(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
12 March 2009 (12.03.2009)

PCT

(10) International Publication Number
WO 2009/031747 A1

(51) International Patent Classification:
F01K 19/04 (2006.01)

(21) International Application Number: PCT/KR2008/002600

(22) International Filing Date: 8 May 2008 (08.05.2008)

(25) Filing Language: Korean

(26) Publication Language: English

(30) Priority Data:
10-2007-0090394 6 September 2007 (06.09.2007) KR
10-2007-0090395 6 September 2007 (06.09.2007) KR
10-2007-0130109 13 December 2007 (13.12.2007) KR

(71) Applicant *(for all designated States except US)*: **KOREA INSTITUTE OF MACHINERY AND MATERIALS** [KR/KR]; 171, Jang-Dong, Yuseong-Gu, Daejeon 305-343 (KR).

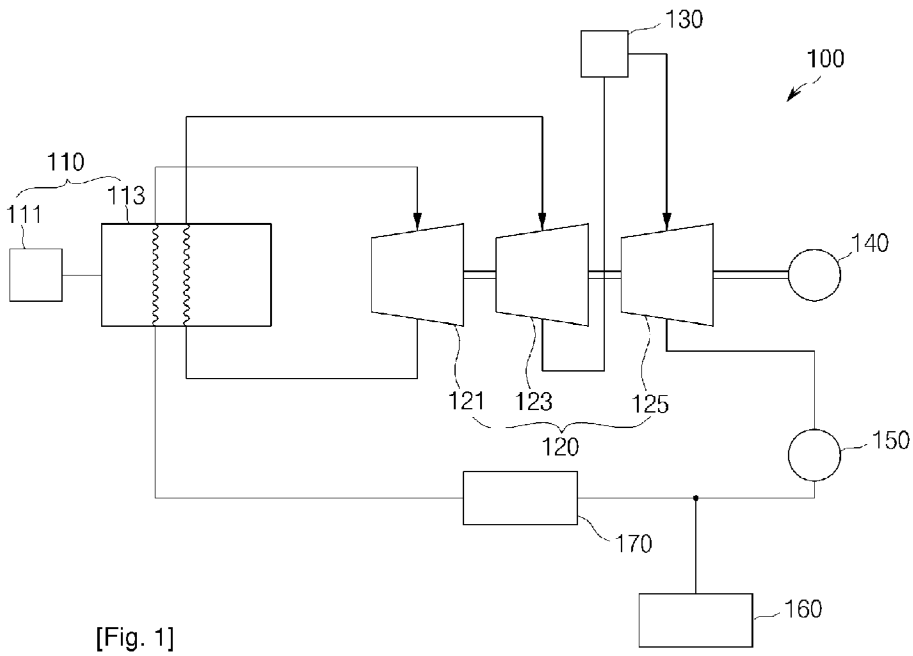
(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **AHN, Kook Young** [KR/KR]; 309-1101, Expo Apt., Jeonmin-dong, Yuseong-gu, Daejeon 305-761 (KR). **LEE, Young Duk** [KR/KR]; 107-1504, Daedoek Techno Valley 1-danji, Gwanpyeong-dong, Yuseong-gu, Daejeon 305-509 (KR). **KIM, Han Seok** [KR/KR]; 1-302, Gongdong Gwanri Apt., Doryong-dong, Yuseong-gu, Daejeon 305-340 (KR). **YU, Sang Seok** [KR/KR]; 106-102, Expo Apt., Jeonmin-dong, Yuseong-gu, Daejeon 305-761 (KR). **LEE, Sang Min** [KR/KR]; 101-1004, Yangji Maeul 1-danji, Banseok-dong, Yuseong-gu, Daejeon 305-150 (KR). **CHO, Ju Hyeong** [KR/KR]; 1084, Uncheon-dong, Heungdeok-gu, Cheongju-si, Chungcheongbuk-do 361-110 (KR). **AHN, Kwan Sik** [KR/KR]; 2705-2201, Baeksong Maeul, Sang-dong, Wonmi-gu, Bucheon-si, Gyeonggi-do 420-762 (KR). **JEONG, Hyun Il** [KR/KR]; 301, 109-5, Songpa-dong, Songpa-gu, Seoul 138-170 (KR).

(74) Agent: **CHANG & HAN PATENT & LAW FIRM**; 1405, Gangnam Building, 1321-1, Seocho-dong, Seocho-gu, Seoul 137-857 (KR).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID,

[Continued on next page]

(54) Title: POWER PLANT HAVING PURE OXYGEN COMBUSTOR



[Fig. 1]

(57) Abstract: Provided is a power plant having a pure oxygen combustor. The power plant includes a heat supplying unit supplying a heated steam; a turbine unit generating mechanical energy by rotating a turbine using the heated steam supplied by the heat supplying unit; a power generator converting mechanical energy generated by the turbine unit into electrical energy; a steam condenser condensing steam passing through the turbine unit; and a first combustor disposed at one side of the turbine unit and reheating the steam supplied to the turbine unit by using pure oxygen combustion.

WO 2009/031747 A1

IL, IN, IS, JP, KE, KG, KM, KN, KP, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report*

Description

POWER PLANT HAVING PURE OXYGEN COMBUSTOR

Technical Field

[1] The present invention relates to a high efficiency power plant, and more particularly, to a power plant equipped with a pure oxygen combustor to improve thermal efficiency using pure oxygen combustion.

Background Art

[2] From the related art, a research for designing an efficient power plant has proceeded. Various power plants to obtain high efficiency have been designed. Among them the Rankine cycle, which is applied to a thermal power plant is also called a steam cycle or a vapor cycle and uses steam as a working fluid. The Rankine cycle is realized by each element, such as a water supplying pump (adiabatic compression), a boiler and a superheater (isobaric heating), a turbine (adiabatic expansion), and a steam condenser (isobaric heat dissipation).

[3] There have been many efforts to apply the principle of a regenerative cycle, a reheat cycle, etc. to a power plant to improve the thermal efficiency of the plant. However, even when such a regenerative cycle or reheat cycle is used, the used steam is not directly heated. Thus, the thermal efficiency of the thermal power plant is not fully achieved. In a conventional power generation system, when steam is reheated using heat exchange of a combustion gas, the temperature of a discharged combustion gas is high, and a thermal loss is large.

[4] Meanwhile, there also have been many efforts for designing a more efficient power plant in connection with other systems, such as fuel cells.

[5] In general, fuel cells convert chemical energy into electrical energy by electrochemical reaction in anode and cathode. In fuel cells, a reactant is supplied continuously from the outside and reaction products are continuously removed to the outside of a fuel cell system.

