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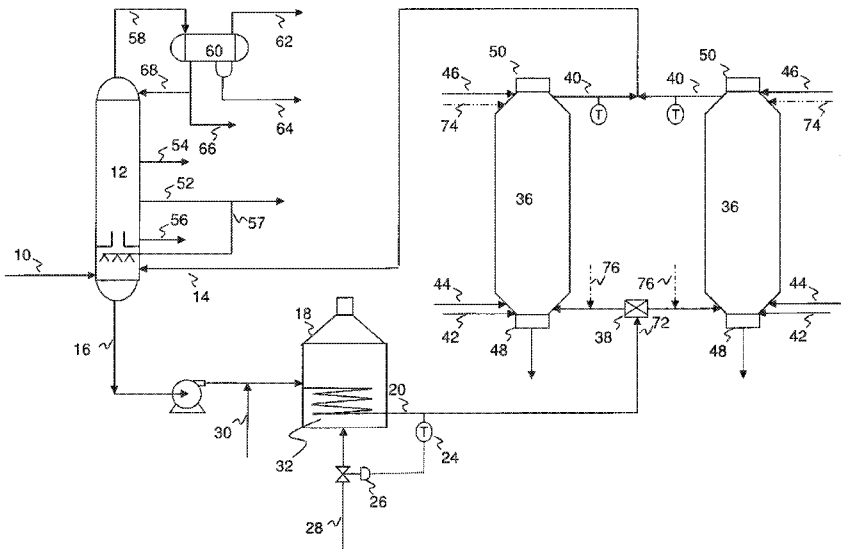
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(54) **Title:** IN SITU COKING OF HEAVY PITCH AND OTHER FEEDSTOCKS WITH HIGH FOULING TENDENCY

Figure 1



(57) **Abstract:** Processes and systems for in situ heating of a heavy pitch within a coking drum are disclosed. The in situ heating may provide for processing of neat pitch, improving coking operations and increasing liquid yield.

WO 2019/178109 A1

IN SITU COKING OF HEAVY PITCH AND OTHER FEEDSTOCKS WITH HIGH FOULING TENDENCY

BACKGROUND

[0001] Upgrading of heavy pitch and other high fouling feedstocks via delayed coking is at best challenging, if not impossible. Heavy pitch may be derived from various processes including solvent deasphalting, supercritical solvent deasphalting (such as a Rose unit or LCFining), resid slurry hydrocracking, and also residual oil derived from tight oil, among others. The difficulty in processing of heavy pitch via delayed coking is predominantly due to the operational reliability, or rather unreliability, caused by rapid coking of the fired heater tubes, which forces unit slowdown or shut down for mechanical heater tube decoking.

[0002] In processing heavy pitch and dealing with the aforementioned problems, refiners opt for processing these pitch streams by blending them with vacuum resid, atmospheric resid and other lighter hydrocarbon streams while designing and/or operating the coker for high throughput ratio in order to achieve an acceptable heater run length. As a consequence, blending with other streams demands higher coker unit design or processing capacity, along with higher capital and operating expenses. Higher recycle rates and recycling of light coker gas oil in order limit the heater tube fouling also increases the unit size and leads to increased coke production and a reduction in liquid yield. The residual oil derived from tight oil sources are highly paraffinic in nature demanding higher heat input for conversion and therefore accelerate heater tube fouling.

SUMMARY OF THE DISCLOSURE

[0003] Embodiments herein relate to processes for in situ coking of heavy pitch, derived from solvent deasphalting, supercritical solvent deasphalting, resid hydrocracking, slurry hydrocracking and residual oil from shale (tight) oil via delayed coking process for production of distillates and coke. Embodiments herein allow for heating of the neat pitch or residual oil derived from shale oil to an incipient coking temperature, and thereafter completing the coking reaction in the coke drums with the aid of a separate heating medium. At the end of the coking cycle, the coke drum will

contain partially converted pitch, which is then subjected to additional heat by the heating medium to the final reaction temperature, thus completing the reaction. The lower heater coil outlet temperature, due to heating the feed only to the incipient coking temperature, will prevent rapid coking of the heater tubes and increases the heater and unit run length significantly. Moreover, the proposed schemes herein allow coking under a set of operating conditions that maximizes liquid yield from each feedstock. Also, lower capital and operating expenses associated with such processes and systems disclosed herein favors the economics of the design or expansion project, whatever the case may be.

