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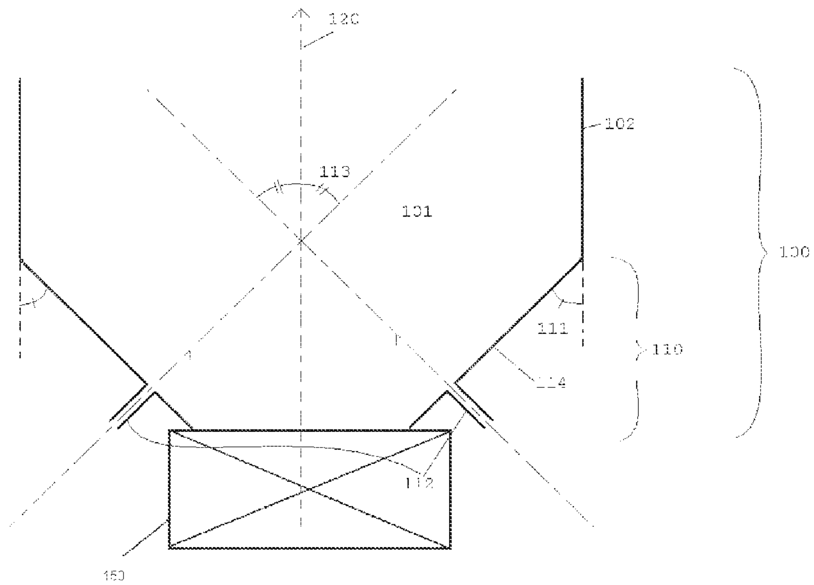

(57) Abstract: Coke drum assembly is provided with a vessel having a body portion defining an interior, a central axis, and having a lower portion including a sidewall, and at least one feed inlet coupled with the lower portion in fluid communication with the interior of the vessel. The at least one feed inlet is directed toward the central axis of the vessel, and angled upwardly at a feed inlet angle relative to the central axis. At a location opposite the feed inlet, the side wall of the lower portion is angled upwardly at an opposing wall angle relative to the central axis, wherein the feed inlet angle is less than or equal to the opposing wall angle. Method also is provided for delayed coking using the coke drum assembly disclosed herein.

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COKER FEED INLET DESIGN TO MINIMIZE EFFECTS OF IMPINGEMENT

BACKGROUND

Field

[0001] The field of the disclosed subject matter Is delayed coking. More particularly, the field is systems and methods for dispensing fluid to delayed coke drams.

Description of Related Art

[0002] In delayed coking, a petroleum stream containing heavy distillation fractions ("resid" or "residuum") is typically heated rapidly in a fired heater or tubular furnace to create a mixture of hot liquid and vapor, which is then fed to a large steel vessel commonly known as a coke dram. The coke drum is maintained under conditions in which coking occurs (e.g., greater than about 400° C. under super-atmospheric pressures). Delayed coke drums are typically cylindrical vessels with a cone shape at the bottom, and can range in diameter anywhere from about 15 to in excess of 30 feet. The height of a delayed coke drum is typically two to five times the diameter.

[0003] During the delayed coking process, the heated resid undergoes high temperature decomposition to produce more valuable liquid and gaseous products and solid or semi-solid coke residue. The volatile components are removed overhead and pass on to a fractionator. The solid or semi-solid coke left behind accumulates in the drum. When the coke reaches a certain level, a switch valve is actuated to redirect the resid to an empty "sister" drum. The hydrocarbon vapors in the full dram, now off line, are then purged with steam and the drum is quenched with steam and water to lower the temperature to less than about 100 ^{0} C—after which the water is drained. When the cooling and draining steps are complete, the top and bottom heads of the dram are opened and the coke is removed by drilling and/or cutting. For example, high velocity water jets can be lowered in through the top of the dram.

[0004] Typically, each end of a delayed coking dram is capped with a removable steel member or the like called a "head." The process of removing the top and bottom heads of a coke drum is called "unheading" or "deheading." There are several conventional methods for opening the heads of a coke dram. One method is to completely remove the bottom head from the vessel and, optionaliy, carry it away. Another method is to swing the bottom head out of the way, as on a hinge or pivot, while the head remains coupled to the vessel. (See e.g. U.S. Patent No. 6,264,829.) Manually removing the heads, especially the bottom heads can be difficult and time consuming work. To help reduce the time and expense, the industry has developed semi-automatic or fully automatic systems for the bottom unheading.