[6] Fuel cells use various fuels, such as a fossil fuel, a liquid fuel, and a gaseous fuel. Fuel cells can be classified into low temperature type fuel cells of less than 100℃, intermediate temperature type fuel cells of about 150 to 300℃, and high temperature type fuel cells of 600℃ or higher according to its working temperature. In addition, fuel cells can be classified into phosphoric acid fuel cells (PAFC), molten carbonate fuel cells (MCFC), solid oxide fuel cells (SOFC), polymer electrolyte fuel cells (PEFC), etc. according to the type of an electrolyte.

[7] Low temperature type PEFC are mainly used for transportation or home power generator, and high temperature type MCFC or SOFC are mainly used for large scale

power generation.

[8] A conventional method of additionally using an exhaust gas of a fuel cell has been devised. In other words, a high temperature gas exhausted in an MCFC system or a PAFC system is used for cooling/heating, etc. so as to use heat more efficiently. However, additional power generation is not easy in the conventional method of additionally using the exhaust gas of the fuel cell. So, it is needed to invent a new system to make more electric power generation in order to use the heat more efficiently.

[9] When the steam is produced by heat exchanging with the exhausted gas from a fuel cell and the steam is used to drive conventional steam turbine, the amount of electric power generation is not large. A hybrid system can also be constituted by connecting a gas turbine to the fuel cell. However, it is very difficult to constitute such a hybrid system due to some technical problems.

[10] A conventional fuel cell system has a high efficiency. However, the development of a hybrid system with other engines is needed to take superiority over competitive technologies.

[11] As an example, when such a fuel cell system is connected to a gas turbine, higher efficiency can be obtained. However, it is difficult to redesign the inside of the conventional fuel cell system and simultaneous operations that link the fuel cell and the gas turbine is very complicated.

[12] When a high temperature exhausted gas from the fuel cell system is used as a heat supplying source of the bottoming system, total power generation efficiency can be increased. Thus, the needs for development of a high efficiency power plant combining the thermal power plant with the fuel cell system are increasing.

[13] As such, the development of a power plant designed to more efficiently increase thermal efficiency is needed.

[14] In addition, in various general industry field, such as power plants, motor vehicles, boilers, etc., a lot of fossil fuel, such as petroleum, coal, etc., are combusted as a heat source. Thus, an enormous amount of a combustion gas is exhausted to the atmosphere from various exhaust sources so that the content of carbon dioxide (CO_2) in the atmosphere increases gradually.

[15] As such, global warming due to the so-called greenhouse effect becomes serious, and the development of a method of reducing CO_2 that is inevitably dissipated from the power plant using a fossil fuel, etc. is in urgent need.

[16] Accordingly, the development of a system for obtaining high efficiency and for reducing CO_2 generated in the power plant without dissipating CO_2 to the atmosphere is required.

Disclosure of Invention

Technical Problem

[17] The present invention provides a power plant having a pure oxygen combustor to improve thermal efficiency and separate carbon dioxide (CO_2) from exhausted gas.

[18] The present invention also provides a power plant having a pure oxygen combustor which is more economical and is designed to achieve high efficiency in connection with other systems.

Technical Solution

[19] In a power plant having a pure oxygen combustor according to the present invention, steam supplied to a turbine unit is directly heated by using the pure oxygen combustor so that higher thermal efficiency can be obtained. In addition, an additional recovery pump is provided so that high concentration carbon dioxide (CO_2) can be recovered from a gas exhausted by a steam condenser and a power plant that is more economical and has higher efficiency can be provided in connection with other systems.

Advantageous Effects

[20] As described above, a power plant having a pure oxygen combustor according to the present invention has the following advantages.

[21] First, the steam is directly heated using pure oxygen combustion such that a high efficiency power plant is designed and high concentration carbon dioxide (CO_2) is separated from an exhausted gas.

[22] Second, since the combustor is designed such that a portion of steam is injected directly into the combustor, the temperature of the combustor is lowered and overheating of a particular portion can be prevented.

[23] Third, since a waste steam of other facilities is supplied to obtain energy, a power plant can be designed that is economical and environment-friendly by using a simple, economical cooling unit.

[24] Fourth, system can have high efficiency because steam is generated by the high temperature exhausted gas from fuel cell and only a small amount of additional fuel is needed in pure oxygen combustor of the invented system.

[25] Fifth, intermediate pressure and intermediate temperature steam passing through an intermediate pressure turbine is reheated using pure oxygen combustion such that a low pressure turbine can operate with the degree of dryness at 90% or greater at a lower turbine outlet pressure.

Brief Description of the Drawings

[26] FIG. 1 schematically illustrates a power plant having a pure oxygen combustor according to an embodiment of the present invention.

[27] FIG. 2 illustrates a formula when methane is supplied as a fuel from the power plant having a pure oxygen combustor of FIG. 1 and pure oxygen combustion is performed.

[28] FIG. 3 schematically illustrates a first combustor of the power plant having the pure oxygen combustor of FIG. 1.

[29] FIG. 4 is a graph showing the Rankine cycle of the power plant having the pure oxygen combustor of FIG. 1.

[30] FIG. 5 schematically illustrates a power plant having a pure oxygen combustor according to another embodiment of the present invention.

[31] FIG. 6 schematically illustrates a power plant having a pure oxygen combustor according to another embodiment of the present invention.

[32] FIG. 7 schematically illustrates a power plant having a pure oxygen combustor according to another embodiment of the present invention.

[33] <Explanation of Reference Numerals Designating the Major Elements of the Drawings>

[34] 100, 200, 300, 400 : power plant having pure oxygen combustors

[35] 110, 210, 310, 410 : heat supplying unit

[36] 111, 211 : heater 113, 213 : boiler

[37] 120, 220, 320, 420 : turbine unit 121, 221 : high pressure turbine

[38] 123, 223 : intermediate turbine 125, 225 : low pressure turbine

[39] 130, 230, 330, 430 : first combustor 131 : inlet portion

[40] 133 : injection hole 135 : main body portion

[41] 140, 240, 340, 440 : power generator

[42] 150, 250, 350, 450 : steam condenser

[43] 160, 260, 360, 460 : recovery pump

[44] 170, 270, 470 : water supplying pump

[45] 280 : pump actuator 281 : second combustor

[46] 283 : second turbine unit 285 : second power generator

[47] 411 : fuel cell system 413 : heat exchanger

Best Mode for Carrying Out the Invention

[48] According to an aspect of the present invention, invented power plant with pure oxygen combustor is composed of: a heat supplying unit supplying a heated steam; a turbine unit generating mechanical energy by rotating a turbine using the heated steam supplied by the heat supplying unit; a power generator converting mechanical energy generated by the turbine unit into electrical energy; a steam condenser condensing steam passing through the turbine unit; and a first combustor disposed at one side of the turbine unit and reheating the steam supplied to the turbine unit by using pure oxygen combustion.

