An organic rankine binary cycle power generation system includes: a superheater heating a working fluid by exchanging heat with discharged heat; a turbine receiving the working fluid from the superheater and generating mechanical energy; a power generator connected to a power shaft of the turbine and generating power; a condenser keeping gas-state and liquid-state working fluids having passed through the turbine; a pump pumping the liquid-state working fluid in the condenser; a buffer tank disposed in a working fluid line between the pump and the superheater and keeping the gas-state and liquid-state working fluids; a compressor connected to the power shaft of the turbine, connected to the condenser and the buffer tank through diverging lines, respectively; and an expansion valve disposed in a bypass line connecting the buffer tank and the condenser and forcibly evaporating the working fluid moved by a pressure difference between the buffer tank and the condenser.
FIG. 1

Prior Art
FIG. 2

Prior Art
<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Pressure (bar)</th>
<th>Liquid Density (kg/m³)</th>
<th>Vapour Density (kg/m³)</th>
<th>Liquid Enthalpy (kJ/kg)</th>
<th>Vapour Enthalpy (kJ/kg)</th>
<th>Liquid Entropy (kJ/kgK)</th>
<th>Vapour Entropy (kJ/kgK)</th>
<th>Liquid Cp (kJ/kgK)</th>
<th>Vapour Cp (kJ/kgK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0000</td>
<td>0.53594</td>
<td>1404.0</td>
<td>3.2613</td>
<td>200.00</td>
<td>404.93</td>
<td>1.0000</td>
<td>1.7502</td>
<td>0.90675</td>
</tr>
<tr>
<td>2</td>
<td>0.0000</td>
<td>0.68180</td>
<td>1391.4</td>
<td>4.0099</td>
<td>206.48</td>
<td>408.69</td>
<td>1.0225</td>
<td>1.7504</td>
<td>0.91546</td>
</tr>
<tr>
<td>3</td>
<td>1.0000</td>
<td>0.82225</td>
<td>1376.5</td>
<td>4.9202</td>
<td>212.00</td>
<td>412.45</td>
<td>1.0467</td>
<td>1.7511</td>
<td>0.92225</td>
</tr>
<tr>
<td>4</td>
<td>1.0000</td>
<td>1.0175</td>
<td>1366.6</td>
<td>6.3468</td>
<td>218.50</td>
<td>416.21</td>
<td>1.0696</td>
<td>1.7520</td>
<td>0.92914</td>
</tr>
<tr>
<td>5</td>
<td>2.0000</td>
<td>1.2880</td>
<td>1352.2</td>
<td>7.1568</td>
<td>224.20</td>
<td>419.96</td>
<td>1.0924</td>
<td>1.7534</td>
<td>0.93613</td>
</tr>
<tr>
<td>6</td>
<td>2.0000</td>
<td>1.4543</td>
<td>1336.8</td>
<td>8.9545</td>
<td>230.97</td>
<td>423.74</td>
<td>1.1143</td>
<td>1.7549</td>
<td>0.94324</td>
</tr>
<tr>
<td>7</td>
<td>3.0000</td>
<td>1.7584</td>
<td>1325.1</td>
<td>10.1859</td>
<td>237.60</td>
<td>427.50</td>
<td>1.1372</td>
<td>1.7570</td>
<td>0.95045</td>
</tr>
<tr>
<td>8</td>
<td>3.0000</td>
<td>2.1202</td>
<td>1311.2</td>
<td>11.9393</td>
<td>244.60</td>
<td>431.24</td>
<td>1.1603</td>
<td>1.7592</td>
<td>0.95778</td>
</tr>
<tr>
<td>9</td>
<td>4.0000</td>
<td>2.5179</td>
<td>1297.0</td>
<td>14.0708</td>
<td>252.24</td>
<td>434.97</td>
<td>1.1843</td>
<td>1.7615</td>
<td>0.96520</td>
</tr>
<tr>
<td>10</td>
<td>4.0000</td>
<td>2.9577</td>
<td>1282.5</td>
<td>16.4421</td>
<td>260.14</td>
<td>438.69</td>
<td>1.2083</td>
<td>1.7642</td>
<td>0.97273</td>
</tr>
<tr>
<td>11</td>
<td>5.0000</td>
<td>3.4541</td>
<td>1267.7</td>
<td>19.1112</td>
<td>267.11</td>
<td>442.38</td>
<td>1.2324</td>
<td>1.7670</td>
<td>0.98035</td>
</tr>
<tr>
<td>12</td>
<td>5.0000</td>
<td>4.0117</td>
<td>1252.5</td>
<td>22.1210</td>
<td>274.15</td>
<td>446.05</td>
<td>1.2564</td>
