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(54) **MINIMAL SOUR GAS EMISSION FOR AN
INTEGRATED GASIFICATION COMBINED
CYCLE COMPLEX**

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(57) **ABSTRACT**

Disclosed is a process to start-up, operate, and shut down a
gasifier and an integrated gasification combined cycle com-
plex with minimal sour gas emissions while additionally
reducing the release of contaminants such as carbon monox-
ide, hydrogen sulfide, and nitrogen oxides. The process is
accomplished by starting up with a sulfur free feedstock and
by scrubbing any ventable sour gases free of sulfur contami-
nants prior to release of any such gases to the atmosphere.

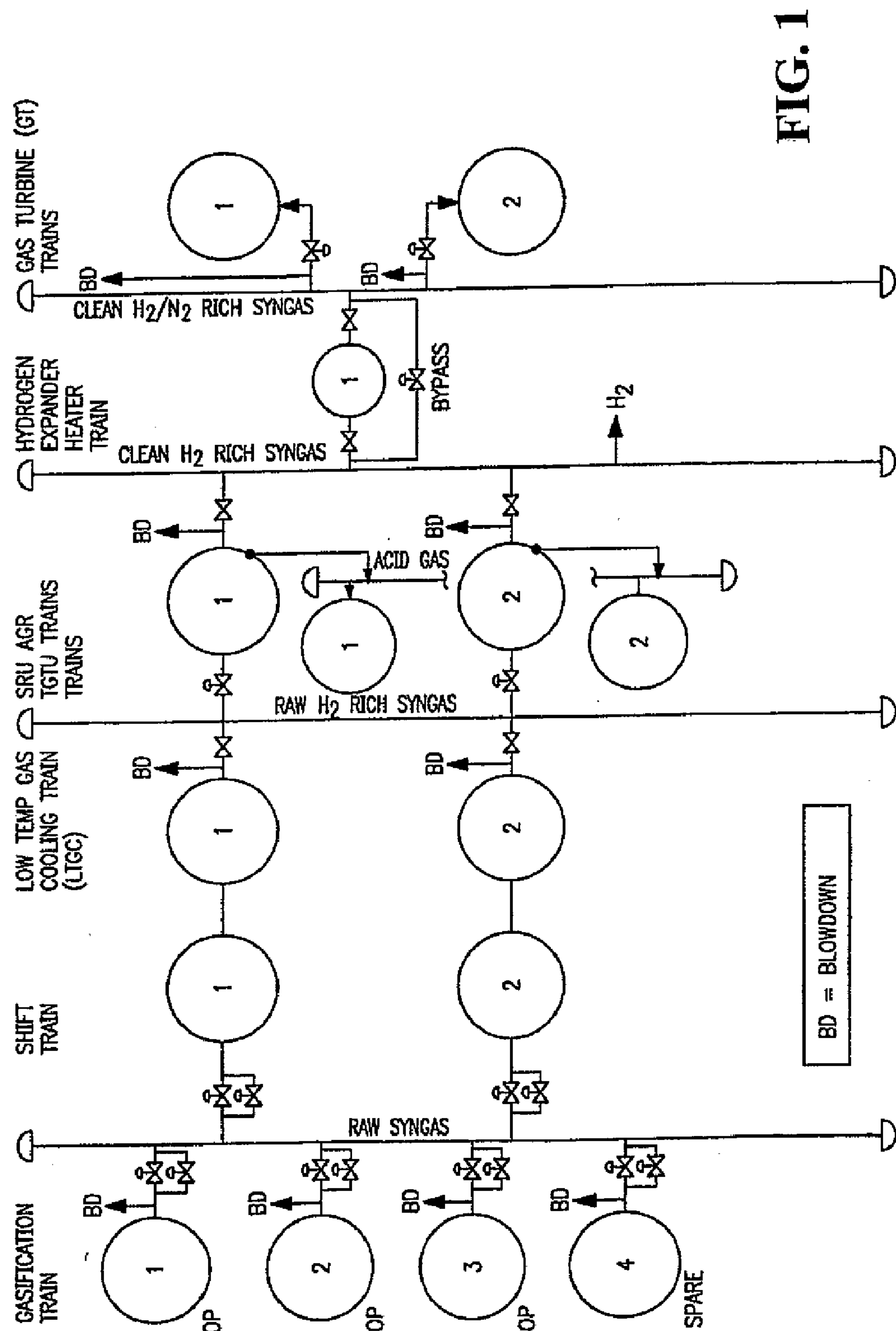
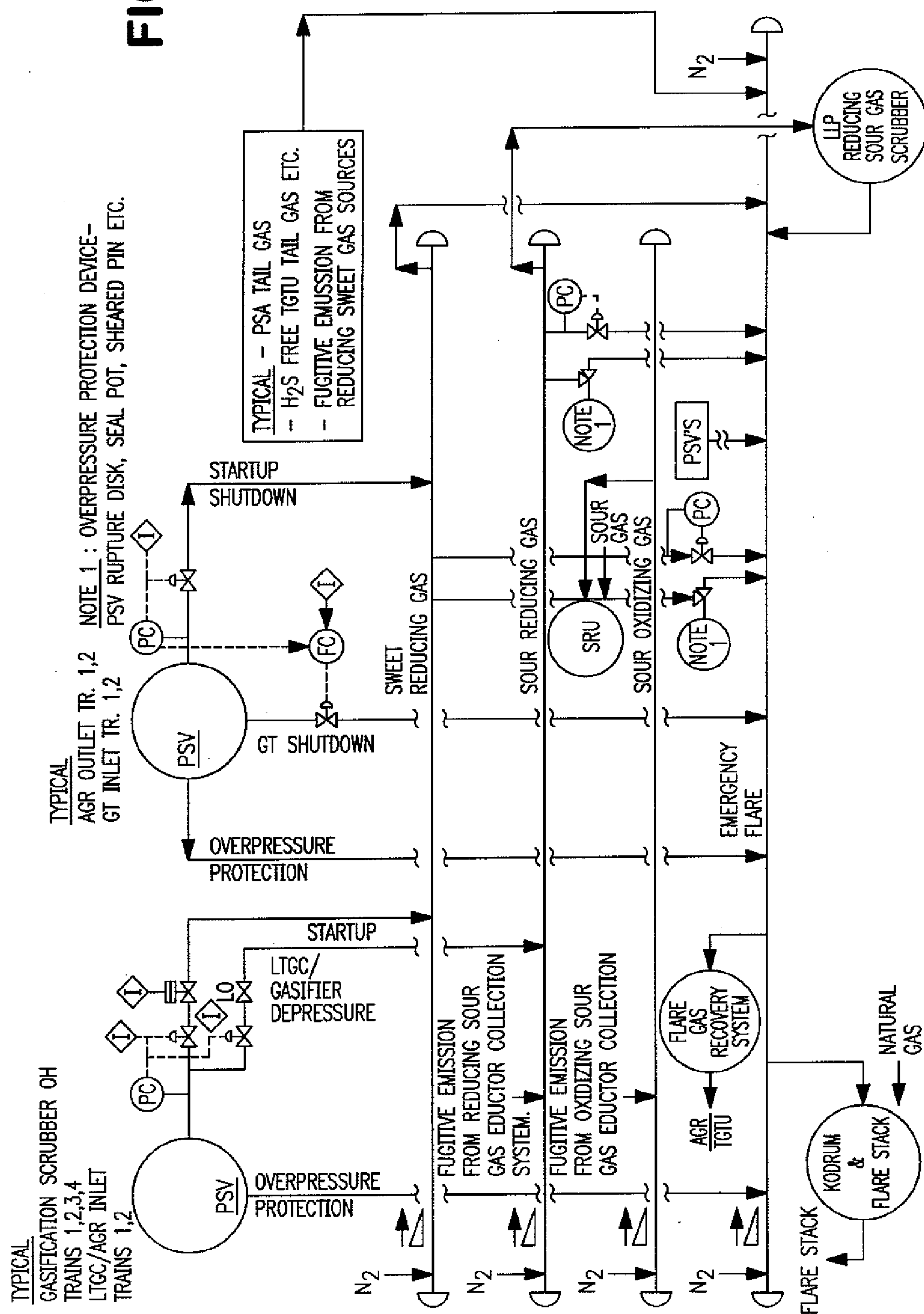


