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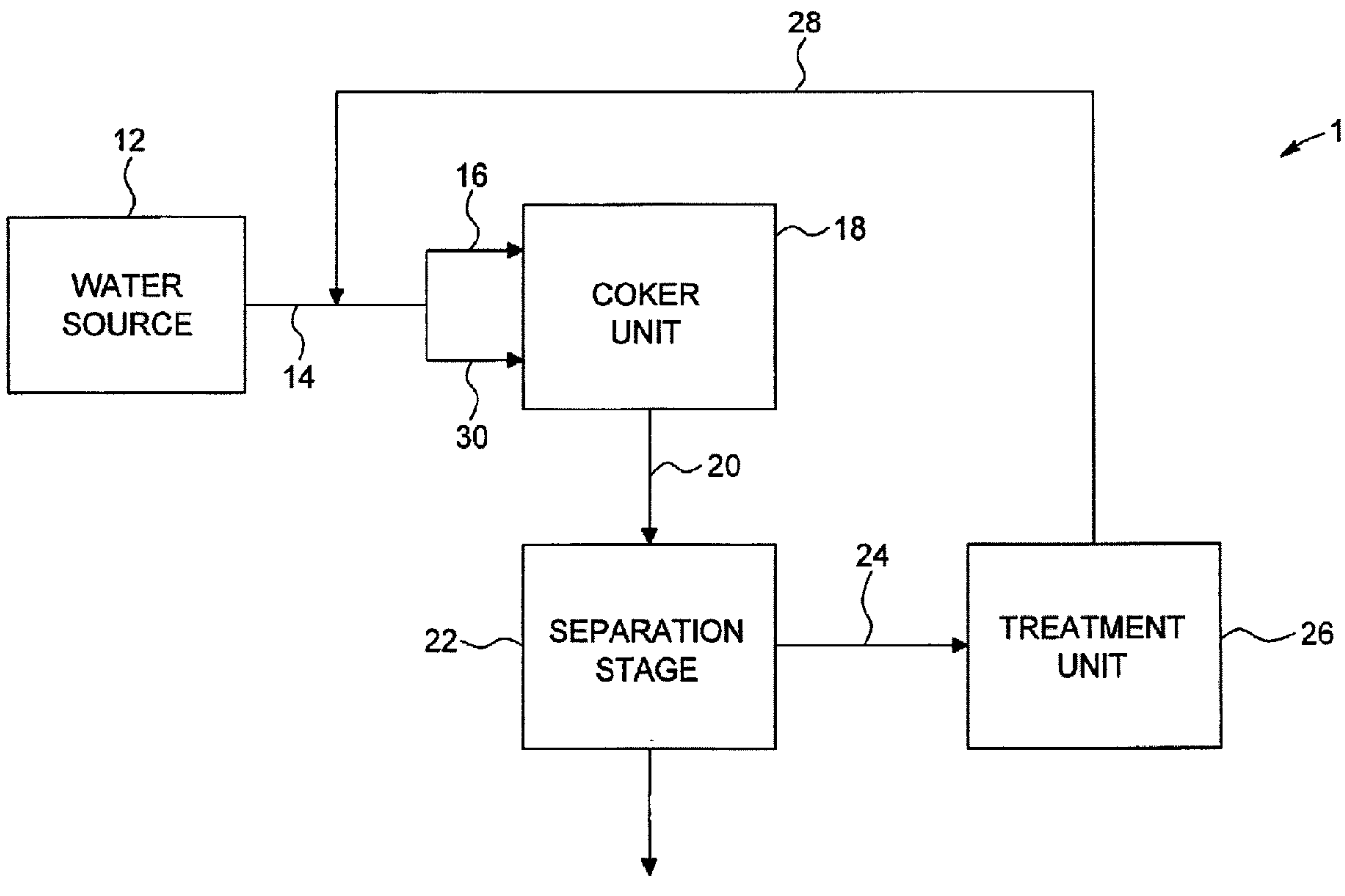
(54) **Title: RECYCLE OF COKER WATER FOR AN OIL SANDS BITUMEN COKING OPERATION**



(57) **Abrégé/Abstract:**
A process and system for recycling petroleum coke cutting water back into a petroleum coking operation using oil sand bitumen feedstock. Spent petroleum coke cutting water is subjected to settling followed by a treatment stage, to produce a solids reduced water stream having a pre-determined maximum target solids concentration. The treatment facilitates recycling of the cutting water back into the petroleum coking operation as petroleum coke cutting or quench water. The treatment stage includes either of hydrocycloning, sintered metal filtration, flotation or any combination thereof.

ABSTRACT

A process and system for recycling petroleum coke cutting water back into a petroleum coking operation using oil sand bitumen feedstock. Spent petroleum coke cutting water is subjected to settling followed by a treatment stage, to produce a solids reduced water stream having a pre-determined maximum target solids concentration. The treatment facilitates recycling of the cutting water back into the petroleum coking operation as petroleum coke cutting or quench water. The treatment stage includes either of hydrocycloning, sintered metal filtration, flotation or any combination thereof.

RECYCLE OF COKER WATER FOR AN OIL SANDS BITUMEN COKING OPERATION

TECHNICAL FIELD

The technical field relates to coking of oil sands bitumen based feedstocks as well as the use and recycling of water for the coking operation.

BACKGROUND

Bitumen upgrading facilities often include coker units that enable delayed coking of the bitumen feedstock. Coker units also require a relatively large quantity of water for certain steps in the coking process, e.g., coke quenching water and coke cutting water. Coke quenching water is used to cool the coker drums after the high temperature thermal cracking of the bitumen feedstock. When the bitumen derived coke is at a suitable temperature after cooling, coke cutting water is used to remove bitumen derived coke that has deposited within the coker drums from the thermal cracking.

Water for use in petroleum coker units has typically relied on nearby natural water sources such as rivers, or other sources of water. There are several drawbacks with relying on natural water sources as coke quench water or coke cutting water, including overall inefficient water usage.

In addition, spent water released from petroleum coker units has typically required active management, including distribution to different collecting and containment basins,. In a bitumen mining, extraction and upgrading plant, water management and containment have various challenges partly due to the quantity and variety of different water containing streams.

SUMMARY

Processes, systems, and techniques for recycling petroleum coke cutting water back into a petroleum coking operation are described.

There is provided a process including obtaining spent coker water from a coker unit configured to generate petroleum coke from an oil sands bitumen feedstock. The process also includes providing the spent coker water to a gravity settling basin to produce settled solid materials and supernatant water. The supernatant water is retrieved from the gravity settling basin, the supernatant water having an initial total suspended solids (TSS). The supernatant water is treated to produce a solids reduced water stream having a predetermined target TSS, wherein the treatment comprises hydrocycloning. At least a portion of the solids reduced water stream is recycled to the coker unit for use as coker quench water and/or coke cutting water.

The predetermined target TSS may be at most about 200 ppm on a monthly average.

The step of hydrocycloning may include providing a hydrocyclone. The hydrocyclone includes an inlet section, a first tapered conical section downstream of the inlet section and a second tapered conical section downstream of the first tapered conical section and having a smaller cone angle than the first tapered conical section. The hydrocycloning may include introducing the supernatant water into the inlet so that the supernatant water rotates about an axis of the hydrocyclone and passes through the conical sections, extracting finer solids through an overflow outlet in the inlet section and extracting coarser solids through an underflow outlet from the second tapered section.

The step of treating the supernatant water may further include filtration.

The filtration may include sintered metal filtration.

The filtration may include pressure leaf filtration.

The step of treating the supernatant water may further include flotation.

