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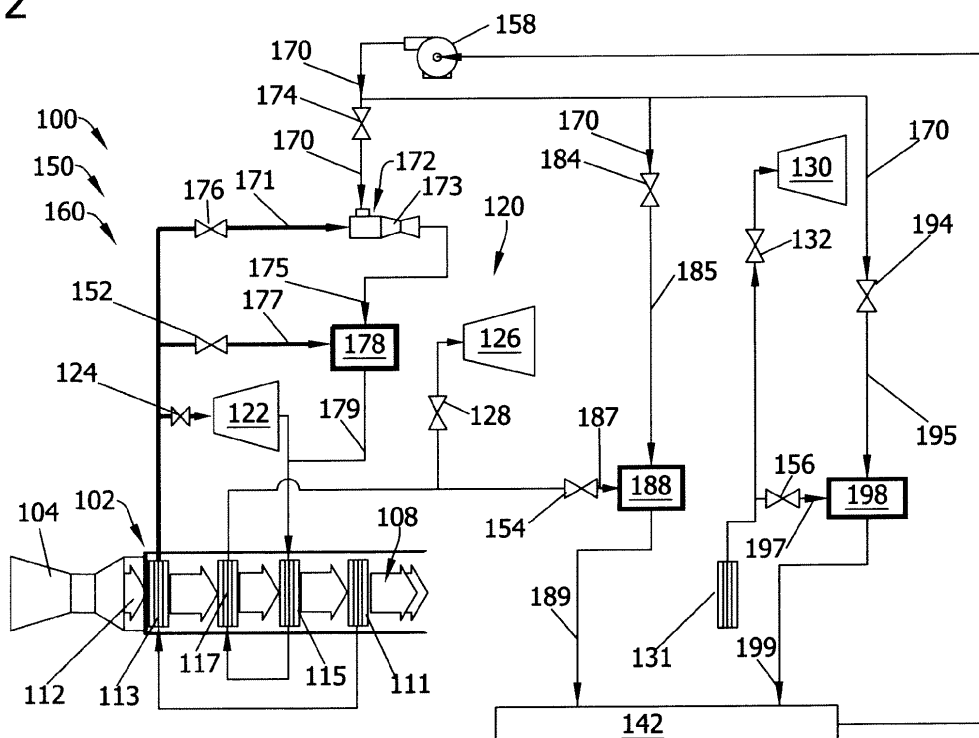
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(54) **Method and system for operating a steam generation facility**

(57) An attemperation system (160) includes at least one eductor (172) coupled in flow communication with at least one water source (142/158) and at least one steam source (102). The at least one eductor is configured to channel steam (171) from the at least one steam source to induce motive forces on water (170) channeled from

the at least one water source. The attemperation system also includes at least one attemperator (178) coupled in flow communication with the at least one eductor. The at least one attemperator is configured to receive water (175) channeled from the at least one eductor and steam (177) channeled from the at least one steam source.

FIG. 2



Description

BACKGROUND OF THE INVENTION

[0001] The embodiments described herein relate generally to steam generation facilities and, more particularly, methods and systems for attemperating steam within steam generation facilities.

[0002] At least some known steam generation facilities, such as, combined cycle plants, include at least one steam generator. At least some known steam generators are heat recovery steam generators (HRSGs) that are coupled in flow communication with a heat source, a water source, and a plurality of steam turbine components, such as high-pressure, intermediate-pressure, and low-pressure turbines. In operation, the HRSG receives water and heat and boils the water to generate high-temperature, high-pressure steam for use in driving the turbines, which in turn drive devices, such as generators and pumps. In the event of a steam turbine trip, at least of a portion of steam residing in portions of the HRSG is channeled to other portions of the HRSG or other components, such as a steam condensing device. During such channeling, steam may contact components that may not be designed and/or fabricated for continuous exposure to such high-temperature, high-pressure steam.

[0003] In at least some of these known steam generation facilities, the steam is attemperated to reduce the effects of contact with the steam. For example, such attemperation is typically achieved with dedicated attemperation devices that are coupled in flow communication with oversized, joint-usage, high- to intermediate-pressure feedwater pumps. Such feedwater pumps provide sufficient positive pressure to overcome steam pressures to achieve the desired attemperation substantially throughout a full range of operating conditions. However, such oversizing typically includes increased capital and operating costs.

[0004] In other known steam generation facilities, such attemperation may be achieved with low-pressure water pumps. Generally, one in such facilities, low-pressure water pump is operated continuously with a second low-pressure water pump in a standby condition. Generally, a single, low-pressure water pump creates sufficient head pressure to overcome steam pressure for at least partially achieving a desired attemperation. However, because of lower discharge pressures, often a plurality of such low-pressure water pumps must be used to generate sufficient attemperating water flow to fully achieve desired attemperation. Typically, as such, a period of time is required to enable the second low-pressure water pump to achieve sufficient pumping capacity after a turbine trip to enable the desired attemperation to be achieved. The addition of redundant low-pressure water pumps increases capital costs associated with facility installations and increases the time delay before a desired attemperation of the high-pressure, high-temperature steam being channeled from the HRSG may be

achieved. Moreover, continuous operation of the more low-pressure water pumps increases operational costs, such as auxiliary power usage and maintenance costs associated with such equipment.

BRIEF DESCRIPTION OF THE INVENTION

[0005] This Brief Description is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Brief Description is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

[0006] In one aspect, a method for operating a steam generation facility is provided. The method includes inducing a motive force on water by channeling steam into at least one eductor to form a steam-driven cooling fluid stream. The method also includes channeling the steam-driven cooling fluid stream to at least one attemperator. The method further includes channeling steam from at least one steam source to the at least one attemperator. The method also includes injecting the steam-driven cooling fluid stream into the steam channeled through the at least one attemperator to facilitate cooling the steam channeled from the at least one steam source.

