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(71) Applicant *(for all designated States except US)*: **LINC ENERGY LTD** [AU/AU]; 32 Edward Street, Brisbane, Queensland 4000 (AU).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **RAVIKUMAR, Ravi** [US/US]; 1330 Post Oak Blvd, Suite 700, Houston, Texas 77056 (US). **DABEE, Sanjiv** [ZA/US]; 1330 Post Oak Blvd, Suite 700, Houston, Texas 77056 (US). **KONING, Bert** [NL/AU]; 32 Edward Street, Brisbane, Queensland 4000 (AU). **PATEL, Bipin** [CA/US]; 1330 Post Oak Blvd, Suite 700, Houston, Texas 77056 (US). **ULBRICH, Andreas** [ZA/AU]; 32 Edward Street, Brisbane, Queensland 4000 (AU).

(74) Agent: **CASH, David E.**; Linc Energy Ltd, GPO Box 1315, Brisbane, Queensland 4001 (AU).

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(54) **Title**: CONDITIONING OF SYNGAS FROM UNDERGROUND COAL GASIFICATION

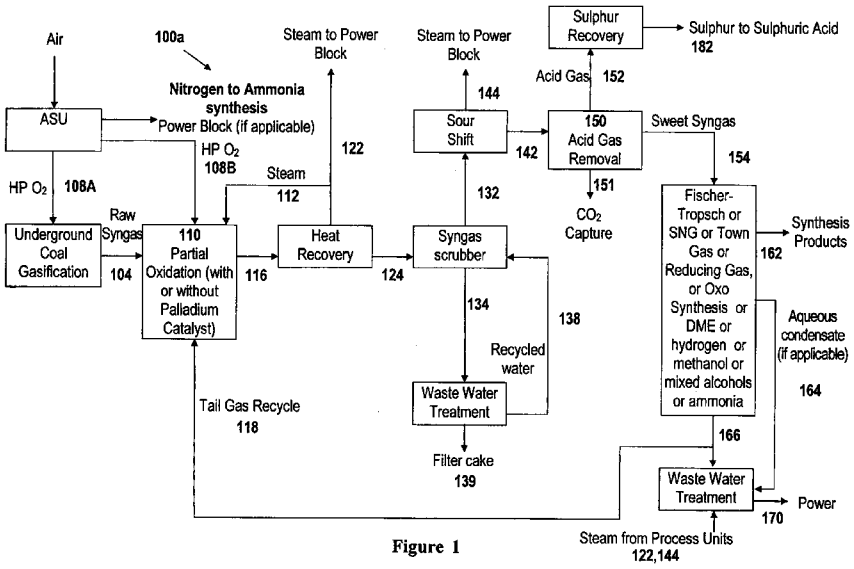

Figure 1

(57) **Abstract**: Systems and methods are described for conditioning an underground coal gasification syngas stream. Raw syngas (104) is fed to a partial oxidation unit to produce a processed syngas (116) substantially depleted of heavy hydrocarbons and, optionally, methane. An air separation unit can be configured to provide oxygen to both the underground coal gasifier (108A) and the partial oxidation unit (108B).

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CONDITIONING OF SYNGAS FROM UNDERGROUND COAL GASIFICATION

TECHNICAL FIELD

[0001] The field of the invention is syngas conditioning, especially as it relates to syngas produced by underground coal gasification. In particular, the invention concerns a method and system for removing heavy hydrocarbons from raw syngas using a partial oxidation unit.

BACKGROUND ART

[0002] Underground coal gasification yields raw syngas at relatively high pressure that contains H_2, CO, CO_2, CH_4, H_2O, heavy hydrocarbons, and oxygenated compounds. Such syngas may first be cooled to condense out the heavy hydrocarbons, and then cleaned with water scrubbing. See, *e.g.*, U.S. patent publ. no. 2007/0181854 to Briesch *et al.* (publ. Aug. 2007). Such practice can add significant expense to the cost of the process due to the separation of heavy hydrocarbons and sour water streams that are produced when the raw syngas is cooled. These separation products, such as phenol and tars, require further cleaning before they can be sold as byproducts.

[0003] Briesch and all other extrinsic materials discussed herein are incorporated by reference in their entirety. Where a definition or use of a term in an incorporated reference is inconsistent or contrary to the definition of that term provided herein, the definition of that term provided herein applies and the definition of that term in the reference does not apply.

[0004] EPO patent publ. no. 0486174 to Texaco Development Corp. discusses using a partial oxidation unit to produce high purity hydrogen from a refinery offgas. However, the Texaco processes are not specifically indicated for high pressure underground gasification syngas but rather for refinery gas, natural gas and refinery waste streams such as heavy oil and petroleum coke.

[0005] Thus, there is still a need for systems and methods for conditioning an underground gasification syngas stream that eliminate the need to process heavy hydrocarbons such as tar, phenol and creosotes, downstream of a condenser.

SUMMARY OF INVENTION

[0006] The inventive subject matter provides apparatus, systems and methods for

conditioning raw syngas produced by underground coal gasification.

[0007] According to a first aspect of the present invention there is provided a method of removing heavy hydrocarbons from raw syngas produced by underground coal gasification, said method comprising the step of: processing the raw syngas in a partial oxidation unit using oxygen to produce processed syngas substantially depleted of the heavy hydrocarbons.