[0004] In one aspect, embodiments disclosed herein relate to a process for producing coke. The process may include: heating a heavy pitch to an incipient coking temperature to produce a heated coker feedstock; feeding the heated coker feedstock to a coking drum; heating the heated coker feedstock in situ within the coking drum via direct heat exchange with a superheating medium; subjecting the heated coker feedstock to thermal cracking in the coking drum to crack a portion of the heavy pitch to produce a cracked vapor product and a coke product.

[0005] In another aspect, embodiments disclosed herein relate to a process for producing coke. The process may include: heating a heavy pitch to an incipient coking temperature to produce a heated coker feedstock; feeding the heated coker feedstock to a coking drum; heating the heated coker feedstock with a superheating medium and subjecting the heated coker feedstock to thermal cracking in the coking drum to crack a portion of the heavy pitch to produce a cracked vapor product and a coke product.

[0006] In another aspect, embodiments disclosed herein relate to a process for producing coke. The process may include: heating a heavy pitch to an incipient coking temperature to produce a heated coker feedstock; mixing the heated coker feedstock with a superheating medium and feeding the mixture to a coking drum; subjecting the heated coker feedstock to thermal cracking in the coking drum to crack a portion of the heavy pitch to produce a cracked vapor product and a coke product.

[0007] In another aspect, embodiments disclosed herein relate to a process for producing coke. The process may include: heating a heavy pitch to an incipient coking temperature to produce a heated coker feedstock; feeding the heated coker

feedstock to a coking drum; heating the heated coker feedstock in situ within the coking drum and subjecting the heated coker feedstock to thermal cracking in the coking drum to crack a portion of the heavy pitch to produce a cracked vapor product and a coke product.

[0008] In another aspect, embodiments disclosed herein relate to a system for producing coke. The system may include: a heater for heating a heavy pitch to an incipient coking temperature to produce a heated coker feedstock; a flow line for feeding the heated coker feedstock to a coking drum; a heater for heating a superheating medium to produce a heated superheating medium; a flow line for supplying the heated superheating medium to the coking drum for heating the heated coker feedstock in situ within the coking drum via direct heat exchange with the superheating medium; a flow line for recovering a cracked vapor product from the coking drum while subjecting the heated coker feedstock to thermal cracking in the coking drum to crack a portion of the heavy pitch to produce the cracked vapor product and a coke product.

[0009] In another aspect, embodiments disclosed herein relate to a system for producing coke. The system may include: a heater for heating a heavy pitch to an incipient coking temperature to produce a heated coker feedstock; a flow line for feeding the heated coker feedstock to a coking drum; a flow line for supplying a superheating medium for heating the heated coker feedstock and subjecting the resulting heated coker feedstock to thermal cracking in the coking drum to crack a portion of the heavy pitch to produce a cracked vapor product and a coke product.

[0010] In another aspect, embodiments disclosed herein relate to a system for producing coke. The system may include: a heater for heating a heavy pitch to an incipient coking temperature to produce a heated coker feedstock; a mixer for mixing the heated coker feedstock with a superheating medium and a flow line for feeding the mixture to a coking drum to subject the heated coker feedstock to thermal cracking in the coking drum to crack a portion of the heavy pitch to produce a cracked vapor product and a coke product.

[0011] In another aspect, embodiments disclosed herein relate to a system for producing coke. The system may include: a heater for heating a heavy pitch to an incipient coking temperature to produce a heated coker feedstock; feeding the heated

coker feedstock to a coking drum; a control system for controlling an in situ heating of the heated coker feedstock within the coking drum and the coking drum for subjecting the heated coker feedstock to thermal cracking to crack a portion of the heavy pitch to produce a cracked vapor product and a coke product.