FIG. 1

FIG. 2



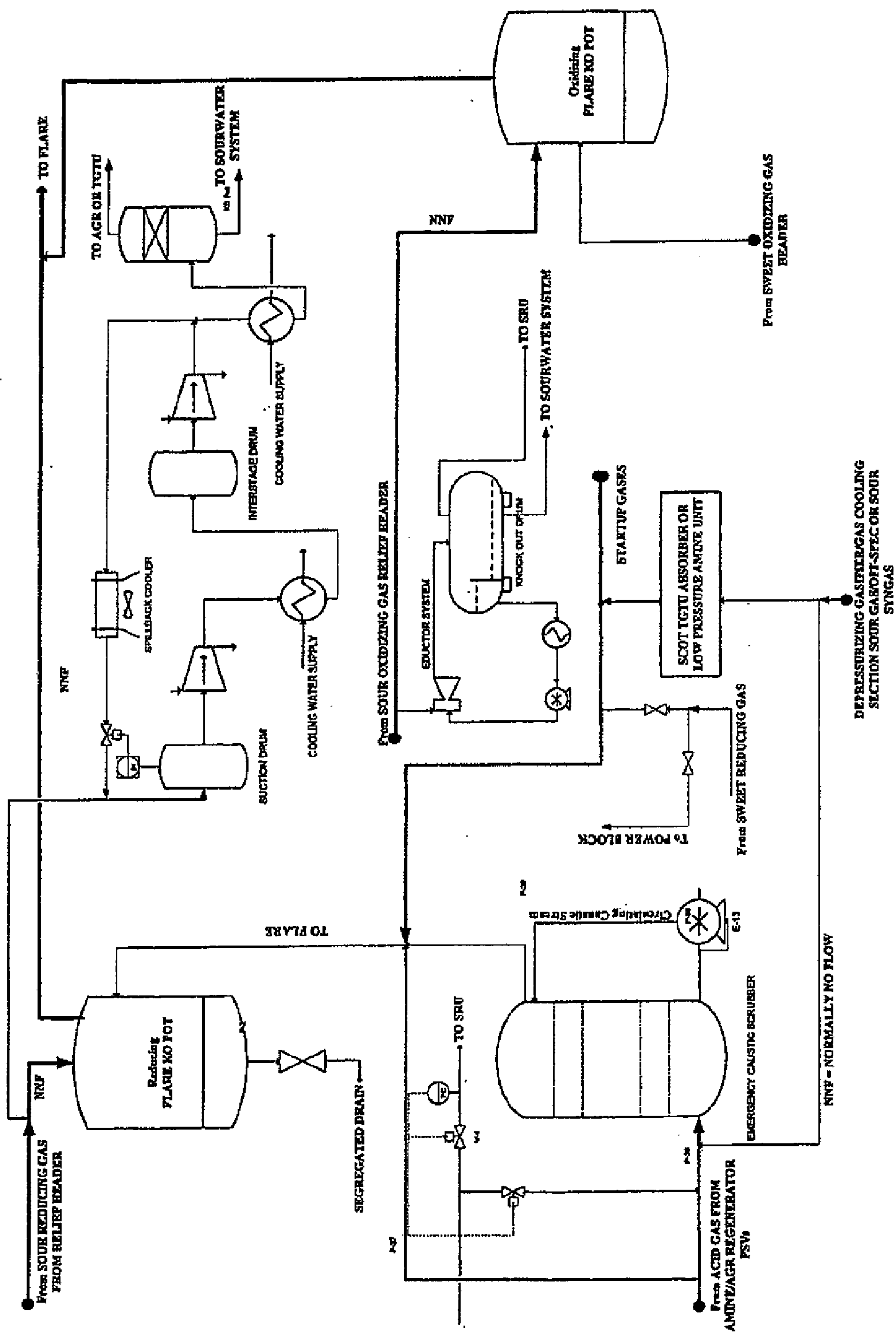


FIG. 3

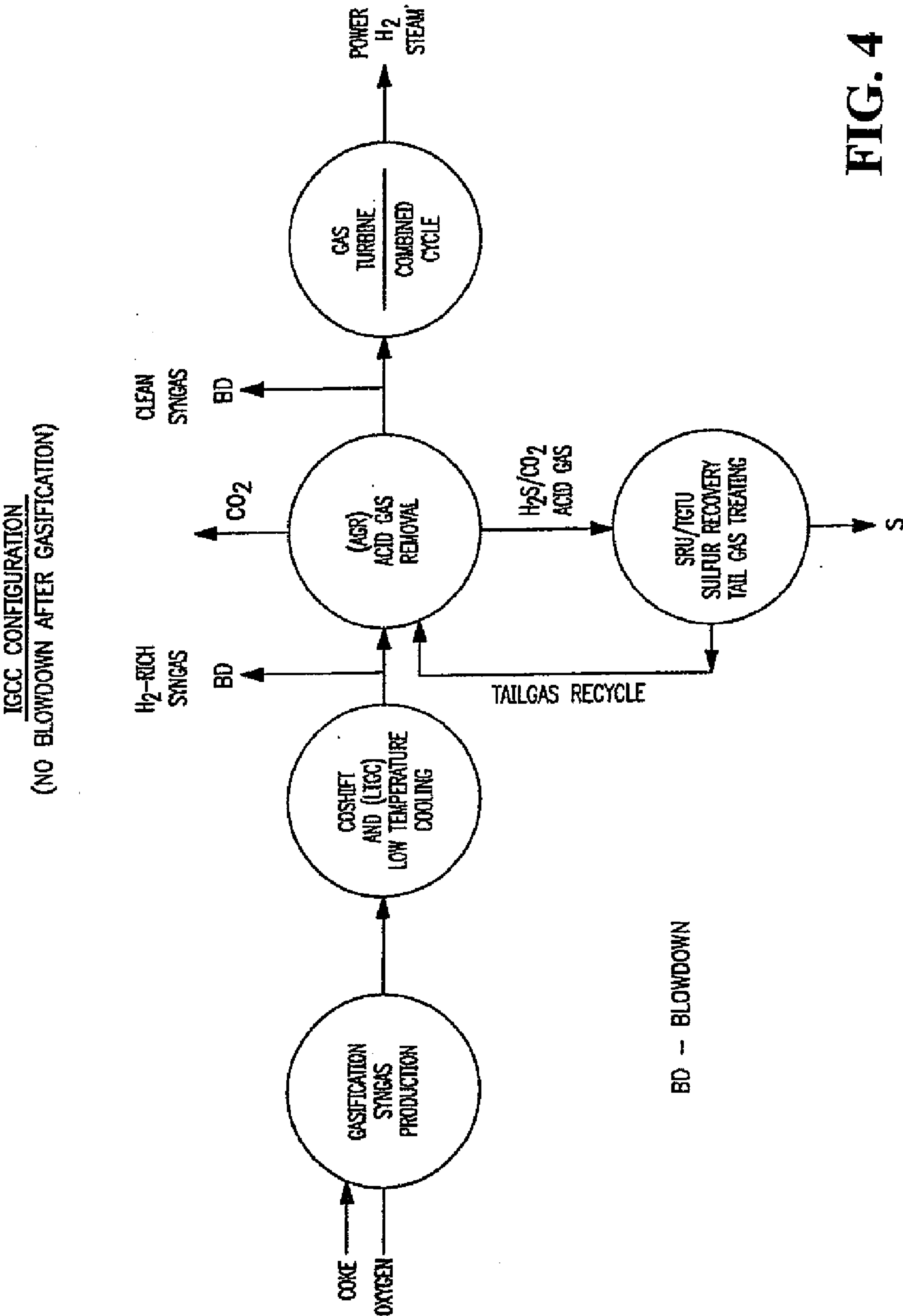


FIG. 4

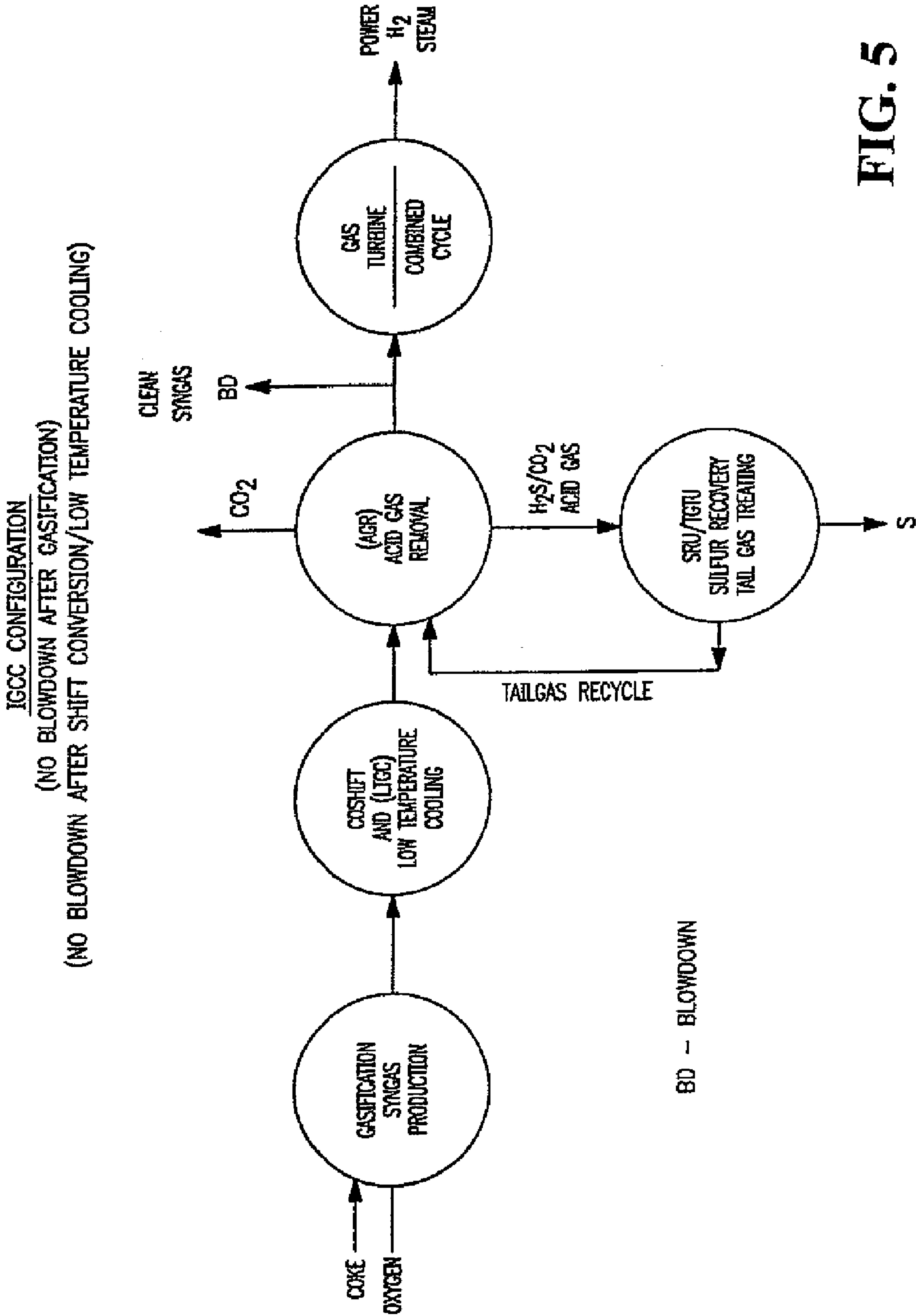
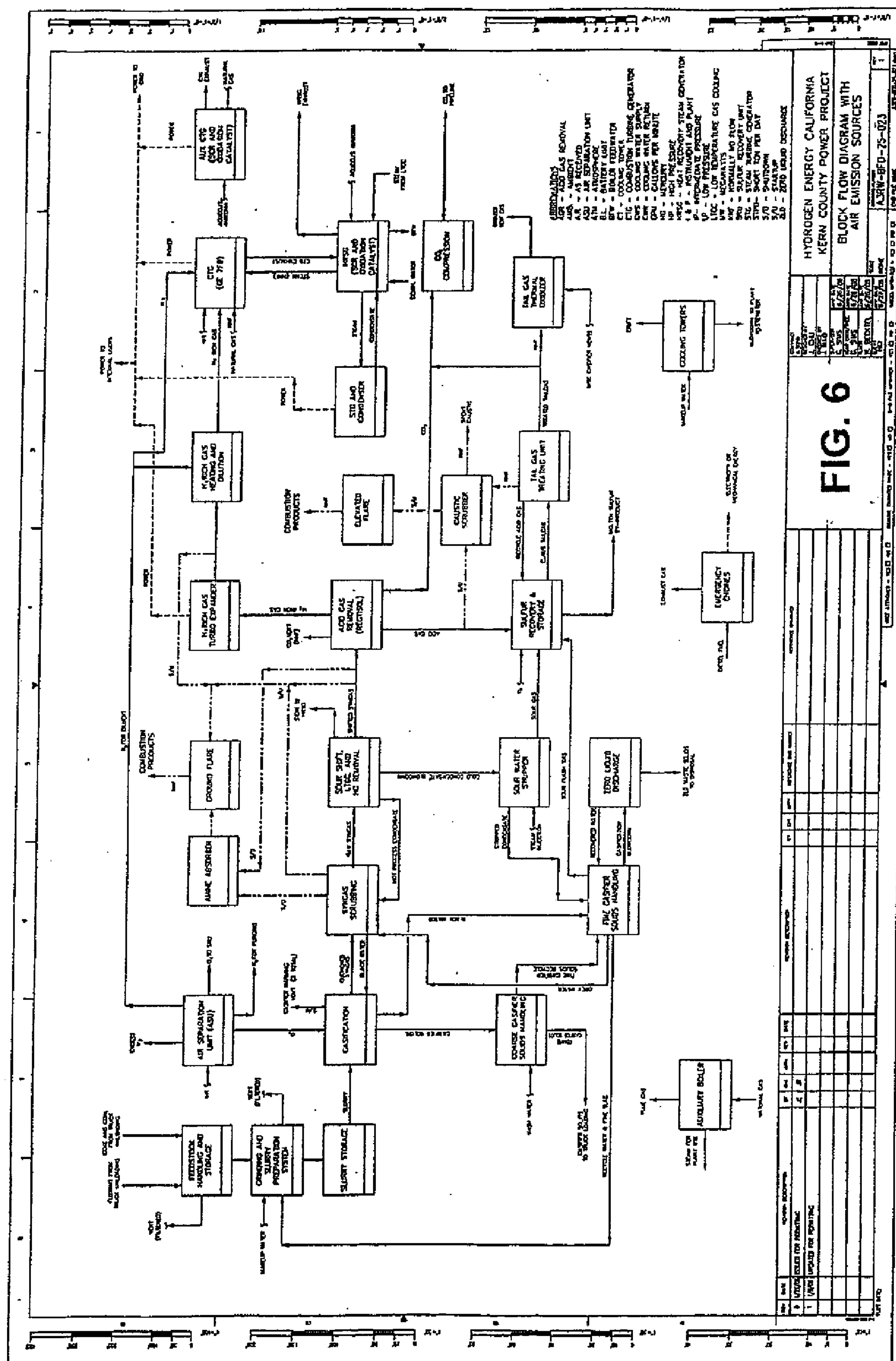


FIG. 5



MINIMAL SOUR GAS EMISSION FOR AN INTEGRATED GASIFICATION COMBINED CYCLE COMPLEX

[0001] This application claims benefit of provisional application Ser. No. 61/084,774 filed Jul. 30, 2008, which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to systems and methods of starting up, operating and shutting down a gasification reactor and an integrated gasification combined cycle (“IGCC”) complex.

[0003] Gasification was first used to produce “town gas” for light and heat. Additionally, coal and other hydrocarbons have been gasified in the past to produce various chemicals and synthetic fuels. More recently gasification technology has been employed to generate electricity in an IGCC complex wherein coal or another hydrocarbon is gasified by partial oxidation using oxygen or air to syngas. Typically, this syngas is then cleaned of particulates, sulfur compounds and nitrogen compounds such as NO_x compounds and then subsequently passed to gas turbine where it is fired. Additionally the hot exhaust gas from the gas turbine is usually passed to a heat recovery steam generator where steam is produced to drive a steam turbine. Electrical power is then produced from the gas turbine and the steam turbine. These IGCC complexes can also be designed to produce hydrogen and capture CO_2 thereby reducing greenhouse gas emissions. Because the emission-forming components are removed from the syngas prior to combustion an IGCC complex produces very low levels of air contaminants, such as NO_x , SO_2 , particulate matter and volatile mercury.

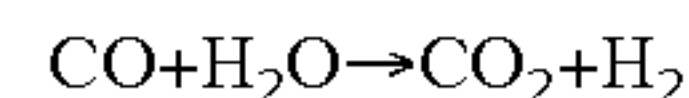
[0004] As mentioned above any hydrocarbon can be gasified, i.e. partially combusted, in contradistinction to combustion, by using less than the stoichiometric amount of oxygen required to combust the solid. Generally the oxygen supply is limited to about 20 to 70 percent of the oxygen required for complete combustion. The reaction of the hydrocarbon-containing feedstock with limited amounts of oxygen results in the formation of hydrogen, carbon monoxide and some water and carbon dioxide. Solids such as coal, biomass, oil refinery bottoms, digester sludge and other carbon-containing materials can be used as feedstocks to gasifiers. Recently petroleum coke has been used as the solid hydrocarbon feed stock for IGCC.