[49] The turbine unit may include a high pressure turbine, an intermediate pressure turbine, and a low pressure turbine according to operating pressure and temperature of

the supplied steam. The first combustor may be interposed between the intermediate pressure turbine and the low pressure turbine, may reheat the steam passing through the intermediate pressure turbine by using pure oxygen combustion, and may supply the reheated steam to the low pressure turbine.

[50] Pressure of steam supplied by the heat supplying unit may be 3 to 10 bar, and temperature of an inlet of the low pressure turbine may be 300 to 500℃.

[51] The power plant may further include: a water supplying pump delivering water condensed by the steam condenser to the heat supplying unit; and a pump actuator comprising a second combustor dividing a portion of the steam passing through the intermediate pressure turbine and reheating the divided steam, a second turbine unit actuating the water supplying pump by rotating the turbine by using the steam reheated by the second combustor, and a second power generator actuating the water supplying pump by converting mechanical energy generated by the second turbine unit into electrical energy.

[52] The second combustor may include: an inlet portion having a plurality of nozzles through which steam, oxygen, and a fuel are injected; and a main body portion into which the remaining steam excluding the steam injected through the inlet portion is injected through an injection hole formed in the side of the main body portion.

[53] The heat supplying unit may supply a waste steam generated from one facility selected from the group consisting of an incinerator furnace, a heating furnace, a factory, and a thermal power plant, to the first combustor, and the steam condenser may be installed in the ground and may condense the steam passing through the turbine unit by using geothermal heat.

[54] The heat supplying unit may include a heat exchanger discharging high temperature and high pressure steam due to an exhaust gas generated in a fuel cell system.

[55] Pressure of the steam passing through the heat exchanger may be 5 to 20 bar, and temperature of an inlet of the turbine unit may be 300 to 600℃.

[56] The first combustor may include: an inlet portion having a plurality of nozzles through which steam, oxygen, and a fuel are injected; and a main body portion into which the remaining steam excluding the steam injected through the inlet portion is injected through an injection hole formed in the side of the main body portion.

[57] The power plant may further include a recovery pump recovering carbon dioxide (CO_2) from exhausted gas by condensing the water in the exhausted gas.

Mode for the Invention

[58] The present invention will now be described more fully with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. First, terms or words used in the present specification and the claims should not be

construed as being limited to general or literal meaning, and the inventor should construe his/her own invention in meaning and concept that coincide with the technical spirit of the invention based on the principle for properly defining the concept of the terms so as to describe his/her own invention in the best manner.

[59] Thus, configurations shown in embodiments and the drawings of the present invention is rather an example of the most exemplary embodiment and does not represent all of the technical spirit of the invention. Thus, it will be understood that various equivalents and modifications that replace the configurations are possible when filing the present application.

[60] A power plant having a pure oxygen combustor according to an embodiment of the present invention will now be described with reference to FIGS. 1 through 4.

[61] FIG. 1 schematically illustrates a power plant having a pure oxygen combustor according to an embodiment of the present invention, and FIG. 2 illustrates a formula when methane is supplied as a fuel to the pure oxygen combustor of the power plant illustrated in FIG. 1

[62] Referring to FIG. 1, a power plant 100 having a pure oxygen combustor according to the current embodiment of the present invention comprises a heat supplying unit 110, a turbine unit 120, a first combustor 130, a power generator 140, a steam condenser 150, a recovery pump 160, and a water supplying pump 170.

[63] The heat supplying unit 110 comprises a heater 111 and a boiler 113, and the heater 111 supplies heat generated by combusting a fuel, such as a fossil fuel, etc., to the boiler 113.

[64] The heater 111 may comprise all of heat supplying units which are not limited to generation of heat by combusting a fuel, such as a fossil fuel, etc., but are able to use heat of a waste gas generated in factory, etc. or supply heat so that heat exchange occurs in the boiler 113 for the purpose of the invention.

[65] The boiler 113 heats water accommodated therein by using heat supplied by the heater 111 to generate high temperature and high pressure steam.

[66] The turbine unit 120 comprises a high pressure turbine 121, an intermediate pressure turbine 123, and a low pressure turbine 125 according to the pressure and temperature of an induced steam.

[67] The high pressure turbine 121 rotates a turbine by expanding the supplied high-temperature and high-pressure steam through a nozzle and thus converts energy of high-temperature and high-pressure steam into mechanical energy.

[68] The intermediate-pressure and intermediate-temperature steam passing through the high pressure turbine 121 is re-supplied to the boiler 113 according to the principle of a reheat system. The temperature of the steam is increased by reheating, and the steam is supplied to the intermediate pressure turbine 123. The turbine is rotated using the same

principle as the high temperature turbine 121, and the energy of the steam is converted into mechanical energy.

[69] In addition, the low-pressure and low-temperature steam passing through the intermediate pressure turbine 123 is supplied to the low pressure turbine 125, and the turbine is rotated using the same principle as the high temperature turbine 121, and mechanical energy is generated.

[70] In this case, the first combustor 130 is interposed between the intermediate pressure turbine 123 and the low pressure turbine 125, and low pressure and low temperature steam passing through the intermediate pressure turbine 123 is directly reheated using pure oxygen combustion, and the heated steam is supplied to the low pressure turbine 125.

[71] The first combustor 130 must use one of either the process byproduct or fossil-fuel excluding nitrogen as a fuel and pure oxygen as an oxidizer.

[72] The fossil fuel may include all fossil fuels, such as solid, liquid, and gaseous fossil fuels. A waste gas or a digester gas excluding nitrogen may be used as the process byproducts.

[73] Referring to FIG. 2, oxygen and methane are supplied to the first combustor 130 of the power planet 100 having the pure oxygen combustor shown in FIG. 1, together with the steam. Since only carbon dioxide (CO_2) and water vapor exist in a combustion gas generated using pure oxygen combustion between oxygen and methane, when water vapor in the combustion gas is condensed by the steam condenser 150, water vapor may be separated from condensed water and high concentration CO_2 may be recovered by the recovery pump 160.

[74] However, this is just an exemplary embodiment of the present invention. Thus, a fossil fuel supplied to the first combustor 130 is not limited to methane, and a variety of types of fossil fuels that cause pure oxygen combustion may be supplied to the first combustor 130 together with oxygen according to the purpose of the invention.

[75] In this way, the first combustor 130 reduces a thermal loss by directly mixing the combustion gas with the steam and, therefore, has high thermal efficiency.