There is also provided a process including obtaining spent coker water from a coker unit configured to generate petroleum coke from an oil sands bitumen feedstock. The process also includes providing the spent coker water to a gravity settling basin to produce settled solid materials and supernatant water. The supernatant water is retrieved from the gravity settling basin, the supernatant water having an initial total suspended solids (TSS). The supernatant water is treated to produce a solids reduced water stream having a predetermined target TSS, wherein the treatment comprises sintered metal filtration. At least a portion of the solids reduced water stream is recycled to the coker unit for use as coker quench water and/or coke cutting water.

The sintered metal filtration may use sintered metal media in an inside-out filter configuration, wherein solid/liquid barrier separation occurs on an inside of a closed-end tubular filter element.

There is also provided a process including obtaining spent coker water from a coker unit configured to generate petroleum coke from an oil sands bitumen feedstock. The process also includes providing the spent coker water to a gravity settling basin to produce settled solid materials and supernatant water. The supernatant water is retrieved from the gravity settling basin, the supernatant water having an initial total suspended solids (TSS). The supernatant water is treated to produce a solids reduced water stream having a predetermined target TSS, wherein the treatment comprises flotation. At least a portion of the solids reduced water stream is recycled to the coker unit for use as coker quench water and/or coke cutting water.

The flotation may include dissolved air flotation.

The process may further include combining the solids reduced water stream with make-up water to form the coker quench water and/or coker cutting water.

The make-up water may be derived from a sewage effluent.

The make-up water may be derived from API separator effluent.

The process may further include supplying the solids reduced water stream to the coker unit as coker quench water and coker cutting water.

The initial TSS of the supernatant water may be at most 1000 ppm.

The step of treating the supernatant water may be performed to produce a solids reduced water stream having a particle size not exceeding about 1600 μm.

There is also provided a system including a coker feed water supply assembly for supplying cutting water and/or quenching water to a coker unit configured to generate petroleum coke from an oil sands bitumen feedstock. The system also includes a settling system for receiving spent coker water from the coker unit and subjecting the spent coker water to gravity settling to produce settled solid materials and supernatant water. The system also includes a treatment unit for treating the supernatant water to produce a solids reduced water stream having a predetermined target TSS, the treatment unit including a hydrocyclone. A treated water recycle assembly recycles at least a portion of the solids reduced water stream to the coker unit for use as coker quench water and/or coke cutting water.

The hydrocyclone may include an inlet section, a first tapered conical section downstream of the inlet section, a second tapered conical section downstream of the first tapered conical section and having a smaller cone angle than the first tapered conical section, an overflow outlet for extracting finer solids from the inlet section, and an underflow outlet for extracting coarser solids from the second tapered section. The supernatant water is introduced into the inlet so that the supernatant water rotates about an axis of the hydrocyclone and passes through the conical sections.

The treatment unit may further include a filtration device.

The filtration device may include a sintered metal filtration device.

The filtration device may include a pressure leaf filtration device.

The treatment unit may further include a flotation separator system.

There is also provided a system including a coker feed water supply assembly for supplying cutting water and/or quenching water to a coker unit configured to generate petroleum coke from an oil sands bitumen feedstock. The system also includes a settling system for receiving spent coker water from the coker unit and subjecting the spent coker water to gravity settling to produce settled solid materials and supernatant water. The system also includes a treatment unit for treating the supernatant water to produce a solids reduced water stream having a predetermined target TSS, the treatment unit including a sintered metal filtration device. A treated water recycle assembly recycles at least a portion of the solids reduced water stream to the coker unit for use as coker quench water and/or coke cutting water.

The sintered metal filtration device may include sintered metal media in an inside-out filter configuration, wherein solid/liquid barrier separation occurs on an inside of a closed-end tubular filter element.

There is also provided a system including a coker feed water supply assembly for supplying cutting water and/or quenching water to a coker unit configured to generate petroleum coke from an oil sands bitumen feedstock. The system also includes a settling system for receiving spent coker water from the coker unit and subjecting the spent coker water to gravity settling to produce settled solid materials and supernatant water. The system also includes a treatment unit for treating the supernatant water to produce a solids reduced water stream having a predetermined target TSS, the treatment unit including a flotation separator system. A treated water recycle assembly recycles at least a portion of the solids reduced water stream to the coker unit for use as coker quench water and/or coke cutting water.

The flotation separator system may include a dissolved air flotation separator.

The system may further include a make-up water source providing make-up water that is combined with the solids reduced water stream to produce a coker feed water for use as the coke quench water and/or coke cutting water.

The make-up water source may include a sewage effluent.

The make-up water source may include an API separator effluent.

The coker feed water supply assembly may include a quench water supply assembly and a cutting water supply assembly.

The treatment unit may be configured to produce the solids reduced water stream having a particle size not exceeding about 1600 μm.

The gravity settling system may include at least one settling basin.

The gravity settling system may include a surge pit for receiving the spent coker water and producing an overflow stream, a sump for receiving the overflow stream from the surge pit, and at least one settling basin for receiving water from the sump and allowing further setting of particles entrained in the water.

In some implementations, there is provided a process comprising:

obtaining spent coker water from a coker unit configured to generate petroleum coke from an oil sands bitumen feedstock;

subjecting the spent coker water to a gravity settling stage to produce settled solid materials and supernatant water;

retrieving the supernatant water from the gravity settling stage, the supernatant water having an initial total suspended solids (TSS);

subjecting a feedwater stream comprising the supernatant water to flotation to produce a solids reduced water stream having a reduced TSS; and

recycling at least a portion of the solids reduced water stream to the coker unit for use as coker quench water and/or coker cutting water.

It is also noted that the feed water stream can include the supernatant water and an additional water stream.

BRIEF DESCRIPTION OF DRAWINGS

Fig 1 is a block diagram of a system.

Fig 2 is another block diagram of a system.

Fig 3 is a process flowchart.

DETAILED DESCRIPTION

Techniques for recycling petroleum coke cutting water back into a petroleum coking operation are described. Spent petroleum coke cutting water is subjected to settling followed by a treatment stage, to produce a solids reduced water stream having a pre-determined maximum target solids concentration. The treatment facilitates recycling of the cutting water back into the petroleum coking operation as petroleum coke cutting or quench water.

Water used in different stages of the petroleum coking operation should meet certain quality criteria. Water containing certain components may be inappropriate for use as coke quench water and/or coke cutting water. For example, water containing suspended solids may cause abrasion and/or fouling in pipelines, equipment or fittings. The concentration and size of solids in water used for various coking operations may be reduced or limited to enhance operations.

In the context of petroleum coking operations, the bitumen feedstock may contain components that result in spent coke waters that are relatively high in undesirable compounds, such as suspended solids, as compared to the spent coke water from a coker unit receiving a conventional oil feedstock. The undesirable compounds may come from the coking of the bitumen itself or from the upstream extraction processes that use chemical addition to extract the bitumen from the oil sands ore.

Suspended solids from cokers using oil sands bitumen feedstock have a higher mineral content, and can therefore be more abrasive, than those at cokers receiving conventional oil feedstock because of carryover of non-petroleum solids with the bitumen. Although the mineral content of the coke is higher than that from other delayed cokers, the coke particles are highly concentrated in carbon, with some hydrocarbon. The carbon and hydrocarbon are much less abrasive than mineral solids would be. Although the rate of wear of the cutting nozzles can vary with the concentration of coke suspended solids in the cutting water, high pressure nozzles such as those used for coke cutting can show significant wear from water flow alone. With worn nozzles, a cutting water jet is more spread and does not cut as cleanly, and therefore takes longer to cut out the coke. A worn nozzle with a diffuse jet tends to produce more suspended particles, increasing the suspended particles load in downstream uses of the spent coker water. Keeping the fines concentration of the recycled water low helps minimize these issues.