[0008] According to a second aspect of the present invention there is provided a system for removing heavy hydrocarbons from raw syngas produced by underground coal gasification, wherein the system comprises: a partial oxidation unit configured to receive the raw syngas and oxygen, and produce a processed syngas substantially depleted of the heavy hydrocarbons.

[0009] The description below relates to both the first and second aspects of the invention.

[0010] As used herein, the term "substantially depleted" means less than about 10 vol%. For example, "substantially depleted of heavy hydrocarbons" means less than about 10 vol% of heavy hydrocarbons. In especially preferred embodiments, the processed syngas comprises less than about 5 vol% of heavy hydrocarbons, and even more preferably, less than about 1 vol% of heavy hydrocarbons.

[0011] The partial oxidation (POX) unit can be of any suitable size, shape and construction. The POX unit can utilise thermal partial oxidation (TPOX) or catalytic partial oxidation (CPOX) to process the raw syngas. If using CPOX, any suitable type of catalyst can be used. Preferably the catalyst is palladium.

[0012] The POX unit can be fluidly coupled to one or more types of upstream or downstream gas-processing or treatment units. Any suitable types of units can be used. For example, the method can comprise fluidly coupling an acid gas removal unit to the partial oxidation unit, wherein the acid gas removal unit is configured to receive at least a portion of the processed syngas and produce at least one of a Fischer-Tropsch fluid, synthetic natural gas (SNG), town gas, reducing gas, oxo sythesis fluid, dimethyl ether (DME), hydrogen, methanol, mixed alcohols, ammonia or fuel gas for power generation.

[0013] The POX unit can be configured to receive raw syngas in any suitable way. For example, the POX unit can be fluidly coupled to a well head of a production well of an underground coal gasifier. Alternatively, the POX unit can be fluidly coupled to an upstream unit (or units) for processing or treating the raw syngas prior to it reaching the POX unit. The POX unit can have a filter for removing particulates from the raw syngas and this can be of any

suitable construction.

[0014] The POX unit can be configured to receive oxygen from any suitable source and in any suitable way. For example, the POX unit can be fluidly coupled to a tank of compressed air or to an air separation unit. Preferably the POX unit is fluidly coupled to an oxidant supply unit (for example an air separation unit) that also provides oxygen to the underground coal gasifier. As the air separation unit is already providing oxygen to the underground coal gasifier, the duties of the air separation unit only need to be incrementally increased to also provide oxygen to the POX unit.

[0015] The POX unit can be configured to receive steam from any suitable source and in any suitable way. For example, the method can further comprise the step of thermally coupling the processed syngas and water to produce steam, wherein the partial oxidation unit can be configured to receive at least a portion of the steam. In this instance, a heat exchanger unit can be fluidly coupled to the POX unit.

[0016] A feed to the partial oxidation unit can be heated in a feed effluent exchanger to improve the partial oxidation unit's efficiency.

[0017] In addition to the underground coal gasification syngas, any other type of hydrocarbon can be co-fed to the POX unit. Hence, the POX unit can be configured to receive a co-fed hydrocarbon other than the raw syngas in any suitable way.

[0018] In one embodiment, the step of processing the raw syngas comprises converting the heavy hydrocarbons to additional syngas, and wherein the processed syngas comprises the additional syngas.

[0019] In another embodiment, if the raw syngas further comprises methane, the processed syngas can be substantially depleted of methane using the POX unit.

[0020] According to a third aspect of the present invention there is provided a method for removing heavy hydrocarbons from an underground gasification syngas, comprising: receiving raw syngas containing heavy hydrocarbons from a source; processing the raw syngas in a partial oxidation unit using oxygen to produce a processed syngas substantially depleted of the heavy hydrocarbons; and providing an air separation unit configured to provide oxygen to the source and the partial oxidation unit.

[0021] A source, which is preferably an underground coal gasification plant, can be

configured to provide raw syngas that contains heavy hydrocarbons. The raw syngas can be fed to a partial oxidation unit configured to receive the raw syngas and produce a processed syngas substantially depleted of the heavy hydrocarbons. In addition to the underground coal gasification syngas, any other hydrocarbon can be co-fed to the partial oxidation unit.

[0022] An air separation unit can be configured to provide oxygen to the source and the partial oxidation unit. As the air separation unit is already providing oxygen to the underground source, the duties of the air separation unit only need to be incrementally increased to also provide oxygen to the partial oxidation unit.

[0023] The invention according to the third aspect can have one or more features as described for the first and second aspects of the invention.

[0024] The inventive subject matter discussed herein also eliminates the need to process heavy hydrocarbons such as tar, phenol and creosotes, which are condensed out when the raw syngas is cooled. Instead, the heavy hydrocarbons can be converted to additional syngas that can be used as fuel.

[0025] Various objects, features, aspects and advantages of the inventive subject matter will become more apparent from the following detailed description of preferred embodiments, along with the accompanying drawing figures in which like numerals represent like components.

BRIEF DESCRIPTION OF DRAWINGS

[0026] Fig. 1 is a schematic of a first embodiment of a system for conditioning an underground gasification syngas stream.

[0027] Fig. 2 is a flowchart of an embodiment of a method for removing heavy hydrocarbons from an underground gasification syngas.

[0028] Fig. 3 is a schematic of a second embodiment of a system for conditioning an underground gasification syngas stream.