[0005] A typical gasifier operates at very high temperatures such as temperatures ranging from about 1000°C . to about 1400°C . and in excess of $1,600^\circ\text{C}$. At such high temperatures any inert material in the feedstock is melted and flows to the bottom of the gasification vessel where it forms an inert slag. There are three basic types of gasifiers that are either air or oxygen fed gasifiers. Specifically, gasifiers can be characterized as a moving bed, an entrained flow, or a fluidized bed. Moving bed gasifiers generally contact the fuel in counter-current fashion. Briefly, the carbon-containing fuel is fed into the top of a reactor where it contacts oxygen, steam and/or air in counter-current fashion until it has reacted to form syngas. In the entrained flow gasifier the fuel or hydrocarbon-containing feedstock contacts the oxidizing gas in co-current fashion until syngas is produced which exits the top of the reactor while slag flows to the bottom of the reactor. Finally, in the fluidized-bed gasifier the hydrocarbon-containing fuel or

feedstock is passed upwards with a steam/oxygen gas where it is suspended until the gasification reaction takes place.

[0006] The gasifier in an IGCC complex is integrated with an air separation unit (“ASU”), a gas purification or clean up system such as an acid gas removal (“AGR”) process, and a combined cycle power plant or “power block” which is the gas turbine unit. The ASU is used to separate air such that a pure oxygen stream can be sent to the gasifier.

[0007] In order to convert syngas produced by the gasifier to hydrogen fuel for both power generation and/or hydrogen sales, the syngas from the gasification block or gasifier must be shifted to convert the CO and water in the syngas to CO_2 and hydrogen. The water gas shift reaction is:



CO shift technology is commonly used in conventional hydrogen and ammonia plants. Where the syngas is derived from gasification, the CO shift unit is typically located upstream of a sulfur removal unit and therefore uses “sour” shift catalysts. Shift catalysts can be cobalt-molybdenum-based catalysts which are readily commercially available from a number of suppliers. The catalyst life is typically three years. For a high degree of CO_2 capture additional stages of shift may be required. The heat from the highly exothermic shift reaction can be effectively utilized by generating steam for internal plant consumption.

[0008] As set out above this “shift reaction” is practiced widely in the refining and petrochemical industries. Examples of gasification plants utilizing sour shift technology include the Convent Hydrogen Plant in Louisiana, the Dakota Gasification Plant in North Dakota, and the petcoke gasification plant in Coffeyville, Kans. The Coffeyville plant uses gasification technology for ammonia and CO_2 production.