[0005] From the late 1930s through the 1950s, heated resid **was** predominately fed to delayed coke dmms through a single horizontal side-inlet in a side wall near the bottom of the dram. There are several disadvantages with this design, as illustrated in N. A. Weil and F. S. Rapasky, "Experience with Vessels of Delayed Coking Units," Proceedings of the American Petroleum Institute, Section III Refining, pp. 214-232 (1958). For example, heated resid of conventional delayed coke dmms are directed across the drum against the wall opposite the inlet. Thus, the wall opposite the inlet is subjected to higher heat than the remainder of the drum. The thermal shock caused by this non-uniform heat distribution can cause recurrent plastic deformation of the coke drum bottom and eventual ovalization, as well as leaks in nearby gasketed joints, metal fatigue, and cracks in the drum.

[0006] From the late 1950s to the early 2000s, the side inlet feed design was often replaced with a single vertical bottom-inlet design. Relative to the single side-inlet design, this configuration reduced the non-uniform temperature distribution and concomitant leak problems. Typically, the bottom feed inlet is through the center of the bottom head and the feed line therefore must be disconnected before the bottom head is removed.

[0007] More recently, actuated severe service valves have been suggested in the industry by a number of vendors as a safer and more time efficient alternative to the use of bottom heads on delayed coking drums. Since about 2001, possible valves for this purpose have been disclosed by, among others, Zimmermann and Jansen GmbH, Curtiss-Wright Flow Corporation and Velan inc. (See e.g., Zimmermann and Jansen GmbH U.S. Pat. Nos. 5,116,022 and 5,927,684, Curtiss-Wright Flow Control Corporation U.S. **Pat** Nos. 6,565,714, 6,660,131, 6,843,889, 6,964,727, 6,989,081 and 7,033,460 and Velan Inc. U.S. Patent Application No. 2005/0269197). However, if one replaces a coke drum bottom head with a severe service valve, the concurrent use of a vertical bottom feed-inlet becomes much more problematic and, in some cases, impossible. To be repetitively and continuously operable through numerous coking/decoking cycles without removal, severe sendee valve closure requires a lateral feed system located above the valve apparatus. As a result, the industry is moving back to the use of a single horizontal side-inlet feed nozzle despite the associated thermal stress problems. This is illustrated, for example, in U.S. Patent No. 6,926,807.

[0008] US Patent No. 7,316,762 and US Patent No. 6,926,807 have attempted to address the stress induced leakage problems encountered in coke drums when a valve is used as a bottom head in combination with a single side feed inlet. However, these proposed solutions are directed to the symptom rather than the source of the problem by focusing on valve insulation and seal design to increase thermal stress resistance rather than attempting to mitigate the uneven feed distribution that causes the thermal stress.

[0009] U.S. Pat. No. 7,1 15,190 ("the '1 90 patent") describes "a tangential injection system for use within a delayed coking system ... . The tangential injection system comprises a spool, [and] a tangential dispenser, ... wherein the tangential dispenser comprises a delivery main surrounding the perimeter of the spool that functions to deliver a residual byproduct ... to a plurality of feed lines positioned ... at distances around the delivery main for the purpose of providing tangential dispensing of the residual byproduct into the vessel, thus effectuating even thermal distribution throughout the vessel." See, the '1 90 patent, abstract. As noted in the '190 patent, however, such tangential injection systems are complex in design and operation.

[0010] As an alternative, the '190 patent also notes that certain prior art dispensers comprise "two opposing, co-axial inlet feeds coupled to a vessel in the form of a coke drum." See, the '1 90 patent, col. 4, lines 55-59. As recognized by the '190 patent, however, such conventional co-axial dispenser arrangements are only minimally effective due to operational issues, such as pressure differentials between inlets. See, the '1 90 patent, col. 3, lines 6-22,

[0011] U.S. Patent No. 7,736,470 ("the '470 patent") attempts to address the uneven feed distribution that causes the thermal stress. For example, the '470 patent discloses methods and mechanisms that "utilize a split piping system to dispense fluid through two

Of more inlets into a spool that is connected to a coke drum." See, the '470 patent, col. 3, lines 52-54. According to the '470 patent, "itjlie fluid may be introduced to the spool in opposing directions toward a central vertical axis of the spool at any angle between minus 30 degrees and 30 degrees relative to the horizontal, or less preferably, tangential to the sides of the spool." See, the '470 patent, col. 3, lines 57-61.

[0012] Although generally effective, there remains a need in the industry to provide more effective solutions to the high thermal stress problems caused by the lateral side introduction of heated resid to coke drums in view of the industry's desire to replace coke drum bottom heads with valves.

SUMMARY OF THE INVENTION

[0013] The purpose and advantages of the present application will be set forth in and apparent from the description that follows. Additional advantages of the disclosed subject matter will be realized and attained by the methods, apparatus, and devices particularly pointed out in the written description and claims thereof, as well as from the appended drawings.

