

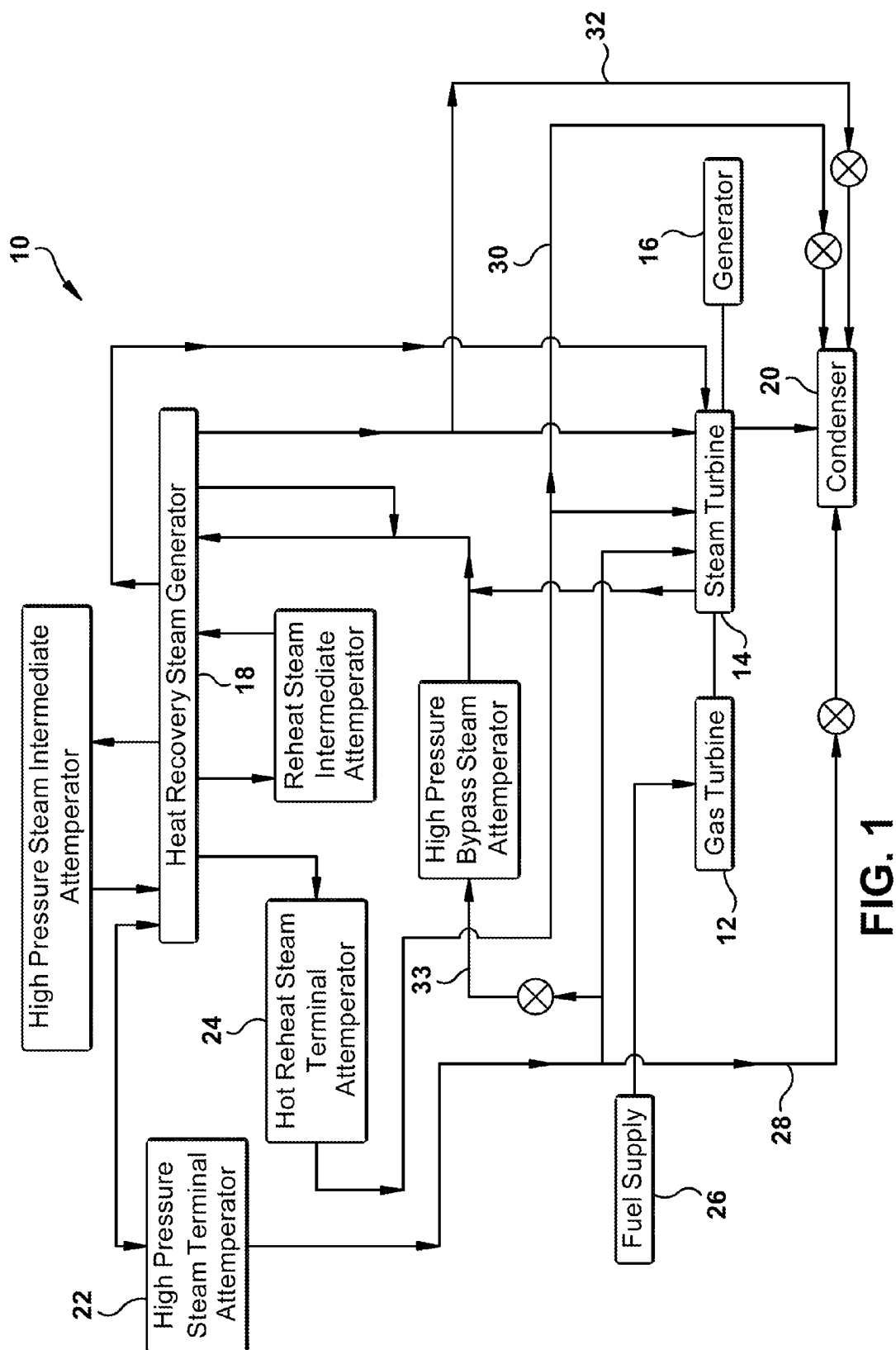


FIG. 1

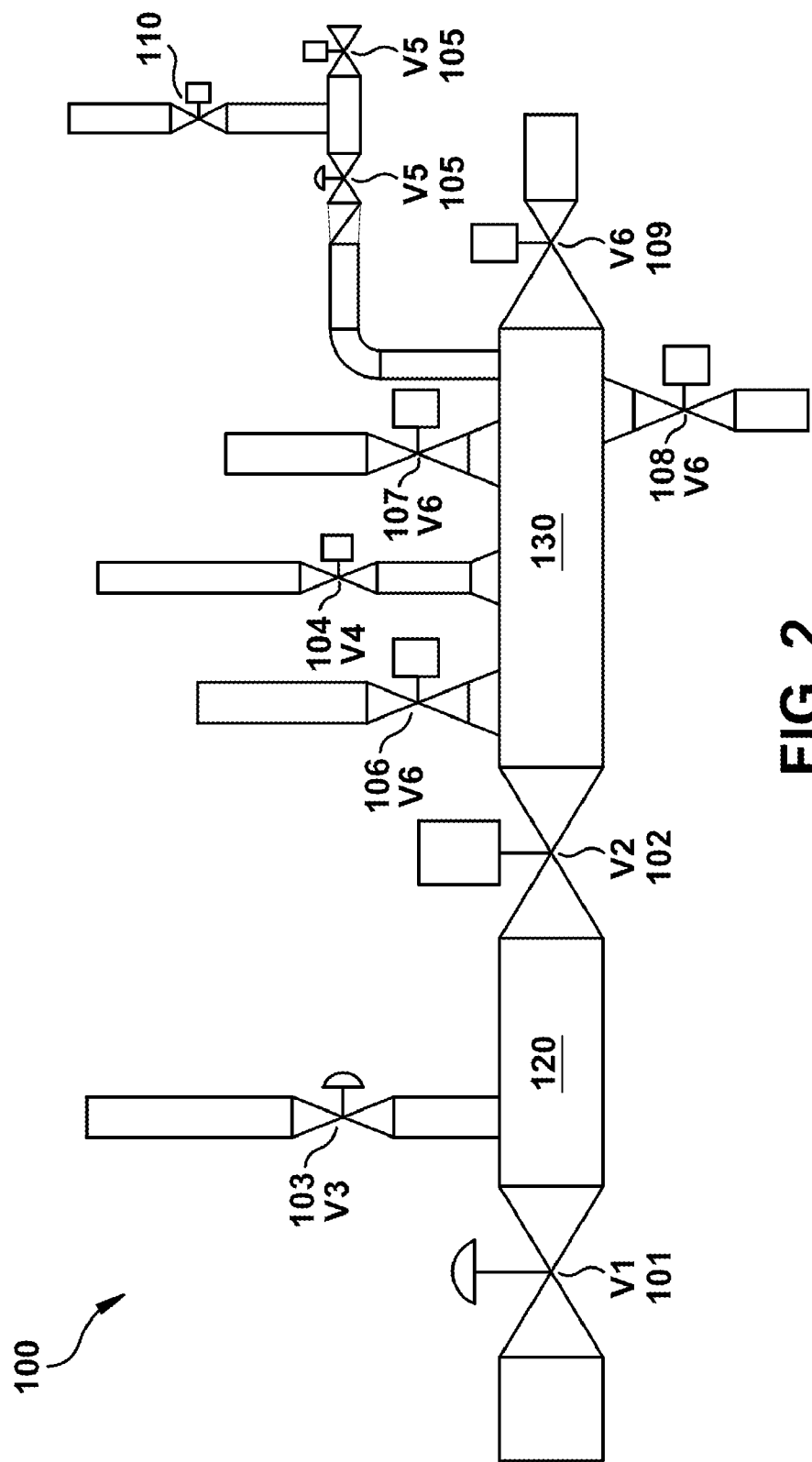


FIG. 2

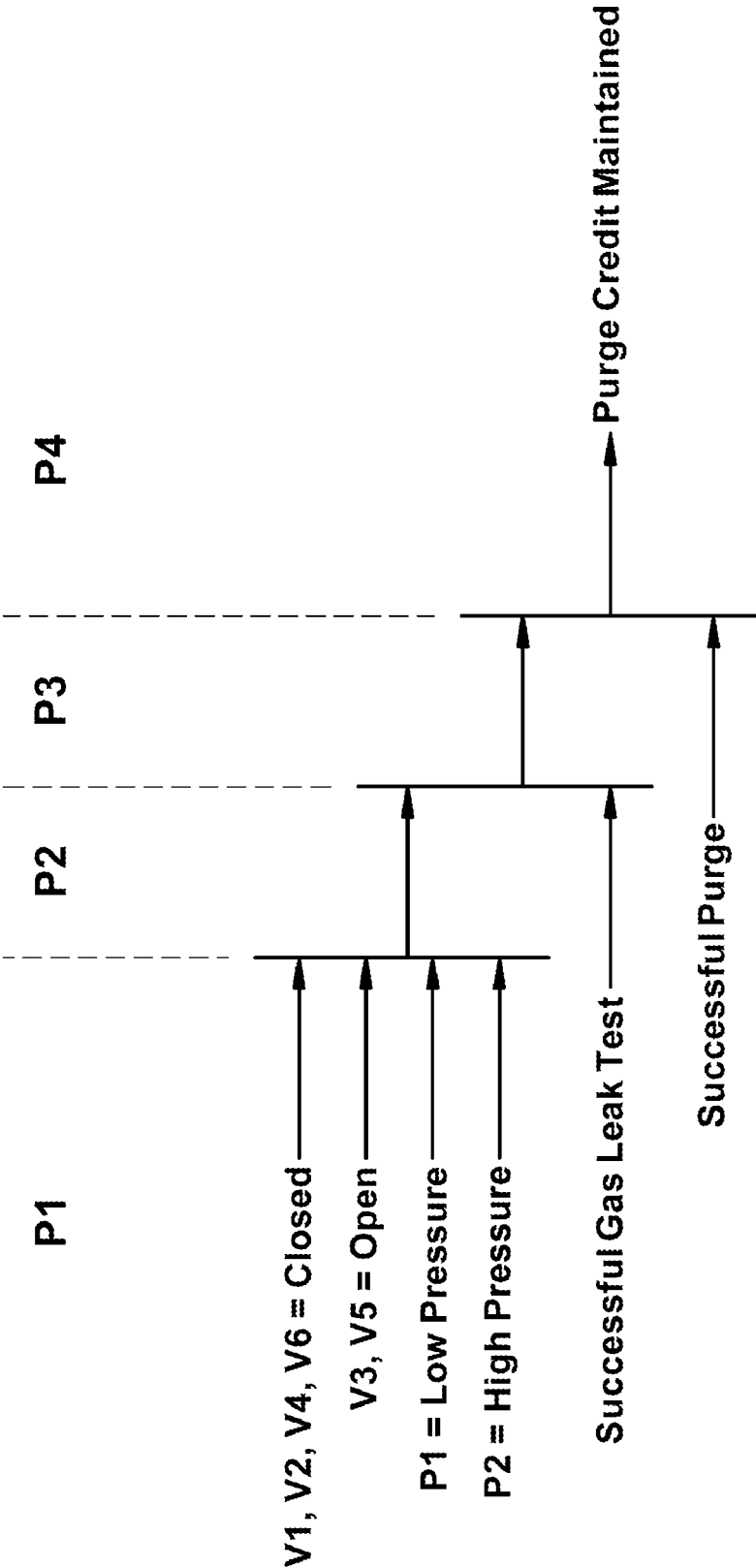


FIG. 3

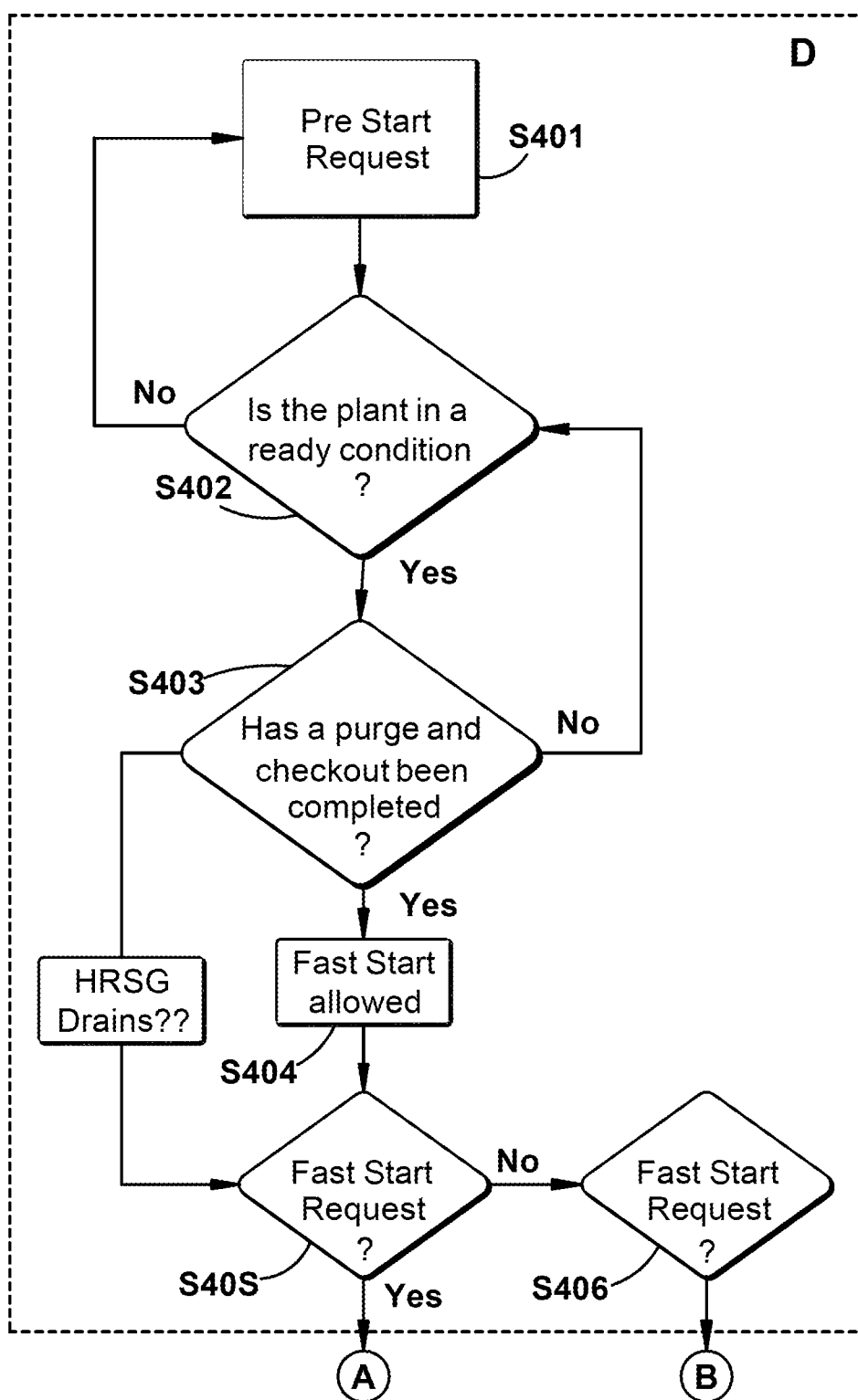


Fig. 4A

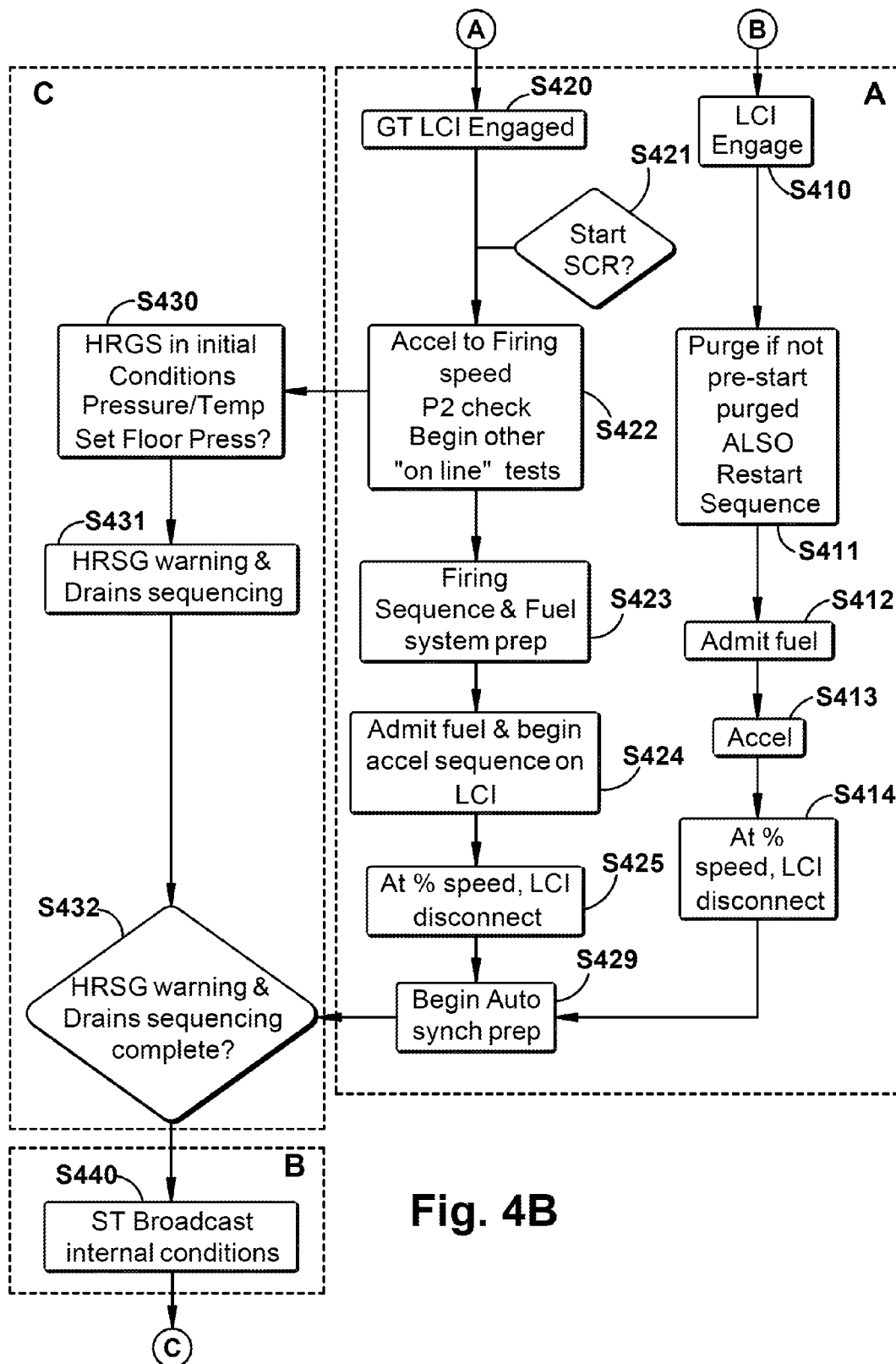


Fig. 4B

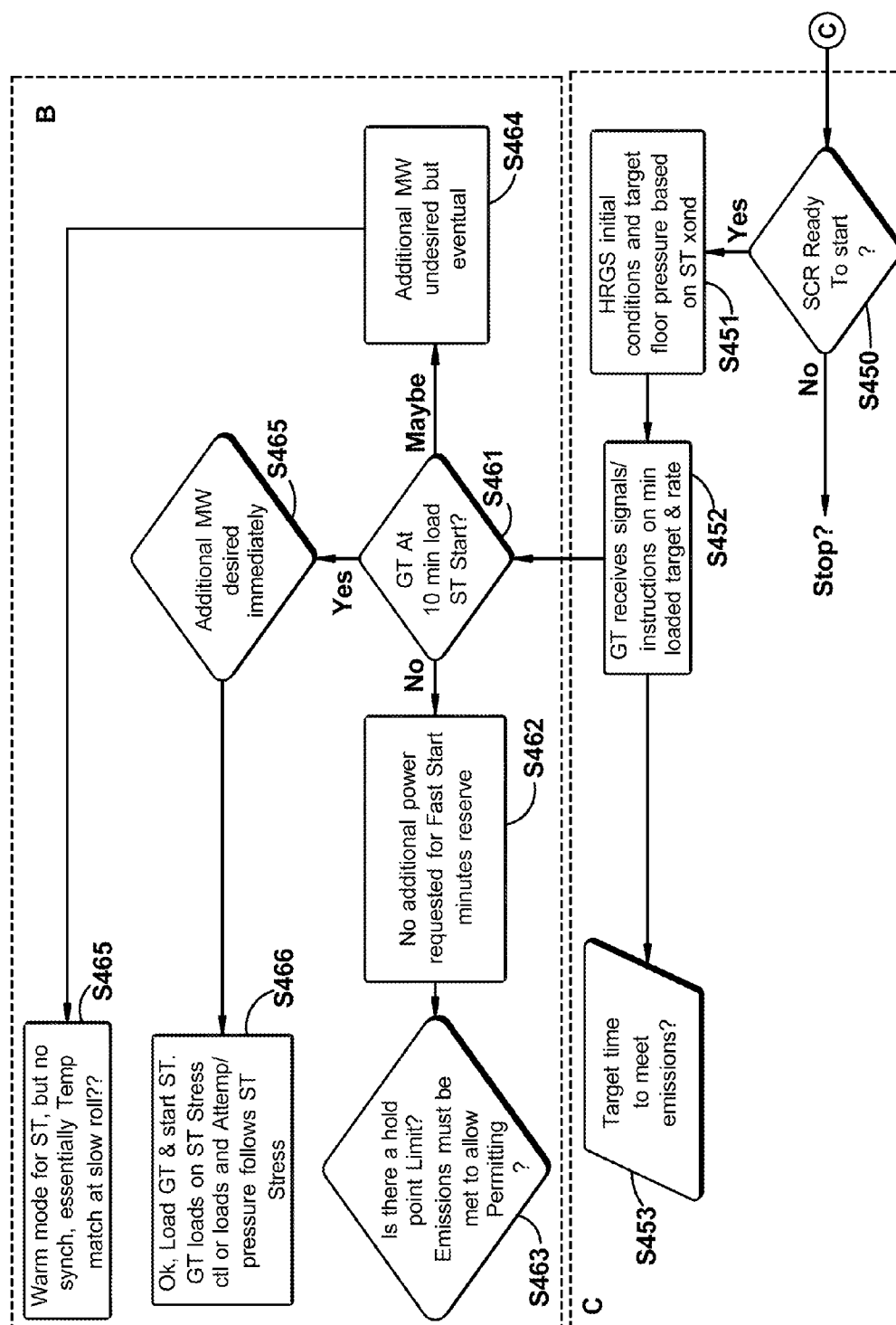


Fig. 4C

COMBINED CYCLE POWER PLANT WITH RESERVES CAPABILITY

[0001] This application is based on U.S. Provisional Patent Application 61/012,625, entitled "Combined Cycle Power Plant with Reserves Capability" filed Dec. 10, 2007, which this application claims benefit and is herein incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] This invention relates generally to a combined cycle power plant. In particular, the invention relates to a combined cycle power plant that can be configured to support multiple ancillary and reserves services, in addition to a current capability to load follow, execute regulation, and meet intermediate power generation service.

[0003] There are some known combined cycle power plants, such as, but not limited to, U.S. Pat. No. 25,268,594A1 to Hitachi, which may be directed to a Fast Start By-Pass Damper Design; U.S. Pat. No. 26,254,280A1—to Siemens, which may be directed to a Compressor Extraction, Auxiliary Boiler Elimination; U.S. Pat. No. 40,693,086—to Hitachi, which may be directed to a Reheat Bypass to Condenser; U.S. Pat. No. 6,957,540—to Siemens, which may be directed to a Multimode complex cycle power plant; and US20040013511 to Siemens which may be directed to a Steam System Pre-heating Siemens Corp.