[0007] In another aspect, an attemperation system is provided. The system includes at least one eductor coupled in flow communication with at least one water source and at least one steam source. The at least one eductor is configured to channel steam from the at least one steam source to induce motive forces on water channeled from the at least one water source. The system also includes at least one attemperator coupled in flow communication with the at least one eductor. The at least one attemperator is configured to receive water channeled for the at least one eductor and steam channeled from the at least one steam source.

[0008] In another aspect, a steam generation facility is provided. The facility includes at least one water source and at least one steam source. The facility also includes at least one eductor coupled in flow communication with the at least one water source and the at least one steam source. The at least one eductor is configured to channel steam from the at least one steam source to induce motive forces on water channeled from the at least one water source. The facility also includes at least one attemperator coupled in flow communication with the at least one eductor. The at least one attemperator is configured to receive water channeled for the at least one eductor and steam channeled from the at least one steam source.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] There follows a detailed description of embodiments of the invention by way of example only with reference to the accompanying drawings, in which:

Figure 1 is a schematic block diagram of an exemplary steam generation facility;

Figure 2 is a schematic block diagram of an exemplary attemperation system using an eductor that may be used with the steam generation facility shown in Figure 1; and

Figure 3 is a flow diagram illustrating an exemplary method of operating the steam generation facility shown in Figures 1 and 2.

DETAILED DESCRIPTION OF THE INVENTION

[0010] Figure 1 is a schematic block diagram of an exemplary steam generation facility 100. In the exemplary embodiment, steam generation facility 100 includes at least one steam generator, that is, a heat recovery steam generator (HRSG) 102. HRSG 102 is coupled in flow communication with a gas turbine exhaust manifold 104 and a residual heat exhaust stack 106. Also, in the exemplary embodiment, HRSG 102 includes a plurality of water-steam element bundles 108 and a plurality of water-steam separation units 110. Bundles 108 and units 110 are coupled in flow communication in an orientation that facilitates heating water (not shown) from subcooled conditions to superheated steam conditions within bundles 108, while separating water (not shown) from steam (not shown) within separation units 110. Bundles 108 include at least one high-pressure (HP) superheater, that is, a first HP superheater (HPSH-1) 111 that is coupled in flow communication with a second HP superheater (HPSH-2) 113. Bundles 108 also include at least one intermediate-pressure (IP) superheater, that is, a first IP, or reheat superheater (RHSH-1) 115 coupled in flow communication with a second IP, or reheat superheater (RHSH-2) 117. Bundles 108 further include at least one low-pressure (LP) superheater (LPSH) 131. Each superheater 111, 113, 115, 117, and 131 is described in more detail below with respect to configuration and functionality within steam generation facility 100. Water and steam are heated to superheated conditions via heat transfer from hot gases 112 channeled from gas turbine exhaust manifold 104 through HRSG 102. Stack 106 is coupled in flow communication with HRSG 102 to enable cooled exhaust gases 114 to be exhausted via stack 106.

[0011] Steam generation facility 100 also includes a steam turbine system 120. In the exemplary embodiment, system 120 includes a high-pressure (HP) steam turbine 122 that is coupled to HRSG 102, or more specifically, HPSH-2 113, via at least one HP admission control valve 124. Also, in the exemplary embodiment, steam turbine system 120 includes an intermediate-pressure (IP) steam turbine 126 that is coupled to HRSG 102, or more specifically, RHSH-2 117, via at least one IP admission control valve 128. Moreover, in the exemplary embodiment, steam turbine system 120 includes a low-pressure (LP) steam turbine 130 that is coupled in flow

communication with IP steam turbine 126 and that is coupled to LPSH 131 within HRSG 102 via at least one LP admission control valve 132.

[0012] In the exemplary embodiment steam generation facility 100 also includes a combined condensate-feedwater system 140. In the exemplary embodiment, system 140 includes any number of condensate booster pumps, condensate pumps, feedwater booster pumps, feedwater pumps, deaerating units, piping, valving, and any other components known in the art (none shown) that enables steam generation facility 100 to function as described herein. Also, in the exemplary embodiment, system 140 is coupled in flow communication with HRSG 102 and with a steam condensing unit 142.

[0013] Steam generation facility 100 also includes a steam bypass system 150. In the exemplary embodiment, steam bypass system 150 includes an HP bypass pressure control valve (PCV) 152 that is coupled in flow communication with HRSG 102, or more specifically, HPSH-2 113. Also, in the exemplary embodiment, steam bypass system 150 includes an IP bypass PCV 154 that is coupled in flow communication with HRSG 102, or more specifically, RHSH-2 117. Moreover, in the exemplary embodiment, steam bypass system 150 includes a LP bypass PCV 156 that is coupled in flow communication with HRSG 102. Also, in the exemplary embodiment, system bypass system 150 includes at least one condensate extraction pump (CEP) 158 that is coupled in flow communication with steam condensing unit 142.

[0014] Steam bypass system 150 also includes an attemperation system 160. In the exemplary embodiment, attemperation system 160 includes an HP portion 162 that is coupled in flow communication with HP PCV 152. Also, in the exemplary embodiment, attemperation system 160 includes an IP portion 164 that is coupled in flow communication with IP PCV 154. Further, in the exemplary embodiment, attemperation system 160 includes an LP portion 166 that is coupled in flow communication with LP PCV 156. Each portion 162, 164, and 166 is coupled in flow communication with CEP 158. Attemperation system 160 and associated portions 162, 164, and 166 are described in more detail below.

[0015] In the exemplary embodiment, steam generation facility 100 is a combined cycle electric power generation facility. Alternatively, steam generation facility 100 may be any facility that enables attemperation system 160 to function as described herein. Also, in the exemplary embodiment, facility 100 includes at least one steam generator, i.e., HRSG 102. Alternatively, facility 100 may include any type of steam generator that enables attemperation system 160 to function as described herein.

[0016] During operation of steam generation facility 100, hot exhaust gases 112 are channeled from gas turbine exhaust manifold 104 through HRSG 102. As gases 112 flow about water-steam element bundles 108, heat is transferred from gases 112 to water and/or steam flowing through bundles 108. As heat is transferred from gas-

es 112, such gases 112 are cooled prior to being exhausted via stack 106.