[76] In addition, when the combustion gas is mixed with the steam by installing a combustor using the air, a large amount of nitrogen in the air is flown in, and CO_2 cannot be recovered, and the amount of an uncondensed gas that must be discharged to the outlet of the turbine increases, and thus the case is not appropriate to a power generation system. On the other hand, when the first combustor 130 is installed as in the power plant 100 having the pure oxygen combustor shown in FIG. 1, an uncondensed gas discharged to the rear end of the turbine unit 120 includes only CO_2. Thus, the amount of discharge of the uncondensed gas is small and high concentration CO_2 may be recovered.

[77] The structure of the first combustor 130 of the power plant 100 having the pure oxygen combustor of FIG. 1 will now be described with reference to FIG. 3 in more detail. FIG. 3 schematically illustrates the first combustor of the power plant having the pure oxygen combustor of FIG. 1.

[78] Referring to FIG. 3, the first combustor 130 comprises an inlet portion 131 having a plurality of nozzles through which steam, oxygen, and a fossil fuel are injected, and a main body portion 135 into which the remaining steam excluding the steam injected through the inlet portion 131 is injected through an injection hole 133 formed in the side of the main body portion 135.

[79] A portion of a fuel, oxygen, and water vapor is injected through the nozzles of the inlet portion 131, and pure oxygen combustion is performed between the injected oxygen and fuel so that a high temperature combustion gas can be obtained. The high temperature combustion gas and steam injected through the inlet portion 131 are mixed so that a desired temperature combustion gas can be obtained.

[80] In other words, a mixture of the combustion gas and the steam generated using pure oxygen combustion is supplied to the low pressure turbine 125 to generate mechanical energy, and the mixture of the combustion gas and steam passing through the low pressure turbine 125 passes the steam condenser 150. In this case, water vapor is condensed and discharged in the form of water. CO_2 that is not condensed by the steam condenser 150 is recovered by the recovery pump 160 interposed between the steam condenser 150 and the water supplying pump 170.

[81] Since a portion of the steam is injected into the first combustor 130 through the nozzles of the inlet portion 131 together with oxygen and a fossil fuel, overheating of the inlet portion 131 due to pure oxygen combustion between oxygen and the fossil fuel can be prevented, and nitrogen oxide (NO_x) due to overheating can be prevented from being generated.

[82] In addition, unlike heating using other heat exchangers, the steam is directly injected into the first combustor 130, and heated by pure oxygen combustion which leads to an enhanced thermal efficiency.

[83] In order to describe how to increase the thermal efficiency of the power plant 100 having the pure oxygen combustor according to the present invention, the Rankine cycle due to the power plant 100 having the pure oxygen combustor shown in FIG. 1 is illustrated in FIG. 4.

[84] FIG. 4 is a graph showing the Rankine cycle of the power plant having the pure oxygen combustor of FIG. 1.

[85] Referring to FIG. 4, a low pressure turbine used in a conventional thermal power plant operates with the Rankine cycle having the condition of 1-2-3-5-1. On the other hand, like in the power plant 100 having the pure oxygen combustor of FIG. 1, when

the inlet of the low pressure turbine 125 is reheated by using the first combustor 130 performing pure oxygen combustion, the low pressure turbine 125 operates with the Rankine cycle having the condition of 7-1-2-3-4-6-7.

[86] In other words, in the conventional power plant due to the Rankine cycle, the low pressure turbine 125 operates with the condition of a wet vapor at point 5 of FIG. 4 corresponding to the outlet of the low pressure turbine 125. Thus, dryness fraction must be maintained at 90% or greater to prevent erosion of a turbine blade.

[87] However, when the inlet of the turbine is reheated using pure oxygen combustion, the low pressure turbine 125 may operate at point 6 of FIG. 4 indicating a lower turbine outlet pressure while dryness fraction is maintained at 90% or greater.

[88] The pressure of the steam supplied by the heat supplying unit 110 may be 3 to 10 bar, and the temperature of the inlet of the low pressure turbine 125 may be 300 to 500°C.

[89] For example, the pressure of the outlet of the low pressure turbine 125 is an absolute pressure of approximately 0.04 kgf/cm^2, and the temperature of the inlet of the low pressure turbine 125 is 300 to 400°C.

[90] Thus, as illustrated in FIG. 4, when the thermal power plant 100 having the pure oxygen combustor of FIG. 1 is used, more efficient operation is possible at point 6. Thus, electrical efficiency is improved by about 2 to 3% for the low pressure turbine 125 only.

[91] The power generator 140 converts mechanical energy generated by the turbine unit 120 into electrical energy.

[92] The steam condenser 150 condenses the steam passing through the turbine unit 120 by using cooling water. The steam is re-condensed by the steam condenser 150 into water.

[93] In addition, seawater, etc. may be used as cooling water but the present invention is not limited to this. All cooling units may be used that condense the steam according to other purposes of the invention.

[94] CO_2 that is discharged through the steam condenser 150 is separated from water and is recovered by the recovery pump 160, and water condensed by the steam condenser 150 is delivered to the boiler 113 through the water supplying pump 170.

[95] A power plant 200 having a pure oxygen combustor according to another embodiment of the present invention will now be described with reference to FIG. 5. FIG. 5 schematically illustrates a power plant having a pure oxygen combustor according to another embodiment of the present invention.

[96] Referring to FIG. 5, the power plant 200 having the pure oxygen combustor according to current embodiment comprises a heat supplying unit 210, a turbine unit 220, a first combustor 230, a first power generator 240, a steam condenser 250, a recovery pump 260, a water supplying pump 270, and a pump actuator 280.

[97] The pump actuator 280 comprises a second combustor 281 which divides the steam passing through the intermediate pressure turbine 223 and reheats the divided steam, a second turbine unit 283 which generates mechanical energy by rotating the turbine by using steam passing through the second combustor 281, and a second power generator 285 which actuates the water supplying pump 270 by converting mechanical energy generated by the second turbine unit 283 into electrical energy.

[98] The second combustor 281 of the pump actuator 280 heats the steam passing through the intermediate pressure turbine 223 by pure oxygen combustion, supplies the heated steam to the second turbine unit 283, and converts energy of the steam into mechanical energy by using the second turbine unit 283.

[99] The water supplying pump 270 may be directly actuated using mechanical energy generated by the second turbine unit 283, and mechanical energy generated by the second turbine unit 283 is converted by the second power generator 285 into electrical energy. And the water supplying pump 270 may be actuated using electrical energy.

[100] A mixture of low-pressure and low-temperature steam and CO_2 that is exhausted by the second turbine unit 283 of the pump actuator 280 is supplied to the steam condenser 250 and is processed in the same manner as a mixture of a combustion gas and the steam exhausted by the low pressure turbine 225.

