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(71) Applicant: **Kanbier, D.**
2231 JZ Rijnsburg (NL)

(72) Inventor: **Kanbier, D.**
2231 JZ Rijnsburg (NL)

(54) **Dry recovery of oil from Athabasca tar sands**

(57) Oil products are recovered from tar sands after cracking of the oil in the presence of the sand. The non - recovered part of the oil on the sand is burnt off to provide the energy required for the process.

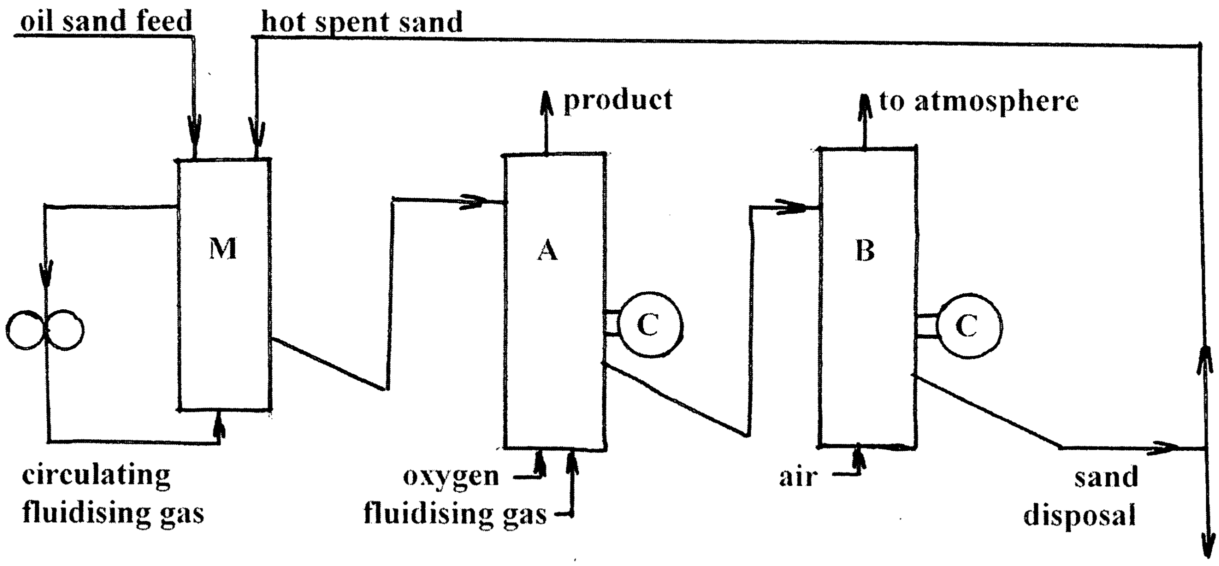

Fig.1

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Description

Background.

[0001] Recovery of oil from Athabasca tar sands, further called oil sands, is till now mainly done by the Clark Hot Water Extraction process. This process uses hot water to separate a large part of the tar, or heavy oil, from the sand. In view of the quantity of water involved, this method is from an environmental point of view undesirable; moreover the availability of water poses a restriction to the scale of development of this energy source.

[0002] The considerable energy requirement of the recovery operations is met by the combustion of natural gas. This forms an undesirable inroad on the countries gas resources.

[0003] The object of the present invention is the reduction of water- and natural gas consumption for the recovery of oil from oil sands.

Summary of the invention.

[0004] The object is achieved by conversion of the oil in the presence of the sand, so that a major part of the oil can be separated from the sand in a vaporous form. The combustible components left on or in the sand are burnt to supply the energy, that is necessary to heat the oil sand to the reaction temperature and to supply the energy for further work up systems.

Detailed description.

Oil sand heating and conversion.

[0005] The main problem in handling oil sands is its stickiness, which problem moreover increases with temperature. This problem is overcome by dropping the cold tar sand on a fluidised hot sand bed, where cold oil sand and hot spent sand are mixed in a ratio such, that the mixing temperature is in the range of 80 - 550°C, preferably 300 - 500°C.

[0006] The mixture of fresh oil sand and hot spent sand is sent to a reaction zone with a fluidised bed, where the oil is partially evaporated, partially converted into lighter, vaporous material. Depending on the oil content of the oil sand, it may be possible to drain, or separate by mechanical means, a part of the oil from the sand after the first mixing of oil sand and hot spent sand, mentioned above.

[0007] Depending on the conversion process to be used, and on the possibility of oil drainage after the first mixing described above, more hot sand may be added to raise the temperature of the oil/sand mixture to the desired reactor entry temperature.