[0017] Also, during operation, subcooled water (not shown) is channeled from steam condensing unit 142 to HRSG 102 via combined condensate-feedwater system 140. Subcooled water receives heat transferred from cooled exhaust gases 114 and the temperature of such subcooled water is elevated. The water temperature increases as it flows through successive water-steam element bundles 108, wherein the water is eventually heated to saturation conditions. As steam is formed within the saturated water, the steam and water are separated via separation units 110, wherein water is returned to bundles 108 for subsequent heating and steam formation, while steam is channeled to subsequent bundles 108 to receive additional heat transfer to superheated steam conditions. Specifically, steam that is at least partially superheated is channeled to HPSH-1 111, prior to being channeled to HPSH-2 113, to form high-pressure (HP) superheated main steam (not shown). In the exemplary embodiment, such superheated HP main steam has thermodynamic conditions including, but not limited to, temperatures and pressures that enable operation of steam generation facility 100 as described herein.

[0018] Superheated HP main steam is channeled to HP admission control valve (ACV) 124 for admission to HP steam turbine 122. Heat energy within the superheated HP main steam is transferred to rotational kinetic energy within HP steam turbine 122. Superheated intermediate pressure (IP) exhaust steam (not shown) is channeled from HP steam turbine 122 to HRSG 102, or more specifically, to RHSH-1 115, for subsequent reheating. In the exemplary embodiment, such IP exhaust steam has thermodynamic conditions including, but not limited to, temperatures and pressures that enable operation of steam generation facility 100 as described herein. IP exhaust steam is channeled to RHSH-1 115, prior to being channeled to RHSH-2 117 to form intermediate-pressure (IP) superheated reheat steam (not shown). In the exemplary embodiment, such superheated IP reheat steam has thermodynamic conditions including, but not limited to, temperatures and pressures that enable operation of steam generation facility 100 as described herein.

[0019] Superheated IP reheat steam is channeled to IP admission control valve (ACV) 128 for admission to IP steam turbine 126. Heat energy within the superheated IP reheat steam is transferred to rotational kinetic energy within IP steam turbine 126. Superheated low pressure (LP) exhaust steam (not shown) is channeled from IP steam turbine 126 to LP turbine 130. Moreover, superheated LP steam from LPSH 131 is channeled to LP steam turbine 130 via LP ACV 132. Heat energy within the superheated LP steam is transferred to rotational kinetic energy within LP steam turbine 130. LP exhaust steam (not shown) is channeled from LP steam turbine 130 to steam condensing unit 142 for recycling through the thermodynamic cycle described herein. Operation of bypass system 150 and embedded attemperation sys-

tem 160 are described in more detail below.

[0020] Figure 2 is a schematic block diagram of an exemplary attemperation system 160 using an eductor 172 that may be used with steam generation facility 100. In the exemplary system 160 is embedded within steam bypass system 150 and includes three individual portions: an HP portion 162, an IP portion 164, and a LP portion 166 (each shown in Figure 1).

[0021] In the exemplary embodiment, HP portion 162 includes at least one high-pressure (HP) eductor 172 that is coupled in flow communication with condensate extraction pump (CEP) 158 via a first valve. In the exemplary embodiment, the first valve is a high-pressure (HP) bypass temperature control valve (TCV) 174. Eductor 172 includes a converging-diverging nozzle 173 that enables the use of at least a portion of HP superheated main steam to induce a motive force on cooling water for steam quenching as described in more detail below. HP portion 162 also includes a second valve, i.e., a high-pressure control valve (HPCV) 176, that couples HP eductor 172 in flow communication with second high-pressure superheater (HPSH-2) 113, and that facilitates control of steam flow through HP portion 162. A third valve, i.e., HP bypass PCV 152, works in combination with HP eductor 172 and HPCV 176 to provide pressure and temperature control within steam generation facility 100, while facilitating the reduction of unnecessary expenditure of thermal storage within HRSG 102, and thereby facilitating a subsequent near-term restart of turbine system 120. HP portion 162 also includes at least one HP attemperator 178 that is coupled in flow communication with HP bypass PCV 152, HP eductor 172, HP steam turbine 122, and first reheat superheater (RHSH-1) 115. In the exemplary embodiment, HP bypass PCV 152, HP bypass TCV 174, and HPCV 176 are automatically-operable and are operably synchronized with each other as described in more detail below.

[0022] During operation, in the exemplary embodiment, only one CEP 158 is continuously in service and is used for channeling subcooled condensate water 170 from steam condensing unit 142 at thermodynamic conditions including, but not limited to, temperatures and pressures that enable operation of steam generation facility 100 as described herein. Alternatively, all CEPs 158 are removed from service until HP portion 162 is placed in service, at which time, at least one CEP 158 is placed in service in operational synchronization with HP bypass PCV 152, HP bypass TCV 174, and HPCV 176. Therefore, attemperation system 160 facilitates reducing auxiliary power usage associated with steam generation facility 100 by reducing the amount of idle service associated CEPs 158. Furthermore, attemperation system 160 facilitates reducing capital costs of constructing steam generation facility by reducing a need for redundant CEPs 158 and by reducing excess feedwater pumping capacity.