<td>1.7698</td>
<td>0.98808</td>
</tr>
<tr>
<td>13</td>
<td>6.0000</td>
<td>4.6282</td>
<td>1237.0</td>
<td>25.4946</td>
<td>281.26</td>
<td>449.89</td>
<td>1.2804</td>
<td>1.7725</td>
<td>0.99587</td>
</tr>
<tr>
<td>14</td>
<td>6.0000</td>
<td>5.2926</td>
<td>1221.1</td>
<td>28.2979</td>
<td>288.45</td>
<td>453.23</td>
<td>1.3049</td>
<td>1.7752</td>
<td>1.00388</td>
</tr>
<tr>
<td>15</td>
<td>7.0000</td>
<td>6.0397</td>
<td>1204.7</td>
<td>33.5298</td>
<td>295.71</td>
<td>456.95</td>
<td>1.3299</td>
<td>1.7779</td>
<td>1.01188</td>
</tr>
<tr>
<td>16</td>
<td>7.0000</td>
<td>6.9508</td>
<td>1187.7</td>
<td>38.2727</td>
<td>303.05</td>
<td>460.63</td>
<td>1.3549</td>
<td>1.7807</td>
<td>1.01997</td>
</tr>
<tr>
<td>17</td>
<td>8.0000</td>
<td>8.1913</td>
<td>1170.3</td>
<td>43.5745</td>
<td>310.52</td>
<td>463.00</td>
<td>1.3799</td>
<td>1.7836</td>
<td>1.02827</td>
</tr>
<tr>
<td>18</td>
<td>8.0000</td>
<td>9.6309</td>
<td>1152.1</td>
<td>49.5029</td>
<td>318.04</td>
<td>467.18</td>
<td>1.4049</td>
<td>1.7865</td>
<td>1.03607</td>
</tr>
<tr>
<td>19</td>
<td>9.0000</td>
<td>10.9441</td>
<td>1135.3</td>
<td>56.3131</td>
<td>325.68</td>
<td>470.38</td>
<td>1.4299</td>
<td>1.7893</td>
<td>1.04407</td>
</tr>
<tr>
<td>20</td>
<td>9.0000</td>
<td>12.8749</td>
<td>1118.7</td>
<td>63.2655</td>
<td>333.14</td>
<td>473.69</td>
<td>1.4549</td>
<td>1.7922</td>
<td>1.05207</td>
</tr>
<tr>
<td>21</td>
<td>10.000</td>
<td>14.6164</td>
<td>1093.1</td>
<td>71.6868</td>
<td>341.31</td>
<td>476.77</td>
<td>1.4799</td>
<td>1.7950</td>
<td>1.06007</td>
</tr>
<tr>
<td>22</td>
<td>10.000</td>
<td>16.3960</td>
<td>1068.6</td>
<td>81.2653</td>
<td>349.93</td>
<td>479.73</td>
<td>1.5050</td>
<td>1.7978</td>
<td>1.06807</td>
</tr>
<tr>
<td>23</td>
<td>11.000</td>
<td>18.3948</td>
<td>1044.7</td>
<td>91.2563</td>
<td>358.50</td>
<td>482.53</td>
<td>1.5307</td>
<td>1.8006</td>
<td>1.07607</td>
</tr>
<tr>
<td>24</td>
<td>11.000</td>
<td>20.5468</td>
<td>1021.4</td>
<td>102.3994</td>
<td>367.50</td>
<td>485.13</td>
<td>1.5565</td>
<td>1.8034</td>
<td>1.08407</td>
</tr>
<tr>
<td>25</td>
<td>12.000</td>
<td>22.9225</td>
<td>998.36</td>
<td>114.7722</td>
<td>376.50</td>
<td>487.69</td>
<td>1.5824</td>
<td>1.8062</td>
<td>1.09207</td>
</tr>
<tr>
<td>26</td>
<td>12.000</td>
<td>25.6800</td>
<td>976.10</td>
<td>128.7131</td>
<td>385.54</td>
<td>490.19</td>
<td>1.6082</td>
<td>1.8090</td>
<td>1.10007</td>
</tr>
<tr>
<td>27</td>
<td>13.000</td>
<td>28.8051</td>
<td>955.00</td>
<td>143.5232</td>
<td>394.52</td>
<td>492.67</td>
<td>1.6340</td>
<td>1.8118</td>
<td>1.10807</td>
</tr>
<tr>
<td>28</td>
<td>13.000</td>
<td>32.3851</td>
<td>935.12</td>
<td>159.3232</td>
<td>403.19</td>
<td>495.19</td>
<td>1.6599</td>
<td>1.8146</td>
<td>1.11607</td>
</tr>
<tr>
<td>29</td>
<td>14.000</td>
<td>36.4560</td>
<td>916.12</td>
<td>176.1232</td>
<td>411.68</td>
<td>497.71</td>
<td>1.6857</td>
<td>1.8174</td>
<td>1.12407</td>
</tr>
<tr>
<td>30</td>
<td>14.000</td>
<td>40.9760</td>
<td>898.12</td>
<td>194.3232</td>
<td>420.19</td>
<td>500.23</td>
<td>1.7114</td>
<td>1.8202</td>
<td>1.13207</td>
</tr>
<tr>
<td>31</td>
<td>15.000</td>
<td>45.9760</td>
<td>881.12</td>
<td>214.5232</td>
<td>428.68</td>
<td>502.71</td>
<td>1.7372</td>
<td>1.8228</td>
<td>1.14007</td>
</tr>
</tbody>
</table>
ORGANIC RANKINE BINARY CYCLE POWER GENERATION SYSTEM