Referring to Fig 1, in some implementations a petroleum coking with water recycling system 10 includes a water source 12 from which a source water stream 14 is retrieved and supplied as coke cutting water 16 to a petroleum coker unit 18. The petroleum coke cutting operation produces a spent cutting mixture 20 that is released from the coker unit 18 and subjected to a gravity separation stage 22.

The gravity separation stage 22 receives the spent cutting mixture 20 that includes petroleum coke and water. The gravity separation stage 22 may include one or more basins for separating the petroleum coke from the water. In some implementations, the petroleum coke settles to the bottom of a basin and supernatant water 24 may be retrieved from the gravity separation stage 22.

Still referring to Fig 1, the supernatant water 24 is fed to a treatment unit 26 for further removal of undesired compounds from the water in order to produce a recycle water stream 28. In some implementations, the treatment unit 26 is configured to provide solids removal treatment to reduce the total suspended solids (TSS) of the supernatant water 24 to below a pre-determined maximum target value, such as 200 ppm on average on a monthly basis. In some implementations, the treatment unit includes at least a hydrocyclone. In other implementations, the treatment unit includes at least a sintered metal filtration device. In yet other implementations, the treatment unit includes at least a dissolved air flotation separator. In yet other implementations, any of the above-described treatments may be used in combination with each other. Moreover, the treatment unit may also include other treatments.

The resulting treated water may be used to form a recycle water stream 28 that is fed back as petroleum coker water. The recycle water stream 28 may be added to the source water stream 14 and/or another make-up water stream in order to provide a petroleum coker water, which may be used as coke cutting water 16 and/or coke quenching water 30.

Fig 3 is a process flowchart of a process for supplying water to a petroleum coker unit and then treating spent water for recycle back into the petroleum coker unit. The process includes supplying cutting water and/or quenching water to the coker unit (Step 100). The coker unit produces spent coker water including water and particulate solids that can be retrieved for further processing (Step 102). The spent coker water is then subjected to a settling process to produce a mix of settled particulate solids and supernatant water including residual suspended solids (Step 104). The supernatant water is retrieved and treated with a suspended solids removal treatment to produce a solids reduced water stream 18 (Step 106). The resulting solids reduced water stream has a total suspended solids concentration no greater than a predetermined target concentration, for example about 200 ppm (0.02 wt% solids) average on a monthly basis with a particle size of less than 1600 μm. The solids reduced water stream 16 is fed to the coker unit as coker quench water and/or cutting water (Step 108). Such a process thus reduces the demand for other external sources of water for bitumen coking operations.

The suspended solids removal treatment removes impurities in spent coker water, as upgrading of oil sands bitumen results in spent coker water having a higher level of suspended particulate matter than in more traditional hydrocarbon upgrading processes. If the spent coker water is not properly treated, damage may be caused to coker unit components and accumulation of impurities may occur in the recycle system. Using an approximate 200 ppm TSS threshold and a particle size of less than 1600 μm helps reduce such possible damage resulting from abrasion of coker unit components. Smaller particle sizes have been found to cause less material erosion and thus a greater proportion of such smaller solid particles may be allowed to remain in the recycle stream.

In some implementations, the process can reduce an amount of wastewater from a bitumen coking process which would otherwise be supplied, for example, to an effluent pond or a tailings system. For instance, wastewater originating from a coker unit that is not recycled and fed into an effluent pond may be diverted to a tailings pond, via pumps. In the long term, this water diversion accumulates in the tailings ponds resulting in loss of tailings containment capacity. Treatment and recycling of spent coker water can reduce or eliminate the required diversion of wastewater to effluent or tailings ponds.

Recycling coking wastewater as coker quench water can also offset demands for fresh water usage. If this fresh water is supplied from an adjacent body of natural water, demands on such sources may be reduced or maintained within limits that are set to minimize impacts on the environment.

Additional details for some implementations will be described further below.

Supplying of petroleum coker water

Referring to Fig 2, the water for use as petroleum coker water may be retrieved from the water source 12 using a retrieval pump 32. The water source 12 may include a fresh water source (e.g. a natural body of water) and/or another water source, e.g. a cooling water pond or API separator water 34 retrieved from an API separator or associated pond 36. The source water stream 14 may be combined with other water sources as well as the recycle water stream 28 to form a coker feed water 38, which may be supplied to the coker unit 18 via one or more supply pumps 40a, 40b, 40c.

The coker feed water 38 may be provided for use as coker quench water and/or coker cutting water 18.

Bitumen coking operations

In some implementations, the coker feed water 38 is provided as coker cutting water 18 for cutting out the petroleum coke that has deposited within the coker drums of the coker unit 18. The resulting spent cutting mixture 20 includes water and bitumen derived coke.

Regarding bitumen coking operations, the coker unit 18 typically includes one or more pairs of coker drums. In Fig 2, the coker drum pairs 42a, 42b, 42c are illustrated as a single entity, but it should be understood that they are operated in tandem. In general, while one of the coking drums is in thermal coking operation mode, the other coking drum undergoes quenching and cutting for petroleum coke cooling and removal followed by preparation for its next coking stage. A first coker drum may be initially heated by an adjacent drum that is already in its coking stage. When the coking drum reaches an adequate or pre-selected temperature (which may be nominally 900°F), it may be ready to receive a bitumen charge from a coker furnace. In the operating drum, the bitumen undergoes thermal cracking which yields light hydrocarbons in the form of a coking product vapour and petroleum coke that remains in the coker drum. The coking product vapour is sent to a fractionator, which can fractionate out various different hydrocarbon product streams. At this point, the operating drum contains some porous bitumen and coke.

Water is then introduced into the drum for quenching purposes. The quenching may include an initial stage of quench-steaming following by quench-soaking. The quench-steaming stage includes adding quench water into the coker drum at a flowrate such that the high temperature of the coker drum causes most of the quench water to be converted to steam. The resultant steam may strip additional hydrocarbons from the pores of the bitumen remaining in the coker drum. During the quench-steaming stage, the mixture of steam and effluent vapours may continue to be sent into the fractionator to continue recovering as much high value hydrocarbon products as possible. Afterwards, during the quench-soaking stage, more quenching water may be added at higher flowrates into the coker drum to further reduce the temperature of the coker drum and prepare the drum for coke cutting and cleaning.

For example, each coker quenching cycle may last approximately 4 hours per coker drum. Depending on how many coker drum pairs are used in a given coking operation, quenching may be done on multiple coker drums at a time (e.g. one per pair). During the quench-steaming stage, quenching may be initiated with a flow of about 300 USGPM for about 55 minutes. Then, the quench water flow may be increased at a rate of about 7.5 USGPM/min for 85 minutes, reaching a final flow rate of about 3,200 USGPM, which may be held for an additional 50 minutes. During this time, the quench water is retained in the drum and exposed to high temperature for extended time. The retained quenching water may be retained for sufficient time to reduce the temperature of the coker drum to a pre-determined level and then the water may be released as a spent quench water stream. Draining spent quench water from the coker drum may take several hours. Much of the quenching water is thus lost to evaporation, while some quenching water that still remains in the coker drum. In some implementations, approximately 25% of coke quench recycle water may be lost to steam and recovered as sour water and the remaining water flows out with the coke cutting water during draining and cutting operations.

Following the quenching operation, coke cutting water is used to hydraulically cut the deposited petroleum coke from the coker drum and the resulting spent cutting mixture 20 includes water and a relatively high amount of petroleum coke.