[0023] Also, during operation, in the exemplary embodiment, HP ACV 124 is opened to enable steam to

flow (not shown) from HPSH-2 113 to HP steam turbine 122. Moreover, in operation, in the exemplary embodiment, HP bypass PCV 152, HP bypass TCV 174, and HPCV 176 are each closed. Therefore, at least initially, there is substantially no steam flow and no water flow through HP eductor 172 and/or HP attemperator 178. Alternatively, HPCV 176 is at least partially opened to enable a substantial continuous flow of HP steam and condensate water through eductor 172 and attemperator 178, thereby facilitating a further reduction in auxiliary power usage. Further, in operation, in the event of a steam turbine system 120 trip wherein a substantially instantaneous removal of steam turbine system 120 from service occurs, including HP steam turbine 122, and the rapid closing of HP ACV 124. As such, a buildup of superheated steam pressure within HPSH-1 111 and HPSH-2 113, as well as other portions of HRSG 102 coupled in flow communication with HPSH-1 111 and HPSH-2 113 occurs. Moreover, an increasing pressure transient occurs in conjunction with a substantial reduction in cooling fluid flow through HRSG 102. During such operation, the injection of hot exhaust gases 112 from gas turbine exhaust manifold 104 may not be reduced, thereby facilitating an increasing temperature transient in HRSG 102. As such, during operation, in the exemplary embodiment, steam bypass system 150, including embedded attemperation system 160, is placed in service to facilitate reducing the associated increasing pressure transient within HRSG 102. Specifically, HP bypass PCV 152, HP bypass TCV 174, and HPCV 176 are moved from a closed position to an at least partially open position.

[0024] More specifically, in operation, HP bypass TCV 174 opens enough to enable subcooled condensate water 170 to be channeled from steam condensing unit 142 to eductor 172 at thermodynamic conditions including, but not limited to, temperatures and pressures that enable operation of steam generation facility 100 as described herein, via CEP 158. Also, HPCV 176 opens sufficiently to enable a first portion of HP superheated main steam 171 to be channeled from HPSH-2 113 to HP eductor 172 at thermodynamic conditions including, but not limited to, temperatures and pressures that enable operation of steam generation facility 100 as described herein. HP bypass PCV 152 and HPCV 176 modulate in operational synchronization with each other to facilitate maintaining HP bypass steam pressure and temperature at values substantially similar to, or below, pressures and temperatures within RHSH-1 115. Steam 171 channeled into eductor 172 via HPCV 176 expands into eductor 172 to facilitate inducing a venturi effect therein, wherein a velocity of steam 171 flow increases and a pressure drop is induced. The induced pressure drop "draws" water 170 flowing via HP bypass TCV 174 into eductor 172, and at least a portion of kinetic energy of steam 171 is transferred to water 170, thus inducing a motive force on water 170. Steam 171 and water 170 mix within nozzle 173 to form a steam-driven cooling fluid stream 175 that is channeled towards HP attemperator 178 at thermodynamic

conditions including, but not limited to, temperatures and pressures that enable operation of steam generation facility 100 as described herein, i.e., to facilitate cooling superheated steam 171 channeled from HPSH-2 113.

[0025] Also, during operation, HP bypass PCV 152 shifts open sufficiently to permit channeling a second portion of HP superheated main steam 177 from HPSH-2 113 to HP attemperator 178 at thermodynamic conditions including, but not limited to, temperatures and pressures that enable operation of steam generation facility 100 as described herein. Attemperator 178 receives superheated steam 177 via HP bypass PCV 152 and steam-driven cooling fluid stream 175 from HP eductor 172. Moreover, superheated steam 177 is quenched by injecting steam-driven cooling fluid stream 175 into superheated steam 177 to form a quenched steam 179 that is channeled from HP attemperator 178 to RHSH-1 115, thus facilitating cooling of superheated steam 177 channeled from HPSH-2 113. Quenched steam 179 is also channeled through RHSH-1 115 and RHSH-2 117 towards IP portion 164 of attemperation system 160, as described in more detail below.

[0026] IP portion 164, in the exemplary embodiment, includes at least one intermediate-pressure (IP) attemperator 188 that is coupled in flow communication with condensate extraction pump (CEP) 158 via a first valve, i.e., an intermediate-pressure (IP) bypass temperature control valve (TCV) 184. IP attemperator 188 is also coupled in flow communication with IP bypass PCV 154. IP bypass PCV 154 facilitates controlling pressures and temperatures within steam generation facility 100, while reducing unnecessary expenditures of thermal storage within HRSG 102, thereby facilitating a subsequent near-term restart of turbine system 120. IP attemperator 188 is also coupled in flow communication with steam condensing unit 142. In the exemplary embodiment, IP bypass PCV 154 and IP bypass TCV 184 are each automatically-operable and are operably synchronized with each other as discussed in more detail below. Moreover, in the exemplary embodiment, IP bypass PCV 154 and IP bypass TCV 184 are each automatically-operable and are operably synchronized with HP bypass PCV 152, HP bypass TCV 174, and HPCV 176.

[0027] During operation, in the exemplary embodiment, similar to the operation described above for HP portion 162, only one CEP 158 is continuously in service to channel subcooled condensate water from steam condensing unit 142 up to IP bypass TCV 184. Alternatively, all CEPs 158 are removed from service until IP portion 164 is placed in service, wherein at least one CEP 158 is placed in service in operational synchronization with IP bypass PCV 154 and IP bypass TCV 184.

[0028] Also, during operation, in the exemplary embodiment, IP ACV 128 is opened to enable steam to flow (not shown) from RHSH-2 117 to IP steam turbine 126. Further, in operation, in the exemplary embodiment, IP bypass PCV 154 and IP bypass TCV 184 are each closed. Therefore, at least initially, there is substantially

no steam flow and/or water flow through IP attemperator 188.

[0029] Further, in operation, in the event of a steam turbine system 120 trip, substantially instantaneous removal of steam turbine system 100 from service, including IP steam turbine 126, the rapid closure of IP ACV 128. As such a buildup of superheated steam pressure within RSH-1 115 and RSH-2 117, as well as other portions of HRSG 102 coupled in flow communication with RSH-1 115 and RSH-2 117 occurs. Moreover, quenched steam 179 from HP portion 162 is also channeled through RSH-1 115 and RSH-2 117. An increasing pressure transient occurs in conjunction with a substantial reduction in cooling fluid flow (not shown) through HRSG 102. As such, injection of hot exhaust gases 112 from gas turbine exhaust manifold 104 may not be reduced, thereby facilitating an increasing temperature transient in HRSG 102. In operation, in the exemplary embodiment, steam bypass system 150, including embedded attemperation system 160, is placed in service to facilitate reducing the associated increasing pressure transient within HRSG 102. Specifically, IP bypass PCV 154 and IP bypass TCV 184 are at least partially opened.