TECHNICAL FIELD

[0001] The present invention relates to an organic rankine binary cycle power generation system, and more particularly, to an organic rankine binary cycle power generation system that can improve efficiency of thermal energy by operating an ORC and a heat pump cycle with single working fluid.

BACKGROUND ART

[0002] Environment and energy industries in the modern society are not only highlighted as promising industries in the 21st century, but recognized as important indexes of national competitiveness.

[0003] Further, in the modern society, there is general acceptance that it is necessary to develop and popularize renewable energy capable of replacing the fossil fuel energy in order to solve the global warming, a confronted problem.

[0004] Accordingly, many countries have recognized the renewable energy industry as a high value-added industry and kept supporting relating industries to promote them.

[0005] In particular, in use of renewable energy, it is an important concern to improve the efficiency of a system and it is recognized as a first problem to develop a technology for the improvement.

[0006] As a part of these, there are many technological studies for improving efficiency in the field of an organic rankine cycle using industrial waste heat or renewable energy.

[0007] A typical rankine cycle power generation system converts shaft power, which is generated by vapor increasing in pressure through an evaporator and rotating a turbine, into electrical energy.

[0008] In the existing rankine cycle, water is used as working fluid and is efficient for a high-temperature heat source, but it causes an economic problem by decreasing efficiency of a system including a heat source at middle and low temperatures (70 to 400°C), so it is inappropriate to use.

[0009] An ORC (Organic Rankine Cycle) for solving the problem of efficiency reduction of the rankine cycle including a middle/low-temperature heat source uses an organic compound as working fluid instead of water.

[0010] That is, an organic rankine cycle power generation system is the same in basic configuration as a thermal power generation system, but uses an organic compound.

[0011] An organic rankine cycle, which is used to generate power using a low-temperature heat source having relatively low exergy, unlike the existing rankine cycle, requires to operate with a low energy heat source, so it is advantageous that the working fluid has a low boiling point, a high vapor pressure, and low latent heat and high density for increasing the mass flow rate at the inlet of a turbine.

[0012] Further, the organic rankine cycle has low efficiency around 10% because it uses a middle/low heat source, so it is used as a bottoming cycle for recovering waste heat or discharged heat generated usually in industrial processes.