DESCRIPTION OF EMBODIMENTS

[0029] In **Figure 1 and 3**, a syngas processing system 100a, 100b is shown having an underground coal gasification unit, which is a source for raw syngas 104 containing heavy hydrocarbons. In preferred embodiments, the raw syngas 104 can be directly fed to a partial oxidation unit 110 without cooling the syngas, such as by using refractory-lined piping or heat

traced lines to preserve the thermal energy and reduce O_2 to the partial oxidation unit 110. An alternative embodiment provides for pre heating of the raw syngas 104 with a feed-effluent exchanger utilizing the energy of stream 112 to improve the efficiency of the partial oxidation unit 110. Additionally hydrocarbons and fluids other than raw syngas 104 may be co-fed to the partial oxidation unit 110. An air separation unit is preferably configured to provide oxygen streams 108A and 108B to the underground coal gasification process and the partial oxidation unit 110, respectively.

[0030] The partial oxidation unit 110 can be configured to receive the raw syngas 104, which can be reacted with oxygen 108B and steam 112 to produce a processed syngas 116 that is substantially depleted of heavy hydrocarbons. Tail gas 118 may be re-cycled to the partial oxidation unit 110 to produce additional syngas. The partial oxidation unit 110 advantageously converts the heavy hydrocarbons to additional syngas using oxygen 108B from the air separation unit, which is already used to supply oxygen 108A to the underground coal gasification process. Thus, only an incremental increase in oxygen production by the air separation unit is needed, which adds little to the overall cost of operation of the air separation unit. It is contemplated that much of the methane in the raw syngas 104 can also be converted to syngas by the partial oxidation unit 110. By removing heavy hydrocarbons, and optionally methane, from the raw syngas, downstream cleaning of the processed syngas 116 can be simplified.

[0031] In currently preferred embodiments, the partial oxidation unit 110 includes a palladium catalyst, although any commercially suitable catalyst could be used such that the heavy hydrocarbons in the raw syngas 104 are converted to syngas. This use of a catalyst is optional, as partial oxidation can also occur at a higher temperature without any catalyst. Use of a catalyst will depend on the level of particulates in the raw syngas. It is contemplated that a ceramic bed can be disposed in the partial oxidation unit 110 above a palladium catalyst bed and used to filter the solids and allow for periodic removal of particulates, such as during periods of maintenance, to control the pressure drop. If the feed gas contains excessive solids/fines, a non-catalytic system is envisioned, although not required. The partial oxidation unit 110 having a catalyst can alternatively comprise a honey comb structure, which advantageously is not plugged by particulates in the feed gas.

[0032] The processed syngas 116 from the partial oxidation unit 110 can be cooled to recover heat via steam generation. At least a portion of the resulting steam 122 can be fed to the partial oxidation unit 110 as steam 112. The remaining portion of the steam 122 can be used for other purposes.

[0033] The cooled syngas 124 can be scrubbed in a scrubber where a waste fluid 134 can be sent to a waste treatment unit. Water 138 can be recycled from the waste fluid 134 in the waste treatment unit, and reused in the scrubber. Filter cake 139 can be produced from the remaining waste fluid. This filter cake 139 can be processed further in a fluidized bed combustor to burn off the carbon and recover metals such as vanadium, nickel and iron.

[0034] The scrubbed fluid 132 can be fed to a sour shift unit where the fluid 132 can be processed to produce a sour syngas 142 having a desired ratio of H_2 and CO. The sour syngas 142 can then be sent to an acid gas removal unit 150 where it can be processed to produce a clean syngas 154. Steam 144 produced in the shift or other units may be used for power generation.

[0035] In some contemplated embodiments, the acid gas removal unit 150 can include an EconoSolv™ process that produces acid gas 152, and clean syngas 154. However, other commercially suitable acid gas removal processes could alternatively be used. The acid gas removal unit may produce a CO_2 stream 151 that is send to any suitable form of carbon capture. The acid gas may be converted to sulfur, sulfuric acid, fertilizers or other useable products, stream 182. One skilled in the art would understand that various production units that are commercially known in the art could be used to produce a desired synthesis product including, for example stream 162: a Fischer Tropsch liquid, synthetic natural gas (SNG), town gas, reducing gas, oxo synthesis fluid, dimethyl ether (DME), hydrogen, methanol, mixed alcohols, ammonia, and stream 170: fuel gas for power generation. Tail gas 166 and condensate 164 may be used for power generation.

[0036] In **Figure 2**, a method 200 for removing heavy hydrocarbons from an underground gasification syngas is shown. In step 210, raw syngas containing heavy hydrocarbons is received from a source, which can be an underground coal gasification plant in step 212.

[0037] In step 220, the raw syngas can be processed in a partial oxidation unit using oxygen to produce a processed syngas substantially depleted of the heavy hydrocarbons. In step 222, the partial oxidation unit optionally includes a palladium catalyst, although any commercially suitable catalyst could be used. In alternative embodiments, partial oxidation can occur without the use of a catalyst. In step 224, the raw syngas can also include methane, and the processed syngas is preferably substantially depleted of the methane. In step 226, the partial oxidation unit can convert the heavy hydrocarbons, and optionally methane, in the raw syngas to additional syngas, which makes up at least a portion of the processed syngas.

[0038] In step 230, an air separation unit can be provided that is configured to provide

oxygen to the source and the partial oxidation unit.