[0004] Peaking or simple cycle plants execute fast starts and are then replaced by efficient generation over a longer time period. Several of the above noted documents, including the Hitachi Bypass Fast Start duct By-Pass system, address such matters. Siemens has multiple documents on the subject of fast start and cycling plants. These Siemens include the SCC6-5000F intermediate duty plant, and multiple articles about Siemens 501 cycling capability. Siemens Westinghouse offered multiple configurations of fast starting and cycling power plants, such as their "Hybrid Peaker" (SCC6-5000F) that provides for intermediate service peaking and of the fast 10-minute start characteristics of peaker plant without a high temp SCR.

[0005] Moreover, the current assignee of the application, General Electric Company, has a portfolio of combined cycle (CC) power plants (CCPP), such as, but not limited to, those disclosed in U.S. Pat. No. 27,113,562A1, Method and Apparatus for Starting Up Combined Cycle Power Systems (Rapid Response); U.S. Pat. No. 04,207,864, Damper (HRSG damper design); U.S. Pat. No. 04,208,882, Startup Attenuator (terminal attenuator and control strategies); U.S. Pat. No. 04,598,551, Apparatus and Method for Controlling Steam Turbine Operating Conditions During Starting and Loading (RH bypass); U.S. Pat. No. 05,361,585, Steam Turbine Split Forward Flow; U.S. Pat. No. 05,412,936, Method of Effecting Start-up of a Cold Steam Turbine System