[0013] An organic compound used as working fluid in the organic rankine cycle vaporizes even at a low temperature due to the low boiling point, so the organic rankine cycle requires being able to operate using middle/low temperature heat, solar heat, geothermy, and the like, and Freon-based refrigerants and hydrocarbon series materials such as propane are generally used as the organic compound.

[0014] A common organic rankine cycle includes, as a configuration diagram of FIG. 1 and an operation diagram of FIG. 2, includes a pump 18, a superheater (evaporator) 10, a turbine 12, and a condenser 16.

[0015] The cycle process of working fluid in the organic rankine cycle is composed of circular processes of a compressing process by the pump 18, an endothermic process by the superheater 10, an expanding process by the turbine 12, and a heat discharging process by the condenser 16.

[0016] In detail, a superheated organic compound at the outlet of the turbine 12, as can be seen from FIGS. 1 and 2, is condensed through the condenser (2 to 3) and compressed into saturated liquid by the pump 18 (3 to 4).

[0017] Thereafter, the organic compound that has been subcooled through the compression by the pump reaches saturation evaporation temperature by exchanging heat with a heat source through the superheater 10 (4 to 5) and then vaporizes (5 to 1). The organic compound in a saturated vapor state at the outlet of the superheater 10 expands through the turbine (1 to 2), and in this process, the expansion work is converted into mechanical energy and the mechanical energy operates a generator 14 connected with the turbine 12, thereby generating power. The organic compound at the outlet of the turbine 12 flows in a superheated state into the condenser and condensed again, and these processes are circulated.

[0018] When water that is working fluid in the existing rankine systems expands through a turbine, at a saturation vaporization point, it is maintained in a two-phase state at the outlet of the turbine, but an organic compound is maintained in a superheated vapor state. Accordingly, an organic compound produces less liquid drops in the turbine of an organic rankine system, so stress in turbine blades decreases and a saturation cycle system that does not need a superheating area at the outlet of a superheater can be achieved.

[0019] However, the efficiency of an organic rankine cycle is very low up to now and there are many studies and efforts for solving this problem.

DISCLOSURE

Technical Problem

[0020] An aspect of the present invention is to provide an organic rankine binary cycle power generation system that increases efficiency of an organic rankine cycle, that is, increases efficiency of power generation by reducing a waste of heat and efficiently using power, by operating an organic rankine cycle and a heat pump cycle with single working fluid.

Technical Solution

[0021] According to an aspect of the present invention, there is provided an organic rankine binary cycle power generation system that includes: a superheater heating a working fluid by exchanging heat with discharged heat; a turbine receiving the working fluid from the superheater and generating mechanical energy; a power generator connected to a power shaft of the turbine and generating power; a condenser keeping gas-state and liquid-state working fluids...
having passed through the turbine; a pump pumping the liquid-state working fluid in the condenser; a buffer tank disposed in a working fluid line between the pump and the superheater and keeping the gas-state and liquid-state working fluids; a compressor connected to the power shaft of the turbine, connected to the condenser and the buffer tank through diverging lines, respectively, and taking the working fluid inside from the condenser, compressing and heating the working fluid, and sending the working fluid to the buffer tank by using power from the turbine; and an expansion valve disposed in a bypass line connecting the buffer tank and the condenser and forcibly evaporating the working fluid moved by a pressure difference between the buffer tank and the condenser, in which the working fluid is a single working fluid shared by a first cycle line made by a series of the turbine, the condenser, the pump, the buffer tank, and the superheater and a second cycle line made by a series of the compressor, the buffer tank, the expansion valve, and the condenser.

Further, the turbine may be any one of a screw turbine, a displacement turbine, and a turbo turbine.

In addition, the power generator and the compressor may be connected to the power shaft of the turbine and operated together.

In addition, a cooling line for cooling the gas-state working fluid through heat exchange may be further connected to the condenser.

Further, the condenser and the buffer tank may each have a plurality of separators having a plurality of holes and vertically spaced from each other, and the plurality of separators may distribute the temperature of the gas-state and liquid-state working fluids in a plurality of layers by delaying convection of the kept working fluid.