[0012] In another aspect, embodiments disclosed herein relate to a process for producing coke. The process may include: heating a heavy pitch to an incipient coking temperature to produce a heated coker feedstock; feeding the heated coker feedstock to a coking drum; heating the heated coker feedstock in situ within the coking drum via direct heat exchange ; and subjecting the heated coker feedstock to thermal cracking in the coking drum to crack a portion of the heavy pitch to produce a cracked vapor product and a coke product.

[0013] In another aspect, embodiments disclosed herein relate to a process for producing coke. The process may include: heating a heavy pitch to an incipient coking temperature to produce a heated coker feedstock; mixing the heated coker feedstock with a superheating medium; feeding the mixture to a coking drum; heating the mixture in situ within the coking drum via direct heat exchange with the superheating medium; and subjecting the mixture to thermal cracking in the coking drum to crack a portion of the heavy pitch to produce a cracked vapor product and a coke product.

[0014] In another aspect, embodiments disclosed herein relate to a system for producing coke. The system may include: a heater for heating a heavy pitch to an incipient coking temperature to produce a heated coker feedstock; a flow line for feeding the heated coker feedstock to a coking drum; a heater for heating a superheating medium to produce a heated superheating medium; a flow line for supplying the heated superheating medium for heating the heated coker feedstock in situ within the coking drum via direct heat exchange with the superheating medium; a flow line for recovering a cracked vapor product from the coking drum.

[0015] Other aspects and advantages will be apparent from the following description and the appended claims.

BRIEF DESCRIPTION OF DRAWINGS

[0016] Figure 1 is a simplified diagram of a coking process and apparatus according to embodiments disclosed herein.

DETAILED DESCRIPTION

[0017] Embodiments herein relate to systems and processes for in situ coking of heavy pitch and other high fouling feedstocks via delayed coking process. Heavy pitch feedstocks may include any number of refinery process streams which cannot economically be further distilled, catalytically cracked, or otherwise processed to make fuel-grade blend streams. Typically, these materials are not suitable for catalytic operations because of catalyst fouling and/or deactivation by ash and metals. Embodiments herein are directed toward use of heavy pitch or other high fouling feedstocks as a coker feedstock, including heavy pitch derived from solvent deasphalting, ROSE Unit, resid hyrocracking, slurry hydrocracking and residual oil from shale (tight) oil.

[0018] In some embodiments, the above feedstocks may be fed neat (undiluted) to a coking unit for delayed coking. In other embodiments, the feedstocks may be minimally diluted, such as via addition of up to 10 wt% of a diluent. Diluents useful in embodiments herein may include common coker feedstocks such as atmospheric distillation residuum, vacuum distillation residuum, catalytic cracker residual oils, hydrocracker residual oils, and residual oils from other refinery units. Inclusion of a minimal level of diluent may enhance the processability of the heavy pitch and other high fouling feedstocks without incurring a significant penalty on equipment sizing and other advantages noted herein associated with processing of a neat or near neat heavy pitch.

[0019] Feedstocks that may be used according to embodiments herein may have a high Conradson carbon content, such as greater than 35 wt%. Feedstocks that may be used according to embodiments herein may also have a high asphaltene content, such as greater than 15 wt%, greater than 25 wt%, or even greater than 35 wt%, such as an asphaltene content that can be as high as the Conradson carbon content.

[0020] As known in the art, the coker feedstock may be treated upstream of the coking unit. For example, the coker feedstock may undergo a hydrotreating process, a

desalting process, a demetallization process, a desulfurization process, or other pretreatments processes useful to produce a desirable coke product.