[0014] In accordance with one aspect of the disclosed subject matter, a coke drum assembly is provided. The coke drum assembly includes a vessel having a body portion defining an interior and a central axis. The vessel further has a lower portion including a sidewafl, and at least one feed inlet directed toward the central axis of the vessel, and angled upwardly at a feed inlet angle relative to the central axis. The side wall of the lower portion at a location opposite the feed inlet is angled upwardly at an opposing wall angle relative to the central axis of the vessel and the feed inlet angle relative the central axis is less than or equal to the opposing wall angle.

[0015] For example, as embodied herein, the opposing wall angle is equal to or greater than about 45° relative to the central axis and the feed inlet angle is equal to or less than about 45° relative to the central axis of the vessel. In one embodiment, each feed inlet angle is approximately equal to the opposing wall angle.

[0016] In accordance with another aspect, at least two feed inlets are evenly spaced about the lower portion of the vessel around the central axis of the vessel. For example, in one embodiment, at least two feed inlets are generally directed toward a common focal point in the interior of the vessel. As embodied herein, the common focal point can be located along the central axis of the vessel.

[0017] In some embodiments, a feed pipe system is in fluid communication with the at least one feed inlet, wherein the at least one feed inlet includes at least two feed inlets spaced about the lower portion of the vessel, the feed pipe system including a primary feed pipe and a plurality of branch feed pipes extending from the main feed pipe, each branch feed pipe extending to a respective one of the at least two feed inlets.

[0018] Another aspect of the disclosed subject matter provides a method of delayed coking. The method comprises providing a coke dmm assembly that includes a vessel having a body portion defining an interior and a central axis, a lower portion including a sidewalf, and at least one feed inlet coupled with the lower portion in fluid communication with the interior of the vessel. The feed inlets are directed toward the central axis of the vessel, and angled upwardly at a feed inlet angle relati ve to the central axis. The side wall of the lower portion at a location opposite the feed inlet relative the central axis is angled upwardly at an opposing wall angle relative to the central axis of the vessel and the feed inlet angle is less than or equal to the opposing wail angle. The method also comprises directing a fluid stream from a refinery operation through at least one feed inlet.

[0019] As embodied herein, at feast two feed inlets having a feed inlet angle less than or equal to the opposing wall angle can be provided, wherein the fluid streams directed through each of the feed inlets are substantially similar.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] FIG. ! is a schematic representation of a lateral cross-sectional side view of one embodiment of the Sower portion vessel described herein.

[0021] FIG. 2 is a schematic representation of a cross-sectional plan view of the system of FIG. 1.

DETAILED DESCRIPTION OF THE INVENTION

[0022] Reference will now be made in detail to embodiments of the disclosed subject matter, examples of which are illustrated in the accompanying drawings. The systems and methods presented herein are generally directed to a more predictable and maintainable manner of dispensing fluid to a coke drum to alleviate thermal stress. For purposes of illustration and without limitation, an exemplary embodiment of the disclosed subject matter is shown, for example, in Figs. 1 and 2.

[0023] In accordance with one aspect of the disclosed subject matter, a coke drum assembly is provided. The coke drum assembly includes a vessel having a body portion defining an interior and a central axis. The vessel further has a lower portion including a sidewall, and at least one feed inlet directed toward the central axis of the vessel, and angled upwardly at a feed inlet angle relative to the central axis. The side wall of the lower portion at a location opposite the feed inlet is angled upwardly at an opposing wall angle relative to the central axis of the vessel and the feed inlet angle is less than or equal to the opposing wall angle.

[0024] For the purpose of illustration and not limitations, reference will be made to an exemplary embodiment as depicted in the drawings. With reference to Fig. 1, a vessel 100 is provided having a body portion defining an interior 101 and a central axis 120. The vessel can have a variety of shapes and sizes suitable for the intended use in the industry. Additionally, the vessel can be constructed from a variety of materials suitable for the intended use in the industry. It is contemplated that the presently disclosed subject matter is not intended to be limited to a vessel of a particular size or shape; rather, the presently disclosed subject matter is intended to be used in any vessel configuration that is suitable for delayed coking operations.

[0025] With reference to Fig. 1, a lower portion 110 of the vessel includes a sidewall 114. At least segments of the iowrer portion sidewall are angled 111 relative to the central axis 120 of the vessel. For example, the lower portion can be conical in shape, such that the sidewall extends continuously about the central axis at a constant angle; although the lower portion can have an alternate shape suitable in the industry. The presently disclosed subject matter is not limited to a lower portion having a conical shape; rather, it is contemplated that the lower portion could also be toriconical, or divided into two conical portions with different angles relative to the central axis, or conical with a straight cylindrical portion befowr the conical portion prior to the bottom flange, or combinations thereof. Any configuration that is capable of being using in connection with a delayed coking operation is considered to he within the scope of the presently disclosed subject matter.