Advantageous Effects

As set forth above, according to exemplary embodiments of the invention, a single working fluid shared by a first cycle line that is an ORC system made by a series of the turbine, the condenser, the pump, the buffer tank, and the superheater and a second cycle line that is a heat pump cycle made by a series of the compressor, the buffer tank, the expansion valve, and the condenser, and the buffer tank and the condenser that are in common in the first and second cycle lines supplement each other. Accordingly, it is possible to not only reduce a loss of thermal energy, but increase efficiency of mechanical energy by connecting the compressor to the power shaft of the turbine to operate it. Therefore, efficiency of power generation is improved.

DESCRIPTION OF DRAWINGS

FIG. 1 is a diagram illustrating a typical organic rankine cycle in the related art;

FIG. 2 an operation diagram of a common organic rankine cycle;

FIG. 3 is a diagram illustrating an operation relationship of an organic rankine binary cycle power generation system according to an exemplary embodiment of the present invention;

FIGS. 4A to 4C are operation diagrams illustrating an energy efficiency relationship according to the organic rankine binary cycle power generation system illustrated in FIG. 3;

FIG. 5 is a cross-sectional view illustrating separators installed in a condenser and a buffer tank and a corresponding operation relationship, based on the buffer tank illustrated in FIG. 3; and

FIG. 6 is a table listing properties of working fluid used in the present invention.

MODE FOR INVENTION

Exemplary embodiments of the present invention will now be described in detail with reference to the accompanying drawings.

An organic rankine binary cycle power generation system according to an exemplary embodiment of the present invention is characterized by including; a superheater heating a working fluid by exchanging heat with discharged heat; a turbine receiving the working fluid from the superheater and generating mechanical energy; a power generator connected to a power shaft of the turbine and generating power; a condenser keeping gas-state and liquid-state working fluids having passed through the turbine; a pump pumping the liquid-state working fluid in the condenser; a buffer tank disposed in a working fluid line between the pump and the superheater and keeping the gas-state and liquid-state working fluids; a compressor connected to the power shaft of the turbine, connected to the condenser and the buffer tank through diverging lines, respectively, and taking the working fluid inside from the condenser, compressing and heating the working fluid, and sending the working fluid to the buffer tank by using power from the turbine; and an expansion valve disposed in a bypass line connecting the buffer tank and the condenser, in which the working fluid is a single working fluid shared by a first cycle line made by a series of the turbine, the condenser, the pump, the buffer tank, and the superheater and a second cycle line made by a series of the compressor, the buffer tank, the expansion valve, and the condenser.

Prior to describing the present invention, it should be understood that an organic rankine binary cycle power generation system according to the present invention has been intended to increase efficiency of power generation by recovering thermal energy from heat discharged from an internal combustion engine or industrial facilities.

That is, the present invention has been made to reduce a loss of heat by preventing cooling for condensing working fluid as much as possible in comparison to existing systems and reuse the heat for power generation.

Therefore, the present invention does not use the technology for cooling air at room temperature or less and may be used for heating air at room temperature or more, but it will not be described in detail.

Hereinafter, exemplary embodiments of the present invention will be described with reference to accompanying drawings.