In some implementations, the spent cutting mixture 20 may be released via a water release system that may be configured to combine multiple spent cutting mixture streams 20a, 20b, 20c to a single gravity separation stage 22, or the different streams may be fed individually into the gravity separation stage 22.

Gravity separation stage for spent coke water

Referring still to Fig 2, the spent cutting mixture 20 is fed to the gravity separation stage 22 in order to separation the water from the petroleum coke.

In some implementations, the gravity separation stage 22 may include a single settling basin 44 that receives the entire spent cutting mixture 20. The petroleum coke fraction settles to the bottom of the settling basin 44 while the supernatant water 24 may be recovered using a water recovery assembly including a supernatant water pump 46 coupled to a pipeline having an inlet that may be arranged in the setting basin 44. The inlet may be arranged within the settling basin 44 to facilitate retrieval of supernatant water with low petroleum coke content, e.g. by locating the inlet away from bottom of the settling basin and away from the feed of spent cutting mixture 20. In this scenario, the single settling basin 44 may be sized and configured to receive the spent cutting water output from the coker unit and to allow sufficient residence time and depth to facilitate settling of the petroleum coke solid fraction and forming a supernatant water layer that can be retrieved. In some implementations, the gravity separation stage 22 may include a surge pit and sump arrangement 48, where the surge pit receives the spent cutting mixture 20 and allows the petroleum coke to settle out and an overflow stream flows into the sump. The water 52 in the sump is then pumped to a second stage settling basin 54 where some additional petroleum coke entrained with the overflow stream 52, which may be finer than the coke removed in the surge pit, may settle out to form a settled coke bottoms and supernatant water 24.

It should be understood that the gravity separation stage 22 may include one of more single settling basins 44 arranged in parallel, one or more two-basins 48, 54 configurations arranged in parallel, or one or more single settling basin 44 and one or more two-basins 48, 54 provided to receive spent coker water 20 from a given coker unit 18. The supernatant water from each operating basin may then be fed to the treatment unit 26.

In some implementations, the settling basins 44, 54 may be provided with sufficient retention time to facilitate settling conditions to produce supernatant water 24 that can be efficiently treated and recycled. The settling basins 44, 54 may also be provided with baffles in order to increase system capacity.

Treatment of supernatant water

Due to the composition and processing of bitumen feedstocks, the spent coker waters produced during coking operations include a relatively higher concentration of certain components compared to waters derived from traditional hydrocarbon coking. Some of the components, such as suspended solids can remain in the water phase even after the spent coker waters have been subjected to settling to separation the petroleum coke from the water.

Bitumen feedstock obtained from oil sands is different from traditional hydrocarbon feedstocks processed by coking operations, notably in that oil sands bitumen tends to include higher concentrations of inorganic and organic solids that have a higher mineral content, and can therefore be more abrasive. These solids accumulate in the petroleum coke at higher levels than normal. Since such solids can cause a number of problems in process streams and equipment, especially at higher concentrations, an additional removal treatment to reduce the solids content below a threshold facilitates recycling of the coker water in bitumen coking operations. However, allowing spent coker water to merely settle to separate solid materials from supernatant water without any further treatment will not produce water of sufficient quality for use in the coker unit.

Since oil sands ore includes a relatively high amount of solids–including sand, silt and clay,bitumen feedstocks and petroleum coke derived from the ore include solids that are much more abrasive in nature than in conventional hydrocarbon upgrading operations. In addition, some of the solids may be fine particulates, such as clays, that do not readily settle out under the influence of gravity. Thus, while some larger solids, such as sand or coke particles, are more easily separable by gravity settling, other solids may not be removed in this manner.

The supernatant water 24 obtained from the gravity separation stage 22 may include a TSS concentration of 1000 ppm or higher. Referring to Fig 2, in some implementations the supernatant water 24 is fed to a treatment unit 26 for subjecting the supernatant water to a suspended solids removal treatment to produce a solids reduced water stream having a TSS concentration 200 ppm or below on average on a monthly basis. The treatment unit 26 may also be configured and operated to achieve certain particle size characteristics, e.g. a particle size less than 1600 μm.

To achieve the above-described water quality, different systems can be used as treatment units. In some implementations, a hydrocyclone is used. The hydrocyclone includes an inlet section, a first tapered conical section downstream of the inlet section and a second tapered conical section downstream of the first tapered conical section and having a smaller cone angle than the first tapered conical section. The design of the outer wall of the inlet section separates the feed solids prior to entering the main body of the cyclone and conical sections. The outer wall and surroundings define a passageway extending along a downwardly inclined volute path. This inlet design reduces turbulence. Finer solids are extracted through an overflow outlet in the inlet section and coarser solids are extracted through an underflow outlet from the second tapered section. The configuration of the first and second tapered conical sections increases tangential velocity in the first section of the hydrocyclone, while providing a long residence time in the separation zones in the second section of the hydrocyclone. This helps reduce the amount of fines in the underflow from the hydrocyclone. The above-described design of the hydrocyclone accomplishes a better reduction of total suspended solids in coker cutting water derived from the processing of oil sands bitumen feedstock, than other types of hydrocyclones. One example hydrocyclone that incorporates the inlet and cone design features is the KrebsTM gMAX1-3232 and gMax1-M1 model hydrocyclone, having a 1" inlet/outlet, with a capacity of 5 GPM at 20 psi differential pressure.

In other implementations, the treatment unit 26 includes a sintered metal filtration device. The sintered metal filtration device includes sintered metal media in an inside-out filter configuration, wherein solid/liquid barrier separation occurs on an inside of a closed-end tubular filter element. At the end of each filtration cycle, solids are backwashed off the inside of the filter elements and discharged as a concentrated slurry or wet cake. One example sintered metal filtration device that incorporates an inside-out filter configuration is the Mott™ 12" Automated Hypulse™ LSI Filter system, including fourteen 2" diameter x 70" long Grade 0.5 micron filter elements, with a 40.7 ft^2 filter surface area with an initial feed flow rate of approximately 8-10 GPM.

In yet other implementations, the treatment unit 26 includes a dissolved air flotation (DAF) separator. A mix of the supernatant water and aerated recycle flow are introduced at the bottom side of the unit. The mixed flow is distributed to individual Floatation Enhancement Cells (FECs) within the flotation tank. The FECs provides even distribution of the flow across the separator. Retention time within the unit will vary with the amount of the solids reduced water stream being processed. Flocculated particles attach to the aerated water and rise to the surface close to the plate inside the FEC. The solids reduced water is drawn back down between the FECs to a collection area below the bottom of the FECs. The solids reduced water flows up over a divider plate at the top of the tank, into a reservoir and is then discharged by gravity out of the unit. A portion of the flow is captured and "recycled" back to an Air Dissolving Tube (ADT). This recycled water from the ADT is introduced at the bottom of the unit, to be combined with the untreated supernatant water. Floated materials are collected at the top of the FECs and directed towards a sludge collection rake assembly. The rake pushes the floated material over a simple beach design and deposits the material into a small sludge collection trough that is discharged by gravity. Grit or other debris, which do not float, are collected in a bottom of the unit. An example DAF separator is the Krofta Technologies Corporation Multifloat DAF MFV-2000 unit with a hydraulic capacity at 1000mg/L of TSS of 1500 US GPM.

In some implementations, the treatment unit 26 may also include any combination of the above-described treatment devices, including a hydrocyclone, a sintered metal filtration device and a dissolved air flotation separator. Additional filtration devices or systems may be used also, including a pressure leaf filtration device. One or more of the above devices may be used in combination, in parallel and/or series, and are sized, configured and operated to achieve the pre-determined TSS and particle size criteria for the treated water stream 28 that is used for recycle into the bitumen coking operation.