[0009] Where an IGCC complex is used to capture CO_2 , the CO_2 captured must meet purity standards for compression and injection if the CO_2 is to be injected into oil fields for enhanced oil recovery. An extremely high degree of carbon capture can be achieved by shifting almost all the CO in the raw sour synthesis gas to carbon dioxide and hydrogen, and then recovering nearly all of the CO_2 in the resultant syngas within a downstream AGR unit.

[0010] In an IGCC complex as contemplated herein, shifted syngas effluent from the shift reactor is passed to an acid gas removal unit. A suitable acid gas removal unit could be the Rectisol process licensed by Lurgi AG or Linde AG. The Rectisol Process uses a physical solvent, unlike amine based acid removal solvents that rely on a chemical reaction with the acid gases. While any acid gas removal process can be utilized the Rectisol Process is preferably utilized due to (1) the high syngas pressure and (2) the proven ability of the process to (i) achieve very low (<2 ppmv) sulfur levels in treated fuel gas effluents, (ii) simultaneously produce an acid gas that is suitable for a Claus sulfur recovery unit (“SRU”) and (iii) a CO_2 stream that is suitable for enhanced oil recovery (“EOR”) applications. Ultra-low sulfur content in gas turbine (“GT”) fuel is necessary to allow use of catalysts for CO and NO_x reduction in the GT exhaust because sulfur compounds react with ammonia used in the selective catalytic reduction (SCR) process to form sticky particulates that adhere to catalyst and heat recovery steam generator (“HRSG”) tube surfaces. Rectisol can also remove nearly all COS from the syngas, thus eliminating the need for an upstream hydrolysis reactor that would otherwise be needed to convert COS in the syngas to

H₂S. The deep sulfur removal achieved by the Rectisol unit for H₂-rich syngas coupled with the use of CO oxidation catalysts and SCR allow the power block to achieve NO_x, CO and SO₂ emission levels that are comparable to those for a natural gas-fired combined cycle power plants, but with much lower CO₂ emissions.

[0011] As mentioned above the Rectisol is a purely physical absorption process, which is carried out at low temperatures and benefits from high operating pressure. The absorption medium is methanol. Mass transfer from the gas into the methanol solvent is driven by the concentration gradient of the respective component between the gas and the surface of the solvent, the latter being dictated by the absorption equilibrium of the solvent with regard to this component. The compounds absorbed are removed from the solvent by flashing (desorption) and additional thermal regeneration, so that the solvent is ready for new absorption. The relative ease of removing CO₂ from high pressure synthesis gas as compared to removing it from atmospheric pressure, nitrogen-diluted flue gas is widely recognized as one of the principal benefits of gasification when compared to combustion technologies.

[0012] CO₂ produced by such an IGCC complex, depending on the process unit integration, is between 97 to 99%+ pure with only small traces of other compounds present. This level of purity is required for several reasons. First, it is essential for the product to be very low in water content to minimize or alleviate the formation of carbonic acid (water+CO₂=carbonic acid) which is very corrosive to the steel used in the compression equipment, pipeline, injection/re-injection equipment and the actual wells themselves. Second, the total sulfur content is limited to 30 ppmv or less to further minimize corrosion issues and to mitigate any health concerns to workers or the public in the event of a mechanical failure or release. Third, nitrogen in the product is limited to less than about 2 vol % since excessive amounts of nitrogen may significantly inhibit EOR and permanent sequestration of CO₂.

[0013] The Rectisol unit can be used to produce high purity CO₂ at two pressure levels, atmospheric pressure and about three atmospheres. EOR operations require a CO₂ pressure of 2,000 psig (13.79 MPa), so CO₂ compression above this level is required. CO₂ enters a dense, supercritical phase at about 1,100 psig (7.58 MPa), therefore it remains in a single phase throughout a CO₂ pipeline. The Rectisol acid gas removal unit also produces an acid gas stream containing H₂S.

[0014] The sulfur recovery unit ("SRU") used in the IGCC complex contemplated herein can be a conventional oxygen-blown Claus technology to convert the H₂S to liquid elemental sulfur. The tail gas from the Claus unit can be recycled to the AGR unit to avoid any venting of sulfurous compounds to the atmosphere or routed to a conventional Tail Gas Treating Unit (TGTU).

[0015] While the hydrogen produced in the present IGCC complex is generally used for power production, during off peak demand a portion of such hydrogen can be directed to petroleum refineries after suitable purification using, for instance, conventionally available pressure swing adsorption technology.

[0016] The combustion of the hydrogen fuel to produce power can be carried out by any conventional gas turbines. These turbines can each exhaust into a heat recovery and steam generator ("HRSG"). Steam can be generated at three pressure levels and is used to generate additional electrical energy in a steam turbine.

[0017] A conventional selective catalytic reduction process ("SCR") can be used for post-combustion treatment of effluent gases to reduce NO_x content down to acceptable levels.

[0018] In a conventional start-up of a partial oxidation gas generating process the gas generator is started at atmospheric pressure after preheating to at least 950° C. Until the gasifier is pressurized and downstream processes are brought on-stream the resulting effluent, comprising syngas, is typically burned in a flare. As is well known to those skilled in the art, this results in higher than normal emissions of contaminants such as sulfur. See, for example, U.S. Pat. No. 4,385,906 (Estabrook) and U.S. Pat. No. 3,816,332 (Marion).

[0019] Accordingly, the start-up of a partial oxidation gas generator presents special challenges, including dealing with the contaminant emissions. For example, U.S. Pat. No. 4,378,974 (Petit et al.) discloses a start-up method for a coal gasification plant, in particular a refractory lined rotary kiln. The method of Petit et al. focuses on the problems that arise from coal having a high chlorine content. Petit et al. discloses a reactor where the lining is made of materials susceptible to chlorine-induced cracking in the presence of oxygen. Petit et al. teaches starting the reactor up in stages while maintaining an oxygen content in the reactor at a sufficiently low level to prevent chlorine-induced cracking of the refractory lining.

[0020] Additionally, U.S. Pat. No. 4,385,906 (Estabrook) discloses a start-up method for a gasification system comprising a gas generator and a gas purification train. In the method disclosed by Estabrook the gas purification train is isolated and prepressurized to 50% of its normal operating pressure. The gas generator is then started, and its pressure increased before establishing communication between the generator and the purifier. Purified gases from the purifier may then be burned in a flare until all parts of the process reach appropriate temperature and pressure.

[0021] U.S. Pat. No. 6,033,447 (Moock et al.) discloses a start-up method for a gasification system with a sulfur-free organic liquid, such as propanol. The reference claims that air contaminants, such as sulfur, which are characteristic of start-up, may be eliminated by starting the gasifier with a sulfur-free, liquid organic fuel. Once the gasifier is started up using a sulfur-free liquid organic fuel and reaches the appropriate temperature and pressure conditions the burner is transitioned to a carbonaceous fossil fuel slurry. Only sulfur-free gas is flared.

[0022] The present invention deals with the start-up of a gasifier or an IGCC complex with no sour gas flaring. Flaring is an uncontrolled combustion of flammable gas at the flare tip. Flare flames are visible from substantial distances. The combustion is carried outside the flare tip at the adiabatic flame temperature of the flammable gas, typically as high as 3,000° F. (1649° C.).

BRIEF SUMMARY OF THE INVENTION

[0023] The present invention involves a process of collecting all the potential contaminants or pollutants in blow down conduits associated with the process units that comprise an IGCC complex, during start-up, shutdown and normal operation and treating streams containing these contaminants or pollutants such that the IGCC complex does not flare any streams containing such contaminants or otherwise emit the contaminants into the atmosphere. These potential contaminant or pollutant streams are first treated for sulfur removal, if necessary. The sulfur-free potentially contaminant or contaminant-containing streams are then segregated into either

an oxidizing stream or a reducing stream in a flare header system. These streams are then passed to a flare having several burner stages such that oxidizing and reducing streams are not co-mingled. The flare header system can also be equipped with a Vapor Recovery Unit (VRU) where any usable gas products such as H_2 , CO_2 , sulfur compounds can be recovered. A simplified process block diagram of an IGCC plant with the no sour gas flaring scheme in accordance with the present invention is given in FIG. 6.

[0024] The sour reducing streams generated during gasifier startups which contain sulfur are first passed through a low pressure scrubber containing a solvent that absorbs H_2S such as either amine based or caustic-based solvent before such streams are flared. During normal operations, gas products from the sour reducing streams can be recovered in a tail gas treatment unit and/or an acid gas removal unit via a vapor recovery unit.

[0025] The sour oxidizing stream typically contains only a trace amount of flammable gas, and can contain an oxygen content of greater than about 1.0 vol %. This sour oxidizing stream is passed to a point downstream of the main reactor furnace burner in the Sulfur Recovery Unit Tail Gas Treating Unit.

[0026] The sweet reducing stream typically contains flammable gas with high heating value which can be greater than about 50 BTU/SCF (1869 kilojoules/scm) and oxygen content of less than about 1.0 vol %, is then passed to a vapor recovery unit where the stream is subsequently routed to the feedstream to the Acid Gas Recovery Unit.