[0030] More specifically, in operation, IP bypass TCV 184 is opened sufficiently to enable a portion of subcooled condensate water 170, i.e., a cooling fluid stream 185 to flow from steam condensing unit 142 towards IP attemperator 188 via CEP 158. Also, during operation, IP bypass PCV 154 is opened to enable a portion of IP superheated reheat steam 187 to be channeled from RSH-1 115 to IP attemperator 188. Attemperator 188 receives superheated steam 187 via IP bypass PCV 154 and cooling fluid stream 185 from IP bypass TCV 184. Superheated steam 187 is quenched by injecting cooling fluid stream 185 into superheated steam 187, thereby forming a quenched steam 189 that is channeled from IP attemperator 188 to steam condensing unit 142, and thereby cooling superheated steam 187 channeled from RSH-2 117.

[0031] LP portion 166, in the exemplary embodiment, includes at least one low-pressure (LP) attemperator 198 that is coupled in flow communication with condensate extraction pump (CEP) 158 via a first valve, i.e., a low-pressure (LP) bypass temperature control valve (TCV) 194. LP attemperator 198 is also coupled in flow communication with LP bypass PCV 156. LP bypass PCV 156 facilitates controlling pressures and temperatures within steam generation facility 100, while reducing unnecessary expenditures of thermal storage within HRSG 102, thereby facilitating a subsequent near-term restart of turbine system 120. LP attemperator 198 is also coupled in flow communication with steam condensing unit 142. In the exemplary embodiment, LP bypass PCV 156 and LP bypass TCV 194 are each automatically-operable and are operably synchronized with each other as discussed further below. Moreover, in the exemplary embodiment, LP bypass PCV 156 and LP bypass TCV 194

are each automatically-operable and are operably synchronized with HP bypass PCV 152, HP bypass TCV 174, and HPCV 176. Furthermore, in the exemplary embodiment, LP bypass PCV 156 and LP bypass TCV 194 are each automatically-operable and are operably synchronized with IP bypass PCV 154 and IP bypass TCV 184.

[0032] During operation, in the exemplary embodiment, similar to the operation described above for IP portion 164, only one CEP 158 is continuously in service to channel subcooled condensate water 170 from steam condensing unit 142 to LP bypass TCV 194. Alternatively, all CEPs 158 are removed from service until LP portion 166 is placed in service, wherein at least one CEP 158 is placed in service in operational synchronization with LP bypass PCV 156 and LP bypass TCV 194.

[0033] Also, during operation, in the exemplary embodiment, LP ACV 132 is opened to enable steam to flow (not shown) from LPSH 131 to LP steam turbine 130. Further, in operation, in the exemplary embodiment, LP bypass PCV 156 and LP bypass TCV 194 are each closed. Therefore, at least initially, there is substantially no steam flow and/or water flow through LP attemperator 198.

[0034] Further, in operation, in the event of a steam turbine system 120 trip, substantially instantaneous removal of steam turbine system 100 from service, including LP steam turbine 130, the rapid closure of LP ACV 132. As such a buildup of superheated steam pressure within LPSH 131, as well as other portions of HRSG 102 coupled in flow communication with LPSH 131 occurs. An increasing pressure transient occurs in conjunction with a substantial reduction in cooling fluid flow through HRSG 102. As such, injection of hot exhaust gases 112 from gas turbine exhaust manifold 104 may not be reduced, thereby facilitating an increasing temperature transient in HRSG 102. In operation, in the exemplary embodiment, steam bypass system 150, including embedded attemperation system 160, is placed in service to facilitate reducing the associated increasing pressure transient within HRSG 102. Specifically, LP bypass PCV 156 and LP bypass TCV 194 are at least partially opened.

[0035] More specifically, in operation, LP bypass TCV 194 is opened sufficiently to enable subcooled condensate water 170, i.e., a cooling fluid stream 195 to flow from steam condensing unit 142 towards LP attemperator 198 via CEP 158. Also, during operation, LP bypass PCV 156 is opened to enable a portion of LP superheated steam 197 to be channeled from LPSH 131 to LP attemperator 198. Attemperator 198 receives superheated steam 197 via LP bypass PCV 156 and cooling fluid stream 195 from LP bypass TCV 194. Superheated steam 197 is quenched by injecting cooling fluid stream 195, thereby forming a quenched steam 199 that is channeled from LP attemperator 198 to steam condensing unit 142, and thereby cooling superheated steam 197 channeled from LPSH 131.

[0036] Figure 3 is a flow diagram illustrating an exem-

plary method 200 of operating steam generation facility 100 (shown in Figures 1 and 2). In the exemplary embodiment, a motive force is induced 202 on water 170 (shown in Figure 2) by channeling steam 171 (shown in Figure 2) into at least one eductor 172 (shown in Figure 2), thereby forming steam-driven cooling fluid stream 175 (shown in Figure 2). In addition, steam-driven cooling fluid stream 175 is channeled 204 into at least one attemperator 178 (shown in Figure 2). Moreover, steam 177 (shown in Figure 2) is channeled 206 from at least one steam source, that is, HPSH-2 113 (shown in Figures 1 and 2) to at least one attemperator 178. Method 200 also includes injecting 208 steam-driven cooling fluid stream 175 into steam 177, channeled through at least one attemperator 178, to facilitate cooling steam 177, channeled from at least one steam source, such as, HPSH-2 113.

[0037] In the exemplary embodiment, channeling 210 high-pressure (HP) superheated steam 171 from at least one HP superheater, i.e., HPSH-2 113 to at least one eductor 172. Method 200 also includes channeling 212 HP superheated steam 171 from HPSH-2 113 to attemperator 178 (shown in Figure 2) to facilitate cooling a second portion 177 of HP steam (shown in Figure 2).