[0039] An acid gas removal unit can be fluidly coupled to the partial oxidation unit in step 240, such that the acid gas removal unit can receive at least a portion of the processed syngas and produce at least one of a Fischer Tropsch fluid, synthetic natural gas (SNG), town gas, reducing gas, oxo synthesis fluid, dimethyl ether (DME), hydrogen, methanol, mixed alcohols, ammonia and fuel gas for power generation. In step 250, the processed syngas can be heat exchanged with water to produce steam, and the partial oxidation unit can be configured to receive at least some of the steam.

[0040] As used herein, and unless the context dictates otherwise, the term "coupled to" is intended to include both direct coupling (in which two elements that are coupled to each other contact each other) and indirect coupling (in which at least one additional element is located between the two elements). Therefore, the terms "coupled to" and "coupled with" are used synonymously.

[0041] It should be apparent to those skilled in the art that many more modifications besides those already described are possible without departing from the inventive concepts herein. The inventive subject matter, therefore, is not to be restricted except in the scope of the appended claims. Moreover, in interpreting both the specification and the claims, all terms should be interpreted in the broadest possible manner consistent with the context. In particular, the terms "comprises" and "comprising" should be interpreted as referring to elements, components, or steps in a non-exclusive manner, indicating that the referenced elements, components, or steps may be present, or utilized, or combined with other elements, components, or steps that are not expressly referenced. Where the specification claims refer to at least one of something selected from the group consisting of A, B, C .... and N, the text should be interpreted as requiring only one element from the group, not A plus N, or B plus N, etc.

[0042] Reference to any prior art in the specification is not, and should not be taken as, an acknowledgment or any form of suggestion that this prior art forms part of the common general knowledge in Australia or any other jurisdiction or that this prior art could reasonably be expected to be ascertained, understood and regarded as relevant by a person skilled in the art.

CLAIMS

1. A system for removing heavy hydrocarbons from raw syngas produced by underground coal gasification, wherein the system comprises:

a partial oxidation unit configured to receive the raw syngas and oxygen, and produce a processed syngas substantially depleted of the heavy hydrocarbons.

2. The system of claim 1, wherein the partial oxidation unit utilises thermal partial oxidation.

3. The system of claim 1, wherein the partial oxidation unit utilises catalytic partial oxidation.

4. The system of any one of claims 1 to 3, wherein the partial oxidation unit is fluidly coupled to a well head of a production well of an underground coal gasifier.

5. The system of any one of the preceding claims, wherein the partial oxidation unit is fluidly coupled to an oxidant supply unit that also provides oxygen to the underground coal gasifier.

6. The system of any one of the preceding claims, wherein the partial oxidation unit is fluidly coupled to an air separation unit.

7. The system of any one of the preceding claims, wherein the partial oxidation unit is configured to receive steam.

8. The system of any one of the preceding claims, further comprising a heat exchanger unit configured to allow heat exchange between the processed syngas and water to produce steam, and wherein the partial oxidation unit is configured to receive at least a portion of the steam.

9. The system of any one of the preceding claims, wherein the raw syngas comprises methane, and wherein the processed syngas is substantially depleted of methane.

10. The system of any one of the preceding claims, wherein the partial oxidation unit is fluidly coupled to an acid gas removal unit that is configured to receive at least a portion of the

processed syngas, and produce at least one of a Fischer Tropsch fluid, synthetic natural gas (SNG), town gas, reducing gas, oxo synthesis fluid, dimethyl ether (DME), hydrogen, methanol, mixed alcohols, ammonia and fuel gas for power generation.

11. The system of any one of the preceding claims, wherein the partial oxidation unit is further configured to convert the heavy hydrocarbons to additional syngas, and wherein the processed syngas comprises the additional syngas.

12. The system of any one of the preceding claims, wherein the processed syngas comprises less than 1 vol% of heavy hydrocarbons.

13. A system for conditioning an underground gasification syngas stream, comprising:

a source configured to provide raw syngas containing heavy hydrocarbons;

a partial oxidation unit configured to receive the raw syngas, and produce a processed syngas substantially depleted of the heavy hydrocarbons; and

an air separation unit configured to provide oxygen to the source and the partial oxidation unit.

14. The system of claim 13, wherein the partial oxidation unit comprises palladium.

15. The system of claim 13 or claim 14, wherein the raw syngas further comprises methane, and wherein the processed syngas is substantially depleted of methane.

16. The system of any one of claims 13 to 15, wherein the partial oxidation unit is fluidly coupled to an acid gas removal unit that is configured to receive at least a portion of the processed syngas, and produce at least one of a Fischer Tropsch fluid, synthetic natural gas (SNG), town gas, reducing gas, oxo synthesis fluid, dimethyl ether (DME), hydrogen, methanol, mixed alcohols, ammonia and fuel gas for power generation.

17. The system of any one of claims 13 to 16, wherein the source comprises an underground coal gasification plant.

18. The system of any one of claims 13 to 17, further comprising a heat exchanger configured to allow heat exchange between the processed syngas and water to produce steam, and wherein the partial oxidation unit is configured to receive at least a portion of the steam.

19. The system of any one of claims 13 to 18, wherein the partial oxidation unit is further configured to convert the heavy hydrocarbons to additional syngas, and wherein the processed syngas comprises the additional syngas.