[0027] The sweet oxidizing gas typically contains only a trace amount of flammable gas, and can contain an oxygen content of greater than about 1.0 vol %. This sweet oxidizing stream is passed to a point downstream of the flare burner tip

[0028] The rich acid gas or high H_2S acid gas containing stream typically contains greater than about 10% H_2S . This stream, is passed from the AGR to the SRU during startup. In the case of an unplanned SRU shutdown this stream can be routed to an emergency caustic scrubber to remove the H_2S prior to flaring.

[0029] Further objects, features, and advantages of the present invention will become apparent from consideration of the following description and the appended claims when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] FIG. 1 is a schematic diagram of an IGCC complex flow diagram in accordance with one embodiment of the present invention, where at least one blowdown conduit is present for the syngas production zone, the shift conversion and low temperature gas cooling zones, the acid gas removal zone, and clean hydrogen expander/heating zone.

[0031] FIG. 2 is another schematic diagram of a blowdown system in accordance with one embodiment of the present invention. FIG. 2 shows the blowdown gases from the gasification zone, shift zone and low temperature gas cooling zone, acid gas recovery zone, gas turbine blow down system and blow down systems for other fugitive emission sources such as the solid handling system. FIG. 2 shows the routing of these gases depending on either the H_2S or oxygen contents.

[0032] FIG. 3 is a schematic diagram of flare system suitable for use in accordance with the present invention. FIG. 3 also shows the flare vapor recovery unit integrated within the various streams in the flare header system.

[0033] FIG. 4 is a schematic diagram of an IGCC complex flow diagram in accordance with one embodiment of the present invention, in which at least one blowdown conduit is present for the shift conversion and low temperature gas cooling zones and the acid gas removal zone, and in which there is no blowdown conduit for the syngas production zone.

[0034] FIG. 5 is a schematic diagram of an IGCC complex flow diagram in accordance with one embodiment of the present invention, in which at least one blowdown conduit is present for the acid gas removal zone, and in which there are no blow down conduits for the syngas production zone and for the shift conversion and low temperature gas cooling zones.

[0035] FIG. 6 is a schematic diagram of an IGCC complex flow diagram in accordance with the embodiment of the present invention, where an LP (low pressure) amine scrubber is used for gasification startup (sour reducing gas) gases and a LLP (low low pressure) caustic scrubber is used for SRU (sulfur recovery unit) startup and for emergency acid gas release.

DETAILED DESCRIPTION OF THE INVENTION

[0036] Broadly, in accordance with the present invention the syngas production zone or gasifier in an IGCC complex is started up with a clean, sulfur-free, containing less than about 10 ppmv sulfur hydrocarbon-containing feedstock such as natural gas or a light hydrocarbon liquid such as methanol. The sulfur-free syngas produced in the gasifier, a sweet reducing gas, is then sent to a flare. When the downstream acid gas removal unit and the sulfur recovery unit and the tail gas treatment unit are commissioned, the clean fuel is switched to a high sulfur solid fuel. After the AGR is fully commissioned, the acid gas (H_2S and other contaminants) are concentrated and sent to a sulfur recovery unit e.g. Claus unit to make elemental sulfur. If the acid gas concentration is less than 25% vol H_2S in the acid gas during the start-up, such acid gas is routed to a sour gas scrubber such as an emergency caustic scrubber. Once the SRU is operational, the small amount of unconverted H_2S in the effluent stream of the SRU is sent to the Tail Gas Treating Unit ("TGTU"), where the small amount of sulfur is removed, and the clean tail gas is recycled back to the AGR or to a CO_2 product stream recovered from the AGR unit for export.

[0037] The sulfur-free syngas is combusted in the flare

[0038] When the gasifier is shutdown, sour (sulfur-containing gas) gas is trapped inside the gasifier. This sour gas can be depressured in a controlled manner through a low low pressure (LLP) scrubber to remove the sulfur contaminants. The substantially sulfur-free depressuring gas is then sent to the flare.

[0039] Generally, all emissions containing contaminants during start-up and shut down and if desired, during operation of the IGCC complex are collected in four different headers by an eductor or compressor type collection system also known as the Vapor Recovery Unit (VRU). The gas is either scrubbed free of sulfur and then sent to the flare, or can be recycled back to an upstream unit such as the AGR or SRU for further product (H_2 , CO_2 , and 8) recovery

[0040] In one embodiment of the present invention where petroleum coke is used as the hydrocarbon containing feedstock, the IGCC complex, nominally designed to procure 500 Mega Watts of power, can have three coke grinding trains, three operating plus one additional spare gasifier trains, two shift/low temperature gas cooling trains, two AGR/SRU trains, one TGTU train, one syngas expander and optionally a

pressure swing absorption unit for hydrogen export offsite and two combined cycle power block trains.

[0041] Contaminant or pollutant emissions in accordance with the invention can be characterized as follows:

[0042] 1) Sweet reducing gas stream—with oxygen content less than about 1 vol % and an H_2S content of less than about 50 ppmv, these streams generally emanating from all the units during start-up with a sulfur-free hydrocarbon feedstock;

[0043] 2) Sour reducing gas stream—same as the stream described in item 1) except that H_2S content is greater than about 50 ppmv, these streams generally emanating from the syngas production zone and the shift conversion/low temperature gas cooling zone units after the feed to the syngas production zone is switched to the sulfur containing feed during start up or during shut down after switching to sulfur-free;

[0044] 3) Sour oxidizing gas stream, e.g., having a possible oxygen content greater than about 1 vol % and an H_2S content of a greater than about 10 ppmv; these streams generally emanating from the equipment associated with the SRU that have contacted air during normal operation such as sourwater tanks, sulfur pits, etc;

[0045] 4) Sweet oxidizing gas stream—same as the stream described in item 3) except that the H_2S content is less than about 10 ppmv, which streams generally emanate from the units that have contacted air during normal operation such as solids handling or solids preparation units, sumps, tanks, instrument vents and bridles and safety valves; and

[0046] 5) High H_2S acid gas stream—containing greater than about 10% H_2S such as the feed to the SRU, or AGR zone.

[0047] In one embodiment of the present invention a feedstock that does not contain contaminants such as sulfur-containing compounds i.e., in amounts of about less than about 10 ppmv sulfur, is used to carry out the start up of the integrated gasification combined cycle complex. The sulfur-free feedstock which can be a hydrocarbon feedstock is passed to the syngas production zone which then produces a sweet reducing syngas effluent stream. As the gasification or syngas production zone is being started up this sweet reducing syngas stream is passed to a blow down conduit.

[0048] The sweet reducing syngas effluent stream is then passed via the blow down conduit to a flare.

[0049] When the feed rate to the syngas production zone reaches a predetermined rate at predetermined conditions including a predetermined pressure and temperature, the syngas zone sweet reducing effluent is diverted from the blow down conduit to the shift conversion zone which typically has a low temperature gas cooling zone disposed downstream thereof. The gases passing through the shift conversion zone and the low temperature gas cooling zone and exiting the low temperature gas cooling zone and are characterized as a sweet reducing stream effluent. This sweet reducing stream effluent is then passed to a blow down conduit to a flare.

[0050] Prior to, subsequent to, or contemporaneously with the gasifier start up, the acid gas removal zone is started up with nitrogen or any other inert gas. When the acid gas removal zone has reached predetermined operating conditions including temperature and pressure the sweet reducing gas from the blow down conduit associated with the low temperature gas cooling zone is diverted to the acid gas removal zone. The effluent from the acid gas removal zone is

also characterized as a sweet reducing effluent stream. This sweet reducing stream is then passed through a blow down conduit to a flare and combusted in the same manner as described above.

[0051] Prior to, subsequent to, or contemporaneously with the start-up of the upstream zones the sulfur recovery zone is started up with a start-up gas such as natural gas such that when the sulfur recovery zone has reached operating conditions. The sweet reducing effluent stream from the acid gas removal zone is then diverted from the blow down conduit to the sulfur recovery zone to produce another sweet reducing effluent stream. This sulfur recovery zone sweet reducing effluent stream is then passed to a tail gas treatment unit to produce a tail gas treatment unit sweet reducing effluent. The effluent from the tail gas treatment unit is then passed through a blow down conduit to a flare and combusted in the same manner as described above.

[0052] Subsequently the amount of sulfur-free containing feedstock to the syngas production zone is reduced and the amount of sulfur-containing hydrocarbon feed stock to the syngas production zone is increased. The acid gas removal zone sweet reducing effluent stream is diverted from the sulfur recovery zone and passed to a sour gas scrubber. The effluent from the sour gas scrubber is then passed to a flare.

[0053] When the sulfur concentration of the acid gas removal effluent stream passing to the sour gas scrubber reaches a predetermined value of about 25 volume percent H_2S , this stream is diverted back to the sulfur recovery zone while simultaneously reducing start-up gas to the sulfur recovery zone and increasing the sulfur laden hydrocarbon feedstock to the desired operating feed rate.

[0054] Finally, the tail gas treatment unit effluent presently flowing to the flare is diverted to a point either upstream or down stream of the acid gas removal zone for additional CO_2 recovery.

[0055] Additionally in accordance with the present invention various sweet oxidizing gases collected from sumps, tanks, instrument vents, bridles, and pressure safety valves associated with the various zones in the IGCC complex can be passed to the flare or a thermal oxidizer or incinerator such as those commonly found in some conventional tail gas treating units.

[0056] By following the above start up procedure in accordance with this invention the IGCC complex can be started up with mitigated releases of all noxious contaminants.