[101] The heat supplying unit 210, the turbines unit 220, the first combustor 230, the first power generator 240, the steam condenser 250, the recovery pump 260, and the water supplying pump 270 of the power plant 200 having the pure oxygen combustor illustrated in FIG. 5 are the same elements as the heat supplying unit 110, the turbines unit 120, the first combustor 130, the power generator 140, the steam condenser 150, the recovery pump 160, and the water supplying pump 170 of the power plant 100 having the pure oxygen combustor illustrated in FIG. 1, and thus, a description thereof will be omitted.

[102] In addition, the second combustor 281 has the same configuration as the first combustor 130 and performs the same function as the first combustor 130. In addition, the second turbine unit 283 and the second power generator 285 have the same configuration as the turbine unit 220 and perform the same function as the turbine unit 220 and the first power generator 240, respectively, and thus, a description thereof will be omitted.

[103] A power plant 300 having a pure oxygen combustor according to another embodiment of the present invention will now be described with reference to FIG. 6. FIG. 6 schematically illustrates a power plant having a pure oxygen combustor according to another embodiment of the present invention.

[104] Referring to FIG. 6, the power plant 300 having the pure oxygen combustor and using a waste steam according to the current embodiment of the present invention

comprises a heat supplying unit 310, a turbine unit 320, a first combustor 330, a power generator 340, a steam condenser 350, and a recovery pump 360.

[105] The heat supplying unit 310 supplies a waste steam generated from one facility selected from the group consisting of an incinerator furnace, a heating furnace, a factory, and a thermal power plant, to the first combustor 330.

[106] The heat supplying unit 310 supplying the waste steam in this way is not limited to the incinerator furnace described above, but various industry facilities may be used in the supplying unit 310 to supply the waste steam to the first combustor 330 according to the purpose of the invention.

[107] A plurality of turbine units 320, such as a high temperature turbine, an intermediate temperature turbine, and a low pressure turbine, may be provided according to the temperature and pressure of the supplied steam. However, since a power generation system is actuated using the waste steam discharged from other facility, only one turbine 320 may be provided so as to prevent an increase in costs due to an unnecessary increase in the number of turbines.

[108] In addition, the steam condenser 350 may be installed in the ground and condense the steam passing through the turbine unit 320 using geothermal heat.

[109] A conventional method of condensing the steam by using cooling water supplied by a cooling tower may be used instead of using the steam condenser 350. However, a facility for discharging the waste steam, such as an incinerator furnace, etc. is a previously-equipped facility. Thus, it may be difficult to use cooling water, such as seawater, etc., in a sea region and an inland region in which water supply is not easy, and a high cost is needed in supply of a large amount of cooling water used in cond ensation using a cooling tower. Thus, the conventional method of condensing steam by using cooling water supplied by a cooling tower is not economical.

[110] When the steam condenser 350 is installed under the ground as shown in the power plant 300 having the pure oxygen combustor of FIG. 6, the steam may be cooled down and condensed in a simple and efficient manner, and continuous reuse is possible without an additional cost.

[111] CO_2 that is discharged by the steam condenser 350 is separated from water and is recovered by the recovery pump 360, and water condensed by the steam condenser 350 may be discarded or reused by including an additional water supplying pump (not shown).

[112] The first combustor 330, the power generator 340, and the recovery pump 360 of the power plant 300 having the pure oxygen combustor of FIG. 6 are the same elements as the first combustor 130, the power generator 140, and the recovery pump 160 of the power plant 100 having the pure oxygen combustor of FIG. 1, respectively, and thus a description thereof will be omitted.

[113] A power plant 400 having a pure oxygen combustor according to another embodiment of the present invention will now be described with reference to FIG. 7. FIG. 7 schematically illustrates a power plant having a pure oxygen combustor according to another embodiment of the present invention.

[114] Referring to FIG. 7, the power plant 400 having the pure oxygen combustor according to the current embodiment of the present invention comprises a heat supplying unit 410, a turbine unit 420, a first combustor 430, a power generator 440, a steam condenser 450, a recovery pump 460, and a water supplying pump 470.

[115] The heat supplying unit 410 may comprise a heat exchanger 413 which exhausts the steam heated by an exhaust gas generated in a fuel cell system 411.

[116] The fuel cell system 411 is a system which converts chemical energy into electrical energy by electrochemical reaction in anode and cathode. A high temperature gas is discharged by the fuel cell system 411 to the outside of the fuel cell system 411.

[117] Examples of the fuel cell system 411 include phosphoric acid fuel cells (PAFC), molten carbonate fuel cells (MCFC), solid oxide fuel cells (SOFC), polymer electrolyte fuel cells (PEFC), etc. according to the type of an electrolyte. An MCFC system 411 is used in the power plant 400 having the pure oxygen combustor of FIG. 7.

[118] The fuel cell system 411 exhausts a high temperature gas of approximately 300 to 370℃. The heat from the high temperature gas is recovered by the heat exchanger 413 and generates high temperature steam.

[119] The power plant 400 having the pure oxygen combustor of FIG. 7 is actuated using high temperature steam.

[120] The heat exchanger 413 may be a heat recovery steam generator (HRSG). An HRSG is a heat exchanger which has been utilized in the field of an industry plant, such as a steam generator, a chemical plant, steel making, an incinerator system, etc.. The HRSG is a waste heat recovery device which recovers the residual heat of a gas turbine exhaust gas and generates the steam for power generation and processes.

[121] In other words, the residual heat of the exhaust gas generated in the fuel cell system 411 is recovered by the heat exchanger 413, and high temperature and high pressure steam is generated.

[122] In addition, the high temperature and high pressure steam generated in the heat exchanger 413 is injected into the first combustor 430 and is reheated using pure oxygen combustion, and the higher temperature steam is supplied to the turbine unit 420.

[123] The turbine unit 420 may be the same element as the turbine unit 120 of the power plant 100 having the pure oxygen combustor of FIG. 1, and an appropriate number of turbines may be provided according to the temperature and pressure of the supplied

steam.

[124] The pressure of the steam supplied from the heat exchanger 413 may be 5 to 20 bar, and the temperature of the inlet of the turbine unit 420 may be 300 to 600°C.

[125] The first combustor 430, the power generator 440, the recovery pump 460, and the water supplying pump 470 of the power plant 400 having the pure oxygen combustor of FIG. 7 are the same elements as the first combustor 130, the power generator 140, the recovery pump 160, and the water supplying pump 170 of the power plant 100 having the pure oxygen combustor of FIG. 1, respectively, and thus a description thereof will be omitted.

[126] In addition, the power plant having the pure oxygen combustor according to embodiments of the present invention can be used in a combined cycle thermal power plant.

[127] The combined cycle thermal power plant is a plant in which, firstly, electricity is generated by rotating a gas turbine by using a fuel, such as a natural gas, a light oil, etc. and exhaust gas heat generated in the gas turbine is recovered by using the HRSG and high temperature steam is produced and secondly, electricity is generated by rotating a steam turbine.