in a Combined Cycle Plant (exhaust bypass around HRSG and intermediate steam extraction from HRSG); and U.S. Pat. No. 06,626,635, System for Controlling Clearance Between Blade Tips and a Surrounding Casing in Rotating Machinery. Reference to these commonly assigned patents and applications can provide further insight into the scope of the instant invention, and the subject matter herein.

BRIEF DESCRIPTION OF THE INVENTION

[0006] In one aspect of the invention, a combined cycle (CC) power plant comprises a gas turbine; a steam turbine; a

condenser; a heat recovery steam generator (HRSG), the HRSG comprising an attenuator and a high pressure superheater and attenuator; the high pressure superheater and attenuator disposed at a discharge terminal of the high pressure superheater and attenuator and at a discharge terminal of the HRSG reheater; a generator, and a fuel supply. The steam turbine is connected by multiple conduits to the heat recovery steam generator (HRSG) and the steam turbine exhaust is connected to the condenser wherein support multiple ancillary and reserves to load follow, execute regulation, and meet intermediate power generation service needs in an expedited start process.

[0007] Another aspect of the invention provides a method of providing and operating a combined cycle (CC) power plant. The combined cycle (CC) power plant comprises a gas turbine; a steam turbine; a condenser; a heat recovery steam generator (HRSG), the HRSG comprises an attenuator and a high pressure superheater and attenuator, the high pressure superheater and attenuator disposed at a discharge terminal of the high pressure superheater and attenuator and at a discharge terminal of the HRSG reheater; a generator, a fuel supply; wherein the fuel supply comprises a piping configuration to supply fuel to the power plant, the fuel supply comprises at least two pressure cavities in fluid communication with each other be a series of valves, the series of valves control flow there between and when the series of valves are operated with each other, permit fuel to flow to the combined cycle power plant in a controlled manner to allow fast start up of the combined cycle power plant and to permit dilution and removal of combustible gasses has been completed in the combined cycle power plant before a combined cycle power plant start command is provided. The method comprises controlling the series of valves, opening and closing selected ones of the series of valves to provide a first pressure in one section of the fuel supply and a second pressure in another section of the fuel supply. Wherein, the first pressure is lower than the second pressure; conducting a gas leak test in the fuel supply of the combined cycle (CC) power plant; if the gas leak test is successful, conducting a purge of the fuel supply of the combined cycle (CC) power plant; and if the purge of the fuel supply of the combined cycle (CC) power plant is successful maintaining the purge and starting the combined cycle (CC) power plant.