An organic rankine binary cycle power generation system according to the present invention has a first cycle section that is an ORC system, as illustrated in FIG. 3, including a series of a superheater 10 that recovers heat from an external facility and heats working fluid, a turbine 20 that converts expansion energy of working fluid heated through the superheater 10 into mechanical energy for operating a power generator 24, a condenser 28 that keeps the working fluid that has passed through the turbine 20 in vapor and
liquid states, and a pump 30 that sending the liquid-state working fluid in the condenser 28 to the superheater 10.
[0040] Further, the organic rankine binary cycle power generation system according to the present invention has, together with the first cycle section, a second cycle section that is a heat pump cycle including a series of a buffer tank 32 that is disposed in working fluid lines 1.5 and 1.5' between the pump 30 and the superheater 10 and keeps a predetermined amount of working fluid, a compressor 26 that is connected to a power shaft of the turbine 20, is connected to the condenser 28 and the buffer tank 32 through diverging lines 1.6 and 1.7, respectively, takes working fluid from the condenser 28 using power from the turbine 20, compresses the working fluid at high temperature and high pressure, and sends the working fluid to the buffer tank 32, and an expansion valve 34 that is disposed in a bypass line 1.8 between the buffer tank 32 and the condenser 28 and controls the amount of working fluid flowing from the buffer tank 32 to the condenser 28.
[0041] The working fluids circulating through the first and second cycle sections are the same, mixed in the condenser 28 and the buffer tank 32 shared by the first and second cycle sections, and separated in accordance with liquid vapor states and a temperature difference in the condenser 28 and the buffer tank 32.
[0042] Accordingly, in the present invention, the first and second cycle sections are paralleled and combined in circular configurations, thereby obtaining a binary cycle configuration.
[0043] The configurations of the present invention are described in more detail.
[0044] First, the superheater 10 is connected with a heat-discharging line H from an internal combustion engine or an industrial facility, recovers heat by exchanging heat with the heat-discharging line H, and heats a working fluid therein.
[0045] Herein, in operation conditions of the present invention, it is assumed that the temperature of a heat source flowing through the heat-discharging line H is higher than a predetermined temperature to which a working fluid is heated in the superheater 10. For example, as described below, it may be assumed that the range of 85 to 120° C., which is the predetermined temperature of a working fluid heated in the superheater 10, satisfies the conditions of temperature in the predetermined temperature. An example of temperature is based on a fluid (R245fa) having the properties listed in FIG. 6.
[0046] Further, the turbine 20 expands a saturated working fluid supplied through the working fluid line connected with the superheater 10, thereby obtaining mechanical energy.
[0047] Herein, in the first and second cycle sections, a pressure difference is low and a temperature difference due to phase changes is also low, so a working fluid that is the working medium can change in phase in the first and second cycle sections including the turbine 20.
[0048] Accordingly, for the turbine 20, a screw type expander (screw type turbine) or a displacement type expander (displacement type turbine) may be used, other than a turbo type expander (turbo type turbine) using blades.
[0049] That is, a working fluid to be used in the present invention is selected from organic working fluids that has, as described below, a pressure in the range of 2.5 to 6.0 bar in a saturated vapor state, liquid-state enthalpy in the range of 250 to 295 kJ/kg, an gas-state enthalpy in the range of 430 to 455 kJ/kg within a low temperature range of 40 to 70° C., and a pressure in the range of 9.0 to 19.0 bar in a saturated vapor state, liquid-state enthalpy in the range of 320 to 370 kJ/kg, and gas-state enthalpy in the range of 470 to 485 kJ/kg within a high temperature range of 85 to 120° C.
[0050] Accordingly, the working fluid in a high temperature range of 85 to 120° C. may be in a liquid state in the turbine 20.
[0051] When a liquid-state working fluid expands at a high pressure together with a gas-state working fluid, it hits against blades of a turbo type expander and the shock may cause a problem with the durability and stability of the turbo type expander having the blades.
[0052] Obviously, when a working fluid can sufficiently keep a dry vapor state at the inlet of the turbine 20, a turbo type expander higher in efficiency than a screw type expander or a displacement type expander may be used.
[0053] Further, the power generator 24 that generates power from the mechanical energy produced by the turbine 20 is connected to the power shaft 22 of the turbine 20.
[0054] The power generator 24 may be replaced with other parts, so detailed description is not provided.
[0055] In addition, a compressor 26 that, as described below, takes a working fluid from the condenser 28 through the diverging line 1.6 connected to the condenser 28, compresses and heats the working fluid, and sends it into the buffer tank 32 through the diverging line 1.7 connected to the buffer tank 32 to be described below, using the mechanical energy produced by the turbine 20, is connected, other than the power generator 24, to the power shaft 22 of the turbine 20, as described above.
[0056] The compressor 26, as described above, performs a series of process of taking a gas-state working fluid from the condenser 28, compressing and heating it, and then sending it to the buffer tank 32.
[0057] Accordingly, the turbine 20, the power generator 24, and the compressor 26 are connected by the power shaft 22 of the turbine 20, and the power generator 24 and the compressor 26 are operated in cooperation with each other by power from the turbine 20.
[0058] Meanwhile, the condenser 28 receives and keeps a gas-state working fluid that has undergone expanding and a liquid-state working fluid that has been heated from the turbine 20.
[0059] In the present invention, the condenser 28 does not necessarily require a cooling line or a fan (not illustrated) for forcibly removing condensing heat for condensing a gas-state working fluid.
[0060] That is, since the gas-state working fluid is discharged through the diverging line connected with the compressor 26, the inside of the condenser 28 is under a low pressure. Further, as described below, the organic working fluid has a boiling point in the range of 40 to 70° C., has a relatively small temperature difference in comparison to an expansion temperature of 85 to 120° C., and can naturally condenses while flowing through the working fluid line L.2 between the turbine 20 and the condenser 28.
[0061] Above all, direct cooling for condensing the working fluid in the condenser 28 is made by an expansion valve 34 forcibly evaporating the working fluid flowing from the buffer tank 32 to the condenser 28 through a bypass line 1.8, which is described below.
[0062] Accordingly, the basic configuration for forcibly recovering the condensing heat of the working fluid in the condenser 28 is the expansion valve 34, and the cooling line
C or the fan may be provided for more accurate control, supplementing the expansion valve 34 for condensing the working fluid.