[0021] In conventional coking processes, the coker feedstock is heated to coking temperature and then allowed to reside in the coke drum for completion of coking/cracking reaction by utilizing the energy that has already been imparted into it via the coking heater. Other designs heat the feedstock to a temperature greater than the coking temperature so as to promote cracking and quench the feedstock upstream of the coke drum. In contrast, processes herein heat the heavy pitch / high fouling feed to an incipient coking temperature, a temperature which is not adequate to drive the coking reaction to completion. The balance of energy is then imparted to the heater effluent that is accumulated inside the coke drum so that the coking/cracking reaction is driven to completion. The balance of energy may be imparted to the heater effluent immediately upstream and/or inside the coke drum, via a superheated medium introduced to the coke drum via the feed line either after the filling cycle is completed and/or during the cycle as the coke drum is being filled. A separate source of energy at temperatures high enough is required other than the coker heater. To the inventor's knowledge, in situ heating of a neat heavy pitch / high fouling feedstock in a coke drum has not heretofore been performed.

[0022] In the fired heater, the heavy pitch / high fouling feed is heated, not to the full coking temperature as practiced in conventional delayed coking, but only to an incipient coking reaction temperature. The incipient coking reaction temperature may depend upon the heavy pitch / high fouling feedstock or feedstock mixture used, and may be different for different feedstocks. The completion of the coking reaction is accomplished inside the coke drum, with the aid of a separate heating medium directly imparting energy to the coker heater effluent, and thus driving the coking reaction to its completion. The in situ heating of the heavy pitch / high fouling feed may continue for a length of time required for the coking reaction to approach completion, and this length of time may also vary depending upon the type of heavy pitch / high fouling feedstock being used. However, for each feedstock, pilot testing may be performed to determine the incipient coking temperature, a duration of coke drum in situ heating, and preheated pitch level inside the coke drum, as part of the process design of the unit.

[0023] Embodiments herein relate to the processing of 100% (neat) pitch / high fouling feedstock with high Conradson carbon (>35 wt%) and an asphaltene content that can be as high as the Conradson Carbon content. Embodiments herein allow higher unit run length when processing 100% (neat) pitch / high fouling feed from sources discussed above or residual oil derived from Shale (tight) Oil that under normal coking conditions lead to severely limited unit run length and lower liquid yield. The ability to process neat pitch, of the feedstock categories mentioned above: eliminates the need to significantly blend in other diluents that makes the unit capacity requirements higher; increases the unit effective run length; increases liquid yield; and, decreases the unit utility requirements.

[0024] Referring now to Figure 1, a coking process according to embodiments disclosed herein is illustrated. A heavy pitch / high fouling feedstock 10 is introduced into the bottom portion of a coker fractionator 12, where it combines with hydrocarbons condensed from coker vapor stream 14 (i.e., an internal recycle stream that is generated). The heavy pitch / high fouling feedstock may additionally be heated in one or more preheat exchangers prior to flow to the bottom of the main coker fractionator 12.

[0025] The resulting mixture 16 (the heater charge stream) is then pumped through a coker heater 18, where its temperature is increased to the incipient coking temperature of the stream, such as between 500°F and 750°F. The temperature of the heater effluent stream 20 may be measured and controlled by use of a temperature sensor 24 that sends a signal to a control valve 26 to regulate the amount of fuel 28 fed to the heater 18. If desired, steam or boiler feedwater 30 may be injected into the heater to reduce coke formation in the tubes 32.

[0026] The heater effluent stream 20 may be recovered from the coker heater 18 for feed to coking drums 36. Two or more drums 36 may be used in parallel, as known in the art, to provide for continued operation during the operating cycle (coke production, coke recovery (decoking), preparation for next coke production cycle, repeat). A switch valve 38, such as a three-way or four-way valve, for example, diverts the heater effluent stream to the desired coking drum 36, which is in the filling mode of operation.

[0027] The coke drum 36 in filling mode is allowed to accept feed until the material reaches a certain safe level inside the coke drum. At this point, the feed may be routed to another coke drum ready for filling.

[0028] Once the coke drum is filled with heater effluent (the heavy pitch heated to the incipient coking temperature), the contents of the coke drum are further heated via injection of a suitable superheating medium. The superheating medium may be injected into coke drum 36 via flow line 76, which may connect to the heater effluent transfer line intermediate the diverter valve 38 and the coking drum 36. Alternatively, or additionally, the superheating medium may be injected directly into the coking drum via one or more inlets (not shown) at or near a bottom of the coking drum, such as through or near bottom head 48. In some embodiments, the superheating medium may be fed along with the heater effluent during the fill cycle.