20. The system of any one of claims 13 to 19, wherein the processed syngas comprises less than 1 vol% of heavy hydrocarbons.

21. A method of removing heavy hydrocarbons from raw syngas produced by underground coal gasification, said method comprising the step of:

processing the raw syngas in a partial oxidation unit using oxygen to produce processed syngas substantially depleted of the heavy hydrocarbons.

22. The method of claim 21, wherein the partial oxidation unit utilises thermal partial oxidation.

23. The method of claim 21, wherein the partial oxidation unit utilises catalytic partial oxidation.

24. The method of any one of claims 21 to 23, wherein the partial oxidation unit is fluidly coupled to a well head of a production well of an underground coal gasifier.

25. The method of any one of claims 21 to 24, wherein the partial oxidation unit is fluidly coupled to an oxidant supply unit that also provides oxygen to the underground coal gasifier.

26. The method of any one of claims 21 to 25, wherein the partial oxidation unit is fluidly coupled to an air separation unit.

27. The method of any one of claims 21 to 26, wherein the partial oxidation unit is configured to receive steam.

28. The method of any one of claims 21 to 27, further comprising a heat exchanger unit configured to allow heat exchange between the processed syngas and water to produce steam, and wherein the partial oxidation unit is configured to receive at least a portion of the steam.

29. The method of any one of claims 21 to 28, wherein the raw syngas comprises methane, and wherein the processed syngas is substantially depleted of methane.

30. The method of any one of claims 21 to 29, wherein the partial oxidation unit is fluidly coupled to an acid gas removal unit that is configured to receive at least a portion of the processed syngas, and produce at least one of a Fischer Tropsch fluid, synthetic natural gas (SNG), town gas, reducing gas, oxo synthesis fluid, dimethyl ether (DME), hydrogen, methanol, mixed alcohols, ammonia and fuel gas for power generation.

31. The method of any one of claims 21 to 30, wherein the partial oxidation unit is further configured to convert the heavy hydrocarbons to additional syngas, and wherein the processed syngas comprises the additional syngas.

32. The method of any one of claims 21 to 31, wherein the processed syngas comprises less than 1 vol% of heavy hydrocarbons.

33. A method for removing heavy hydrocarbons from an underground gasification syngas, comprising:

receiving raw syngas containing heavy hydrocarbons from a source; processing the raw syngas in a partial oxidation unit using oxygen to produce a processed syngas substantially depleted of the heavy hydrocarbons; and

providing an air separation unit configured to provide oxygen to the source and the partial oxidation unit.

34. The method of claim 33, wherein the partial oxidation unit comprises palladium.

35. The method of claim 33 or claim 34, wherein the raw syngas further comprises methane, and wherein the processed syngas is substantially depleted of methane.

36. The method of any one of claims 33 to 35, further comprising fluidly coupling an acid gas removal unit to the partial oxidation unit, and wherein the acid gas removal unit is configured to receive at least a portion of the processed syngas and produce at least one of a Fischer Tropsch fluid, synthetic natural gas (SNG), town gas, reducing gas, oxo synthesis fluid, dimethyl ether (DME), hydrogen, methanol, mixed alcohols, ammonia and fuel gas for power generation.

37. The method of any one of claims 33 to 36, wherein the source is an underground coal gasification plant.

38. The method of any one of claims 33 to 37, further comprising thermally coupling the processed syngas and water to produce steam, and wherein the partial oxidation unit is configured to receive at least a portion of the steam.

39. The method of any one of claims 33 to 38, wherein the step of processing the raw syngas comprises converting the heavy hydrocarbons to additional syngas, and wherein the processed syngas comprises the additional syngas.

40. The method of any one of claims 33 to 39, wherein the processed syngas comprises less than 1 vol% of heavy hydrocarbons.

41. The system of any one of claims 1 to 20, wherein the partial oxidation unit is further configured to receive a co-feed hydrocarbon or other fluid other than raw syngas.

42. The method of any one of claims 21 to 40, wherein the partial oxidation unit is further configured to receive a co-feed hydrocarbon or other fluid other than raw syngas.

43. The system of any one of claims 1 to 20 and 41, wherein a feed to the partial oxidation unit is heated in a feed effluent exchanger to improve the partial oxidation unit's efficiency.

44. The method of any one of claims 21 to 40 and 42, wherein the feed to the partial oxidation unit is heated in a feed effluent exchanger to improve the partial oxidation unit's efficiency.