[0057] Another embodiment of the above start up procedure in accordance with the present invention involves passing the sulfur-free start up feedstock through the syngas production and the shift conversion zone including the low temperature gas cooling zone prior sending it to a blow down conduit for flaring. FIG. 4 depicts a schematic process flow diagram that would permit this type of start up. In yet another embodiment of the start-up procedure the sulfur free start up feedstock is passed through the syngas production zone, the shift conversion zone, low temperature gas cooling zone and the acid gas removal zone prior to sending it to a blow down conduit for flaring. FIG. 5 depicts a schematic process flow diagram that would permit this type of start up.

[0058] Another embodiment of the present invention provides for a process for shutting down an integrated gasification combined cycle complex with mitigating the release of noxious contaminants such as sulfur. More specifically in the shut down procedure the feedstock to the syngas production zone is switched to a sulfur-free, i.e. about less than 10 ppmv

sulfur, feedstock. Once the syngas stream using the sulfur laden hydrocarbon feedstock is displaced by the syngas using the sulfur free feedstock, the effluent from the syngas production zone now a sweet reducing gas is diverting from the shift conversion zone and depressurized to a blow down conduit associated with the syngas production zone. The effluent from the syngas production zone is then passed to a flare.

[0059] Subsequently, the effluent from the low temperature gas cooling zone associated with the shift conversion zone is diverted from the acid gas removal zone and depressurized to a blow down conduit associated with the shift conversion zone. This effluent stream is then passed to a flare.

[0060] The effluent from the acid gas reduction zone is then depressurized. Specifically the hydrogen rich syngas is passed to a flare. The acid gas is depressurized to the sulfur recovery zone.

[0061] The gaseous effluent from the sulfur recovery zone is depressurized to a tail gas treating unit.

[0062] The effluent from the tail gas treating unit is diverted from its recycle to the acid gas removal zone and is depressurized to a flare in accordance with the present invention.

[0063] Finally the fuel to the turbines in the power block zone is switched from hydrogen to natural gas.

[0064] In another embodiment the gasifier and shift zone can both be depressurized by diverting the sweet reducing effluent stream from the low temperature cooling zone to the flare, with the remainder of the IGCC complex being shut down as described above.

[0065] In another embodiment of the present invention is to provide for a process for shutting down an integrated gasification combined cycle complex while mitigating the release of noxious contaminants such as sulfur in a manner that does not use a sulfur-free feedstock as described above. The effluent from the syngas production zone now a sour reducing gas is diverted from the shift conversion zone and depressurized to a blow down conduit associated with the syngas production zone. The effluent from the syngas production zone is then slowly discharged to a low pressure sour gas scrubber (such as an amine scrubber) for sulfur removal by throttling one or more pressure control valves. The effluent from the sour gas scrubber is passed to a flare for combustion as described above.

[0066] Subsequently, the effluent from the low temperature gas cooling zone associated with the shift conversion zone is diverted from the acid gas removal zone and depressurized to a blow down conduit associated with the shift conversion zone. This sour reducing effluent stream is then slowly discharged to a low pressure scrubber by throttling one or more pressure control valves. The effluent from the low pressure scrubber is passed to a flare in accordance with the present invention.

[0067] The effluent from the acid gas reduction zone is then depressurized. Specifically the hydrogen-rich syngas is passed to a flare to be combusted and treated in accordance with the present invention. The acid gas effluent is depressurized to the sulfur recovery zone.

[0068] The gaseous effluent from the sulfur recovery zone is depressurized to a tail gas treating unit.

[0069] The effluent from the tail gas treating unit is diverted from its recycle to the acid gas removal zone and is depressurized to a flare in accordance with the present invention.

[0070] Finally the fuel to the turbines in the power block zone is switched from hydrogen to natural gas.

[0071] In another embodiment the gasifier and shift zone can both be depressurized by diverting the sour reducing effluent stream from the low temperature cooling zone to a low pressure scrubber and then to a flare, with the remainder of the IGCC complex being shut down as described above.

[0072] In yet another embodiment the gasifier, shift and acid gas removal zones can be depressurized by commencing the acid removal zone shut down as described above and not depressurizing the gasifier and shift individually prior to the depressurization of the acid gas removal zone as described above.

[0073] For the purposes of this invention the tail gas treating unit comprises of the following components and operates as described below.

[0074] In this invention, the tail gas treatment unit can contain either one standard amine absorber for both normal operations and gasifier shutdown operations or two amine absorbers one dedicated for gasifier shutdown and the other for normal operating conditions. The TGTU unit also contains several exchangers, pumps, filters and a stripping column. The TGTU amine absorber is used to remove the H_2S in the TGTU feed. The H_2S is absorbed in the amine and the rich amine (H_2S laden amine solvent) is regenerated to an essentially sulfur free amine by stripping the rich amine with steam in the stripping column or regenerator. This regenerated amine is reused in the TGTU process and the H_2S from the stripping process is recycled back to the sulfur recovery unit for further sulfur removal. The TGTU also contains a thermal oxidizer or incinerator for the combustion of tail gas effluent, SRU startup gases, fugitive emissions, and gases from the sulfur pits, sulfur storage tanks and sulfur loading docks.

[0075] For the purposes of this invention, the flare header system can contain the following components and operates as described below.

[0076] The flare header system as shown in FIG. 3 is divided in to several streams depending on the H_2S and/or oxygen content. These streams are separated into: sour reducing gas, sour oxidizing gas, sweet reducing gas, sour reducing gas and high acid or H_2S gas streams. A vapor recovery unit of the eductor or compressor type is used to recover any usable or saleable gases from the header system. Included in the flare system is an emergency caustic scrubber for the removal of H_2S from high acid gas streams in the event of an emergency shut down or during the startup of the sulfur recovery unit. Separate flare knock out drums are required to remove any water from the gases before they are combusted in the flare.

[0077] The start-up hydrocarbon-containing feedstock or fuel that is free of sulfur can be natural gas or light hydrocarbon liquid such as methanol. The start-up fuel rate can be less than or, for instance, about 10% to more than 50% of the normal operating condition ("NOC") of one gasifier throughput. As the gasifier pressure is increased, the rest of the gasification system is commissioned.

[0078] For instance, when the methanol and oxygen mixture is first ignited in the gasifier, the pressure will rapidly increase to 50-150 psig (345-1034 kPa) within minutes after the lightoff with a pressure control valve opened and adjusted to produce such a backpressure. The blow down syngas is routed to the sweet reducing gas header to the flare. A water knockout drum at the inlet of the flare is necessary to remove any condensed moisture from the wet syngas mixture at start-up. The gasifier pressure is gradually increased by throttling the pressure control valve to the blowdown stream. The water

in the syngas includes the equilibrium water at the gasifier operating pressure and any water physically entrained by the syngas flow. As mentioned in one embodiment, the blow down gas is sent to the flare. In order to keep the gasification system gas velocity roughly constant during start-up, an example of the ramp up schedule of the gasifier start-up can be as follows:

- [0079]** Hold pressure at about 150 psig (1034 KPa) for about 1 hour to check leak and tighten flanges if the gasifier has completed a turnaround maintenance;
- [0080]** Increase the gasifier throughput and adjust the pressure of the gasifier accordingly, e.g., about 40% NOC at about 400 psig (2758 KPa), 50% NOC at about 500 psig etc. It can take about 30 minutes to reach about 70% NOC and about 700 psig (4826 KPa) pressure;
- [0081]** When the gasifier throughput reaches about 70% NOC at about 700 psig (4826 KPa), the pressure can be increased until the gasifier pressure reaches the NOC operating pressure (e.g. about 1000 psig (6895 KPa));
- [0082]** Alternatively, for the first gasifier/shift/low temperature gas cooling Acid Gas Removal train start-up, if the AGR can be operated at a reduced pressure and a reduced throughput, the gasifier pressure and throughput can be ramped up to only about 40% NOC throughput at about 400 psig (2758 KPa) for the AGR start-up to save start-up fuel and oxygen. This 40% minimum turn-down is based on the constraints provided by a typical AGR column design;
- [0083]** As the gasifier pressure is increased, the rest of the gasification black water flash system is commissioned (the term "black water" designates the water stream from the gas/water scrubber used to remove particulates from the gasifier which is subsequently flashed to remove any dissolved gases); and
- [0084]** Ramping the gasifier pressure at 50-100% NOC to 100 (689.5 KPa)-1300 psig (8963 KPa). and lining out the unit, it should take a short time to reach the state NOC at full gasifier operating pressure before introducing gas to the shift section.
- [0085]** The syngas from the gasification zone is introduced to the shift section and the low temperature gas cooling ("LTGC") section. The syngas from the gasification zone syngas scrubber overhead is diverted from the flare and introduced to the shift zone and the LTGC zone by first opening the small equalizing valve at the inlet of the shift zone gradually to equalize the upstream and downstream pressure. After the pressure is equalized, then a control valve can be gradually opened to introduce more syngas to the shift zone and downstream. Simultaneously, the pressure control valve controlling the venting of the sweet syngas to the blowdown conduit passing to the flare can be gradually closed as more syngas is introduced to downstream section.
- [0086]** The introduction of syngas to the acid gas removal is performed similar to the introduction of syngas to the shift/LTGC zones. The scrubbed and shifted syngas passing through the AGR zone should be routed to the flare at a blow down conduit located at the outlet of the H₂ rich syngas in the AGR. Any CO₂ stream from the AGR unit can be vented to the atmosphere using a CO₂ vent stack. The AGR sweet acid gas is then sent to the Sulfur Recovery Unit ("SRU"). The SRU can be started up with supplementary firing using natural gas because the sweet acid gas contains practically no H₂S. The SRU refractory heat up is estimated to take at least about 16 to about 24 hours to complete. The SRU should reach steady-

state operation such that it is ready to receive sour acid gas. The effluent from the TGTU low pressure amine scrubber contains mainly CO₂ and is vented to a location downstream of the flare combustor burner during this start-up period.