[0029] Superheating mediums useful in embodiments herein include steam, carbon dioxide, nitrogen and other inert gases, as well as lighter hydrocarbons that are relatively stable at coking temperatures. The superheating mediums, in some embodiments, may have sufficient heat capacity to directly heat the pitch, not condense at coke drum operating conditions, and not react with the heavy pitch or the cracked products.

[0030] The superheating medium may be heated in a separate heater (not shown) prior to admixture with the heater effluent or feed to the coke drum 18. In other embodiments, superheating of the superheating medium may occur in one zone of heater 18 while the heavy pitch is heated to the incipient coking temperature in another zone of the heater. The superheated medium may then be introduced to the coke drum via the feed line, either after the filling cycle is completed and/or during the fill cycle.

[0031] Sufficient in situ heating and residence time is provided in the coking drum 36 to allow the thermal cracking and coking reactions to proceed to completion. In this manner, the heavy pitch feedstock is thermally cracked in the coking drum 36 to produce lighter hydrocarbons, which vaporize and exit the coke drum via flow line 40. Petroleum coke and some residuals (e.g. cracked hydrocarbons) remain in the coking drum 36. When the coking drum 36 is sufficiently full of coke, and the in situ heating has sufficiently driven the coking reaction to completion, the coking cycle

ends. After completion of the coking cycle, the decoking cycle begins in the first coking drum.

[0032] In the decoking cycle, the contents of the coking drum 36 are cooled down, remaining volatile hydrocarbons are removed, the coke is drilled or otherwise removed from the coking drum, and the coking drum 36 is prepared for the next coking cycle. Cooling of the coke normally occurs in three distinct stages. In the first stage, the coke is cooled and stripped by steam or other stripping media 42 to economically maximize the removal of recoverable hydrocarbons entrained or otherwise remaining in the coke. In the second stage of cooling, water or other cooling media 44 is injected to reduce the coking drum temperature while avoiding thermal shock to the coking drum. Vaporized water from this cooling media further promotes the removal of additional vaporizable hydrocarbons. In the final cooling stage, the coking drum is quenched by water or other quenching media 46 to rapidly lower the coking drum temperatures to conditions favorable for safe coke removal. After the quenching is complete, the bottom and top heads or slide valves 48, 50 of the coking drum 36 are removed or opened, respectively. The petroleum coke is then cut, for example, such as by hydraulic water jet, and removed from the coking drum. After coke removal, the coking drum heads or slide valves 48, 50 are replaced or closed, respectively, and the coking drum 36 is preheated and otherwise readied for the next fill and coking cycle.

[0033] During the fill, in situ heating, and coking cycle, the superheating medium and cracked products, including lighter hydrocarbon vapors, are recovered as an overheads fraction 40 from coking drum 36. The overhead fraction 40 is then transferred to the coker fractionator 12 as coker vapor stream 14, where the recovered components are separated into two or more fractions and recovered. For example, a heavy coker gas oil (HCGO) fraction 52 and a light coker gas oil (LCGO) fraction 54 may be drawn off the fractionator at the desired boiling temperature ranges. HCGO may include, for example, hydrocarbons boiling in the range from 650-870°+F. LCGO may include, for example, hydrocarbons boiling in the range from 400-650°F. In some embodiments, other hydrocarbon fractions may also be recovered from coker fractionator 12, such as a quench oil fraction 56, which may include hydrocarbons similar or heavier than HCGO, and/or a wash oil fraction 57. The fractionator

overhead stream, coker wet gas fraction 58, goes to a separator 60, where it is separated into a wet gas fraction 62, a water/aqueous fraction 64, and a naphtha fraction 66. A portion of naphtha fraction 66 may be returned to the fractionator as a reflux 68.