In some implementations, the recycled water 28 that is used as coker quench water has a certain level of quality with respect to its contents. For example, the recycled coker quench water quality criteria may include the following: Total Suspended Solids < 200 ppm, Particle Size < 1600 μm, chloride concentration < 400 ppm, NH_3 concentration < 30 ppm, Total Dissolved Solids < 1000 ppm and H_2S concentration < 20 ppm.

It should be understood that the water criteria may be modified depending on the water quality and flow rates of other streams that may be combined with the recycled stream 28. For example, the TSS and particle size limits may be decreased if other water streams are of lower quality and, conversely, the TSS and particle size limits may be increased if other water streams are of higher quality.

In some scenarios, the treatment unit 26 may be configured and operated to maximize settling. The treatment unit aims to produce a target inlet TSS is about 1,000 ppm.

Recycling of treated water as coker quench or cutting water

Referring still to Fig 2, the treated recycle water 28 may be supplied to a storage tank 58. Alternatively, the treated recycle water may be sent to the water source 12 such as a cooling water pond. The storage tank 58 may be configured and operated for receiving multiple water source streams, such as API separator water 34, fresh make-up water, and/or other sources of water. The storage tank may be configured for blending the different water sources, particularly in the case where the different water sources vary in composition or quality, in order to provide a consistent blend as coker water.

In some implementations, the storage tank provides a final water stream 60 that may be combined with the source water stream 14 to make up the coker feed water 38, as illustrated.

In some scenarios, the coker feed water 38 may be used to supply a pre-determined amount of water to the coker unit 18 in order to meet the requirements of coke quenching and coke cutting. The flow rate of coker feed water 38 will of course depend on the size and operating parameters of the coker unit 18. In some implementations, the flow rate of the coker feed water 38 may be composed of about 50% to 80% of the final water stream 60 The remaining 50% to 20% of the coker feed water 38 flow may include make-up water 14 that is of high quality.

In some implementations, the proportion of recycle water used as part of the coker feed water 38 may be managed in accordance with TSS, and/or D90 concentration present in the recycle water.

In some implementations, make-up water is combined with the recycle water 28 to provide the coker feed water 38. The make-up water is required due water losses in the petroleum coking operation, such as water losses to the petroleum coke, sour water, and evaporation during the coke quench phases. The make-up water represents additional water to meet cutting/quench water demands of the bitumen coking operation. Make-up water may be from various water sources including storm and/or industrial sewers (e.g. in a proportion of about 5% to 10%) and/or a blow-down water recovery system (e.g. in a proportion of about 30% to 40%) and/or an API separator effluent.

Referring still to Fig 2, an equalization tank 62 may also be used upstream and/or downstream of the treatment unit 26 due to the variable flow and water quality of the coke quench and cutting cycles. The equalization tank 62 may be sized, configured and operated in order to provide relatively constant feed composition and flow rate into the treatment unit 26.

The techniques described herein facilitate efficient water usage in a petroleum coking operation. If coke cutting water was not recycled, the spent cutting water would be directed to wastewater ponds. Recycling of the spent cutting or quenching water helps avoid these discharges to natural bodies of water. This reduces overall fresh water requirements and reduce wastewater flow to effluent ponds.

In some implementations, a cutting water supplying assembly may be provided for supplying a portion of the solids reduced water stream to the coker unit as coker cutting water to cut coke from the coker unit. For example, piping containing the solids reduced water stream that is directed towards the quench water system may be connected to with a split to make the solids reduced water stream available for the coke cutting water system.

Various modifications may be made to the disclosed implementations and still be within the scope of the following claims.

CLAIMS

1. A process comprising:

   obtaining spent coker water from a coker unit configured to generate petroleum coke from an oil sands bitumen feedstock;

   providing the spent coker water to a gravity settling basin to produce settled solid materials and supernatant water;

   retrieving the supernatant water from the gravity settling basin, the supernatant water having an initial total suspended solids (TSS);

   treating the supernatant water to produce a solids reduced water stream having a predetermined target TSS, wherein the treating comprises flotation; and

   recycling at least a portion of the solids reduced water stream to the coker unit for use as coker quench water and/or coker cutting water.

2. The process according to claim 1, wherein the predetermined target TSS is at most 200 ppm on a monthly average.

3. The process according to claim 1 or 2, wherein the flotation comprises dissolved air flotation.

4. The process according to any one of claims 1 to 3, wherein the step of treating the supernatant water further comprises hydrocycloning.

5. The process according to claim 4, wherein the hydrocycloning comprises:

   providing a hydrocyclone comprising:

      an inlet section;

      a first tapered conical section downstream of the inlet section; and a second tapered conical section downstream of the first tapered conical section and having a smaller cone angle than the first tapered conical section;

introducing the supernatant water into the inlet so that the supernatant water rotates about an axis of the hydrocyclone and passes through the conical sections;

extracting finer solids through an overflow outlet in the inlet section; and

extracting coarser solids through an underflow outlet from the second tapered section.

6. The process according to any one of claims 1 to 5, wherein the step of treating the supernatant water further comprises filtration.

7. The process according to claim 6, wherein the filtration comprises sintered metal filtration.

8. The process according to claim 6 or 7, wherein the filtration comprises pressure leaf filtration.

9. The process according to any one of claims 1 to 8, further comprising combining the solids reduced water stream with make-up water to form the coker quench water and/or coker cutting water.

10. The process according to claim 9, wherein the make-up water is derived from a sewage effluent.

11. The process according to claim 9, wherein the make-up water is derived from API separator effluent.

12. The process according to any one of claims 1 to 11, further comprising supplying the solids reduced water stream to the coker unit as coker quench water and coker cutting water.

13. The process according to any one of claims 1 to 12, wherein the initial TSS of the supernatant water is at most 1000 ppm.

14. The process according to any one of claims 1 to 13, wherein the step of treating the supernatant water is performed to produce the solids reduced water stream having a particle size not exceeding 1600 μm.

15. The process of any one of claims 1 to 14, further comprising combining the supernatant water and an additional water stream to form a combined water stream prior to flotation.

16. The process of claim 15, wherein the additional water stream is an aerated water stream.

17. The process of claim 16, wherein the aerated water stream is a recycled aerated water stream.

18. The process of claim 17, wherein the recycled aerated water stream is derived from the solids reduced water stream.

19. The process of claim 18, wherein the recycled aerated water stream is a portion of the solids reduced water stream.

20. The process of claim 15, wherein the additional water stream has a lower solids content compared to the supernatant water.

21. The process of claim 20, wherein the additional water stream is a portion of the solids reduced water stream.

22. The process of any one of claims 15 to 21, wherein the combined stream is supplied into a flotation separator.

23. The process of claim 22, wherein the combined stream is introduced into the flotation separator at a bottom thereof.

24. The process of claim 22 or 23, wherein the flotation separator is a dissolved air flotation separator comprising a flotation tank.

25. The process of claim 24, further comprising distributing the combined stream to flotation enhancement cells located within the flotation tank.

26. The process of any one of claims 22 to 25, wherein the flotation separator comprises a sludge collection rake assembly for separating floated material into a sludge collection unit.