[128] In other words, the thermal power plant having a pure oxygen combustor according to the current embodiment of the present invention is used in the combined cycle thermal power plant, recovers the residual heat of the exhaust gas generated in the gas turbine by using the HRSG to generate high temperature and high pressure steam, and steam passing through the HRSG is supplied to a turbine unit (not shown), and then, the thermal power plant may be realized by using the same process as that performed by the turbine unit 120, the first combustor 130, the power generator 140, the steam condenser 150, the recovery pump 160, and the water supplying pump 170 of the power plant 100 having the pure oxygen combustor of FIG. 1.

[129] While the present invention has been particularly shown and described with reference to exemplary embodiments thereof, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present invention as defined by the following claims.

Claims

[1] A power plant having a pure oxygen combustor, the power plant comprising:
a heat supplying unit supplying a heated steam;
a turbine unit generating mechanical energy by rotating a turbine using the heated steam supplied by the heat supplying unit;
a power generator converting mechanical energy generated by the turbine unit into electrical energy;
a steam condenser condensing steam passing through the turbine unit; and
a first combustor disposed at one side of the turbine unit and reheating the steam supplied to the turbine unit by using pure oxygen combustion.

[2] The power plant of claim 1, wherein the turbine unit comprises a high pressure turbine, an intermediate pressure turbine, and a low pressure turbine according to pressure and temperature of the supplied steam, and the first combustor is interposed between the intermediate pressure turbine and the low pressure turbine, reheats the steam passing through the intermediate pressure turbine by using pure oxygen combustion, and supplies the reheated steam to the low pressure turbine.

[3] The power plant of claim 2, wherein pressure of steam supplied by the heat supplying unit is 3 to 10 bar, and a temperature of an inlet of the low pressure turbine is 300 to 500°C.

[4] The power plant of claim 2, further comprising:
a water supplying pump delivering water condensed by the steam condenser to the heat supplying unit; and
a pump actuator comprising a second combustor dividing a portion of the steam passing through the intermediate pressure turbine and reheating the divided steam, a second turbine unit actuating the water supplying pump by rotating the turbine by using the steam reheated by the second combustor, and a second power generator actuating the water supplying pump by converting mechanical energy generated by the second turbine unit into electrical energy.

[5] The power plant of claim 4, wherein the second combustor comprises:
an inlet portion having a plurality of nozzles through which steam, oxygen, and a fuel are injected; and
a main body portion into which the remaining steam excluding the steam injected through the inlet portion is injected through an injection hole formed in a side of the main body portion.

[6] The power plant of claim 1, wherein the heat supplying unit supplies the first combustor with a waste steam generated from one facility selected from the

group consisting of an incinerator furnace, a heating furnace, a factory, and a thermal power plant, and the steam condenser is installed under the ground and condenses the steam passing through the turbine unit by using geothermal heat.

[7] The power plant of claim 1, wherein the heat supplying unit comprises a heat exchanger discharging high temperature and high pressure steam due to an exhaust gas generated in a fuel cell system.

[8] The power plant of claim 7, wherein pressure of the steam supplied by the heat exchanger is 5 to 20 bar, and temperature of an inlet of the turbine unit is 300 to 600°C.

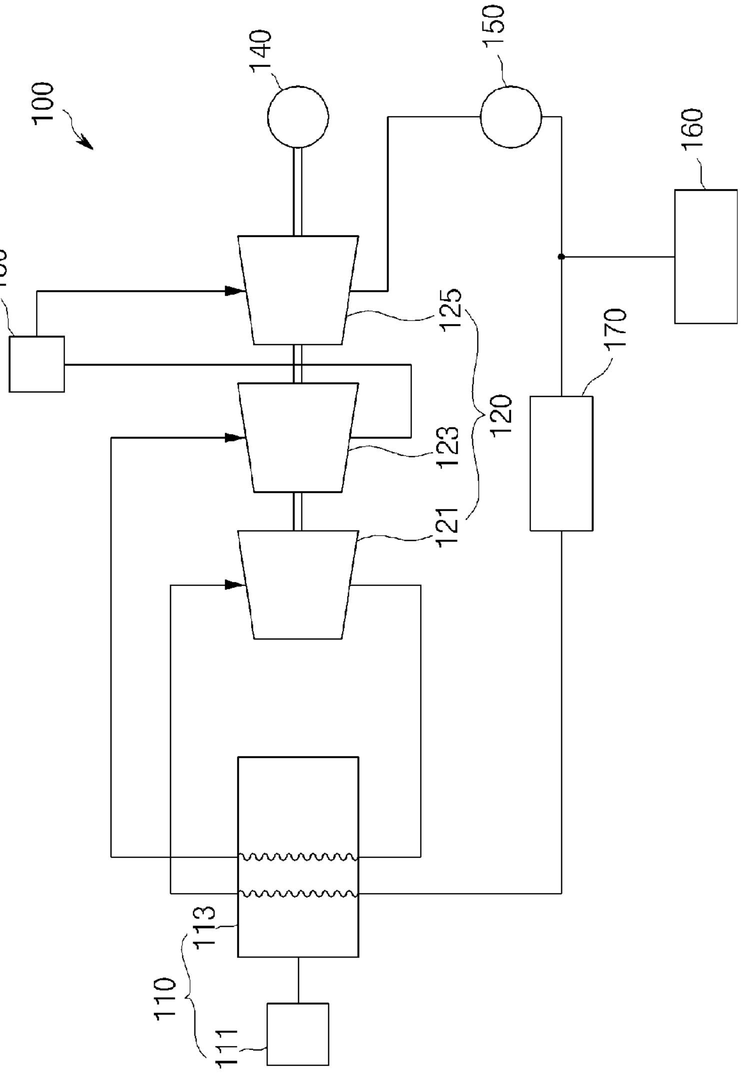
[9] The power plant of one of claims 1 through 8, wherein the first combustor comprises:

an inlet portion having a plurality of nozzles through which steam, oxygen, and a fuel are injected; and

a main body portion in which the remaining steam excluding the steam injected through the inlet portion is injected through an injection hole formed in the side of the main body portion.

[10] The power plant of claim 9, further comprising a recovery pump recovering carbon dioxide (CO_2) separated from water condensed by the steam condenser.