[0026] In some embodiments, the lower portion 110 of the vessel is a separate member, such as a spool coupled to the bottom surface of a delayed coke dmm. The spool encloses an interior space with a side wall having an inside surface and an outside surface. The spool can have a generally hollow cone shape, or other suitable shape. The spool can be flanged around its upper and lower ends to facilitate attachment. Attachment of the spool to the coke drum can be affected by welding or bolting the flange on the upper surface of the spool to a flange surrounding the bottom surface of a delayed coke drum or by any other techniques known in the art for attaching a spool to the bottom of a delayed coke dram.

[0027] Additionally, a bottom deheader valve can be disposed proximate the lower portion of the vessel as known in the industry. The bottom deheader valve can be attached to the lower portion or spool by welding or bolting or by any other techniques known in the art. The spool or lower portion of the vessel provides a transition from the larger diameter or cross-section of the coke dram 101 to the typically smaller diameter or cross section of the coke drum bottom deheader valve.

[0028] As previously noted at least one feed inlet is provided. With reference to Fig. 1, the at least one feed inlet 112 is coupled with the lower portion 110 of the vessel in fluid communication with the interior 101 of the vessel. For purposes of illustration and not limitation, Fig. 1 shows a coke drum assembly including two feed inlets. However, the coke drum can be provided with only one feed inlet in accordance with the disclosed subject matter. Similarly, more than two feed inlets can be provided if desired or needed. Each feed inlet 112 is disposed to direct fluid to flow into and towards the central axis 120 of the vessel and angled upwardly at a feed inlet angle 113 relative to the central axis. It is contemplated that multiple feed inlets may be spaced about the perimeter of the dram. The multiple feed inlets are preferably equidistant with respect to adjacent inlets.

[0029] As further depicted in Fig. 1, at a location opposite the feed inlet, the side wall of the lower portion is angled upwardly relative the central axis at an angle 111. In accordance with the disclosed subject matter, the feed inlet angle 113 relative the central axis is less than or equal to the opposing sidewall angle or opposing wall angle **111** relative the central axis.

[0030] By aligning the feed inlet **112** at an angle **113** relative the central axis no greater than the angle 111 of the opposing lower portion sidewall, substantial reduction in thermal stress is achieved reiative to a single horizontal feed inlet. For example, and as depicted in Fig. 1, the fluid stream or resid from the feed inlet will not be directed into or localized at an opposing wall of the lower portion if the feed inlet angle 113 relative the central axis is less than the opposing wail angle **111**. Rather, as the resid leaves the feed inlet, the flow will tend to expand, which gives rise to a "fanning effect." Having the feed inlet angle **113** no greater than the angle **111** of the opposing lower portion sidewall increases the fanning benefit due to the increase in trajectory distance and time between the feed inlet and the impingement surface. Furthermore, by avoiding direct or localized impingement, the increased spread of resid onto a larger surface due to the fanning effect will provide for a more uniform temperature profile along the vessel wall and reduced peak heat flux. The reduction in peak heat flux therefore decreases the severity of any peak thermal stresses due to the resid impingement. The uniformity of the temperature profile due to the fanning effect decreases average thermal stresses due to resid impingement, and thus reduces incidence of leaking flanges and cracks within the vessel.

[0031] For example, if the opposing wall angle **111** of the lower portion **110** of the vessel is 45" reiative the central axis, the feed inlet angle can be equal to or less than 45° to obtain the fanning benefit and increase in trajectory distance and time. In some embodiments of the presently disclosed subject matter, each feed inlet angle 113 is approximately parallel to the opposing wall angle **111.**

[0032] In accordance with a further aspect of the disclosed subject matter, at least two feed inlets are evenly spaced about the lower portion of the vessel around central axis. Thus, if two feed inlets are provided, the feed inlets are located approximately 180° apart along an inside surface of the lower portion wall. Alternatively, if three feed inlets are provided, the feed inlets are spaced approximately 120 ° apart around the central axis. Alternatively, if four feed inlets are provided, the feed inlets are spaced approximately 90° apart around the central axis. Each feed inlet is directed toward a common focal point, such as along the central axis. In this manner, the fluid streams directed through the feed inlets impinge on one another. This impingement of fluid streams further enhances the fanning effect to minimize thermal stress concentration along the vessel wall In one embodiment, the flow parameters, such as flow velocity and proportion of liquid to vapor, of the fluid stream (202a and 202b) flowing through the feed inlets are substantially equal. The result is a more uniform temperature distribution in the lower portion of the coke dmm relative to a single feed inlet. Additionally, and as previously noted, by aligning the feed inlets at a feed inlet angle no greater than the angle of the opposing side wall relative the central axis, the flow from the inlets will tend to expand and the trajectory distance and time is increased. Hence, even if one of the feed inlets were to become obstructed, direct impingement of resid on a localized area of the opposing cone wall is attenuated.