[0008] Any type of conversion, that can be done in a fluidised bed, may be applied in this reaction zone. Practically, there are two related processes that can best be used, i.e. thermal cracking and partial oxidation. If thermal cracking only is used, the bed temperature will drop below that of the mixture of oil sand and hot spent sand. By the injection of oxygen into the reaction zone, the temperature will obviously be increased.

[0009] The actual reactor bed temperature is likely to be in the range of 450 - 500°C to evaporate the largest possible part of the oil feed, while limiting syn gas reactions (see below) and coke formation.

Side effects of oxidation.

[0010] Combustion and thermal cracking of hydrocarbons have a feature in common: in both processes free radicals play a role in the establishment of a chain process. It is therefore easily envisaged that the two processes are strongly intermingled.

[0011] Combustion is known to be feasible below the auto ignition temperature of the component concerned, by the action of free radicals. Likewise, in a combustion environment, thermal cracking at a given temperature is easier than it would be outside of a combustion zone; a consequence of the action of free radicals emitted by the combustion reactions.

[0012] A similar feature is observed in the reactions between syngas components, carbon monoxide and hydrogen, as further described below under partial oxidation.

Partial oxidation.

[0013] When oxygen is injected in a hydrocarbon environment above the auto ignition temperature, oxidation reactions will take place with measurable velocity. The auto ignition temperature depends on the hydrocarbon composition.

[0014] The first reactions between hydrocarbons and oxygen are those, in which carbon is oxidised to monoxide under the release of hydrogen. This is because the reactions concerned are by far the fastest, compared to other reactions that compete for oxygen.

[0015] The weakest links in hydrocarbon structures are those around the middle of straight chain (paraffinic) molecules or straight chain molecular parts. It follows that with a modest oxygen supply, say one atom per heavy oil molecule, or in the order of 2% by weight on a heavy oil, a considerable cracking effect can be reached. Added to that is the effect of free radicals, that are generated during the oxidation, which promote the thermal cracking reactions.

[0016] The combined effect makes it possible to have an interesting thermal cracking process at a relatively low temperature. The mild conditions reduce the coke forming tendency.

[0017] In the present application, the presence of a large heat sink, in the form of the sand quantity, is an asset, useful to avoid temperature excursions upward by partial oxidations, and downward by thermal cracking.

[0018] If a cold oil sand with 50/50 sand and oil (volume) is mixed with hot spent sand in a ratio to get a mixing temperature of 300°, the resulting mixture contains about 1 part oil and 4.5 parts sand, by weight. If this mixture is heated to 500° by partial oxidation, assuming no evaporation of the feed, about 24% of the carbon in the feed is converted into monoxide. For this, the oxygen consumption is about 30% by weight on oil feed.

[0019] To select the optimum condition is outside the scope of this description.

[0020] Carbon monoxide and hydrogen can amongst others react according to the Boudouard reaction, the water gas reaction and the methane reaction (respectively

[0021] $2CO \Leftrightarrow CO_2 + C$, $CO + H_2 \Leftrightarrow H_2O + C$ and $2CO + 2H_2 \Leftrightarrow CO_2 + CH_4$). Free carbon and methane are not desirable products, moreover the formation of carbon dioxide and water reduce the oxygen efficiency, cause undesired heating and make the product work-up more difficult because of the carbon dioxide removal.

[0022] Outside of an oxidation zone the above syngas reactions do not occur below about 1000°C; in an environment where oxidation takes place, such as coal gasification, they can occur down to 500°C. Therefore, if oxygen is injected, the temperature in the conversion reactor is best limited to 500° maximum. Other criteria, such as coke formation, might lead to further limitation.

[0023] Increase of the partial oxidation share of the oil conversion leads to increased heat generation. This can be coped with by reducing the temperature of the oil sand / hot spent sand mixture, fed to the reactor. If this degree of freedom is exhausted, a cooler can be attached to the reactor, where the excess heat is removed by steam raising. This type of construction is found in some oil catalytic cracking units, where it is used to cool the regenerator.

Product work-up.

[0024] The vaporous cracking products are separated from the sand using means and methods in use in oil refining, e.g. in catalytic cracking. If oxygen injection has been applied, the resulting syngas can be used as fuel gas or as feed to the manufacture of premium diesel oil or methanol, using one of the Fischer Tropsch processes.

Sand heating.