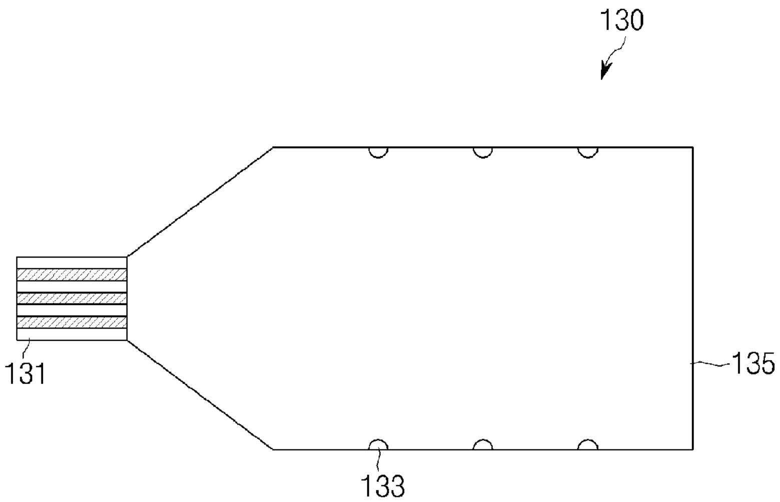
[Fig. 1]



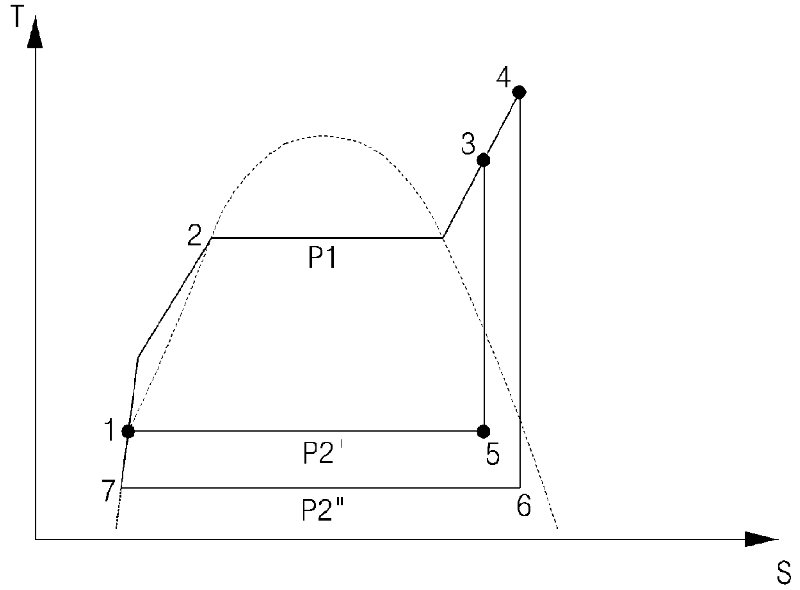
[Fig. 2]

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

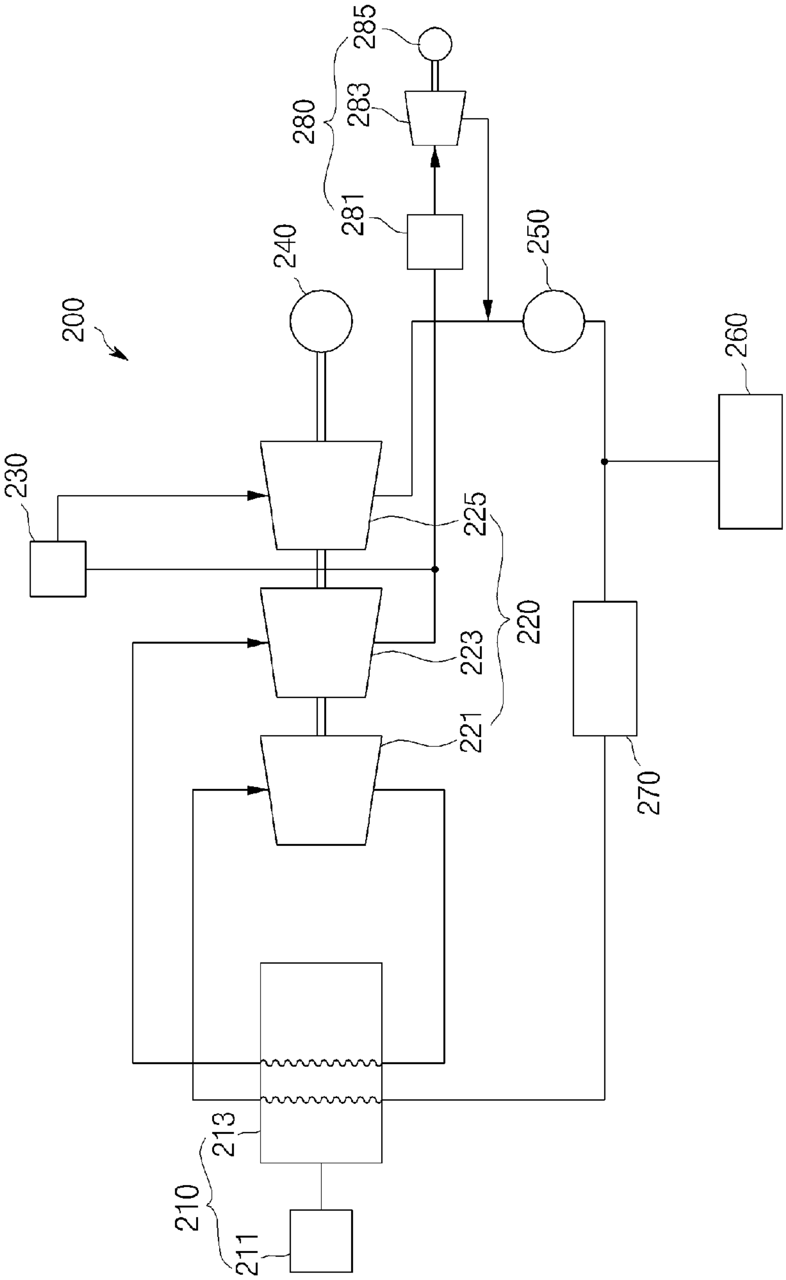
[Fig. 3]