[0033] The coke dmm assembly can further comprise a feed pipe system in fluid communication with the feed inlets. This primary feed pipe 210 can be located downstream from a switch valve and is the dedicated feed pipe for a particular drum. Depending on where the coke dmm is in the delayed coking cycle, the primary fluid stream can be resid, water, steam or a solution containing one or more additives that affect coke morphology. The coke drum assembly can have a primary feed pipe 210 and a plurality of branch feed pipes extending from the main feed pipe to respective feed inlets. For example, a primary feed pipe 210 carrying a primary fluid stream 201 can be coupled with an intersection 220, which in turn is coupled with a system of branch piping with each leg of branch feed pipe (241a and 241b) terminating at a port connected to a corresponding feed inlet (112a and 112b). The primary fluid stream 201 can be routed from the primary feed pipe 210 through the intersection 220 and can be split into secondary fluid streams (202a and 202b) that flow in separate directions along the branch pipes (241a and 241b) and into the vessel chamber through the feed inlets (112a and 112b). For example, if two branch feed pipes are desired for two respective feed inlets, then the intersection 220 (or "feed splitter") can be a "T" shaped fitting, or a "Y" shaped fitting, or "cross" shaped fitting with one port blocked. As embodied herein, the intersection is symmetrical for uniform flow to the various branch feed pipes. For example, the intersection can be a cross shaped fitting with one port reversibly blocked with a flange to serve as a cleaning port. Each branch pipe comprises one or more pipes.

Thai is, each branch feed pipe can be a continuous branch pipe or can be a branch pipe that is further divided by a fitting to one or more feed inlets connected to the lower portion of the vessel.

[0034] As embodied herein, the flow velocity through each branch feed pipe is equal to, or greater than, the flow velocity of the primary fluid (e.g., the combined furnace effluent) in the primary feed pipe 210 prior to the intersection. Maintaining substantially equal mass flow rates and liquid/vapor proportions between the secondary fluid streams, at flow velocities that are equal to, or greater than, the flow velocity of the primary fluid stream, can be accompiished such as by maintaining symmetry between the branch feed pipes.

[0035] For purposes of illustration and without limitation, an exemplary embodiment of the apparatus and method of the disclosed subject matter is shown, for example, in Figs. 1 and 2, and described as follows.

[0036] The methods and apparatuses herein can be utilized, for example, in a delayed coker system where resid feed is passed by a coker furnace and then fed into a number of coke drums. The resid feed that enters a coke drum is at elevated temperatures and pressures, often between 900 and 935° F. and up to 100 psig, and is comprised of two or more phases. The feed can, for example, be comprised of up to about 80 vol. % vapor phase, and up to 20 vol. % of one or more liquid phases. There can also be present a small amount of solid coke. Superficial velocities are high, often on order of 100 ft/see.

[0037] In an exemplary embodiment, a coke drum assembly is provided. The coke drum **100** has a body portion defining an interior 101 and a central axis 120.

[0038] The vessel includes a lower portion 110, referred to herein as a coke drum cone, having a sidewall. As embodied herein, for illustration and not limitation, the sidewall is angled 111 relative to the central axis 120 of the coke dram 100. The lower portion 110 is disposed at, as embodied herein, the bottom surface of a delayed coke drum 102. A coke drum bottom deaheader valve 150 is disposed below the lower portion 110. The lower portion 110 is generally a hollow cone that encloses an interior space with a wall 114 having an inside surface and an outside surface.

[0039] Feed inlets **112** are coupled with the lower portion **110** to allow fluid to flow into the interior space 101 enclosed by the vessel. Each feed inlet 112 is disposed to direct fluid to flow into and towards the central axis (**120**) of the vessel 100 and aligned at a feed inlet angle 113, relative the central axis, to dispose fluid upwardly and centrally into the interior space **101** of the vessel. As embodied herein, the feed inlet angle is equal to or less than the angle of the side wall, as measured with reference to the central axis, at a location opposite the feed inlet. For example, the feed inlet can be parallel to the opposing lower portion sidewail **114** measured in reference to the central axis 120 of the coke drum 100. If more than one feed inlet is provided, as shown, the feed inlets 112 are evenly spaced about the coke drum cone 110 around the central axis 120,

[0040] As embodied herein, the Sower portion 110 of the vessel generally has a cone shape. Therefore, the interior surface (not numbered) of the cone (110) is generally circular in plan view. As depicted, for purpose of illustration and not limitation, two feed inlets (**112a** and **112b**) are located on the same horizontal plane within the cone but positioned 180 degrees apart. In FIG. 2, the flow of secondary streams (202a and 202b) through each of the feed inlets (112a and 112b) is directed toward the central axis. Accordingly, the secondary streams (**202a and 202b**) flow in opposite directions toward one another and toward a common focal point in the interior space (**101**) of the vessel. The common focal point in the interior space of the vessel can be, for example, located on the central axis 120 of the vessel.