[0087] The switching of the sulfur-free startup fuel to coke slurry feed can be performed after the AGR/SRU have reached steady-state operation. The composition of the vented syngas at the AGR will change slightly after the fuel switching. However, the switching of the sweet to sour acid gas to the SRU can be done over about a 30 minute to about one hour period. The sour acid reducing gas coming from the AGR is first routed to a low low pressure ("LLP") scrubber and then to a flare and then switched gradually to the SRU burner. Such switching of flow to the SRU burner is carried out while simultaneously reducing the start-up natural gas supply to the SRU.

[0088] After switching the fuel from clean sulfur-free natural gas or hydrocarbon liquid to coke slurry feed, the AGR acid gas H₂S concentration will steadily increase. The SRU operation is then adjusted to normal operating conditions by feeding H₂S acid gas from the AGR and NH₃ from a sour water stripper to the SRU. The SRU tailgas is sent to the TGTU amine scrubber. The TGTU amine scrubber overhead is first sent to the thermal oxidizer or flare. When the H₂S content in the scrubbed TGTU overhead gas is verified to be acceptable, i.e., less than ppmv 10 ppmv, the tail gas compressor can then be started up in order to route the tail gas to the product CO₂ stream or alternatively, if the H₂S content is too high, it can be routed to a point upstream of the AGR. The CO₂ stream from the AGR is routed to the CO₂ pipeline for sales or EOR.

[0089] The clean H₂ rich syngas can also be routed downstream using the expander bypass line to vent at the gas turbine inlet after the gasifier lightoff. The pressure control valve on an expander bypass can be used to automatically control the expander upstream pressure and the pressure control valve on the blowdown conduit to the flare can be used to automatically control the expander downstream pressure to the gas turbine.

[0090] For a planned shutdown, the shutdown actions can generally be carried out by reversing the steps of the start-up procedure. The gasifier throughput is reduced, e.g., from about 100% to about 70% at its normal operating pressure, and the fuel can be switched from coke slurry to a sulfur-free feedstock such as methanol. The gas turbine can be backed down commensurately. After switching the fuel to the gasifier, the syngas scrubber overhead control valve can be gradually closed, with the pressure control valve opened gradually to vent to the sweet reducing gas blowdown header passing to the flare. As the syngas is vented, the gasifier throughput is reduced simultaneously to minimize venting. When the syngas scrubber overhead control valves are completely closed, the clean syngas is 100% routed to the flare. The pressure and the throughput of the gasifier operating on the clean fuel can be gradually reduced until an arbitrary low throughput is achieved and a reduced gasifier pressure (for example, 50% NOC at 500 psig (3447 KPa) gasifier pressure) is established. The gasifier shutdown sequence is then initiated to shutdown the gasifier in a controlled manner.

[0091] When the gasifier shutdown sequence is initiated to shutdown the gasifier in a controlled manner, the syngas system is bottled up at operating pressure. The gasifier will be depressured gradually through the gasifier blowdown conduit to the flare. The flow rate of the syngas to the flare due to

depressurizing can be calculated by the reduction of inventory accordingly. After the syngas depressuring, the system can be nitrogen purged. The shutdown nitrogen purge is also sent to the flare as well via the gasifier blowdown conduit.

[0092] The pollution control equipment includes all equipment and flow schemes shown in FIGS. 2 and 3. For example, the relief or blow down gases are segregated into various relief headers according to whether the gases contain H_2S and oxygen, as described previously. A recovery system is included to recover any usable gases such as H_2 , CO_2 or sulfur for sales. A ground or elevated flare is used for emergency safety relief, shutdown and start-up operations. The sour gas scrubbers are used for H_2S removal in the startup/shutdown cases and in emergency acid gas release. The following is a non-exclusive example list of the pollution control equipment that may be used in an IGCC complex to carry out an embodiment of the present invention:

[0093] Thermal Oxidizer or Incinerator, Aux Boiler, Duct firing with HRSG (of these units will generally have an SCR downstream)

[0094] Emergency Sour Gas Scrubber (amine or caustic)

[0095] LLP Sour Gas Scrubber (TGTU MDEA absorber)

[0096] Flare Vapor Recovery System (sour gas recycle compressor)

[0097] TGTU Tail Gas Compressor

[0098] Flare Knockout Drum

[0099] Oxidizing Sour Gas Fugitive Emission Collector (eductor) System

[0100] Reducing Sour Gas Fugitive Emission Collector (eductor or compressor) System

[0101] Oxidizing Sweet Gas Fugitive Emission Collector (eductor or aspirator) System

[0102] Reducing Sweet Gas Fugitive Emission Collector (eductor or compressor) System

[0103] Gas Turbine/HRSG Pollution Control Systems

[0104] When pollution-control equipment is all operating properly, the sour gas coming from in the SRU tailgas is scrubbed and the clean TGTU tail gas is recycled back to upstream of the CO_2 compressors.

[0105] While the present invention has been described in terms of preferred embodiments, it will be understood, of course, that the invention is not limited thereto since modifications may be made by those skilled in the art, particularly in light of the foregoing teachings.

What is claimed is:

1. A process for starting up and shutting down an integrated gasification combined cycle complex wherein the integrated gasification combined cycle complex comprises a syngas production zone, shift conversion/low temperature gas cooling zone, acid gas removal zone, sulfur recovery zone and a combined cycle power block zone, wherein each zone has at least one blow down conduit associated with it, wherein the integrated gasification combined cycle complex is started up with a hydrocarbon-containing feedstock not containing contaminants such as sulfur-containing compounds and wherein said startup or shut-down is carried out with sulfur-free or reduced sulfur flaring which process comprises the steps of:

- (a) recovering any sour effluent stream from an applicable zone being started up or shutdown and;
- (b) scrubbing such sour gas to reduce the content of sulfur-containing contaminants during the startup or shutdown prior to venting or flaring such gases;

- (c) recovering a sweet reducing effluent stream from an applicable zone being started up in the integrated gasification combined cycle complex;

- (d) passing the sweet reducing effluent stream from the applicable zone that is being started up through at least one blow down conduit downstream of the applicable zone;

- (e) passing the sweet reducing stream recovered from the blow down conduit in step (c) to a flare or vent;

2. The process of claim 1 wherein oxidizing streams are collected from the group consisting of sumps, tanks, instrument vents, bridals, and pressure safety valves associated with the various zones in the integrated gasification combined cycle complex and such oxidizing streams are passed to the sulfur recovery zone.

3. The process of claim 1 which process further comprises the steps of:

- (a) passing a sulfur-free hydrocarbon feedstock to the syngas production zone to produce a sweet reducing syngas effluent stream;

- (b) passing the sweet reducing syngas effluent stream to a blow down conduit;

- (c) passing the sweet reducing stream from the blow down conduit in step (b) to a flare

- (e) when the feed rate to the syngas production zone reaches a predetermined rate at predetermined conditions including a predetermined pressure and temperature, the syngas zone sweet reducing effluent stream is diverted from the blow down conduit in step (b) to the shift conversion zone having a low temperature gas cooling zone downstream thereof to produce a sweet reducing stream effluent from the low temperature gas cooling zone;

- (f) passing the sweet reducing stream effluent from the low temperature gas cooling zone to a blow down conduit downstream of the low temperature gas cooling zone;

- (g) passing the sweet reducing stream from the blow down conduit in step (f) to a flare;

- (h) starting up the acid gas removal zone with nitrogen or any other inert gas such that when the acid gas removal zone has reached predetermined operating conditions including temperature and pressure the sweet reducing stream effluent from the blow down conduit associated with the low temperature gas cooling zone in step (f) is diverted to the acid gas removal zone to produce a sweet reducing effluent stream;

- (i) passing the sweet reducing effluent stream from the acid gas removal zone in step (h) to a blow down conduit downstream of the acid gas removal zone;

- (j) passing the sweet reducing stream from the blow down conduit in step (i) to a flare;

- (k) starting up the sulfur recovery zone with a start-up gas such as natural gas such that when the sulfur recovery zone has reached operating conditions the sweet reducing effluent stream from the acid gas removal zone is diverted from the blow down conduit in step (j) to the sulfur recovery zone to produce a sweet reducing effluent stream;

- (l) passing the sulfur recovery zone sweet reducing effluent to a tail gas treatment unit to produce a tail gas treatment unit sweet reducing effluent;

- (m) passing the tail gas treatment unit sweet reducing effluent to a thermal oxidizer or flare;