[0063] The internal temperature of the condenser 28 may be controlled in the range of 40 to 70° C, in which the working fluid has a boiling point, by controlling the fan or the cooling line C for cooling the working fluid to supplement cooling due to forcible vaporization of the working fluid through the expansion valve 34.

[0064] Further, as illustrated in FIG. 5, the condenser 28 includes a plurality of plate-shaped separators 28a having a plurality of holes and vertically spaced from each other therein.

[0065] The plurality of separators 28a delay the flow of the liquid-state working fluid in the condenser 28 and allow the gas-state working fluid to flow smoothly through the holes, so they delay convection of the liquid-state working fluid in the condenser 28 so that the temperature of the working fluid changes, depending on the gaps between separators 28a.

[0066] Accordingly, in the working fluid flowing in the condenser 28 through the working fluid line L2 from the turbine 20, the gas-state working fluid is positioned at the upper portion in the condenser 28 and the liquid-state working fluid collects at the lower portion in the condenser 28, so temperature differences according to the gaps between the separators 28a are generated.

[0067] Herein, the diverging line L6 connected with the compressor 26 has an end corresponding to the position of the gas-state working fluid at the upper portion in the condenser 28 and allows the gas-state working fluid in the condenser 28 to flow outside when the compressor 26 is operated such that the internal pressure of the condenser 28 becomes lower than that of the working fluid line L2.

[0068] In the present invention, the bypass line L8 guiding the liquid-state working fluid in the buffer tank 32 to the condenser 28 is formed, and the liquid-state working fluid is分流 between the pump 30 and the working fluid lines L4 and L5 connected to the superheater 10.

[0069] As the condenser 28 described with reference to FIG. 5, separators 32a are disposed in the buffer tank 32 to separate the working fluid therein into a gas state and a liquid state and vertically generate differences in temperature of the working fluid.

[0070] By the separators 32a in the buffer tank 32, the gas-state working fluid is positioned at the upper portion in the buffer tank 32 and the liquid-state working fluid is positioned at the lower portion in the buffer tank 32 due to its own weight.

[0071] The high-temperature and high-pressure working fluid supplied from the compressor 26, as described above, is supplied to the buffer tank 32 through the diverging line L7 and mixed and exchanges heat with the liquid-state working fluid that has been sent by the pump 30.

[0072] The place where the working fluid from the compressor 26 and the working fluid from the pump 30 exchange heat with each other is the portion over the portion where the liquid-state working fluid is in the buffer tank 32. The working fluid at the place, as illustrated in FIG. 5, cannot convect by the separators 32a, so it is preheated higher than the temperature of the liquid-state working fluid over or under it.

[0073] Accordingly, the working fluid line L5 connected to the superheater 10 from the buffer tank 32 is positioned to correspond to the working fluid having a relatively high temperature through the preheating in the buffer tank 32.

[0074] Herein, the preheating temperature for the working fluid supplied to the superheater 10, which is provided for making the heating efficiency of the working fluid stable through the superheater 10, is maintained in the range of 85 to 90% of the temperature of the working fluid in a saturation state with respect to the range between 0° C. and the temperature of the working fluid in a saturation state before expanded by the superheater 10.

[0075] The preheating temperature of the working fluid keeps the heating temperature of the working fluid more stable in preparation for the case when the heating temperature of the working fluid by the superheater 10 is unstable.