27. A system comprising:

a coker feed water supply assembly for supplying cutting water and/or quenching water to a coker unit configured to generate petroleum coke from an oil sands bitumen feedstock;

a settling system for receiving spent coker water from the coker unit and subjecting the spent coker water to gravity settling to produce settled solid materials and supernatant water;

a treatment unit for treating the supernatant water to produce a solids reduced water stream having a predetermined target TSS, the treatment unit comprising a flotation separator system; and

a treated water recycle assembly for recycling at least a portion of the solids reduced water stream to the coker unit for use as coker quench water and/or coker cutting water.

28. The system according to claim 27, wherein the predetermined target TSS is at most 200 ppm on a monthly average.

29. The system according to claim 27 or 28, wherein the flotation separator system comprises a dissolved air flotation separator.

30. The system according to any one of claims 27 to 29, wherein the filtration device further comprises a hydrocyclone.

31. The system according to claim 30, wherein the hydrocyclone comprises:

an inlet section;

a first tapered conical section downstream of the inlet section;

a second tapered conical section downstream of the first tapered conical section and having a smaller cone angle than the first tapered conical section;

an overflow outlet for extracting finer solids from the inlet section; and an underflow outlet for extracting coarser solids from the second tapered section,

wherein the supernatant water is introduced into the inlet so that the supernatant water rotates about an axis of the hydrocyclone and passes through the conical sections.

32. The system according to any one of claims 27 to 31, wherein the treatment unit further comprises a filtration device.

33. The system according to claim 32, wherein the filtration device comprises a sintered metal filtration device.

34. The system according to claim 32 or 33, wherein the filtration device comprises a pressure leaf filtration device.

35. The system according to any one of claims 27 to 34, further comprising a make-up water source providing make-up water that is combined with the solids reduced water stream to produce a coker feed water for use as the coker quench water and/or coker cutting water.

36. The system according to claim 35, wherein the make-up water source comprises a sewage effluent.

37. The system according to claim 35 or 36, wherein the make-up water source comprises an API separator effluent.

38. The system according to any one of claims 27 to 37, wherein the coker feed water supply assembly comprises a quench water supply assembly and a cutting water supply assembly.

39. The system according to any one of claims 27 to 38, wherein the initial TSS of the supernatant water is at most 1000 ppm.

40. The system according to any one of claims 27 to 39, wherein the treatment unit is configured to produce the solids reduced water stream having a particle size not exceeding 1600 μm.

41. The system according to any one of claims 27 to 40, wherein the gravity settling system comprises at least one settling basin.

42. The system according to any one of claims 27 to 41, wherein the gravity settling system comprises:

a surge pit for receiving the spent coker water and producing an overflow stream;

a sump for receiving the overflow stream from the surge pit; and

at least one settling basin for receiving water from the sump and allowing further setting of particles entrained in the water.

43. A process comprising:

obtaining spent coker water from a coker unit configured to generate petroleum coke from an oil sands bitumen feedstock;

subjecting the spent coker water to a gravity settling stage to produce settled solid materials and supernatant water;

retrieving the supernatant water from the gravity settling stage, the supernatant water having an initial total suspended solids (TSS);

subjecting a feedwater stream comprising the supernatant water to flotation to produce a solids reduced water stream having a reduced TSS; and

recycling at least a portion of the solids reduced water stream to the coker unit for use as coker quench water and/or coker cutting water.

44. The process according to claim 43, wherein the flotation is operated such that the reduced TSS of the solids reduced water stream is at most 200 ppm on a monthly average.

45. The process according to claim 43 or 44, wherein the flotation comprises dissolved air flotation.

46. The process according to any one of claims 43 to 45, further comprising combining the solids reduced water stream with make-up water to form the coker quench water and/or coker cutting water.

47. The process according to claim 46, wherein the make-up water is derived from a sewage effluent.

48. The process according to claim 46, wherein the make-up water is derived from API separator effluent.

49. The process according to any one of claims 43 to 48, further comprising supplying the solids reduced water stream to the coker unit as coker quench water and coker cutting water.

50. The process according to any one of claims 43 to 49, wherein the initial TSS of the feedwater stream comprising the supernatant water is at most 1000 ppm prior to the flotation.

51. The process according to any one of claims 43 to 50, wherein the flotation of the feedwater stream is performed to produce the solids reduced water stream having a particle size not exceeding 1600 μm.

52. The process of any one of claims 43 to 51, further comprising combining the supernatant water and an additional water stream to form the feedwater stream prior to the flotation.

53. The process of claim 52, wherein the additional water stream is an aerated water stream.

54. The process of claim 53, wherein the aerated water stream is a recycled aerated water stream.

55. The process of claim 54, wherein the recycled aerated water stream is derived from the solids reduced water stream.

56. The process of claim 55, wherein the recycled aerated water stream is a portion of the solids reduced water stream.

57. The process of claim 52, wherein the additional water stream has a lower solids content compared to the supernatant water.

58. The process of claim 57, wherein the additional water stream is a portion of the solids reduced water stream.

59. The process of any one of claims 52 to 58, wherein the feedwater stream is supplied into a flotation separator.

60. The process of claim 59, wherein the feedwater stream is introduced into the flotation separator at a bottom thereof.

61. The process of claim 59 or 60, wherein the flotation separator is a dissolved air flotation separator comprising a flotation tank.

62. The process of claim 61, wherein the flotation separator comprises flotation enhancement cells located within the flotation tank, and the feedwater stream is fed to the flotation enhancement cells for distribution within the flotation tank.

63. The process of any one of claims 60 to 62, wherein the flotation separator comprises a sludge collection rake assembly for separating floated material into a sludge collection unit.

64. The process of any one of claims 43 to 63, wherein the flotation is operated to achieve predetermined TSS and particle size criteria for the solids reduced water stream prior to recycling as coker quench water and/or coker cutting water.