[0041] A primary fluid stream 201, such as a combined coker effluent, travels through a primary feed pipe 210 downstream from a coker feed switch valve (not shown). The primary fluid stream 201 enters intersection 220. Intersection 220 splits primary fluid stream 201 into secondary fluid streams (**202a and 202b**) that each, independently, exit intersection 220 through opposing outlet ports (not numbered) into corresponding symmetrical branch feed pipes (240a and 240b). The two symmetrical branch feed pipes (**240a and 240b**) carry the secondary fluid streams (202a and 202b) in separate directions. Each branch feed pipe (240a and 240b) is operatively coupled with a respective feed inlet (**112a and 112b**). Feed inlets (**112a and 1212b**) allow fluid to flow into the interior space 101 enclosed by the wall of the vessel.

[0042] The secondary fluid streams flow through the branch feed pipes (240a and **240b**) and through the feed inlets (**112a** and **112b**) into the interior space 101 enclosed by the wall of the vessel at a feed inlet angle **113** relative the central axis 120 equal to or less than the angle of the side wall **14** at a location opposite the feed inlet, i.e., the opposing wall angle ill. Upon entry into the interior space 101 enclosed by the wall of the vessel, the secondary fluid streams tend to expand, which gives rise to a fanning effect.

[0043] The increased spread of the secondary fluid streams due to the fanning effect generates a substantially uniform temperature profile within the vessel and along the wall. If, for example, the feed inlet angle **113** relative the central axis is parallel to the angle lllof the side wall **114** at a location opposite the feed inlet, the fanning benefit is increased due to the increase in trajectory distance and time between the feed inlet and the impingement surface. The fanning effect is also generated when the angle **113** is less than the angle **111** of the side wall **114.**

[0044] Furthermore, the expanded secondary fluid streams flow in opposite directions toward one another and toward a common focal point in the interior space **101** of the vessel. The expanded secondary fluid streams impinge on one another at a common focal point in the interior space **101** of the vessel. The common focal point can be, for example, located on the central axis **120** of the vessel. In this manner, the impinging streams at the focal point further enhance dispersion and fanning of the streams within the vessel.

[0045] As embodied herein, the secondary fluid streams (**202a** and **202b**) are substantially similar due to the symmetrical or otherwise similar branch feed pipes **(240a** and **240b**) for the corresponding feed inlets. Substantially similar secondary fluid streams impinging on one another allow for a more uniform impingement interface of the fluid streams. Should a blockage occur in one of the legs of branch feed pipes (240a **and 240b**), a differential in the flow rate of secondary fluid streams can arise. As embodied herein, however, the feed inlet angle 113 relative the central axis of the vessel is equal to or less than the angle of the side wall at a location opposite the feed inlet. Such a feed inlet angle attenuates or otherwise reduces direct impingement of a secondary fluid stream on a localized area of the opposing vessel wall if such a blockage occurs. If, for example, the feed inlet angle 113 relative the central axis is parallel to the angle of the side wall 114 at a location opposite the feed inlet, trajectory distance and time of impingement between the feed inlet 112 and the opposing vessel wall is increased, if not avoided. Furthermore, by increasing the projected area of the impingement surface due to the fanning benefit, any peak heat flux caused by impingement on an opposing wall is reduced. The reduction in peak heat flux therefore decreases the severity of peak thermal stresses due to impingement. Moreover, the uniformity of the temperature profile due to the fanning effect decreases average thermal stresses due to impingement.

[0046] Hence, as embodied herein, after the secondary fluid streams (202a and 202b) enter the interior space 101 of the vessel and expand due to fanning, the fluid stream is directed within the vessel for normal processing and operations as otherwise known in the industry.

[0047] The systems and methods of the disclosed subject matter have now been described in relation to particular preferred embodiments. However, many other variations and modifications and other uses may be apparent to those skilled in the art such as demonstrated or evident from the various patents and publications identified herein, each of which is incorporated by reference in its entirety.

CLAIMS

What is claimed is:

1. A coke drum assembly comprising:

a vessel having a body portion defining an interior and a central axis, the vessel further having a lower portion including a sidewall; and

at feast one feed inlet coupled with the lower portion in fluid communication with the interior of the vessel, the at least one feed inlet directed toward the central axis of the vessel, and angled upwardly at a feed inlet angle relative the central axis,

the side wall of the lower portion at a location opposite the feed inlet being angled upwardly at an opposing wall angle relative to the central axis of the vessel, the feed inlet angle being less than or equal to the opposing wall angle .

2. The coke drum assembly of Claim 1, wherein the feed inlet angle is approximately equal to the opposing wall angle.

3. The coke dram assembly of Claim 1, wherein the opposing wali angle is equal to or greater than about 45° relative to the central axis and the feed inlet angle is equal to or less than about 45" relative to the central axis of the vessel.