[0008] These and other aspects, advantages and salient features of the invention will become apparent from the following detailed description, which, when taken in conjunction with the annexed drawings, where like parts are designated by like reference characters throughout the drawings, disclose embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a schematic illustration of an exemplary combined cycle power system;

[0010] FIG. 2 is a further schematic illustration of an exemplary combined cycle power system;

[0011] FIG. 3 is a process illustration for the operation of the various valves in the fuel system 100, as embodied by the invention; and

[0012] FIG. 4 illustrates an overall flow chart outlining a process for the start purge system, as embodied by the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0013] This invention comprises a combined cycle (CC) power plant, such as, but not limited to, a 207FA+e (General

Electric Company) combined cycle power plant. The combined cycle power plant (CCPP) can be configured to support multiple ancillary and reserves services in addition to its current capability to load follow, execute regulation, and meet intermediate power generation service needs. The power plant may be shut down, the fuel system tested, staged, the HRSG purged, and then the plant is placed in a standby mode of operation managed by the GE ICS in a condition minimizing net power demand and allowing a reliable and effective start upon notification. The Plant may also use attributes of the fast start methodology to improve normal CC starts through use of the breakout of the purge, the pre-start check-out and standby sequence, and the active torque and load management to ensure the plant meets start power commitments.

[0014] One or more specific embodiments of the present invention will be described below. In an effort to provide a concise description of these embodiments, all features of an actual implementation may not be described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

[0015] While the methods and apparatus are herein described in the context of a combined cycle power system used in an electric utility power generation environment, it is contemplated that the methods and apparatus described herein may find utility in other applications. In addition, the principles and teachings set forth herein are applicable to turbines using a variety of combustible fuels such as, but not limited to, natural gas, gasoline, kerosene, diesel fuel, and jet fuel. In addition, such startup can be utilized in connection with both multi-shaft and single-shaft combined cycle systems. The description herein below is therefore set forth only by way of illustration, rather than limitation.

[0016] FIG. 1 is a schematic illustration of a combined cycle power system 10 in accordance with one embodiment of the present invention. As is known in the art, system 10 includes a gas turbine 12 and a steam turbine 14 coupled to a generator 16. Steam turbine 14 is connected by multiple conduits to a heat recovery steam generator (HRSG) 18 and its exhaust is connected to a condenser 20.

[0017] In the embodiment illustrated in FIG. 1, system 10 includes attemperators 22 at the discharge terminal of the high pressure superheater and attemperator 24 located at the discharge terminal of the reheater in HRSG 18. HRSG 18 may have a once-through or a drum type evaporator, which is capable of tolerating daily startup and loading of gas turbine 12 at an optimized rate with normal life span and maintenance. Such HRSGs in drum type configuration are new and generally unknown in the art.

[0018] During startup and loading the gas turbine and steam turbine, attemperators 22 and 24 operate to reduce the temperature of high pressure and hot reheat steam generated by HRSG 18 that is supplied to steam turbine 14. Particularly, attemperator 22 facilitates satisfying steam turbine criteria for steam temperature to high pressure bowl metal tempera-

ture matching with gas turbine 12 at any load. The temperature of the hot reheat steam for admission to the steam turbine intermediate pressure section is controlled to the steam to metal temperature matching criteria by the reheat steam terminal attemperator 24. Attemperators 22 and 24 are well known in the art and are commercially available, for example, from CCI.

[0019] System 10 also includes a fuel gas supply 26 for fuel supplied to gas turbine 12. In an example embodiment, such supply can be using an auxiliary boiler and intervening heat exchanger between the auxiliary boiler steam outlet and the gas fuel line. The supply, as embodied by the invention, can also comprise a means for heating the fuel during startup provides the advantage of a faster loading of gas turbine 12 as compared to loading without such fuel heating. More particularly, heating fuel with an auxiliary heat source provides the advantage that during startup gas turbine loading can proceed at an enhanced rate, non embodiment, loading can proceed at its fastest rate an enhanced rate, none embodiment loading can proceed at its fastest rate. Specifically, heating the fuel utilizing heat from an auxiliary source allows for uninterrupted loading at an optimized rate to facilitate reduce with lowest exhaust emissions to enhanced load, as embodied by the invention.

[0020] System 10 further includes bypass paths 28, 30 and 32 from HRSG 18 to condenser 20 and bypass path 33 from the high pressure steam line to the cold reheat steam piping that provide alternate high pressure steam flow paths while the steam turbine admission valves are modulated to load the steam turbine at its fastest allowable rate. Bypass paths 28 and 33 include valves that are modulated to control the pressure of the high-pressure steam and the rate of increase of high-pressure steam pressure. Bypass path 30 provides an alternate path for the hot reheat steam while the intermediate pressure control valve is modulated during steam turbine loading. Bypass path 30 includes a valve that is modulated to control the reheat steam pressure while the steam turbine intermediate pressure control valve is modulated during steam turbine loading. Steam bypass path 32 provides an alternate path for the low-pressure steam while the steam turbine low-pressure admission valve is modulated during steam turbine loading. This bypass arrangement allows for 100% or greater steam generation by HRSG 18 with gas turbine 12 at up to maximum load with steam the turbine at any load from no load to a maximum load.

[0021] In addition, a steam turbine loading procedure is utilized that holds constant steam temperature from initial steam admission until all of the steam generated by the HRSG with gas turbine 12 at up to maximum load is being admitted and steam turbine loading can be performed at any gas turbine load up to maximum load. This maybe accomplished by maintaining the set point temperature of the high pressure steam terminal attemperator 22 at either the lowest allowable temperature (for example at approximately 700 F) or if the bowl metal temperature is higher than the minimum, slightly above the measured temperature of the steam turbine high pressure bowl metal temperature when high pressure steam is initially admitted to the steam turbine. Likewise, the hot reheat steam terminal attemperator 24 set point is maintained at either the lowest allowable temperature or if the steam turbine intermediate pressure bowl metal temperature is above the minimum when steam admission is initiated, at a temperature at or slightly above the bowl metal temperature. This startup procedure facilitates steam turbine loading while

facilitating minimum stress resulting from turbine shell or rotor heating. After all steam flow is being admitted to steam turbine 14, the steam temperature is raised at a rate compatible with allowable steam turbine stress and differential expansion to achieve normal steam turbine output and efficiency. Terminal attemperators 22 and 24 provide control of steam temperature during this steam turbine startup.

[0022] For single-shaft systems, where the steam turbine and gas turbine are coupled to a single generator, a steam supply is provided from the first pass of the high pressure superheater to augment cooling steam for the steam turbine last stage buckets during periods when steam bypass to the condenser and results in increased condenser pressure and steam turbine cooling flow requirement.

[0023] FIGS. 2 and 3 illustrate aspects of the fuel supply 26 of FIG. 1, however in further detail and clarification. FIG. 2 is a schematic illustration of an exemplary fuel system 100, as embodied by the invention. FIG. 3 is a process illustration for the operation of the various valves in the fuel system 100, as embodied by the invention, of FIG. 2.

[0024] In FIG. 2, the fuel system 100, as embodied by the invention, comprises a piping configuration to supply fuel, either heated or non-heated, depending on the particulars of the combined cycle power plant, as embodied by the invention. The fuel system 100 comprises at least two pressure cavities 120 and 130. The two pressure cavities 120 and 130 are in fluid communication with each other by a series of valves, which control the flow there between and when operated in concert with each other, permit fuel to flow to the combined cycle power plant, in a controlled manner to allow fast start up of the combined cycle power plant, as embodied by the invention.