[0034] In other embodiments, the superheating medium may comprise a heavier hydrocarbon stream, such as hydrocarbons having a normal boiling point in the range from about 400°F to about 650°F, such as LCGO stream 54. For example, the LCGO fraction 54 may be withdrawn from coker fractionator 12 and partially vaporized in a heater (not shown). The unvaporized portion may be collected and returned to the coker fractionator 12. The vapor portion may then be superheated in the same or a different heater and then introduced into the coke drum for in situ coking.

[0035] Coking systems according to embodiments herein may also include apparatus for recovery and recycle of the superheating medium, if necessary. Such systems may be included within the coker fractionator 12 and associated equipment. For example, the superheating medium recovery apparatus may include a side draw for recovery of a particular temperature cut associated with the superheating medium, or may simply include condensate from the water / aqueous fraction 64. Alternatively, other equipment may be disposed upstream or downstream of the coker fractionator 12 for recovery and recycle of the superheating medium.

[0036] The temperature of the vapors leaving the coke drum via flow line 40 may be an important control parameter used to represent the temperature of the materials within the coking drum 36 during the coking process. For example, conditions may be controlled in a manner to produce many varieties of coke having a volatile combustible material (VCM) content in the range from about 3% to about 25% by weight, as measured by ASTM D3175t.

[0037] The type of coke products produced may also be impacted by the temperature and type of the superheating medium, as well as the duration of the in situ heating. Accordingly, control systems used in embodiments herein may vary for controlling the temperature of the superheating medium fed to the coke drum for the in situ heating.

[0038] As described above, embodiments herein provide for systems and processes for in situ coking of heavy pitch, via delayed coking process, for production of

distillates and coke. Embodiments herein allow for heating of the neat pitch or residual oil derived from shale oil to an incipient coking temperature, and thereafter completing the coking reaction in the coke drums with the aid of a separate heating medium. At the end of the filling cycle, the coke drum will contain partially converted pitch, which is then subjected to additional heat by the heating medium to the final reaction temperature, thus completing the reaction. The lower heater coil outlet temperature, due to heating the feed only to the incipient coking temperature, will prevent rapid coking of the heater tubes and increases the heater and unit run length significantly. Moreover, the proposed schemes herein allow coking under a set of operating conditions that maximizes liquid yield from each feedstock. Also, lower capital and operating expenses associated with such processes and systems disclosed herein favors the economics of the design or expansion project, whatever the case may be. Further, embodiments disclosed herein may enhance or increase favorability of delayed cokers by processing difficult feedstocks at a lower capacity (CPAEX), higher on-stream factor, higher liquid yield, and lower utility consumption (OPEX). Embodiments herein also allows attractive combinations of different technologies, such as supercritical solvent deasphalting (such as LCFining), residue hydrocracking (such as LC-MAX), Resid Slurry Hydrocracking, or processing of high fouling residual oil derived from paraffinic base feedstocks such as shale (tight) oil feedstocks.

[0039] While the disclosure includes a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments may be devised which do not depart from the scope of the present disclosure. Accordingly, the scope should be limited only by the attached claims.

CLAIMS

What is claimed:

1. A process for producing coke, the process comprising:

   heating a heavy pitch to an incipient coking temperature to produce a heated coker feedstock;

   feeding the heated coker feedstock to a coking drum;

   further heating the heated coker feedstock in situ within the coking drum via direct heat exchange; and

   subjecting the heated coker feedstock in the coking drum to thermal cracking to crack a portion of the heavy pitch to produce a cracked vapor product and a coke product.

2. The process of claim 1, wherein the direct heat exchange is via contact of the heated coker feedstock with a superheating medium.

3. The process of claim 1, wherein the steps of heating via direct heat exchange and subjecting occur concurrently.

4. The process of claim 1, wherein the incipient coking temperature is between 500°F and 750°F.

5. The process of claim 1, further comprising feeding the cracked vapor product to a coker separator for recovery of one or more light hydrocarbon fractions.

6. The process of claim 1, further comprising stopping the feed of heated coker feedstock to the coking drum and removal of the coke product from the coking drum.