4. The coke drum assembly according to anyone of the preceding claims, wherein the at least one feed inlet includes at least two feed inlets evenly spaced about the lower portion around the central axis of the vessel.

5. The coke drum assembly of Claim 4, wherein the at least two feed inlets are generally directed toward a common focal point in the interior of the vessel.

6. The coke drum assembly of Claim 5, wherein the common focal point is located along the central axis of the vessel.

7. The coke dram assembly according to anyone of the preceding claims, further comprising a feed pipe system in fluid communication with the at least one feed inlet.

8. The coke drum assembly of Claim 8, wherein the at least one feed inlet includes at least two feed inlets spaced about the lower portion of the vessel, the feed pipe system including a primary feed pipe and a plurality of branch feed pipes extending from the primary feed pipe, each branch feed pipe extending to a respective one of the at least two feed inlets.

9. A method of delayed coking comprising:

providing a coke drum assembly comprising

a vessel having a body portion defining an interior and a central axis;

the vessel further having a lower portion including a sidewail; and

at least one feed inlet coupled with the lower portion in fluid communication with the interior of the vessel, the at least one feed inlet directed toward the central axis of the vessel, and angled upwardly at a feed inlet angle relative the central axis,

the side wall of the lower portion at a location opposite the feed inlet being angled upwardly at an opposing wall angle relative to the central axis of the vessel, the feed inlet angle being less than or equal to the opposing wall angle; and

directing a fluid stream from a refinery operation through said at least one feed inlet.

10. The method of Claim 10, wherein providing the coke drum assembly includes providing at least two feed inlets evenly spaced about the lower portion around the central axis of the vessel.

11. The method of Claim 11, wherein the fluid stream through each of the at least two feed inlets are substantially similar.

AMENDED CLAIMS
received by the International Bureau on 14 May 2013 (14.05.2013)

1. A coke drum assembly comprising:

a vessel having a cylindrical body portion defining an interior and a central axis, the vessel further having a conical lower portion including a sidewall which is angled upwardly at a wall angle relative to the central axis of the vessel; and

at (east two feed inlets coupled with the lower portion in fluid communication with the interior of the vessel, the inlets being evenly spaced about the lower portion of the vessel around the central axis of the vessel and angled upwardly at a feed inlet angle relative the central axis which is less than or equal to the wall angle of the conical lower portion to be directed toward a common point along the central axis of the vessel.

2. The coke drum assembly according to claim 1 or 2, further comprising a feed pipe system in fluid communication with the feed inlets.

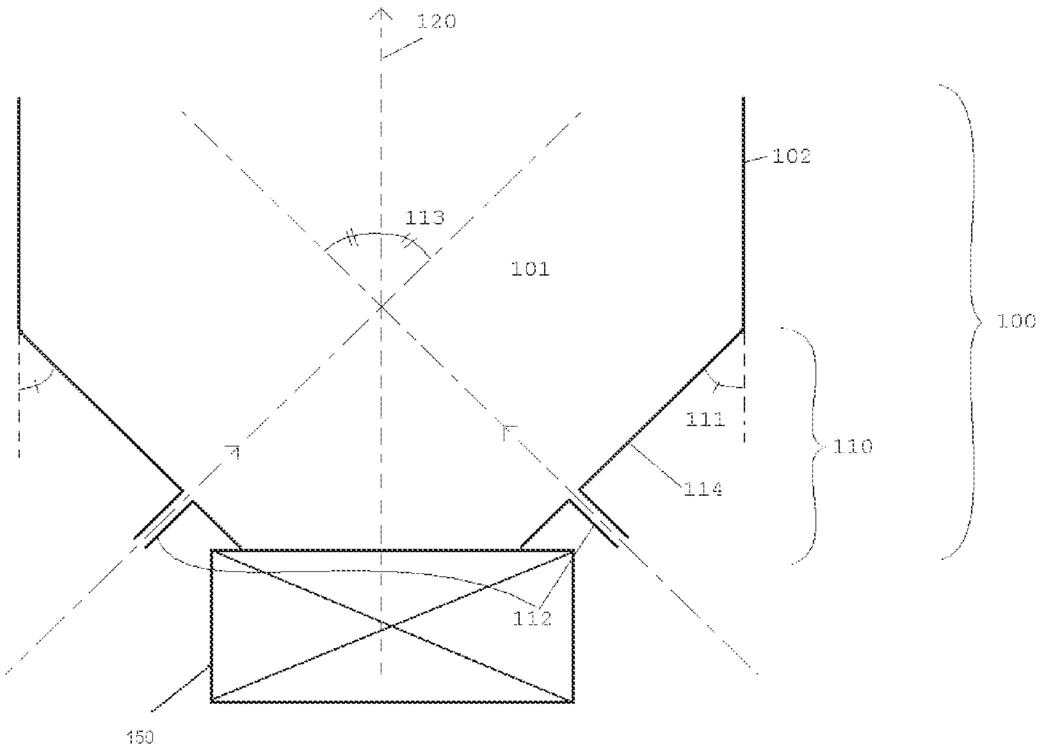
3. The coke drum assembly of Claim 2, wherein the feed pipe system includes a primary feed pipe and a plurality of branch feed pipes extending from the primary feed pipe, each branch feed pipe extending to a respective one of the feed inlets.