[0038] Water 170 is channeled 214 from at least one condensate extraction pump 158 and/or at least one steam condensing unit 142 to at least one eductor 172. Method 200 also includes channeling 216 quenched steam 179 to an IP superheater, i.e., RHSH-1 115 (both shown in Figure 2) and/or channeling quenched steam 189 and/or 199 (both shown in Figure 2) to steam condensing unit 142.

[0039] Described herein are exemplary embodiments of methods and systems that facilitate operating a steam generation facility. Specifically, an attemperation system, embedded within a steam bypass system, both as described herein, facilitates controlling pressures and temperatures within portions of the steam generation facility in the event of significant transients within the facility. Such pressure and temperature control reduces channeling high-pressure, high-temperature steam through components that may not be designed and/or fabricated for continuous exposure to such high-temperature, high-pressure steam. Also, the attemperation system as described herein facilitates reducing a size of high-pressure and/or intermediate pressure boiler feedwater pumps by relying on lower-pressure condensate extraction pumps to overcome steam pressures to achieve the desired attemperation substantially throughout a full range of operating conditions. Moreover, the attemperation system as described herein facilitates reducing auxiliary power usage associated with the steam generation facility by reducing idle service of low-pressure water pumps. Further, the attemperation system as described herein facilitates reducing capital costs of constructing the steam generation facility by reducing a need for redundant low-pressure water pumps. Moreover, the attemperation system as described herein facilitates reducing excess feed-

water pumping capacity, thus reducing capital and operational costs. Also, the attemperation system as described herein channels sufficient attemperating water flow after a significant transient to enable the desired attemperation of the high-pressure, high-temperature steam being channeled from the HRSG to be achieved with little to no time delay.

[0040] The methods and systems described herein are not limited to the specific embodiments described herein. For example, components of each system and/or steps of each method may be used and/or practiced independently and separately from other components and/or steps described herein. In addition, each component and/or step may also be used and/or practiced with other assembly packages and methods.

[0041] For completeness, various aspects of the invention are now set out in the following numbered clauses:

For completeness, various aspects of the invention are now set out in the following numbered clauses:

1. A method for operating a steam generation facility, said method comprising:

inducing a motive force on water by channeling steam into at least one eductor to form a steam-driven cooling fluid stream;

channeling the steam-driven cooling fluid stream to at least one attemperator;

channeling steam from at least one steam source to the at least one attemperator; and

injecting the steam-driven cooling fluid stream into the steam channeled through the at least one attemperator to facilitate cooling the steam channeled from the at least one steam source.

2. A method in accordance with clause 1, wherein inducing a motive force on water by channeling steam comprises channeling a first portion of superheated steam from at least one high-pressure superheater.

3. A method in accordance with clause 2, wherein injecting the steam-driven cooling fluid stream into the steam channeled through the at least one attemperator comprises channeling a second portion of superheated steam from the at least one high-pressure superheater.

4. A method in accordance with clause 3, wherein injecting the steam-driven cooling fluid stream into the steam channeled through the at least one attemperator comprises channeling

quenched steam to at least one intermediate-pressure superheater.

5. A method in accordance with clause 4, wherein channeling quenched steam to at least one intermediate-pressure superheater comprises channeling quenched steam to a steam condensing unit. 5

6. A method in accordance with clause 1, further comprising inducing a motive force on water by channeling water from at least one condensate pump to the at least one eductor. 10

7. A method in accordance with clause 6, wherein channeling water from at least one condensate pump comprises channeling water from at least one steam condensing unit. 15

8. An attemperation system comprising: 20

at least one eductor coupled in flow communication with at least one water source and

at least one steam source, said at least one eductor configured to channel steam from the at least one steam source to induce motive forces on water channeled from the at least one water source; and 25

at least one attemperator coupled in flow communication with said at least one eductor, said at least one attemperator configured to receive water channeled from said at least one eductor and steam channeled from the at least one steam source. 30 35

9. An attemperation system in accordance with clause 8, wherein said at least one eductor is coupled in flow communication with at least one high-pressure superheater. 40

10. An attemperation system in accordance with clause 8, wherein said at least one attemperator is coupled in flow communication with at least one high-pressure superheater. 45

11. An attemperation system in accordance with clause 8 further comprising at least one of:

at least one first valve coupled in flow communication between the at least one water source and said at least one eductor; 50

at least one second valve coupled in flow communication between the at least one steam source and said at least one eductor; and 55

at least one third valve coupled in flow communication between the at least one steam source and said at least one attemperator.

12. An attemperation system in accordance with clause 11, wherein each of said first valve, said second valve, and said third valve are automatically-operable and are operably synchronized with each other.

13. An attemperation system in accordance with clause 8 further comprising at least one of:

a high-pressure portion of said attemperation system;

an intermediate-pressure portion of said attemperation system; and

a low-pressure portion of said attemperation system.

14. A steam generation facility comprising:

at least one water source;

at least one steam source;

at least one eductor coupled in flow communication with said at least one water source and said at least one steam source, said at least one eductor configured to channel steam from said at least one steam source to induce motive forces on water channeled from said at least one water source; and

at least one attemperator coupled in flow communication with said at least one eductor, said at least one attemperator configured to receive water channeled from said at least one eductor and steam channeled from said at least one steam source.

15. A steam generation facility in accordance with clause 14, wherein said at least one water source comprises at least one of at least one condensate extraction pump and a steam condensing unit.

16. A steam generation facility in accordance with clause 14, wherein said at least one steam source comprises a heat recovery steam generator (HRSG).