[0025] In particular, with reference to FIG. 2, pressure cavity 120 has an auxiliary stop valve V1 101 on one side of the pressure cavity 120, and a stop speed ratio valve V2 102 connecting the pressure cavity 120 to pressure cavity 130, and permitting flow there between. Further, a vent valve V3 103 is connected to the pressure cavity 120, which can allow the pressure cavity 120 to be vented to an appropriate venting receptacle or the like.

[0026] The pressure cavity 130 comprises several general control valves (GCVs) V6, 106, 107, 108, and 109. While the pressure cavity 130 as illustrated herein in FIG. 2 comprises 4 such general control valves V6, the pressure cavity 130 can comprise any such number of general control valves V6, in order to permit the system, as embodied by the invention, to allow fast start up of the combined cycle power plant, as embodied by the invention.

[0027] Moreover, pressure cavity 130 comprises vent valves V4 104 and V5 105. As illustrated, either of the vent valves can comprise a multiple vent valve configuration, as embodied by the invention. In this Figure, vent valve V5 105 comprises a multiple (here two) vent valve configuration.

[0028] The valves of the pressure cavity 120 and pressure cavity 130 can comprise any appropriate valve configuration. The valves, as embodied by the invention, either alone or collectively, can comprise rotary valves, gate valves, stem valves, butterfly valves, ball valves, choke valves, or any other valve configuration. Further, valves of the pressure cavity 120 and pressure cavity 130 can be controlled by any appropriate means, such as solenoid, manual, sensor controlled, remotely controlled or any other appropriate control, so the valves work as intended.

[0029] With reference to FIGS. 2 and 3, a feature in known combined cycle power plants with fast starting capabilities for reserves services is a purge system, such as an anticipated start purge system, as embodied by the invention. The anticipated start purge sequence breaks out NFPA 85, as needed for a Heat Recovery Steam Generator HRSG volume exchange from a start sequence allowing completion at a time before the start request, shortening overall combined cycle power plant start time.

[0030] In a standard combined cycle gas turbine start, the combined cycle power plant is prepared to a ready to start condition. A gas turbine start sequence begins with roll off to HRSG purge speed, the purge is completed, and then an ignition sequence begins followed by the acceleration to synch speed. The entirety of a normal gas turbine start sequence can take up to about 30 minutes to complete with the purge sequence consuming approximately 50% of the start time to synchronization.

[0031] The start purge system, as embodied by the invention, uses a principal of HRSG "Purge Credit" to shorten start time. The fundamentals of "purge credit" means having a specific fuel system configuration, completing leak testing, securing the fuel system to a standby condition, and then monitoring conditions after an HRSG purge. This purge credit, as embodied by the invention, permits dilution and removal of combustible gasses has been completed in the combined cycle power plant before a combined cycle power plant start is commanded. The configuration of a purge credit qualified fuel system, as embodied by the invention, includes three block valves (FIG. 2) or the equivalent in series, where a lead pressure cavity 120 formed by the valves is held at low pressure through a vent valve V3 103 to atmosphere, and a N2 block is held in the pressure cavity 130 cavity as illustrated herein.

[0032] As embodied by the invention, the lead pressure cavity 120 pressure and the various valve (101, 102, 103, 104, 105, 106, 107, 108, and 109) positions are monitored by a management control system, not illustrated. The management control system, as embodied by the invention, can ensure safe operating conditions are maintained in the duration of the period after a purge and before a start of the combined cycle power plant.

[0033] The process for the start purge system, as embodied by the invention, is outlined herein with respect to FIGS. 3 and 4. In FIG. 3, the process for the start purge system is divided into process for the start purge periods, P1-P4. While the process for the start purge system is illustrated and described herein in 4 periods, the process for the start purge system can be divided and sub-divided into any appropriate number of periods.

[0034] In period P1, valves V1, V2, V4, and V6 (101, 102, 104, and 106) are closed; valves V3 and V5 (103 and 105) are open, pressure cavity 120 is provided at a "low" pressure and pressure cavity 130 is provided at a "high" pressure, where the pressure of the pressure cavity 120 is less than the pressure in pressure cavity 130.

[0035] In Period P2, a leak test on the fuel system 100, as embodied by the invention, is conducted. If the leak test on the fuel system 100 is successful, in other words, there are no leaks, the process for the start purge system, as embodied by the invention, continues to period P3. In period P3, a purge of the fuel system 100 is conducted, and if the purge is complete

and successful, the process for the start purge system, as embodied by the invention, maintains the purge for the start in the purge system.

[0036] FIG. 4 illustrates an overall flow chart outlining a process for the start purge system, as embodied by the invention. A description of this illustrative and non-limiting embodiment of the process for the start purge system, as embodied by the invention, will now be provided with reference to FIG. 4. In figure 4, there are at least 4 general process areas, a Gas Turbine (GT)/Plant Controls process area "A"; a Steam Turbine Gas Turbine (GT)/Plant Controls process area "B"; a P&A Engineering, PPS systems and HRSG process area "C"; and a GT/Plant Controls and EED Operability/PPS Systems process area "D". The overall flow chart outlining a process for the start purge system, as embodied by the invention, of FIG. 4 will be described hereinafter.

[0037] At the start of the overall process for the start purge system, as embodied by the invention, a pre-start request is received at S401. If the plant is in a "ready" condition, at Step S402, an inquiry as to whether a purge and checkout has been completed is done at Step S403. Also at Step S403, any HRSGs are checked, thus allowing a Fast Start request, if requested at Step S405, to occur. If the overall process for the start purge system is not in a "ready" condition, at Step S402, the overall process for the start purge system returns to Step S402, where the inquiry can be repeated.

[0038] If the purge and checkout has been completed is done at Step S403, a Fast Start, as embodied by the invention, is allowed at Step S404. The overall process for the start purge system, as embodied by the invention, proceeds to Step S405 to determine if there has been a Fast Start request, as embodied by the invention. If no Fast Start request, as embodied by the invention, as standard start request proceeds, at Step S406. Steps S401-S406 comprise Gas Turbine (GT)/Plant Controls process area "A."

[0039] From the a GT/Plant Controls and EED Operability/PPS Systems process area "D" both Steps S405 and S406 proceed to the Gas Turbine (GT)/Plant Controls process area "A". If a standard start request, at Step S406, the process, as embodied by the invention, proceeds to engage the LCI at Step S410, purge at Step S411, if there is not a pre-start purge and restart sequence. Next at step S412 fuel is admitted to the LCI of the system, acceleration of the LCI occurs at step S412, and at a predetermined percentage of LCI speed, the LCI is disconnected at step S414. Thereafter, auto synchronization preparation occurs at step S429.

[0040] If in the Gas Turbine (GT)/Plant Controls process area "A", a Fast Start Request inquiry at Step S405 of the GT/Plant Controls and EED Operability/PPS Systems process area "D", as embodied by the invention, the LCI of the gas turbine (GT) is engaged at step S420. Next, an inquiry to start the SCR is made in step S421. Thereafter, the process provides acceleration to firing speed, a check on pressure cavity 120 and other needed on-line tests are conducted, in step S422. From step S422, the overall process for the start purge system, as embodied by the invention, can proceed to the P&A Engineering, PPS systems and HRSG process area "C" at step S430 where an HRSG is placed in needed initial conditions, including temperature, pressure, and other desired operational HRSG conditions, followed by HRSG warming and drain sequencing at Step S431. In turn the process in the P&A Engineering, PPS systems and HRSG process area "C" determines if the HRSG warming and drain sequencing is complete at Step S432.