[0076] Further, in the buffer tank 32, the pressure of the working fluid flowing inside by the pump 30 and the compressor 26 and there is also a gas-state working fluid.

[0077] Accordingly, in the buffer tank 32, it is required to control the pressure at a predetermined level, and for this purpose, the bypass line L8 guiding the liquid-state working fluid in the buffer tank 32 to the condenser 28.

[0078] In addition, the expansion valve 34 is disposed in the bypass line L8 to forcibly evaporate the working fluid moved by the difference between the internal pressure of the buffer tank 32 and the internal pressure of the condenser 28 and put it into the condenser 28.

[0079] That is, the working fluid forcibly evaporated by the expansion valve 34 condenses the working fluid flowing inside from the turbine 20 by cooling the inside of the condenser 28.

[0080] As described above, in the present invention, a single working fluid is shared by the first cycle line making the ORC system having the series of the turbine 20, the condenser 28, the pump 30, the buffer tank 32, and the superheater 10 and the second cycle line making the heat pump system having the series of the compressor 26, the buffer tank 32, the expansion valve 34, and the condenser 28, and the turbine 20 and the compressor 26 are connected by the power shaft, so the first and second cycle lines operate in cooperation with each other.

[0081] Further, the condenser 28 functions as a common condenser for condensing a working fluid in the first cycle line and functions as an evaporator in the second cycle line.

[0082] The buffer tank 32 functions as an evaporator for evaporating a working fluid, supplementing the superheater 10 in the first cycle line and functions as a condenser in the second cycle line.

[0083] Therefore, the organic rankine cycle power generation system according to the present invention reduces a loss of thermal energy by simultaneously operating the ORC system and the heat pump system, using a single organic working fluid.

[0084] As for the power generation efficiency from this configuration, the efficiency W1 of the first cycle line that is an organic rankine cycle (ORC system), as illustrated in FIG. 4A, and the efficiency W2 of the second cycle line that is a heat pump cycle, as illustrated in FIG. 4B are achieved from the saturation vapor curve constructed by a dotted line. Further, even if overlap of the efficiencies W1 and W2 is taken into consideration, a more increased efficiency is obtained, as illustrated in FIG. 4C.
While the present invention has been illustrated and described in connection with the exemplary embodiments, it will be apparent to those skilled in the art that modifications and variations can be made without departing from the spirit and scope of the invention as defined by the appended claims.

1. An organic rankine binary cycle power generation system comprising:
   a superheater heating a working fluid by exchanging heat with discharged heat;
   a turbine receiving the working fluid from the superheater and generating mechanical energy;
   a power generator connected to a power shaft of the turbine and generating power;
   a condenser keeping gas-state and liquid-state working fluids having passed through the turbine;
   a pump pumping the liquid-state working fluid in the condenser;
   a buffer tank disposed in a working fluid line between the pump and the superheater and keeping the gas-state and liquid-state working fluids;
   a compressor connected to the power shaft of the turbine, connected to the condenser and the buffer tank through diverging lines, respectively, and taking the working fluid inside from the condenser, compressing and heating the working fluid, and sending the working fluid to the buffer tank by using power from the turbine; and
   an expansion valve disposed in a bypass line connecting the buffer tank and the condenser and forcibly evaporating the working fluid moved by a pressure difference between the buffer tank and the condenser,

     wherein the working fluid is a single working fluid shared by a first cycle line made by a series of the turbine, the condenser, the pump, the buffer tank, and the superheater and a second cycle line made by a series of the compressor, the buffer tank, the expansion valve, and the condenser.

2. The system of claim 1, wherein the turbine is any one of a screw turbine, a displacement turbine, and a turbo turbine.

3. The system of claim 1, wherein the power generator and the compressor are connected to the power shaft of the turbine and operated together.

4. The system of claim 1, wherein a cooling line for cooling the gas-state working fluid through heat exchange is further connected to the condenser.

5. The system of claim 1, wherein the condenser and the buffer tank each have a plurality of separators having a plurality of holes and vertically spaced from each other, and the plurality of separators distribute the temperature of the gas-state and liquid-state working fluids in a plurality of layers by delaying convection of the kept working fluid.

* * * * *