17. A steam generation facility in accordance with clause 16, wherein said HRSG comprises at least one of:

- at least one high-pressure superheater;
- at least one intermediate-pressure superheater; and
- at least one low-pressure superheater.
18. A steam generation facility in accordance with clause 14 further comprising at least one of:
- at least one first valve coupled in flow communication between said at least one water source and said at least one eductor;
- at least one second valve coupled in flow communication between said at least one steam source and said at least one eductor; and
- at least one third valve coupled in flow communication between said at least one steam source and said at least one attemperator.
19. A steam generation facility in accordance with clause 18, wherein each of said first valve, said second valve, and said third valve are automatically-operable and are operably synchronized with each other.
20. A steam generation facility in accordance with clause 14 further comprising at least one of:
- a high-pressure portion of said attemperation system;
- an intermediate-pressure portion of said attemperation system; and a low-pressure portion of said attemperation system.
- Claims**
1. An attemperation system (160) comprising:
- at least one eductor (172) coupled in flow communication with at least one water source (142/158) and at least one steam source (102), said at least one eductor configured to channel steam (171) from the at least one steam source to induce motive forces on water (170) channeled from the at least one water source; and
- at least one attemperator (178) coupled in flow communication with said at least one eductor, said at least one attemperator configured to receive water (175) channeled from said at least one eductor and steam (177) channeled from the at least one steam source.
2. An attemperation system (160) in accordance with
- claim 1, wherein said at least one eductor (172) is coupled in flow communication with at least one high-pressure superheater (113).
3. An attemperation system (160) in accordance with claim 1 or 2, wherein said at least one attemperator (178) is coupled in flow communication with at least one high-pressure superheater (113).
4. An attemperation system (160) in accordance with any of the preceding claims, further comprising at least one of:
- at least one first valve (174) coupled in flow communication between the at least one water source (142/158) and said at least one eductor (172);
- at least one second valve (176) coupled in flow communication between the at least one steam source (102) and said at least one eductor; and
- at least one third valve (152) coupled in flow communication between the at least one steam source and said at least one attemperator (178).
5. An attemperation system (160) in accordance with claim 4, wherein each of said first valve (174), said second valve (176), and said third valve (152) are automatically-operable and are operably synchronized with each other.
6. An attemperation system (160) in accordance with any of the preceding claims, 1 further comprising at least one of:
- a high-pressure portion (162) of said attemperation system;
- an intermediate-pressure portion (164) of said attemperation system; and
- a low-pressure portion (166) of said attemperation system.
7. A steam generation facility (100) comprising:
- at least one water source (142/158);
- at least one steam source (102);
- at least one eductor (172) coupled in flow communication with said at least one water source and said at least one steam source, said at least one eductor configured to channel steam (171) from said at least one steam source to induce motive forces on water (170) channeled from said at least one water source; and
- at least one attemperator (178) coupled in flow communication with said at least one eductor, said at least one attemperator configured to receive water (175) channeled from said at least one eductor and steam (177) channeled from said at least one steam source.

8. A steam generation facility (100) in accordance with claim 7, wherein said at least one water source (142/158) comprises at least one of at least one condensate extraction pump (158) and a steam condensing unit (142). 5

9. A steam generation facility (100) in accordance with claim 7 or 8, wherein said at least one steam source comprises a heat recovery steam generator (HRSG) (102). 10

10. A steam generation facility in accordance with Claim 9, wherein said HRSG (102) comprises at least one of: 15
 - at least one high-pressure superheater (111/113);
 - at least one intermediate-pressure superheater (115/117); and
 - at least one low-pressure superheater (131). 20

11. A method for operating a steam generation facility, said method comprising:
 - inducing a motive force on water by channeling steam into at least one eductor to form a steam-driven cooling fluid stream; 25
 - channeling the steam-driven cooling fluid stream to at least one attemperator;
 - channeling steam from at least one steam source to the at least one attemperator; and 30
 - injecting the steam-driven cooling fluid stream into the steam channeled through the at least one attemperator to facilitate cooling the steam channeled from the at least one steam source. 35

12. A method in accordance with claim 1, wherein inducing a motive force on water by channeling steam comprises channeling a first portion of superheated steam from at least one high-pressure superheater. 40

13. A method in accordance with claim 2, wherein injecting the steam-driven cooling fluid stream into the steam channeled through the at least one attemperator comprises channeling a second portion of superheated steam from the at least one high-pressure superheater. 45

14. A method in accordance with claim 3, wherein injecting the steam-driven cooling fluid stream into the steam channeled through the at least one attemperator comprises channeling quenched steam to at least one intermediate-pressure superheater. 50

15. A method in accordance with claim 4, wherein channeling quenched steam to at least one intermediate-pressure superheater comprises channeling quenched steam to a steam condensing unit. 55