[0025] The sand leaving the reaction zone carries the part of the feed oil that is neither evaporated nor converted, and the condensed products like coke. This mixture is fed into a second reaction zone, also applying a fluidised bed, in which the combustibles remaining in and on the sand after conversion are burnt off by air. In line with the practice in oil catalytic cracking, a temperature level of 700°C is adopted. If the combustible content of the sand is more than what is necessary to heat the sand to 700°, a sand cooler may be used, similar to the catalyst cooler sometimes used in the regenerator of an oil catalytic cracking unit, already referred to above under 'partial oxidation'. The net produced sand, after deduction of the hot spent sand recycle, is cooled and disposed of.

Simplified scheme.

[0026] The quantity of oil left on the sand after partial removal, as mentioned above under 'oil sand heating and conversion', might be low enough to omit the conversion process completely, and to feed the sand and remaining oil mixture directly into the bum off reactor, referred to as second reactor in the above description. This might be the case if there is a large demand for energy in the form of steam, e.g. for electricity generation. If this line up is used, the percentage of oil removed after heating can be increased by the use of an imported diluent, which is recovered from the separated oil.

Sand classification.

[0027] If the particle size distribution of the sand in the oil sand reservoir is not favourable for fluidised bed operation, a sand classifier can be used to recover sand particles with the most desired sizes from the spent sand stream to disposal, and return these recovered sand particles to the unit inventory. It may be necessary to crush the sand before classification to reduce the average particle size.

Start up operations.

[0028] For start up operations some natural gas supply, a batch of sand and a batch of torch oil are required.

Preferred embodiment.

[0029] Cold oil sand and recycled hot spent sand are mixed in a mixing vessel M, using a circulating gas stream for fluidisation.

[0030] The mixture is sent to a conversion reactor A, if necessary with more recycled hot spent sand added. Fluidising gas and oxygen are injected in the bottom of the reactor.

[0031] A sand cooler C may be applied as indicated.

[0032] The overhead product of the reactor is freed from entrained sand as in an oil catalytic cracking unit.

[0033] The sand from the reactor is transferred into a second reactor B, again using a fluidised bed, where the remainder of the tar feed is oxidised by air.

[0034] Also here, a cooler C may be applied as indicated.

See fig. 1

Claims

1. A process for the recovery of oil and/or oil derivatives from oil sands, **characterised in that** the oil sand is mixed with hot sand described here-

inafter to reach a temperature, preferably in the range of 300 - 500°C,
fed to a reaction zone A, where the oil is subjected to a conversion process in the presence of the sand, where mixing takes place upstream of or in zone A,
the resulting evaporated feed oil components and vaporous conversion products are separated from the remaining solid/liquid mixture,
the remaining solid/liquid mixture is fed to a reaction zone B, where combustible material is burnt by injection of air,
part of the hot sand from zone B is mixed with the oil sand feed as described above.

2. A process according to claim 1, in which the oil sand is heated by mixing with hot sand in two stages, and where after the first stage heating a part of the oil is recovered as such by separation from the remaining sand/oil mixture, with or without dilution of the oil by lighter hydrocarbons.

3. A process according to claims 1 or 2, in which the conversion process is thermal cracking.

4. A process according to claim 3, in which the thermal cracking is enhanced by oxygen injection into zone A.

5. A process according to claims 1, 2, or 4, in which a sand cooler is attached to zone A, similar to a device called catalyst cooler, as attached to the regenerator in some oil catalytic cracking units.

6. A process according to claims 1, 2, 3, or 4, in which a sand cooler is attached to zone B, similar to a device called catalyst cooler, as attached to the regenerator in some oil catalytic cracking units.

7. A process for the recovery of oil from oil sands, **characterised in that**
the oil sand is mixed with hot sand described hereinafter to reach a temperature in the range of 50-500°C
oil is separated from the sand, with or without the use of a hydrocarbon diluent,
the sand and the oil remained with the sand are fed to a reaction zone B, where combustible material is burnt by injection of air,
part of the hot sand from zone B is used to heat the tar sand feed as described above.

8. A process according to claims 1, 2, 3, 4, 5, 6, or 7, in which a part of the spent sand is subjected to a crushing operation to reduce the average particle size of the sand, and is returned to the unit inventory.

9. A process according to claims 1, 2, 3, 4, 5, 6, 7 or 8, in which the spent sand, which is not recycled for mixing with the feed for heating, is subjected to a separation process, wherein sand with selected particle sizes is recovered to be returned to the unit inventory, and the rest is sent to disposal.

Amended claims in accordance with Rule 137(2) EPC.