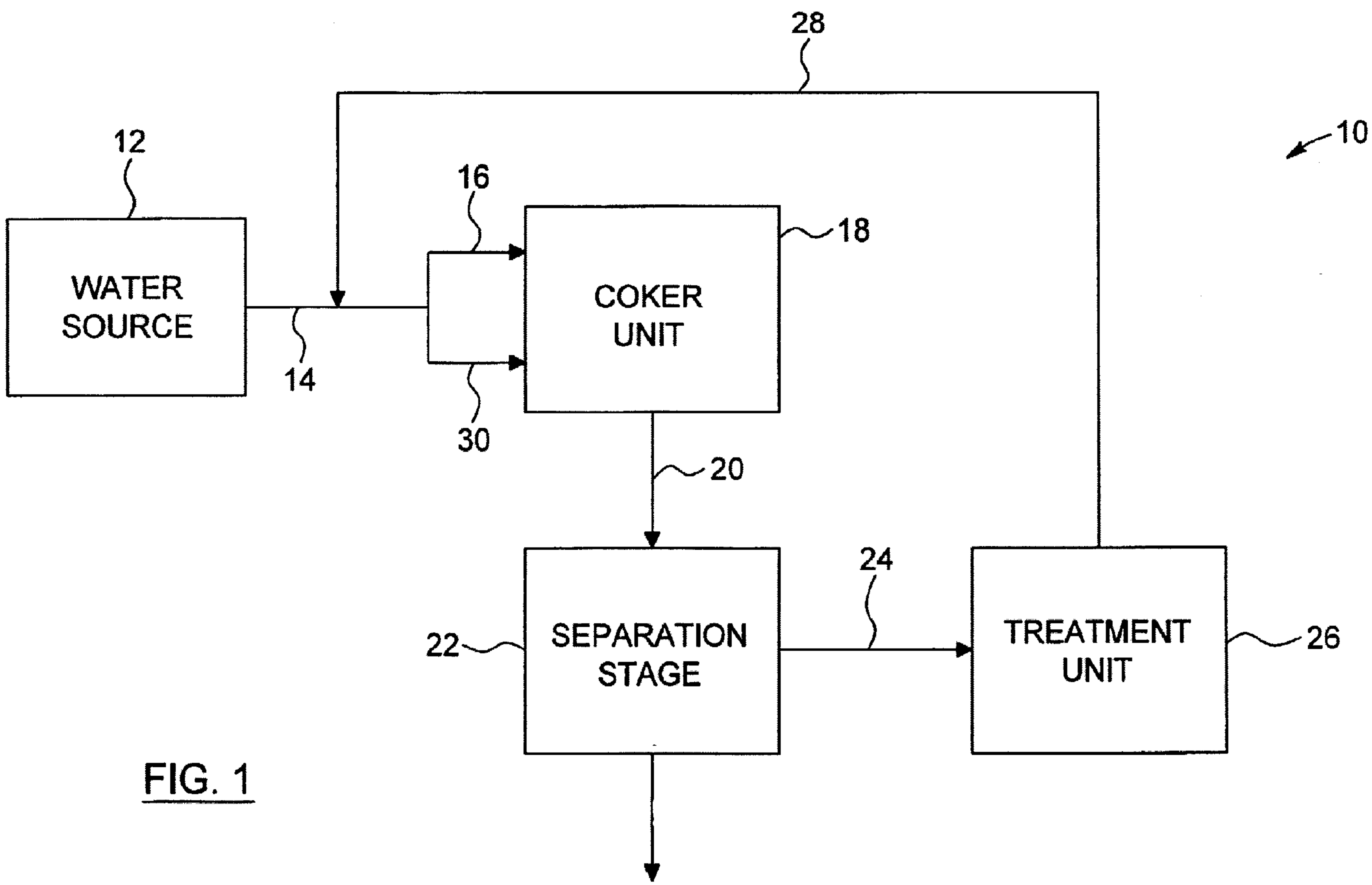
65. The process of any one of claims 43 to 64, wherein subjecting the spent coker water to the gravity settling stage comprises supplying the spent coker water into at least one gravity settling basin.

66. The process of any one of claims 43 to 64, wherein subjecting the spent coker water to the gravity settling stage comprises supplying the spent coker water into a single gravity settling basin and the supernatant water is retrieved therefrom.

67. The process of any one of claims 43 to 64, wherein subjecting the spent coker water to the gravity settling stage comprises:

supplying at least a portion of the spent coker water into a surge pit that produces an overflow stream that flows into a sump; and

retrieving at least a portion of water in the sump for supplying to a gravity settling basin that produces the supernatant water.


28
10
12
16
18
WATER
SOURCE
COKER
UNIT
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30
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24
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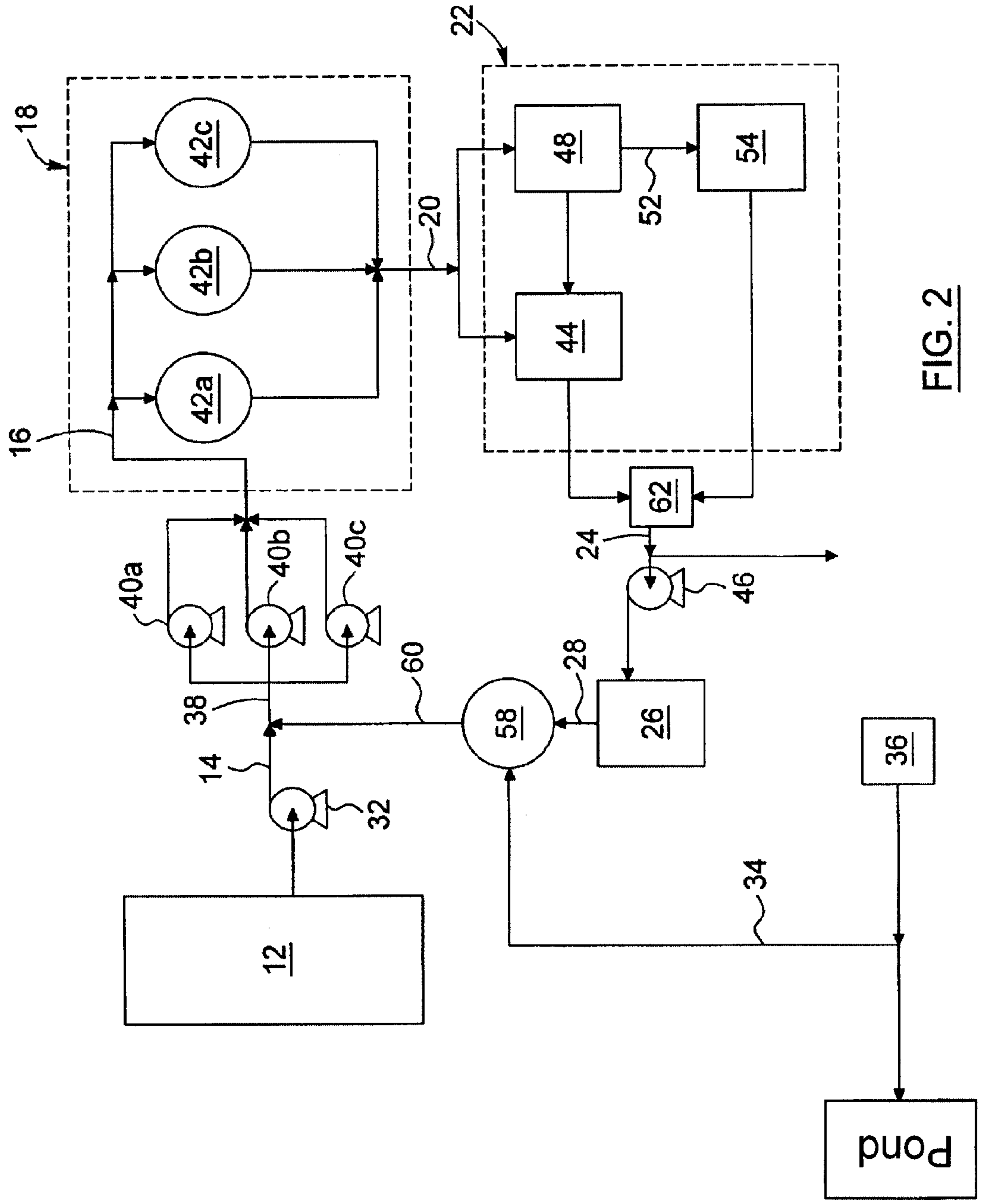
SEPARATION
STAGE
TREATMENT
UNIT
26

FIG. 1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40a
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42a
42b
42c
44
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52
54
58
60
62
Pond