FIG. 1

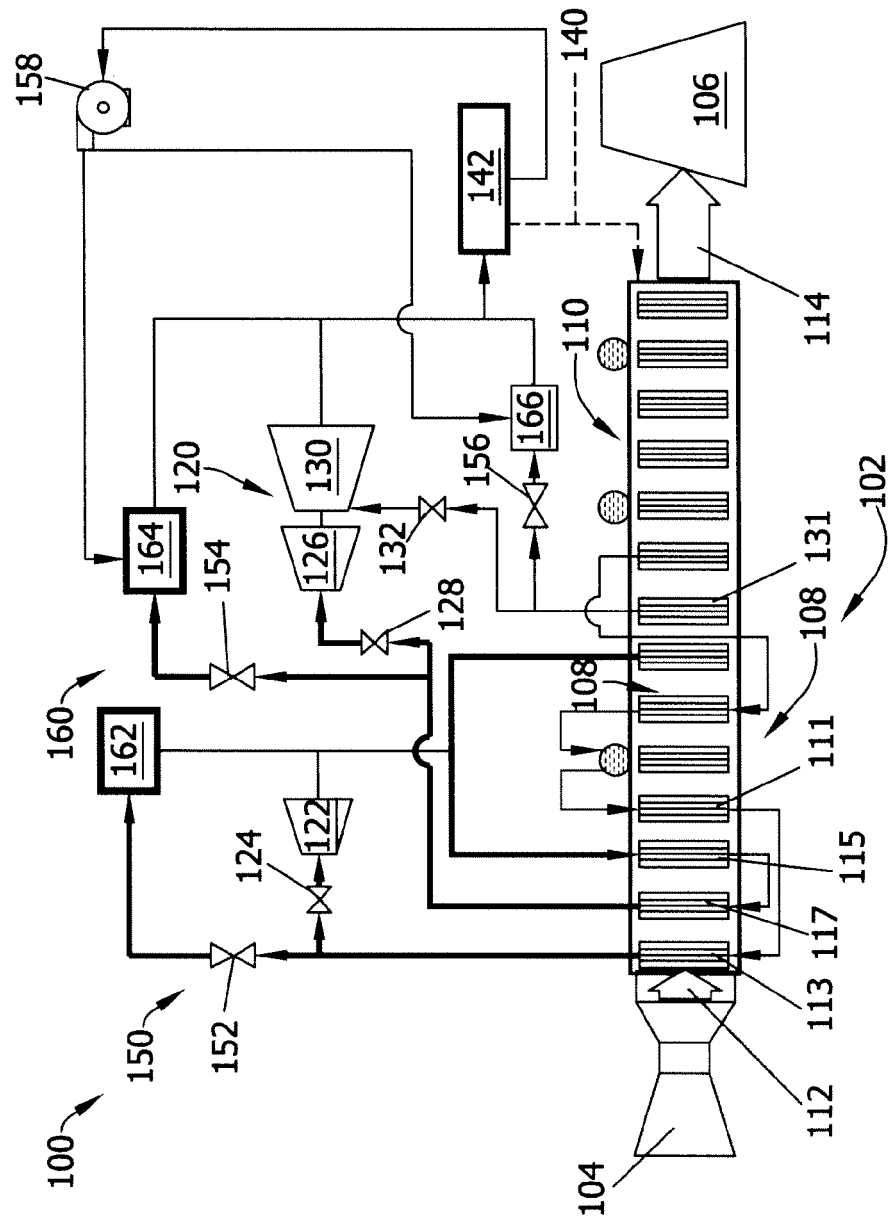


FIG. 2

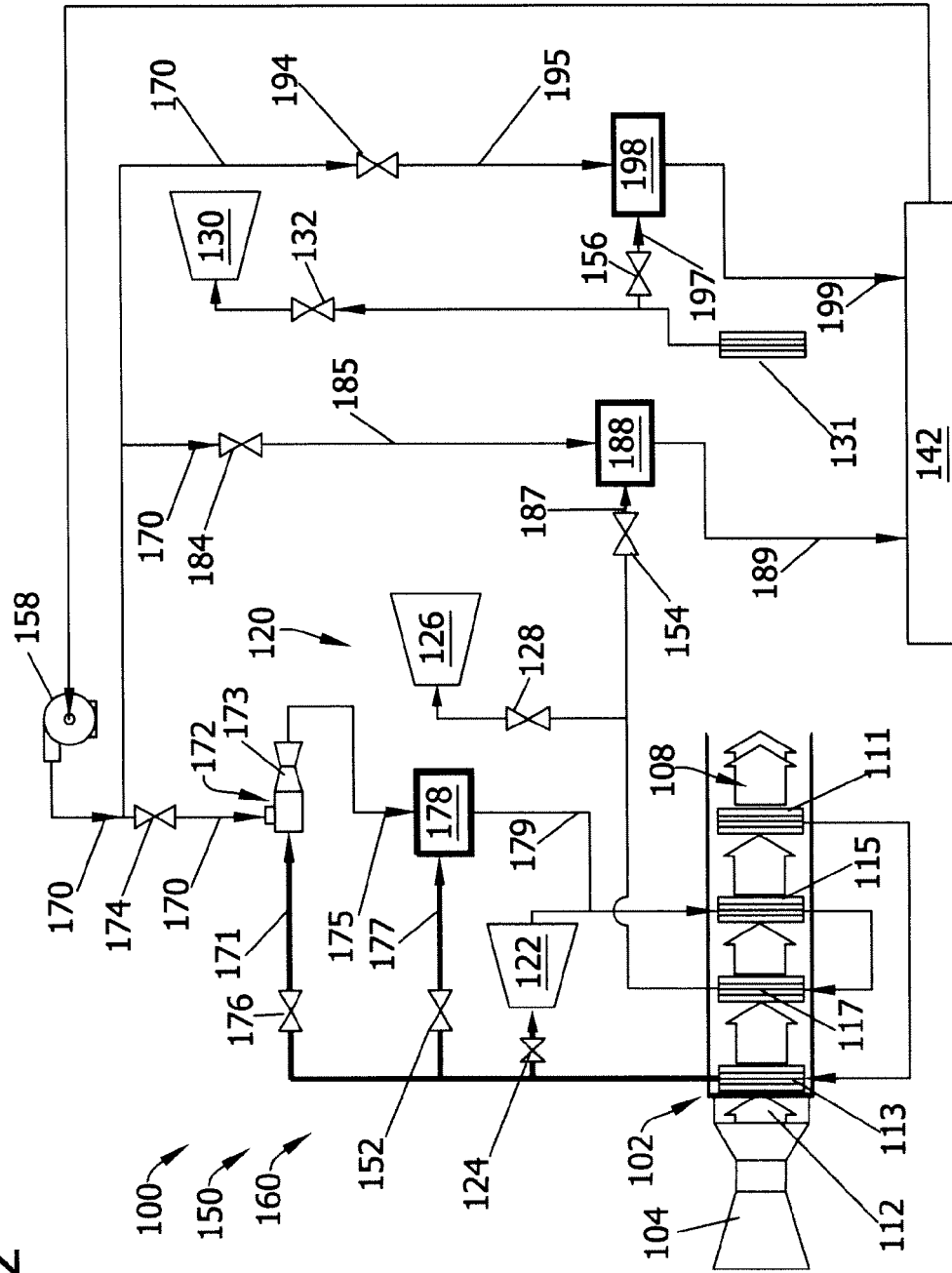


FIG. 3

