F. to increase the temperature of the said coke-containing particles, adding supplementary fuel to said first burning zone to supply additional heat thereto and so as to burn a portion only of said coke on said mineral solid particles, returning a portion of said heated coke-containing mineral solid particles to said coking zone, removing another portion of said heated coke-containing mineral solids from said burning zone to a second high temperature short time burning zone maintained at a higher temperature of 1500 to 3000° F., wherein the coke on said coke-containing mineral solid particles is substantially all burned to carbon dioxide to produce hot flue gas and hot mineral solids, recovering heat from said hot flue gas, passing hot mineral solids from said second burning zone to a cooling zone to recover heat therefrom and then discarding said mineral solids.

2. In a process for recovering oil from froth obtained from tar sand and comprising a mixture of oil, water and mineral solids, the steps which comprise introducing said froth into a low severity coking zone wherein it is contacted with a fluidized dense turbulent bed of hot coke-containing mineral solid particles to remove water and oil and to convert the oil to lower boiling hydrocarbons, fractionating the hydrocarbons into a light stream boiling up to about 500° F., a middle boiling stream boiling between about 400 and 950° F. and a heavy 950° F.+ fraction, passing said heavy fraction to a second fluid coking unit to produce gas and liquid hydrocarbon products and a high value coke, depositing coke on the said mineral solid particles in said first coking zone, removing a portion of the said coke-containing mineral solid particles and passing them to a first burning zone to increase the temperature of the said mineral solid particles, adding supplementary fuel to said first burning zone so that between about 5 to 50% of the coke on said coke-containing mineral solids remains unburned, passing a portion of said heated coke-containing mineral particles back to said first coking zone, passing another portion of said heated coke-containing mineral particles from said first burning zone to a high temperature short time second burner zone maintained at a higher temperature between about 1500 to 3000° F. to burn substantially all the said coke on said coke-containing mineral particles to carbon dioxide to produce hot flue gas and hot mineral solids, removing said hot flue gas overhead and recovering heat therefrom, passing said hot mineral solids to a cooling zone to recover heat therefrom and then discarding said cooled mineral solids.

3. The process of claim **2** where the supplementary fuel is at least a portion of said heavy 950° F.+ stream.

4. The process of claim **2** where said heavy oil fraction is introduced into a clarifier before passing to said second fluid coker to remove solids from said heavy oil fraction.

5. A process for recovering oil from a froth obtained from tar sand and containing oil, mineral solid particles including fine sand and clay particles of less than 10

microns and water, which comprises introducing said froth into a low severity coking zone maintained at a temperature between about 800° F. and 900° F. wherein it is contacted with a fluidized dense turbulent bed of hot coke-containing mineral solid particles to remove oil and water and to convert oil to vapors and coke is deposited on the solid mineral particles to form a protective coke covering on said solid mineral particles and to cause fine mineral solid particles to stick to larger particles having a cohesive layer of coke and to thereby maintain said fine particles in solid reactor, removing converted vapors from said coking zone, removing a portion of the said coke-containing solid particles to a first burning zone maintained at a temperature between about 900° F. and 1200° F. to increase the temperature of the said coke-containing particles, adding supplementary fuel to said first burning zone to supply additional heat thereto and so as to burn a portion only of said coke on said mineral solid particles, returning a portion of said heated coke-containing mineral solid particles to said coking zone, removing another portion of said heated coke-containing mineral solids from said burning zone to a second high temperature short time burning zone maintained at a higher temperature of about 1500° F. to 3000° F., wherein the coke on said coke-containing mineral solid particles is substantially all burned to carbon dioxide to produce high temperature flue gas and hot

mineral solids and the high temperature sinters at least part of the sand and clay fine particles to agglomerate them into larger particles which are easier to remove from the flue gas, recovering heat from said high temperature flue gas, passing hot mineral solids including the sintered particles from said second burning zone to a cooling zone to recover heat therefrom and then discarding said mineral solids and sintered particles.

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