FIG. 2

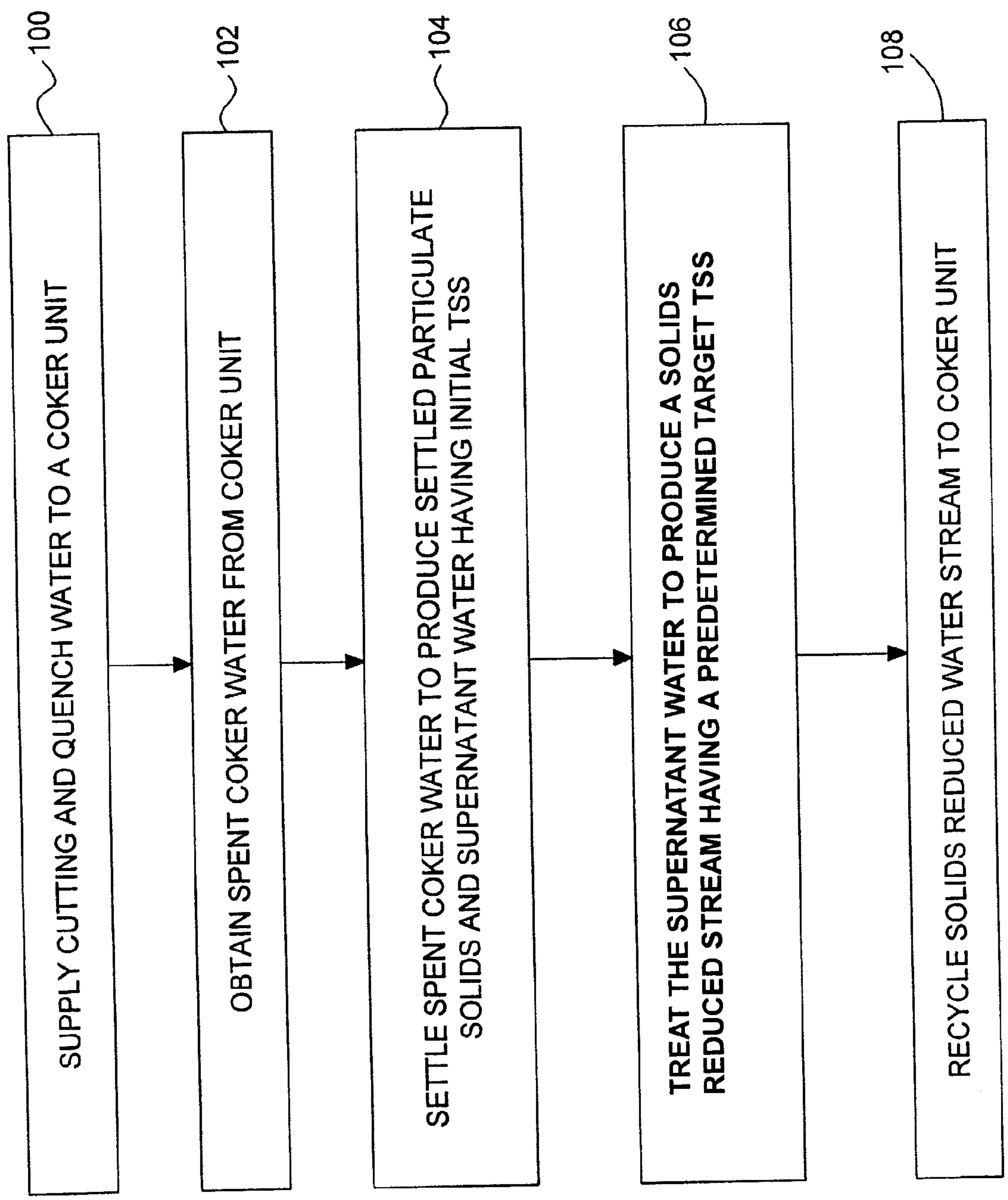
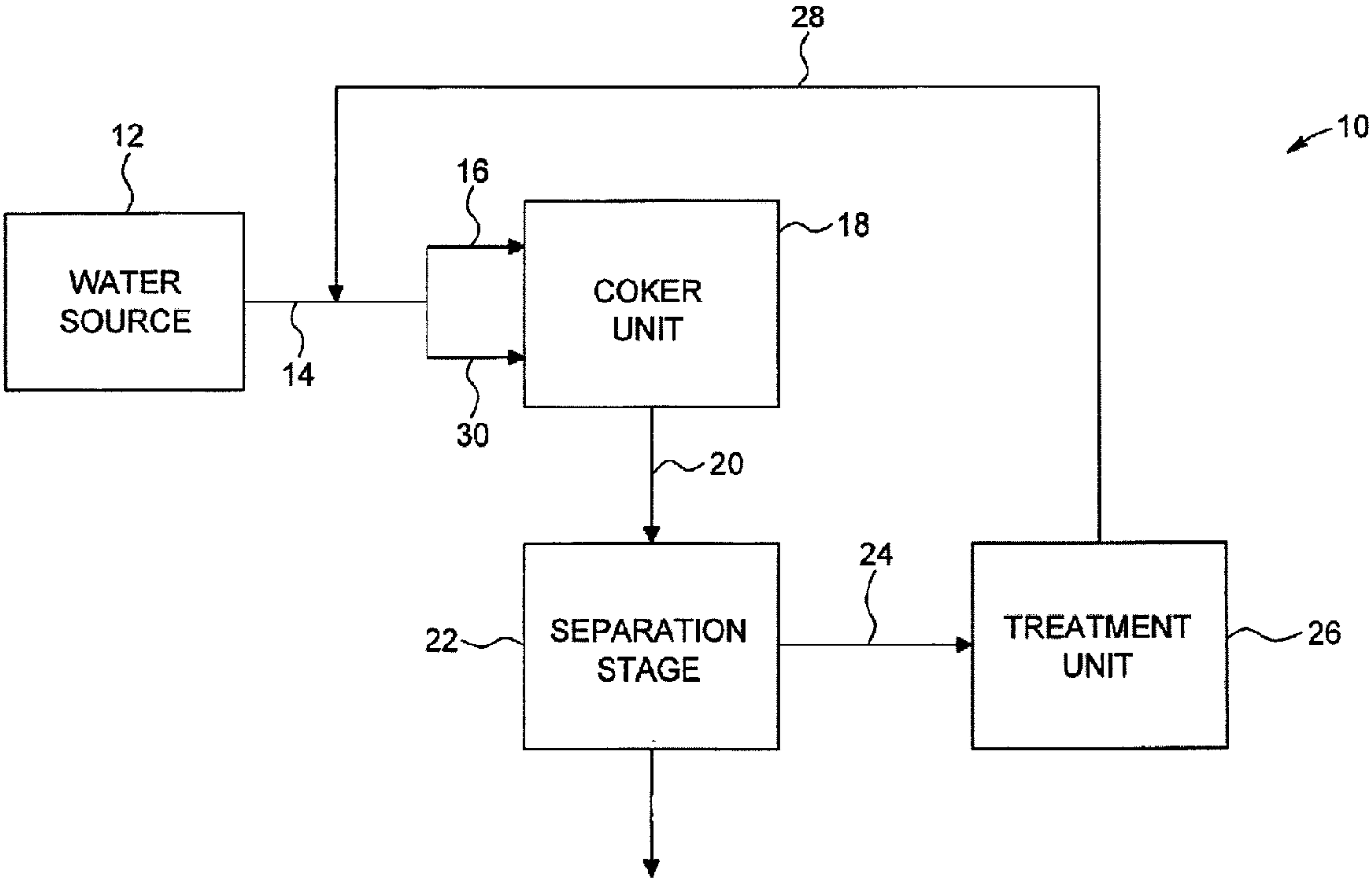

100
SUPPLY CUTTING AND QUENCH WATER TO A COKER UNIT
102
OBTAIN SPENT COKER WATER FROM COKER UNIT
104
SETTLE SPENT COKER WATER TO PRODUCE SETTLED PARTICULATE SOLIDS AND SUPERNATANT WATER HAVING INITIAL TSS
106
TREAT THE SUPERNATANT WATER TO PRODUCE A SOLIDS REDUCED STREAM HAVING A PREDETERMINED TARGET TSS
108
RECYCLE SOLIDS REDUCED WATER STREAM TO COKER UNIT

FIG. 3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10
12
16
18
WATER SOURCE
COKER UNIT
14
30
20
24
22
SEPARATION STAGE
TREATMENT UNIT
26