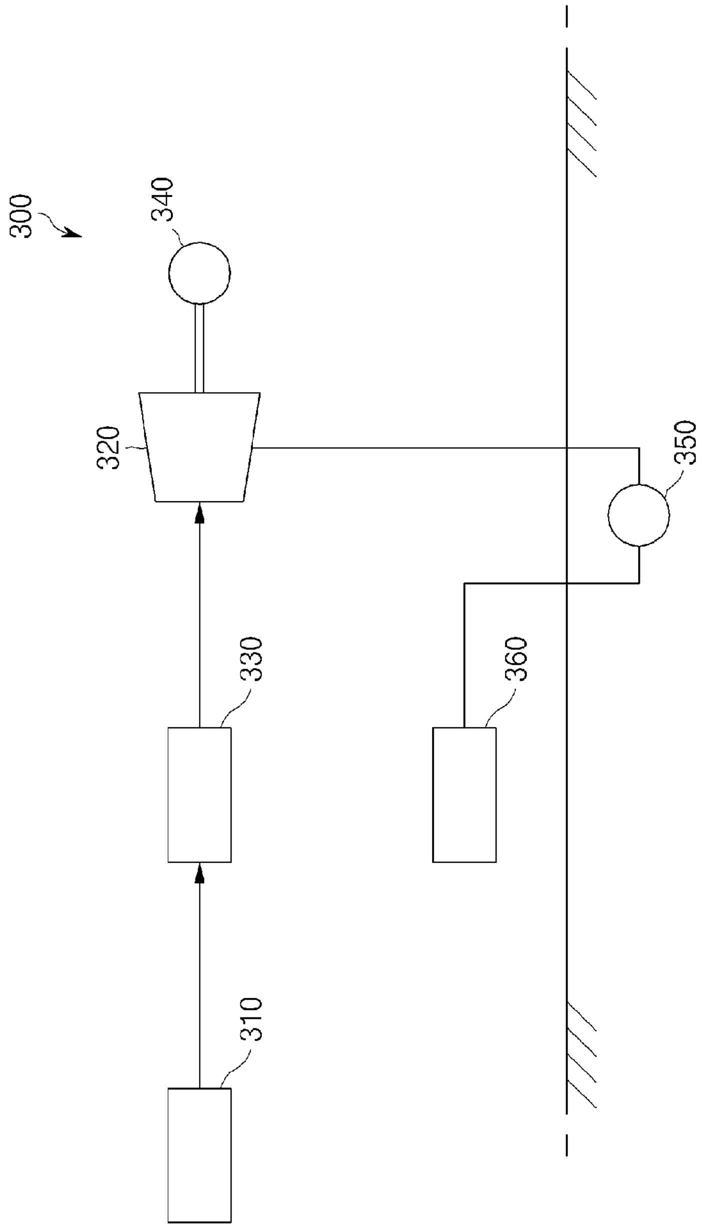
[Fig. 4]



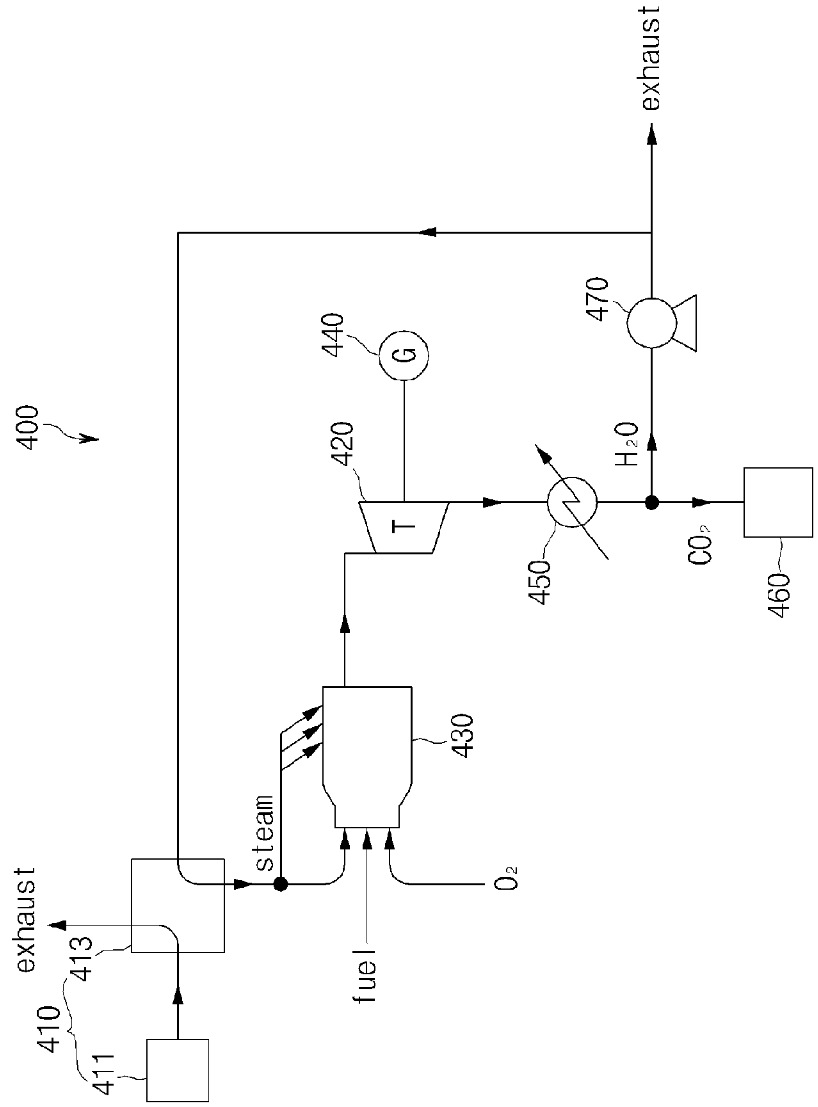
[Fig. 5]


285
283
280
281
240
250
200
260
230
225
220
223
221
270
213
210
211

[Fig. 6]



[Fig. 7]



400
410
411
413
exhaust
steam
fuel
O_2
430
420
T
440
G
450
H_2O
CO_2
460
470
exhaust

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2008/002600

A. CLASSIFICATION OF SUBJECT MATTER

F01K 19/04(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 8 F01K 25/00, F01K 7/02, F01K 7/22

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models since 1975
Japanese utility models and applications for utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKIPASS (KIPO internal) & keywords :

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP 10-002205 A (TOSHIBA CORP.) 6 January 1998 See claim 1 and fig.1	1,6,7 2-5,8-10
A	JP 08-254107 A (TOSHIBA CORP.) 1 October 1996 See abstract and fig.1	1-10
A	JP 07-293207 A (CENTRAL RES INST OF ELECTRIC POWER IND.) 7 November 1995 See abstract and fig.1	1-10
A	US 06742336 B2 (SHUUICHI ITOU.et al.) 1 June 2004 See abstract and fig.4	1-10
A	JP 2003-269188 A (ISHIKAWAJIMA HARIMA HEAVY IND CO.,LTD.) 25 September 2003 See abstract and fig.1	1-10

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 OCTOBER 2008 (20.10.2008)	**20 OCTOBER 2008 (20.10.2008)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon, 139 Seonsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer LEE, TAEK SANG Telephone No. 82-42-481-5492

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 10-002205 A	06.01.1998	NONE	
JP 08-254107 A	01.10.1996	NONE	
JP 07-293207 A	07.11.1995	JP 3611596 B2	19.01.2005
US 06742336 B2	01.06.2004	JP 2003-074309 A US 2003-0043952 A1	12.03.2003 06.03.2003
JP 2003-269188 A	25.09.2003	NONE	