[0041] If step S422 stays within the Gas Turbine (GT)/Plant Controls process area "A" preparation for a firing sequence and fuel system preparation occurs at step S423 and then to step S424 where fuel is admitted and an LCI acceleration sequence is initiated. Subsequently in step S425, at a predetermined percentage of LCI speed, the LCI is disconnected. Thereafter, auto synchronization preparation occurs at step S429.

[0042] From Step S429, the overall process for the start purge system, as embodied by the invention, in the Gas Turbine (GT)/Plant Controls process area "A" determines if HRSG warming and drain sequencing is complete at Step S432, in the P&A Engineering, PPS systems and HRSG process area "C".

[0043] From step S429, when it is determined that the HRSG warming and drain sequencing is complete, the overall process for the start purge system, as embodied by the invention, moves to a Steam Turbine Gas Turbine (GT)/Plant Controls process area "B". Here in step S440, the steam turbine internal conditions are checked to confirm that the overall process for the start purge system, as embodied by the invention, can proceed. If acceptable, the overall process for the start purge system, as embodied by the invention, moves from Steam Turbine Gas Turbine (GT)/Plant Controls process area "B"; to the P&A Engineering, PPS systems and HRSG process area "C" and steps S450-S453.

[0044] In step S450, an inquiry is made to determine if the SCR is ready to start, and if not, the overall process for the start purge system, as embodied by the invention, and the process in the P&A Engineering, PPS systems and HRSG process area "C" can be stopped and may not proceed further, unless intervention occurs. If in step S450, the SCR is ready to start, the overall process for the start purge system, as embodied by the invention, in the P&A Engineering, PPS systems and HRSG process area "C" determines if the HRSG initial conditions and target floor pressure are set, in step S451. Next, in step S452, the gas turbine receives signals/instructions on a lowest possible target and rate given the conditions determined under the overall process for the start purge system, as embodied by the invention, and the operational system, as embodied by the invention. If the gas turbine receives signals/instructions on a lowest possible target and rate given the conditions determined under the overall process for the start purge system, as embodied by the invention, and the system are not yet reached, a time to reach acceptable conditions, such as but not limited to, emissions, is determined in step S453.

[0045] If in step S452, the gas turbine receives signals/instructions on a lowest possible target and rate given the conditions determined under the overall process for the start purge system, as embodied by the invention, and the operational system, as embodied by the invention, is within values where proceeding can occur, the overall process for the start purge system, as embodied by the invention, the P&A Engineering, PPS systems and HRSG process area "C" moves to again to the Steam Turbine Gas Turbine (GT)/Plant Controls process area "B", as illustrated in FIG. 4.

[0046] In the Steam Turbine Gas Turbine (GT)/Plant Controls process area "B"; the overall process for the start purge system, as embodied by the invention, continues from Step S452, where at Step S461, a query is made to determine if the gas turbine is at approximately a 10 minute load for starting as well as the steam turbine. Step S462 provides three possible responses, "no", "yes" and "maybe". If at Step S461, the

query is made to determine if the gas turbine is at approximately a 10 minute load for starting as well as the steam turbine is “no”, they the process proceeds to Step S462 where “no additional power requested for Fast start” signal is generated and to Step S463 where emissions are permitted to be met for permitting of the system 10, as embodied by the invention, for example by letting a hold period elapse.

[0047] If at Step S461, the query is made to determine if the gas turbine is at approximately a 10 minute load for starting as well as the steam turbine is “maybe”, the system 10, as embodied by the invention, and the overall process for the start purge system, as embodied by the invention, determine that additional megawatts (MW) are not desired immediately, however, not entirely ruled out for the system 10 and the overall process for the start purge system, as embodied by the invention in Step S464. Next the overall process for the start purge system, as embodied by the invention, in the Steam Turbine Gas Turbine (GT)/Plant Controls process area “B” provides a “warming mode” for the Steam Turbine, without synchronizing in Step S465. In Step S465, the temperature of the Steam Turbine is generally the same for a slow start of the Steam Turbine.

[0048] However, if at Step S461, the query is made to determine if the gas turbine is at approximately a 10 minute load for starting as well as the steam turbine is “yes”, the overall process for the start purge system, as embodied by the invention, in the Steam Turbine Gas Turbine (GT)/Plant Controls process area “B” provides additional megawatts (MW) immediately in Step S465 and then the process loads the Gas Turbine and starts the Steam Turbine, as embodied by the invention.

[0049] According to the invention, an exemplary combined cycle (CC) power plant, such as, but not limited to, a 7FA+e CC plant with Reserves Service Capability can capture capability of an intermediate simple cycle duty peaking plant with the characteristically high efficiency, low emissions, on line load following and reserves capability of a full combined cycle plant. Due to electric market structure and management, combined cycle gas turbine power plants have participated in what has been called intermediate duty, which includes daily starts and possible on line regulation or load following in the production of energy depending on the plant configuration.

[0050] With relatively recent changes in the market, gas turbines are less likely to be operating at high output for long periods. This functionality, as embodied by the invention, of the system 10, as embodied by the invention, and the overall process for the start purge system, as embodied by the invention can provide for fast plants starts resulting in the capability to achieve non spinning reserve starts (as known in the art) while reducing relatively lower net plant emissions during those starts. The integrated control system approach facilitates a highly integrated plant pre-start automation contributing to start reliability and the management of plant conditions during standby conditions.

[0051] This functionality, as embodied by the invention, of the system 10, as embodied by the invention, and the overall process for the start purge system, as embodied by the invention include the plant ICS integrated control technology. This technology can manage shutdown, standby, a pre-start and plant readiness feature, and fast starting gas turbine allowing the CC plant to participate in ancillary reserves service. Moreover, the system 10, as embodied by the invention, and the overall process for the start purge system, as embodied by the invention can provide for a start purge for heavy-duty gas

turbine that reduces plant start time in normal and fast starts by providing a modification to a fuel system configuration. The anticipated start purge concept uses a standard configuration fuel system, and N2 blocking as in IGCC applications to prevent unplanned leaks from the gas fuel system to the HRSG during purge credit hold periods. This integrated control method can also allow for the checkout of components before a known start at a time that contributes to a high starting reliability that's demanded by today's energy markets.

[0052] The system 10, as embodied by the invention, and the overall process for the start purge system, as embodied by the invention also includes a feature allowing for continued acceleration from Gas Turbine to come off of auto synch without pausing to set firing conditions. The Gas Turbine control and starting means, as embodied by the invention, integrated torque management control system manage conditions through use of advanced control technology to manage fuel pressure, and flow in changing airflow conditions resultant of a fast acceleration. Also, the system 10, as embodied by the invention, and the overall process for the start purge system, as embodied by the invention, with the integrated control system active load management philosophy is capable of actively correcting Gas Turbine loading rates to overcome unforeseen delays in obtaining a power target, therefore providing that non-spinning reserve or load over time commitments may be met.