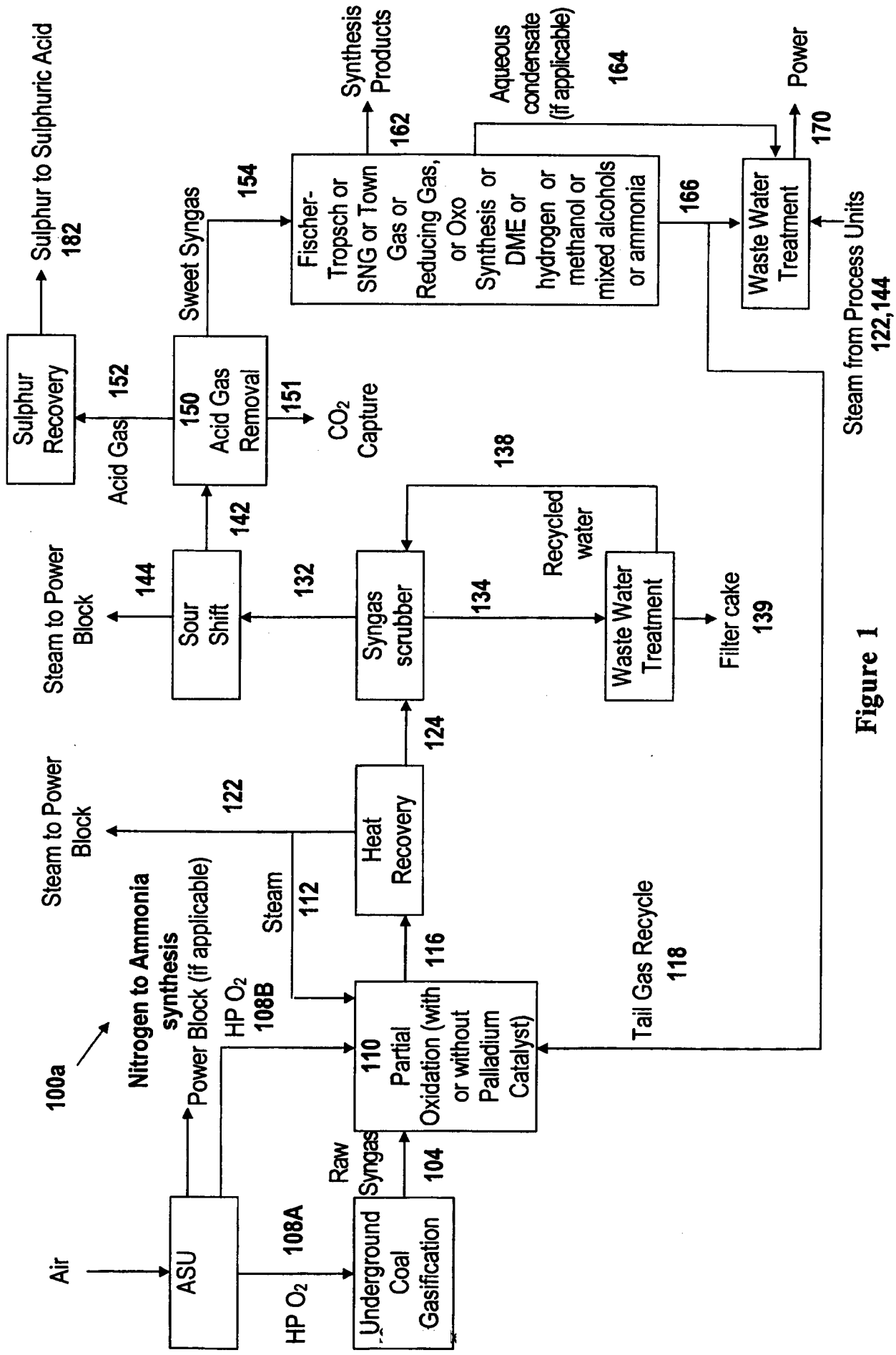
Air
ASU
HP O_2
108A
Underground Coal Gasification
Raw Syngas
104
100a
Nitrogen to Ammonia synthesis
Power Block (if applicable)
HP O_2
108B
110 Partial Oxidation (with or without Palladium Catalyst)
116
Steam
112
Heat Recovery
124
Steam to Power Block
122
Tail Gas Recycle
118
Syngas scrubber
134
Recycled water
Waste Water Treatment
Filter cake
139
138
Sour Shift
132
Steam to Power Block
144
142
150 Acid Gas Removal
151
CO_2 Capture
Acid Gas
152
Sulphur Recovery
Sulphur to Sulphuric Acid
182
Sweet Syngas
154
Fischer-Tropsch or SNG or Town Gas or Reducing Gas, or Oxo Synthesis or DME or hydrogen or methanol or mixed alcohols or ammonia
166
Synthesis Products
162
Aqueous condensate (if applicable)
164
Waste Water Treatment
Power
170
Steam from Process Units
122,144