4. A method of delayed coking comprising:

directing a fluid stream from a refinery operation through the feed inlets of a coke drum assembly comprising a vessel having a cylindrical body portion defining an interior and a central axis, the vessel further having a conical lower portion including a sidewall which is angled upwardly at a wall angle relative to the central axis of the vessel; and

at least two feed inlets coupled with the lower portion in fluid communication with the interior of the vessel, the inlets being evenly spaced about the lower portion of the vessel around the central axis of the vessel and angled upwardly at a feed inlet angle relative the central axis which is less than or equal to the wall angle of the conical lower portion to be directed toward a common point along the central axis of the vessel.

AMENDED SHEET (ARTICLE 19)



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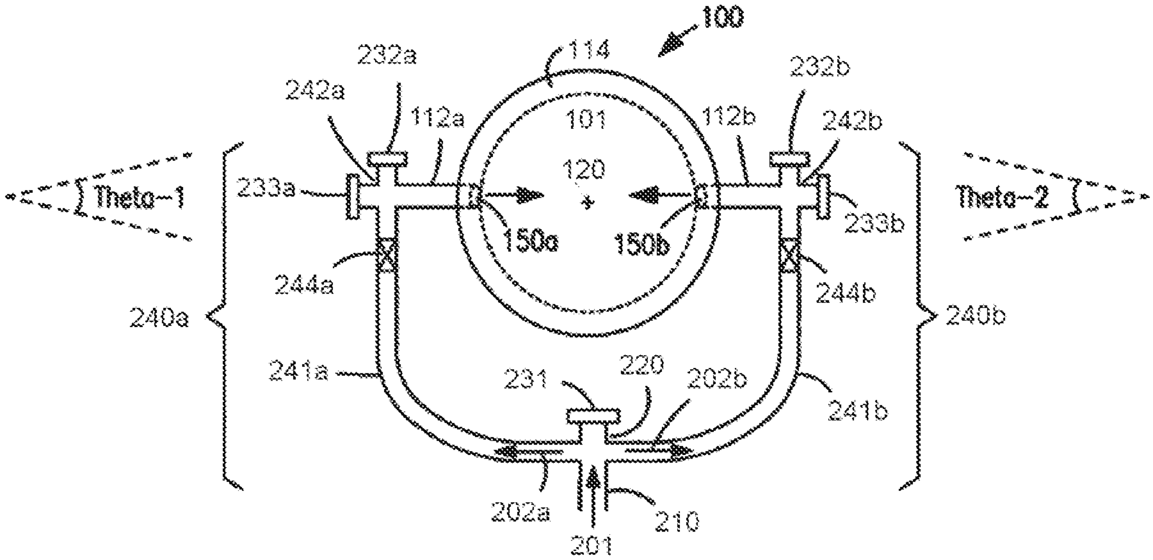
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FIG. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/068692

A. CLASSIFICATION OF SUBJECT MATTER
INV. ClOBl/04 C10B55/00
ADD.

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)
CIOB B01J

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)

EPO-Internal , COMPENDEX, WPI Data, API Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2 702 269 A (JULIUS GELLER) 15 February 1955 (1955-02-15) figure claims 1-3 column 2, line 73 - column 3, line 2 -----	1,3,7,9
X	US 2005/211540 Al (DE MEL0 GUERRA EDUARD0 C [BR] DE MEL0 GUERRA EDUARD0 CARDOSO [BR]) 29 September 2005 (2005-09-29) figures 2,3 paragraph [0113] claims 1-13 -----	1-11
A	US 7 736 470 B2 (CHEN TE-HUNG [US] ET AL) 15 June 2010 (2010-06-15) cited in the application -----	1-11

☐ 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

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"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
19 March 2013	27/03/2013

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2012/068692

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 2702269	A	15-02-1955	NONE		
US 2005211540	A1	29-09-2005	BR PI0400769	A	01-11-2005
			CN 1673318	A	28-09-2005
			FR 2868078	A1	30-09-2005
			JP 4756883	B2	24-08-2011
			JP 2005272836	A	06-10-2005
			US 2005211540	A1	29-09-2005
US 7736470	B2	15-06-2010	NONE		