[0053] The system 10, as embodied by the invention, and the overall process for the start purge system, as embodied by the invention, can add advantages, such as but not limited to, reserve capable a CC plant include capabilities that expand the opportunities for highly efficient low emissions power plants to participate in ancillary services that generally have defaulted to peaking units. Transmission systems have generally started peaking units to fulfill unplanned shortfalls in power, congestion, and forced outages and reserve the fight, and often then shut down the peakers replacing them with more efficient generation over roughly a ½ to one-hour period dependent on the characteristics of the replacement power. Plants participating in power generation through Independent System Operators (ISO) are often given a selection rank based on start time, emissions, and net power capability. A combined cycle power plant with ancillary services characteristics, as embodied by the invention, would achieve a rank desirability, thus could provide extended operational hours without both peaking (simple cycle) and combined cycle units.

[0054] The features of the system 10, as embodied by the invention, and the overall process for the start purge system, as embodied by the invention, include the fast start aspect, such as but not limited to, combined cycle power system, active torque and load management, integrated plant standby and testing controls, and anticipated plant start purge operation. These features are coupled to existing control technology, such as but not limited to, a GE Op Flex (Trademark General Electric Company) extended turndown and rapid response Balance of Plant (BOP) producing a desired plant operational characteristic.

[0055] Other aspects of the system 10, as embodied by the invention, and the overall process for the start purge system, as embodied by the invention, include:

[0056] Pre-Start HRSG Purge

[0057] Gas Fuel System Isolation

[0058] Gas Only Unit

- [0059] Purge Credit System
- [0060] OpFlex Turndown Guarantees
- [0061] Rapid Response System
- [0062] New Unit Only
- [0063] Wide Wobbe fuel flexibility
- [0064] Cold Fuel (Hot Fuel with Larger Auxiliary Boiler)

[0065] Moreover, the combined cycle power plant system 10, as embodied by the invention, includes extended turn-down required to reach emissions compliance quicker (lower load), emissions compliance can establish and end of the approximately 10 minute start; QLD limit (without extended turndown); the approximately 50% turndown; extended turn-down, and combinations thereof.

[0066] Ranges disclosed herein are inclusive and combinable (e.g., ranges of “up to about 25 wt %, or, more specifically, about 5 wt % to about 20 wt %”. is inclusive of the endpoints and all intermediate values of the ranges of “about 5 wt % to about 25 wt %,” etc.). “Combination” is inclusive of blends, mixtures, alloys, reaction products, and the like. Furthermore, the terms “first,” “second,” and the like, herein do not denote any order, quantity, or importance, but rather are used to distinguish one element from another, and the terms “a” and “an” herein do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced item. The modifier “about” used in connection with a quantity is inclusive of the stated value and has the meaning dictated by context, (e.g., includes the degree of error associated with measurement of the particular quantity). The suffix “(s)” as used herein is intended to include both the singular and the plural of the term that it modifies, thereby including one or more of that term (e.g., the colorant(s) includes one or more colorants). Reference throughout the specification to “one embodiment”, “another embodiment”, “an embodiment”, and so forth, means that a particular element (e.g., feature, structure, and/or characteristic) described in connection with the embodiment is included in at least one embodiment described herein, and may or may not be present in other embodiments. In addition, it is to be understood that the described elements may be combined in any suitable manner in the various embodiments.

[0067] While the invention has been described in terms of various specific embodiments, those skilled in the art will recognize that the invention can be practiced with modification within the spirit and scope of the claims.

What is claimed is:

1. A combined cycle (CC) power plant comprising:

- a gas turbine;
- a steam turbine;
- a condenser;

a heat recovery steam generator (HRSG), the HRSG comprising an attemperator and a high pressure superheater and attemperator disposed at a discharge terminal of the high pressure superheater and attemperator and at a discharge terminal of the HRSG reheater;

- a generator;
- a fuel supply;

wherein the steam turbine is connected by multiple conduits to the heat recovery steam generator (HRSG) and the steam turbine exhaust is connected to the condenser wherein support multiple ancillary and reserves to load follow, execute regulation, and meet intermediate power generation service needs in an expedited start process.

2. A combined cycle (CC) power plant according to claim 1, wherein the fuel supply comprises:

- a piping configuration to supply fuel to the power plant, the fuel supply comprises at least two pressure cavities in fluid communication with each other by a series of valves.

wherein the valves control flow there between and when the valves are operated with each other, permit fuel to flow to the combined cycle power plant, in a controlled manner to allow fast start up of the combined cycle power plant and to permit dilution and removal of combustible gasses has been completed in the combined cycle power plant before a combined cycle power plant start command is provided.

3. A combined cycle (CC) power plant according to claim 1, wherein the supply fuel to the power plant comprises at least one of a heated or non-heated fuel.

4. A combined cycle (CC) power plant according to claim 2 wherein the at least two pressure cavities comprise at least one control valve.

5. A combined cycle (CC) power plant according to claim 4, wherein the at least one control valve comprises at least one valve selected from the group comprising:

- rotary valves, gate valves, stem valves, butterfly valves, ball valves, choke valves; and combinations thereof.

6. A combined cycle (CC) power plant according to claim 2 wherein the at least two pressure cavities comprise at least one vent valve.

7. A combined cycle (CC) power plant according to claim 6, wherein the at least one control valve comprises at least one valve selected from the group comprising:

- rotary valves, gate valves, stem valves, butterfly valves, ball valves, choke valves; and combinations thereof.

8. A combined cycle (CC) power plant according to claim 2 wherein the at least two pressure cavities comprise at least one control valve, wherein the at least one control valve is controlled by at least one of: a solenoid control, manual control, sensor control, and remotely control.

9. A method of providing and operating a combined cycle (CC) power plant, the combined cycle (CC) power plant comprising a gas turbine; a steam turbine; a condenser; a heat recovery steam generator (HRSG), the HRSG comprising an attemperator and a high pressure superheater and attemperator, the high pressure superheater and attemperator disposed at a discharge terminal of the high pressure superheater and attemperator and at a discharge terminal of the HRSG reheater; a generator, a fuel supply; wherein the fuel supply comprises a piping configuration to supply fuel to the power plant, the fuel supply comprises at least two pressure cavities in fluid communication with each other by a series of valves, the series of valves control flow there between and when the series of valves are operated with each other, permit fuel to flow to the combined cycle power plant in a controlled manner to allow fast start up of the combined cycle power plant and to permit dilution and removal of combustible gasses has been completed in the combined cycle power plant before a combined cycle power plant start command is provided; the method comprising:

- controlling the series of valves, opening and closing selected ones of the series of valves to provide a first pressure in one section of the fuel supply and a second pressure in another section of the fuel supply, wherein the first pressure is lower than the second pressure;

conducting a gas leak test in the fuel supply of the combined cycle (CC) power plant;
if the gas leak test is successful, conducting a purge of the fuel supply of the combined cycle (CC) power plant; and

if the purge of the fuel supply of the combined cycle (CC) power plant is successful maintaining the purge and starting the combined cycle (CC) power plant.

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