7. The process of claim 2, wherein the superheating medium is contacted with the heated coker feedstock via one or more of a feed inlet upstream of the coking drum, a superheating medium heater upstream of the coking drum , or a feed inlet introducing the superheating medium directly into the coking drum.

8. The process of claim 2, wherein the superheating medium does not condense at coke drum operating conditions during a coking cycle.

9. The process of claim 8, wherein the superheating medium is one or more of steam, carbon dioxide, nitrogen and other inert gases, or one or more light hydrocarbons.

10. The process of claim 2, wherein the superheating medium is fed to the coking drum during a filling cycle, during a coking cycle, or both.

11. The process of claim 1, wherein the heating of the heated coker feedstock in situ continues for a length of time required for the thermal cracking to approach completion.

12. The process of claim 1, wherein the heavy pitch is 100% heavy pitch.

13. The process of claim 1, wherein the heavy pitch comprises up to 10wt% of a diluent.

14. The process of claim 1, wherein the heavy pitch has a Conradson carbon content of 35 wt% or more, and an asphaltene content of 15wt% or more.

15. A process for producing coke, the process comprising:

heating a heavy pitch to an incipient coking temperature to produce a heated coker feedstock;

mixing the heated coker feedstock with a superheating medium;

feeding the mixture to a coking drum;

heating the mixture in situ within the coking drum via direct heat exchange with the superheating medium; and

subjecting the mixture to thermal cracking in the coking drum to crack a portion of the heavy pitch to produce a cracked vapor product and a coke product.

16. The process of claim 15; wherein the superheating medium is one or more of steam, carbon dioxide, nitrogen and other inert gases, or one or more light hydrocarbons.

17. The process of claim 15, wherein the heating of the heated coker feedstock in situ continues for a length of time required for the thermal cracking to approach completion.

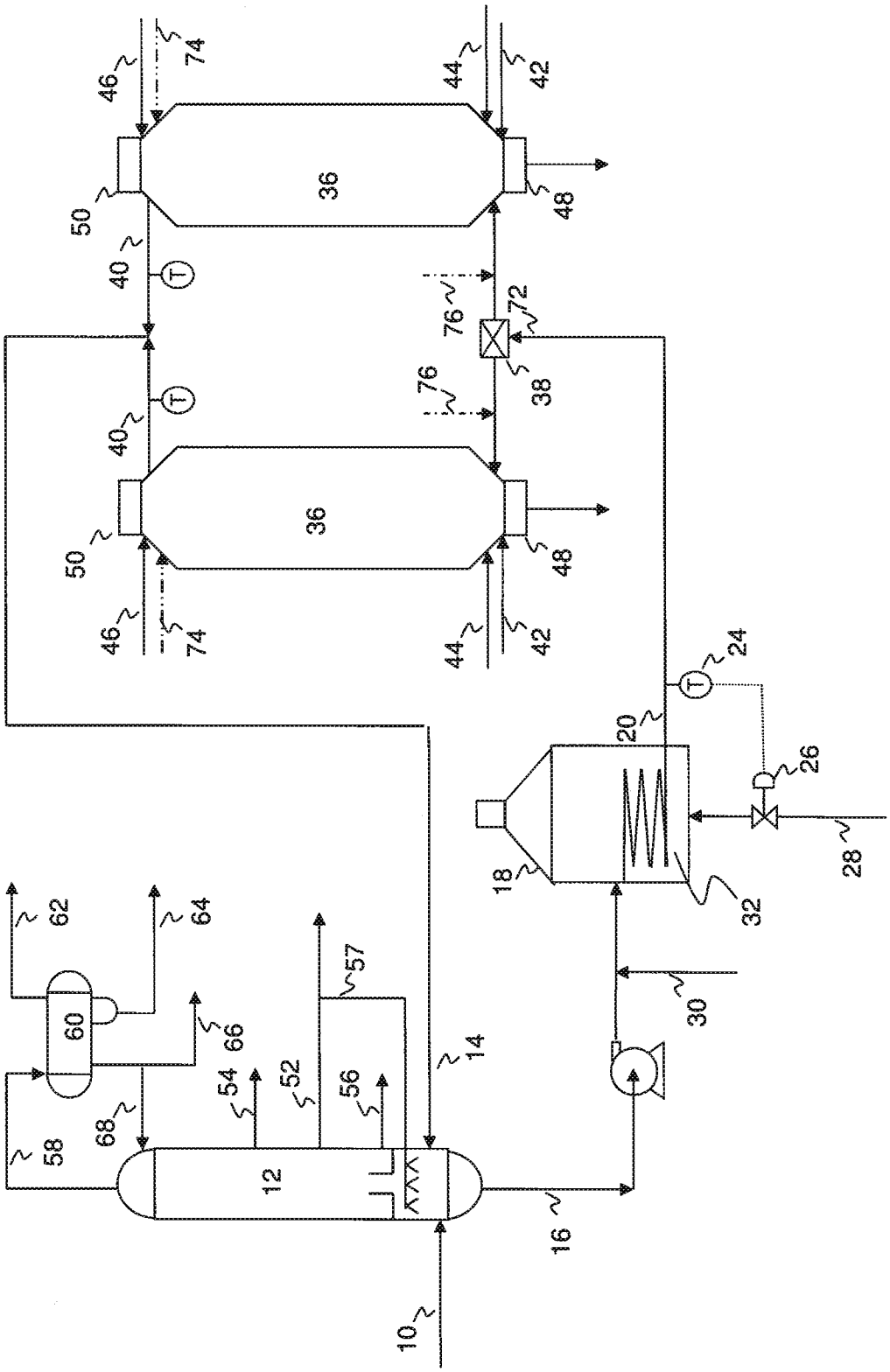
18. The process of claim 15, wherein the heavy pitch is 100% heavy pitch.