- (n) reducing the amount of sulfur-free containing feedstock to the syngas production zone and passing a sulfur-containing hydrocarbon feed stock to the syngas production zone;
 - (o) diverting the acid gas removal zone sweet reducing effluent stream from the sulfur recovery zone to a sour gas scrubber;
 - (p) passing the effluent from the sour gas scrubber to a flare;
 - (q) when the sulfur concentration of the acid gas removal effluent stream passing to the sour gas scrubber reaches a predetermined value, the stream is diverted back to the sulfur recovery zone while simultaneously reducing start up gas to the sulfur recovery zone;
 - (r) diverting the tail gas treatment unit effluent presently flowing to the thermal oxidizer or flare in step (m) to a point either upstream or down stream of the acid gas removal zone.
4. The process of claim 1 which process further comprises the steps of:
- (a) passing a sulfur-free hydrocarbon feedstock to the syngas production zone to produce a sweet reducing syngas effluent stream;
 - (b) passing the sweet reducing syngas effluent stream to the shift conversion zone having a low temperature gas cooling zone downstream thereof to produce a sweet reducing stream effluent from the low temperature gas cooling zone;
 - (c) passing the shift conversion zone effluent sweet reducing stream from the low temperature gas cooling zone to a blow down conduit downstream of the low temperature gas cooling zone;
 - (d) passing the sweet reducing stream from the blow down conduit in step (c) to a flare;
 - (e) starting up the acid gas removal zone with nitrogen or any other inert gas such that when the acid gas removal zone has reached predetermined operating conditions including appropriate temperature and pressure, the sweet reducing stream effluent from the blow down conduit associated with the low temperature gas cooling zone is diverted to the acid gas removal zone to produce a sweet reducing effluent stream;
 - (f) passing the sweet reducing effluent stream from the acid gas removal zone to a blow down conduit down stream of the acid gas removal zone;
 - (g) passing the sweet reducing stream from the blow down conduit in step (f) to a flare;
 - (h) starting up the sulfur recovery zone with a start-up gas such as natural gas such that when the sulfur recovery zone has reached operating conditions, the sweet reducing effluent stream from the acid gas removal zone is diverted from the blowdown conduit in step (f) to the sulfur recovery zone to produce a sweet reducing effluent stream;
 - (i) passing the sulfur recovery zone sweet reducing effluent to a tail gas treatment unit to produce a tail gas treatment unit sweet reducing effluent;
 - (j) passing the tail gas treatment unit reducing gas effluent to a thermal oxidizer or flare;
 - (k) reducing the amount of sulfur-free containing feedstock to the syngas production zone and passing a sulfur-containing hydrocarbon feed stock to the syngas production zone;
 - (l) diverting the acid gas removal zone reducing effluent stream from the sulfur recovery zone to a sour gas scrubber;
 - (m) passing the effluent from the sour gas scrubber to a flare
 - (n) when the sulfur concentration of the acid gas removal effluent stream passing to the sour gas scrubber reaches a predetermined value, the stream is diverted back to the sulfur recovery zone while simultaneously reducing start up gas to the sulfur recovery zone; and
 - (o) diverting the tail gas from the tail gas treatment unit effluent presently flowing to the thermal oxidizer or flare in step (j) to a point either upstream or down stream of the acid gas recovery zone.
5. The process of claim 1 which process further comprises the steps of:
- (a) passing a sulfur-free hydrocarbon feedstock to the syngas production zone to produce a sweet reducing syngas effluent stream;
 - (b) passing the sweet reducing syngas effluent stream to a shift conversion zone having a low temperature gas cooling zone downstream thereof to produce a sweet reducing effluent stream;
 - (c) passing the sweet reducing stream effluent from the low temperature gas cooling zone to the acid gas zone to produce a sweet reducing gas effluent stream;
 - (d) passing the sweet reducing gas effluent from the acid gas removal zone to a blow down conduit down stream of the acid gas removal zone;
 - (e) passing the sweet reducing stream from the blow down conduit to a flare;
 - (f) starting up the sulfur recovery zone with a start-up gas such as natural gas such that when the sulfur recovery zone has reached operating conditions, the sweet reducing effluent stream from acid gas removal zone is diverted from the blown down conduit in step (d) to the sulfur recovery zone to produce a sweet reducing effluent stream;
 - (g) passing the sulfur recovery zone sweet reducing effluent stream to a tail gas treatment unit to produce a tailgas treatment unit sweet reducing effluent;
 - (h) passing the tail gas treatment unit reducing gas effluent to a flare or thermal oxidizer;
 - (i) reducing the amount of sulfur-free containing feedstock to the syngas production zone and passing a sulfur-containing hydrocarbon feed stock to the syngas production zone;
 - (j) diverting the acid gas removal regenerator sweet reducing effluent stream from the sulfur recovery zone to a sour gas scrubber;
 - (k) passing the effluent from the sour gas scrubber to a flare;
 - (l) when the sulfur concentration of the acid gas removal effluent stream passing to the sour gas scrubber reaches a predetermined value, the stream is diverted back to the sulfur recovery zone while simultaneously reducing start-up gas to the sulfur recovery zone; and
 - (m) diverting the tail gas from the tail gas treatment unit effluent presently flowing to the flare or thermal oxidizer in step (h) to a point either upstream or down stream of the acid gas removal zone.
6. A process for shutting down the syngas production zone of an integrated gasification combined cycle complex wherein the integrated gasification combined cycle complex comprises a syngas production zone, shift conversion reaction/low temperature gas cooling zone, acid gas removal

zone, sulfur recovery zone and a combined cycle power block zone, wherein each zone has at least one blow down conduit associated with it wherein the complex is being fed a hydrocarbon-containing feedstock which feedstock contains contaminants such as sulfur, wherein the process comprises the steps of:

- (a) switching the feedstock to the syngas production zone to a sulfur-free hydrocarbon containing feedstock such that a sweet reducing stream effluent is created once the syngas from the sulfur-free feedstock displaces the sulfur-containing feedstock; and
- (b) diverting and depressurizing the sweet reducing stream effluent from the syngas production zone to a blow down conduit associated with the syngas production zone.

7. The process of claim **6** which involves shutting down additional zones and comprises the steps of

- (a) diverting and depressurizing a sweet reducing stream effluent from the low temperature gas cooling zone to the blow down conduit associated with this zone once the sulfur-free syngas from the sulfur-free feedstock displaces the syngas from the sulfur-containing feedstock in syngas production zone;
- (b) passing the effluent from the low temperature gas cooling zone in step (a) to a flare;
- (c) diverting and depressurizing the effluent from the acid gas removal zone as follows:
 - (i) passing a hydrogen rich syngas to a flare;
 - (ii) passing the acid gas to the sulfur recovery zone;
- (d) depressurizing the sulfur recovery zone to a tail gas treating unit ("TGTU") absorber;
- (e) passing the effluent from the low pressure tail gas treating unit absorber to a thermal oxidizer or flare;
- (f) switching the fuel to turbines associated with the power block zone from hydrogen to natural gas.

8. The process of claim **7** which process further comprises the steps of:

- (a) diverting and depressurizing the sweet reducing stream effluent from the acid gas removal zone as follows:
 - i) passing a hydrogen rich syngas to a flare;
 - ii) passing the acid gas to the sulfur recovery zone;
- (b) depressurizing the sulfur recovery zone to a tail gas treating unit absorber;
- (c) passing the effluent from the low pressure tail gas treating unit absorber to a thermal oxidizer or flare;
- (d) switching the fuel to turbines associated with the power block zone from hydrogen to natural gas.

9. A process for shutting down the syngas production zone of an integrated gasification combined cycle complex wherein the integrated gasification combined cycle complex comprises a syngas production zone, shift conversion reaction/low temperature gas cooling zone, acid gas removal

zone, sulfur recovery zone and a combined cycle power block zone, wherein each zone has at least one blow down conduit associated with it wherein the complex is being fed a hydrocarbon-containing feedstock which feedstock contains contaminants such as sulfur, wherein the process comprises the steps of:

- (a) diverting and depressurizing a sour reducing stream effluent from the syngas production zone to a blow down conduit associated with the syngas production zone;
- (b) passing the effluent from the syngas production zone in step (a) to a low pressure scrubber such as amine or caustic scrubber to remove the H_2S gas;
- (c) passing the effluent of the low pressure scrubber to a flare or thermal oxidizer;

10. The process of claim **9** of shutting down the entire processing units of the IGCC which process further comprises the steps of:

- (a) diverting and depressurizing a sour reducing stream effluent from the temperature gas cooling zone to the blow down conduit associated with this zone;
 - (b) passing the effluent from the low temperature gas cooling zone to a low pressure scrubber such as amine or caustic scrubber for H_2S removal;
 - (c) passing the effluent from the low pressure scrubber in step (b) to flare
 - (d) diverting and depressurizing the effluent from the acid gas removal zone as follows:
 - (i) passing a hydrogen rich syngas to a flare;
 - (ii) passing the acid gas to the sulfur recovery zone;
 - (e) depressurizing the sulfur recovery zone to a tail gas treating unit absorber;
- passing the effluent from the low pressure tail gas treating unit absorber to a thermal oxidizer or flare;
- (g) switching the fuel to turbines associated with the power block zone from hydrogen to natural gas.

11. The process of claim **10** which process further comprises the steps of:

- (a) diverting and depressurizing the sour reducing stream effluent from the acid gas removal zone as follows:
 - (i) passing a hydrogen rich syngas to the flare;
 - (ii) passing the acid gas to the sulfur recovery zone;
- (b) depressurizing the sulfur recovery zone to a tail gas treating unit absorber;
- (c) passing the effluent from the low pressure tail gas treating unit absorber to a thermal oxidizer or flare; and
- (d) switching the fuel to the turbines associated with the power block zone from hydrogen to natural gas.

12. The process of claims **9**, **10** and **11** are also used for unplanned emergency shutdown.

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