. process for the recovery of oil and/or oil derivatives from oil sands, in which
the oil sand is mixed with hot sand described hereinafter to reach a temperature, preferably in the range of 300 - 500°C,
the mixture is fed to a reaction zone A, where the oil is subjected to a conversion process in the presence of the sand, in fluidised bed operation,
the resulting evaporated feed oil components and vaporous conversion products are separated from the remaining solid/liquid mixture,
the remaining solid/liquid mixture is fed to a reaction zone B, where combustible material is burnt by injection of air, in fluidised bed operation,
part of the hot sand from zone B is mixed with the oil sand feed as described above,
characterised in that
the conversion in zone A is achieved by partial oxidation of the oil by injection of oxygen or an oxygen containing gas,
which process, at the prevailing temperature of 300-500°C, takes place by cool flame reactions,
and which process entails the desired cracking.

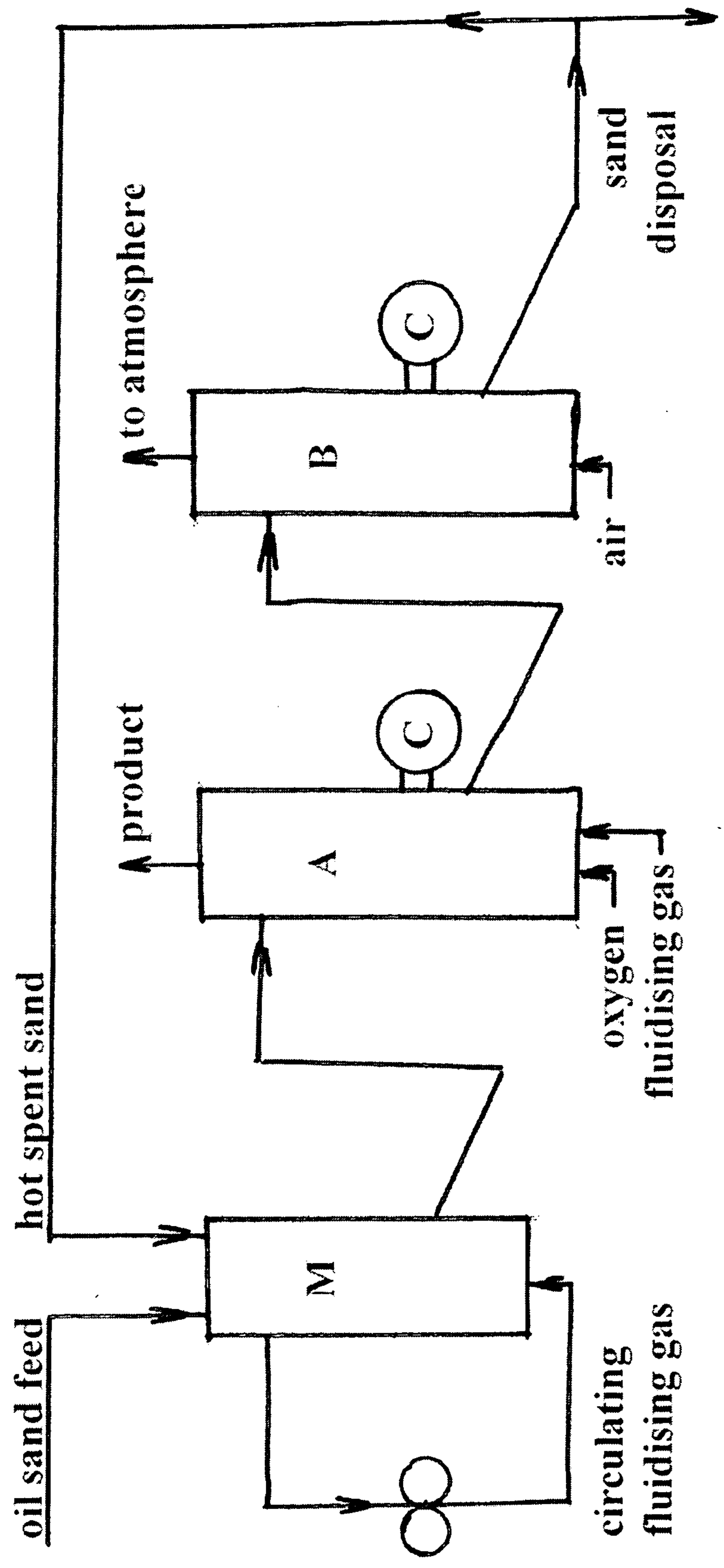
oil sand feed
hot spent sand
M
circulating
fluidising gas
A
product
C
oxygen
fluidising gas
B
to atmosphere
C
air
sand
disposal

Fig.1

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EUROPEAN SEARCH REPORT

Application Number
EP 09 07 5109

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	24 August 2009	Gzil, Piotr

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 09 07 5109

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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24-08-2009

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82