Figure 1

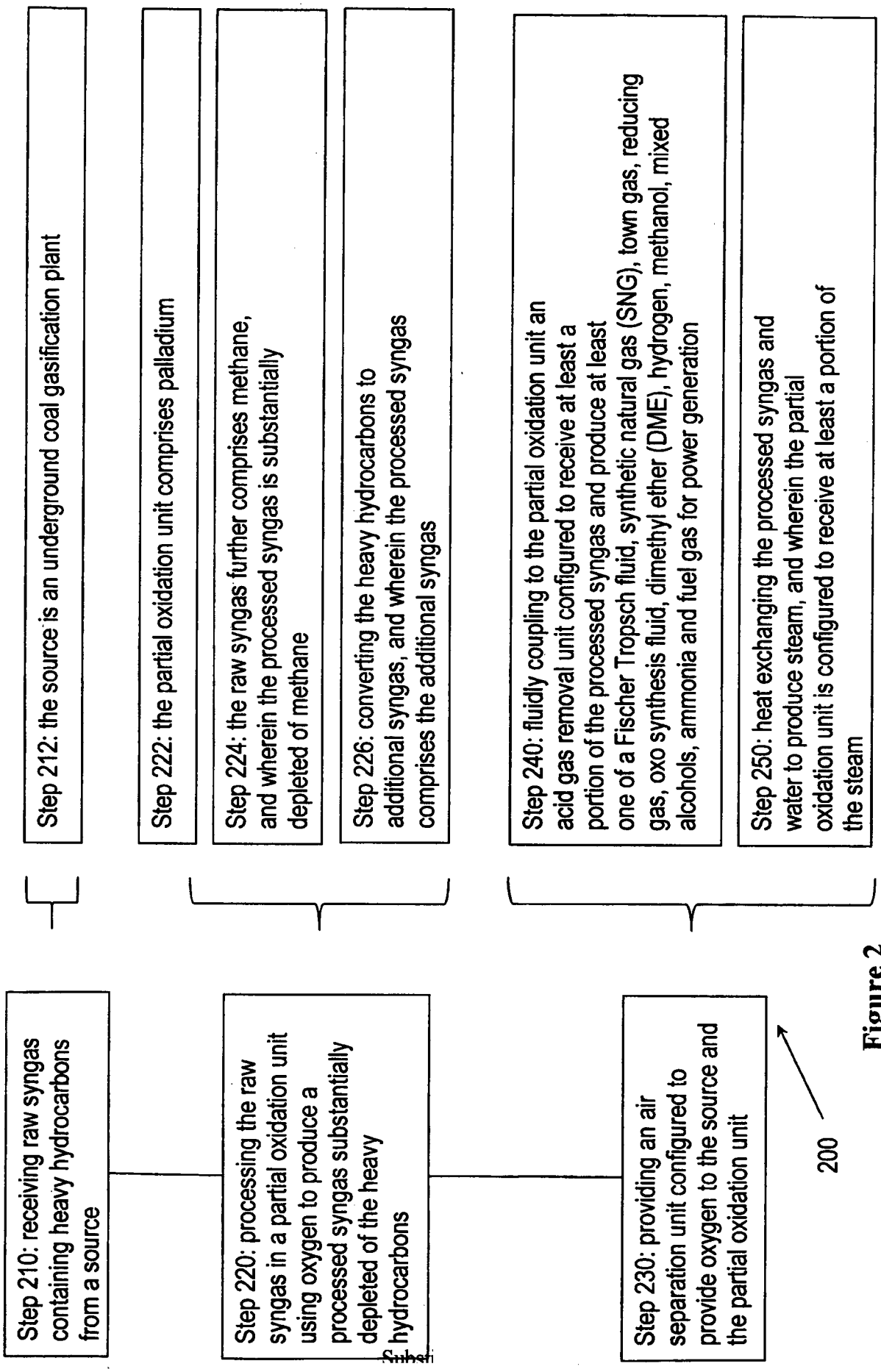
Step 210: receiving raw syngas containing heavy hydrocarbons from a source
Step 220: processing the raw syngas in a partial oxidation unit using oxygen to produce a processed syngas substantially depleted of the heavy hydrocarbons
Step 230: providing an air separation unit configured to provide oxygen to the source and the partial oxidation unit
200
Step 212: the source is an underground coal gasification plant
Step 222: the partial oxidation unit comprises palladium
Step 224: the raw syngas further comprises methane, and wherein the processed syngas is substantially depleted of methane
Step 226: converting the heavy hydrocarbons to additional syngas, and wherein the processed syngas comprises the additional syngas
Step 240: fluidly coupling to the partial oxidation unit an acid gas removal unit configured to receive at least a portion of the processed syngas and produce at least one of a Fischer Tropsch fluid, synthetic natural gas (SNG), town gas, reducing gas, oxo synthesis fluid, dimethyl ether (DME), hydrogen, methanol, mixed alcohols, ammonia and fuel gas for power generation
Step 250: heat exchanging the processed syngas and water to produce steam, and wherein the partial oxidation unit is configured to receive at least a portion of the steam