19. The process of claim 15, wherein the heavy pitch comprises up to 10wt% of a diluent.

20. The process of claim 15, wherein the heavy pitch has a Conradson carbon content of 35 wt% or more, and an asphaltene content of 15wt% or more.

21. A system for producing coke, the system comprising:
    a heater for heating a heavy pitch to an incipient coking temperature to produce a heated coker feedstock;
    a flow line for feeding the heated coker feedstock to a coking drum;
    a heater for heating a superheating medium to produce a heated superheating medium;
    a flow line for supplying the heated superheating medium for heating the heated coker feedstock in situ within the coking drum via direct heat exchange with the superheating medium;
    a flow line for recovering a cracked vapor product from the coking drum.
22. The system of claim 21, further comprising a mixer for mixing the heated coker feedstock with the superheating medium and a flow line for feeding the mixture to the coking drum.
23. The system of claim 21, wherein the flow line for supplying the heated superheating medium is connected to the coking drum.
24. The system of claim 21, wherein the heater for heating the heavy pitch and the heater for heating the superheating medium are disposed in different zones of a common heater.
25. The system of claim 21, further comprising a control system for controlling the in situ heating of the heated coker feedstock within the coking drum.

Figure 1


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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2019/021867

A. CLASSIFICATION OF SUBJECT MATTER

C10B 55/00(2006.01)i, C10B 57/16(2006.01)i

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)
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords:coke, pitch, heat exchagne, thermal crack

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4547284 A (SZE, MORGAN C. et al.) 15 October 1985 See columns 4-7; claims 1-13, 18; fig. 1.	1-25
A	CN 106032470 A (CHINA UNIVERSITY OF PETROLEUM (EAST CHINA)) 19 October 2016 See paragraphs [0008]-[0016], [0065]-[0068]; claims 1-10; fig. 1.	1-25
A	US 4108798 A (SZE, MORGAN C. et al.) 22 August 1978 See the whole document.	1-25
A	CN 101481626 A (SHANDONG UNIVERSITY OF SCIENCE AND TECHNOLOGY) 15 July 2009 See the whole document.	1-25
A	JP 2006-233107 A (JFE STEEL CORP. et al.) 07 September 2006 See the whole document.	1-25

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
21 June 2019 (21.06.2019)	**21 June 2019 (21.06.2019)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2019/021867

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