Figure 2

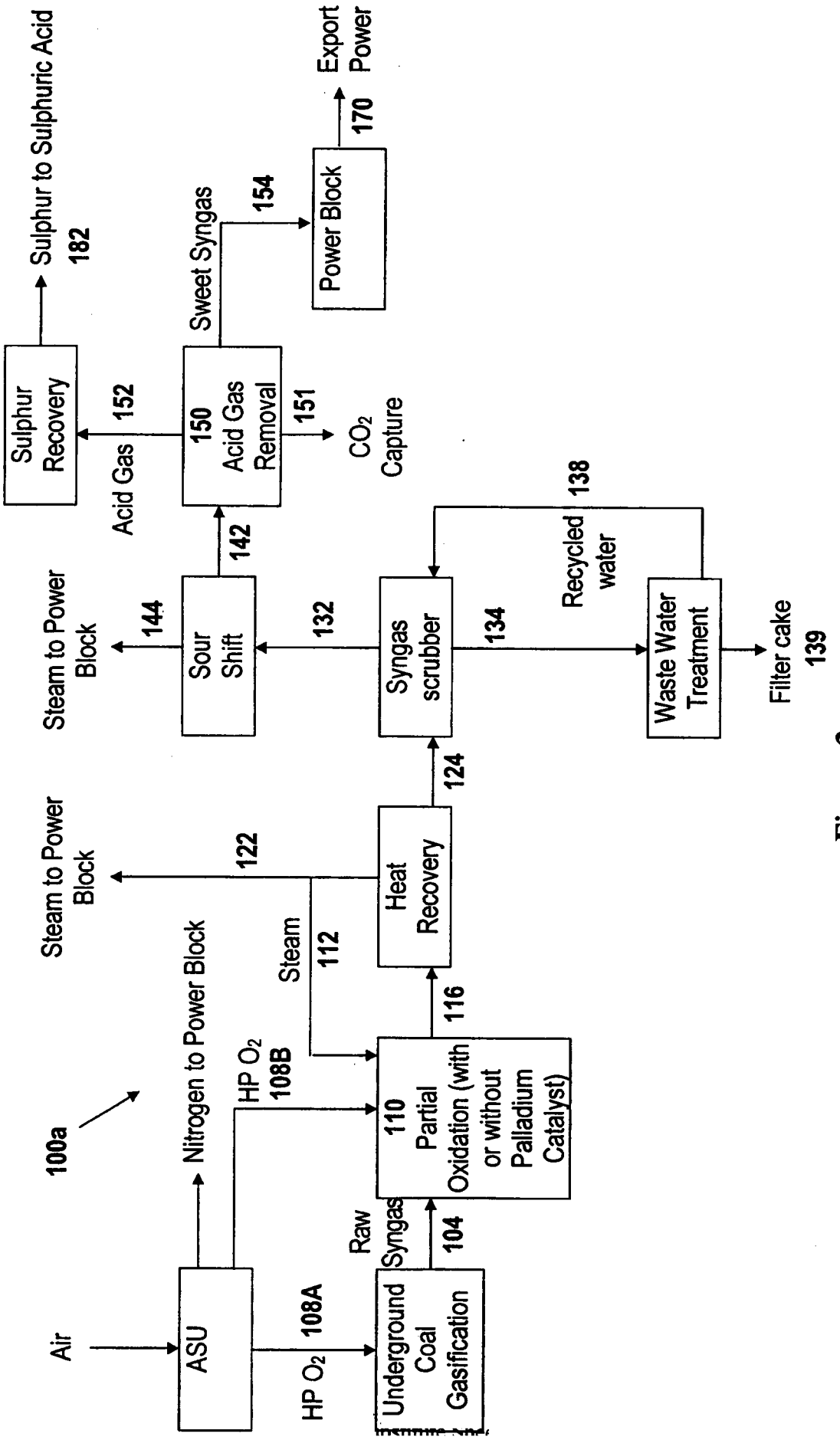
Air
ASU
108A
HP O_2
Underground Coal Gasification
Raw Syngas
104
110 Partial Oxidation (with or without Palladium Catalyst)
116
Heat Recovery
124
Syngas scrubber
134
Waste Water Treatment
Filter cake
139
Recycled water
138
Sour Shift
132
142
150 Acid Gas Removal
151
CO_2 Capture
Acid Gas
152
Sulphur Recovery
Sulphur to Sulphuric Acid
182
Sweet Syngas
154
Power Block
Export Power
170
Steam to Power Block
144
Steam to Power Block
122
Steam
112
HP O_2
108B
Nitrogen to Power Block
100a

Figure 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2011/001693

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

C01B 3/00 (2006.01) ***C10J 3/00*** (2006.01) ***E21B 43/295*** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPODOC, WPI : IC/EC C01B 3/00, C10J 3/00, e21B 43/295 & Keywords(UCG, underground_gasif+, subterranean_gasif+, in_situ_gasif+, +oxid+, POX, +hydrocarbon+, tar, phenol, creosotes), Esp@cenet, Google Patents & Keywords (syngas hydrocarbon removal, gasification & hydrocarbon removal, syngas treatment)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008/0275143 A1 (MALHOTRA et al) 6 November 2008 Abstract, claims 1, 7, 20, paragraph 0018, 0033-0036, 0058-0059, 0063, 0066	1-44
A	US 2008/0244976 A1 (PAISLEY) 9 October 2008 Abstract	1-44
A	US 2007/0181854 A1 (BRIESCH et al) 9 August 2007 Abstract	1-44
A	US 2010/0184873 A1 (BRACHT et al) 22 July 2010 Abstract	1-44

☐ Further documents are listed in the continuation of Box C ☒ See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 April 2012	10/04/2012
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. +61 2 6283 7999	Authorized officer **ASOKA DIAS-ABEYGUNAWARDENA** AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No : (02) 6283 2141

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU2011/001693

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	2008275143	AU	2004221838	AU	2009271698	AU	2009271701
		BR	PI0406675	CA	2510442	CA	2727552
		CA	2728565	CN	1761612	CN	102099284
		CN	102099445	EG	24088	EP	1603831
		EP	2300360	EP	2321386	JP	2006520316
		JP	2011528648	JP	2011528649	NZ	542869
		RU	2005131948	US	2004177555	US	7138001
		US	7932296	US	2008047197	US	2009064582
		WO	2004083115	WO	2010008494	WO	2010008497
US	2008244976	AU	2006304867	BR	PI0619293	CA	2626537
		CN	101312905	CR	9905	EA	200801129
		EC	SP088474	EP	1940736	JP	2009512755
		KR	20080067676	MX	2008005225	NZ	567582
		TW	200827434	WO	2007048058	ZA	200804284
US	2007181854	AU	2007272311	CA	2655445	CL	20742007
		EP	1982052	EP	2041758	PE	03842008
		US	2010162912	WO	2007094908	WO	2008006166
		ZA	200900153				
US	2010184873	EP	2367904	WO	2010079057		

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX