US 20060144585A1

(19) United States
(12) Patent Application Publication
Ha et al.
(10) Pub. No.: US 2006/0144585 A1
(43) Pub. Date: Jul. 6, 2006

(54) EXHAUST GAS HEAT EXCHANGER FOR COGENERATION SYSTEM

(75) Inventors: **Sim Bok Ha**, Kwangmyung-si (KR); **Baik Young Chung**, Inchun-si (KR); **Cheol Soo Ko**, Kunpo-si (KR); **Cheol Min Kim**, Anyang-si (KR)

Correspondence Address:
GREENBLUM & BERNSTEIN, P.L.C.
1950 ROLAND CLARKE PLACE
RESTON, VA 20191 (US)

(73) Assignee: **LG Electronics Inc.**, Seoul (KR)

(21) Appl. No.: **11/298,532**

(22) Filed: **Dec. 12, 2005**

(30) **Foreign Application Priority Data**

Dec. 10, 2004 (KR) .................................. 2004-104370

**Publication Classification**

(51) **Int. Cl.**
*F23J 13/02* (2006.01)
*F24C 15/00* (2006.01)

(52) **U.S. Cl.** ...................................... **165/901**; 126/307 R

(57) **ABSTRACT**

An exhaust gas heat exchanger for a cogeneration system is disclosed which includes exhaust gas discharge tubes each including a bellows tube portion formed at at least a portion of the exhaust gas discharge tube to enable the exhaust gas discharge tube to be thermally expanded and shrunken, so that it is possible to prevent the exhaust gas discharge tube from being damaged due to repeated thermal expansion and shrinkage thereof caused by hot exhaust gas passing through the exhaust gas discharge tube. Accordingly, an enhancement in durability and reliability is achieved.

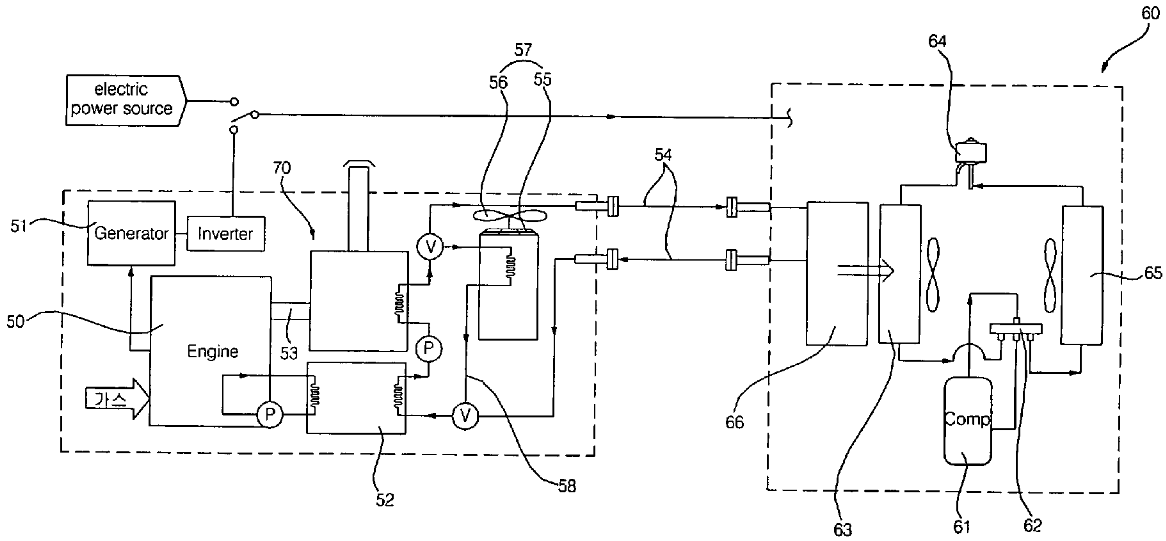


FIG. 1

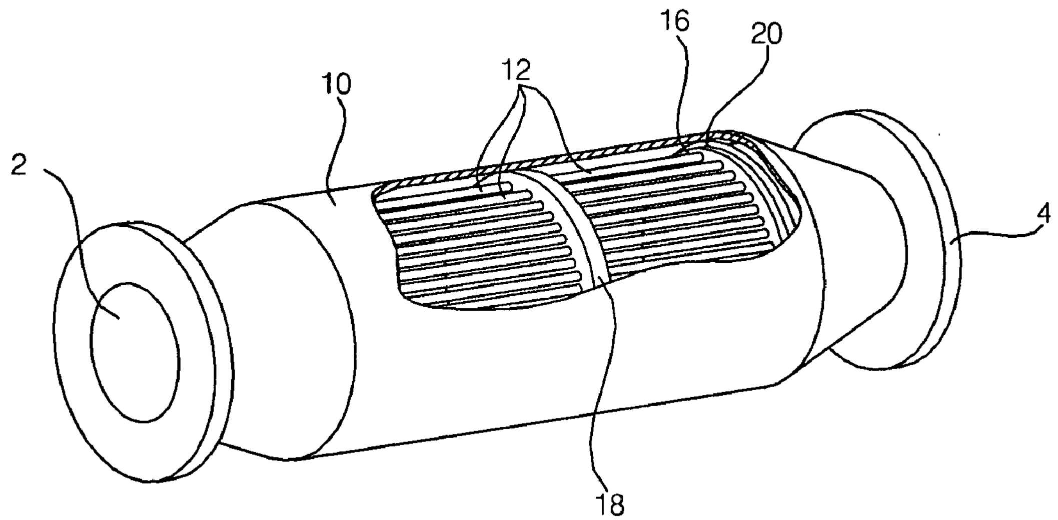



FIG. 2

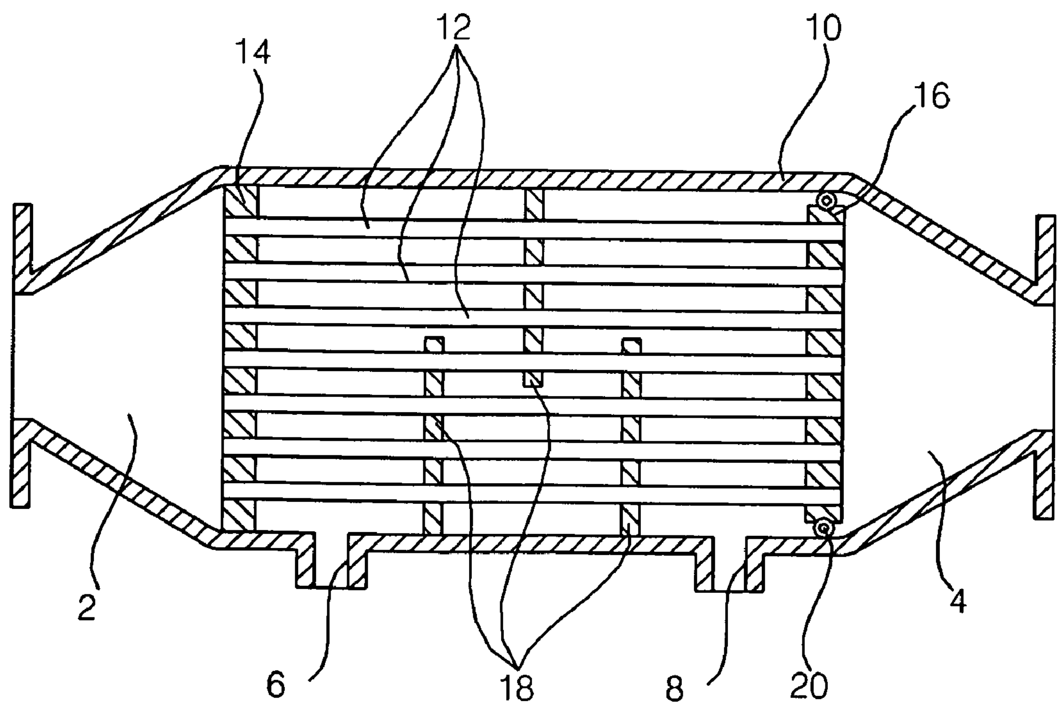


FIG. 3

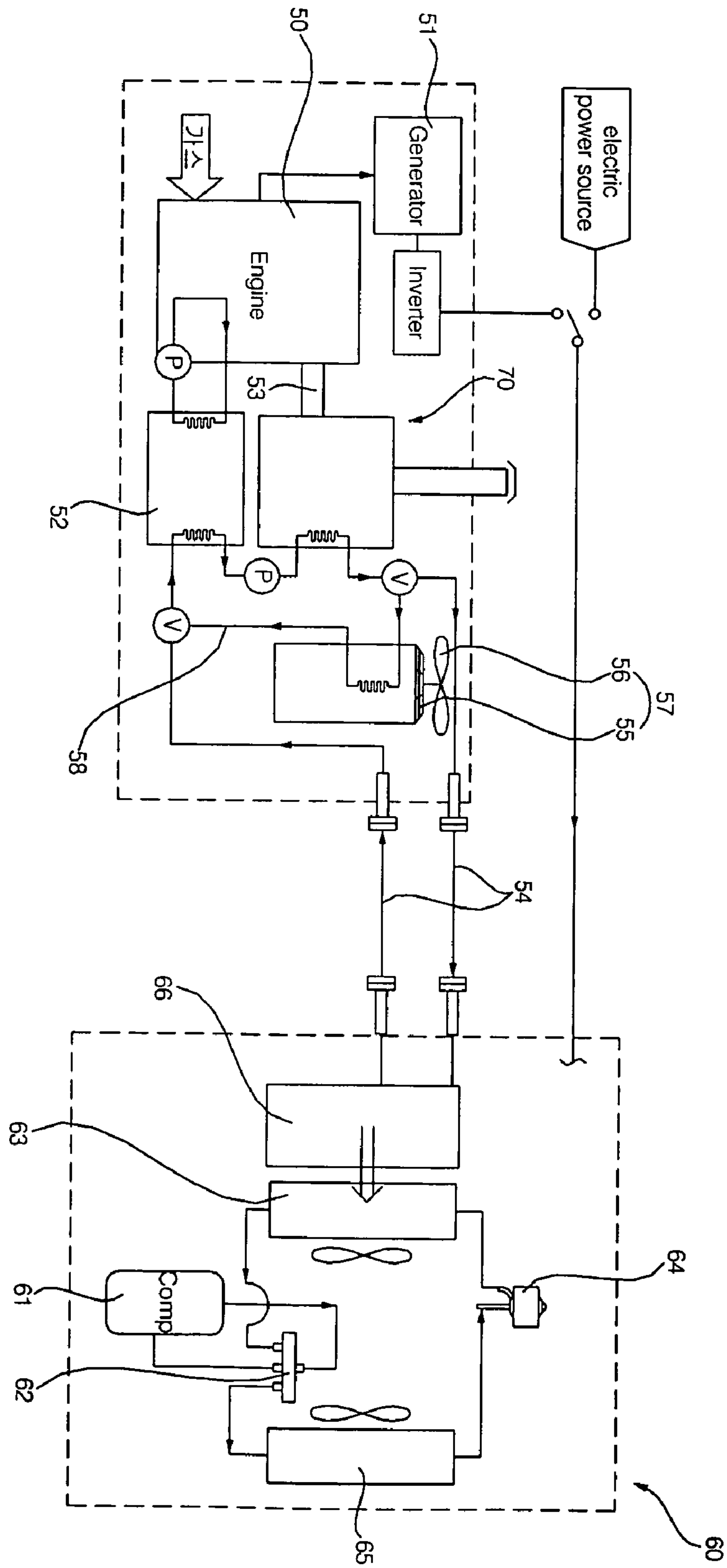

50
51
Generator
electric power source
Engine
Inverter
P
53
70
52
P
V
V
56
57
55
58
54
66
63
64
Comp
61
62
65
60

FIG. 4

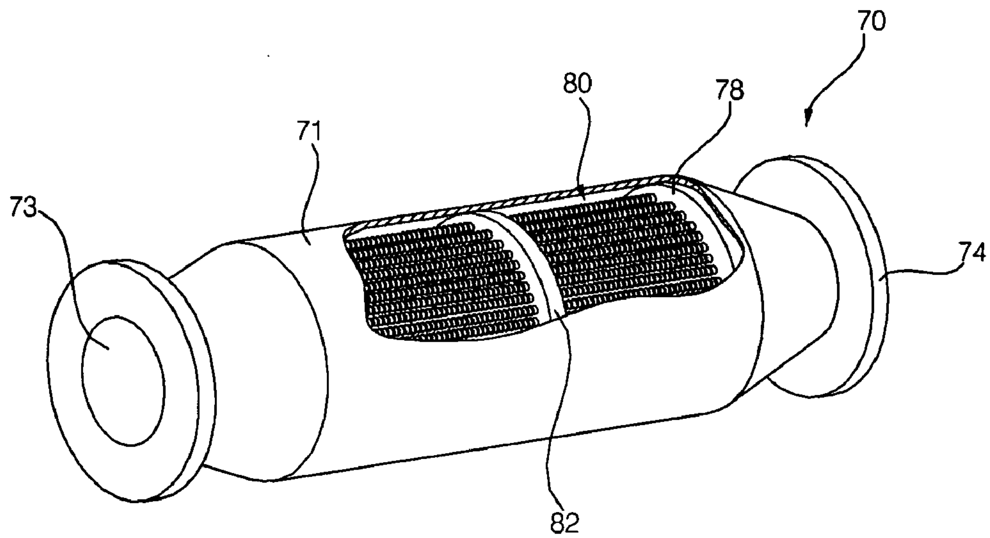



FIG. 5

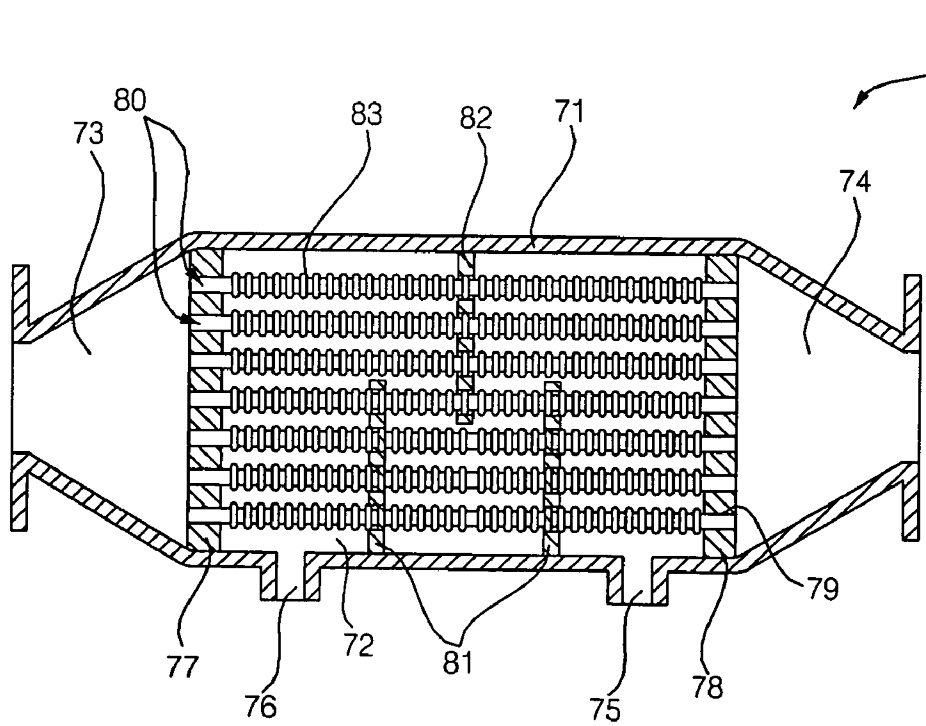


FIG. 6

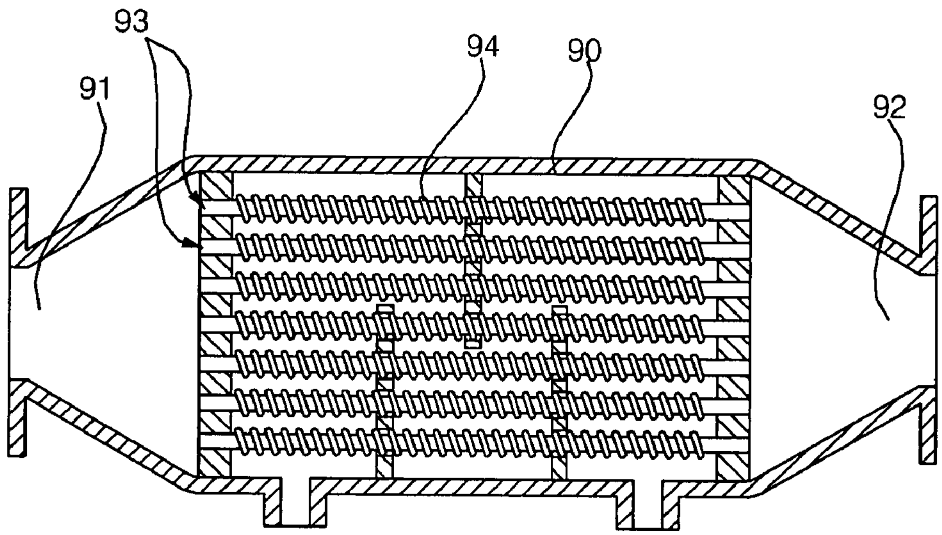



FIG. 7

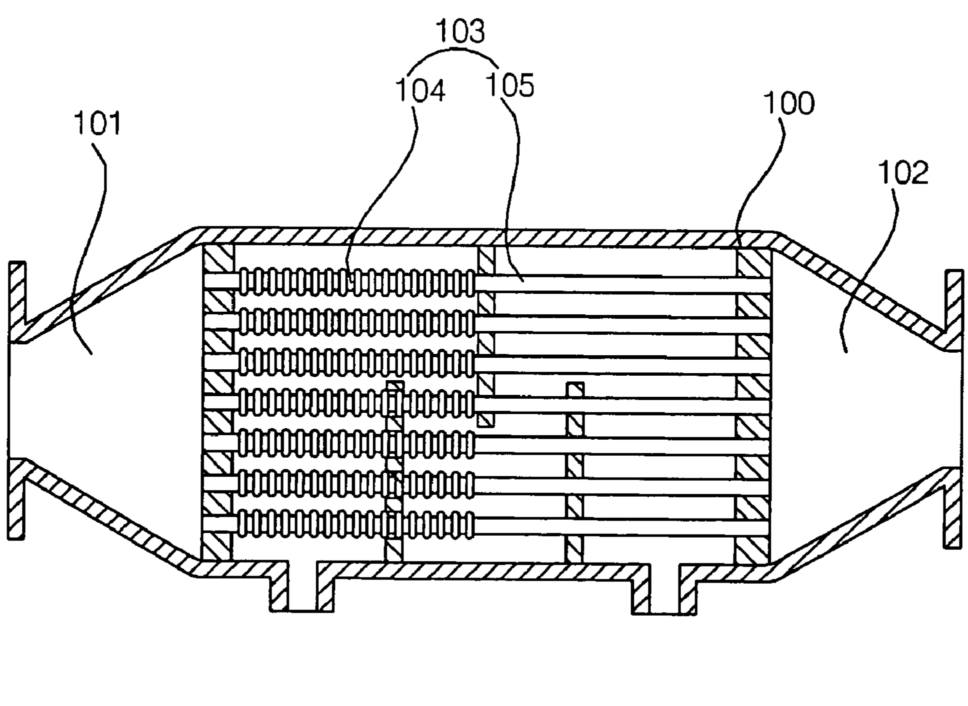


FIG. 8

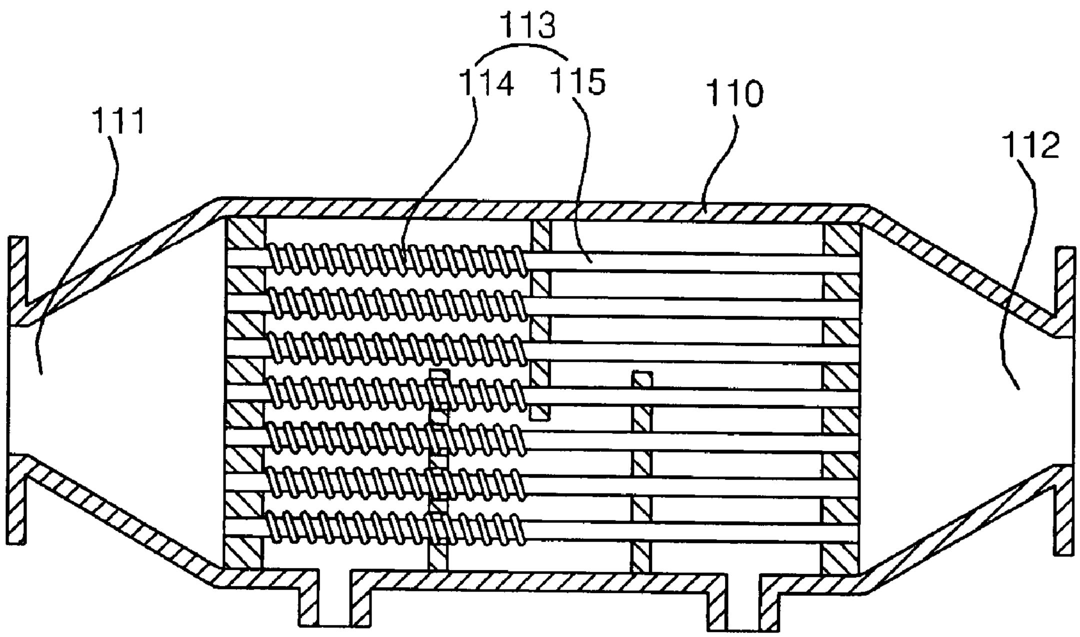
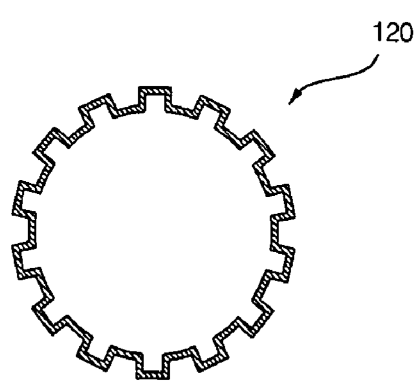



FIG. 9



# EXHAUST GAS HEAT EXCHANGER FOR COGENERATION SYSTEM

## BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to an exhaust gas heat exchanger for a cogeneration system, and, more particularly, to an exhaust gas heat exchanger for a cogeneration system which includes exhaust gas discharge tubes each having a thermally expandable and shrinkable bellows structure such that the exhaust gas discharge tubes are prevented from being damaged due to thermal expansion and shrinkage thereof caused by hot exhaust gas, thereby being capable of achieving an enhancement in durability, an increase in heat transfer area, and an enhancement in heat transfer efficiency according to the increased heat transfer area.

[0003] 2. Description of the Related Art

[0004] In general, cogeneration systems are adapted to generate both electricity and heat from a single energy source.

[0005] Such a cogeneration system can recover heat of exhaust gas or waste heat of cooling water generated from an engine or turbine during an electricity generation operation, so that the cogeneration system can achieve an increase in energy efficiency of 70 to 80% over other systems. By virtue of such an advantage, the cogeneration system has recently been highlighted as an electricity and heat supply source for buildings. In particular, the cogeneration system exhibits highly-efficient energy utilization in that the recovered waste heat is mainly used to heat/cool a confined space and to heat water.

[0006] **FIG. 1** is a partially-broken perspective view illustrating a conventional exhaust gas heat exchanger. **FIG. 2** is a cross-sectional view illustrating the conventional exhaust gas heat exchanger.

[0007] As shown in **FIGS. 1 and 2**, the conventional exhaust gas heat exchanger includes a shell **10** which includes an exhaust gas inlet **2** and an exhaust gas outlet **4** to allow exhaust gas discharged from an engine (not shown) to pass through the shell **10**. The shell **10** also includes a cooling water inlet **6** and a cooling water outlet **8** formed through a peripheral wall of the shell **10**. The exhaust gas heat exchanger also includes a plurality of exhaust gas discharge tubes **12** which are arranged in the shell **10** to define exhaust gas passages, respectively, first and second isolation plates **14** and **16** which are arranged at the exhaust gas inlet **2** and exhaust gas outlet **4**, respectively, to isolate the exhaust gas from a cooling water path defined in the shell **10**, and a flow guide **18** which is arranged in the shell **10** to change the cooling water path.

[0008] The exhaust gas discharge tubes **12** form a cylindrical tube bundle. Each exhaust gas discharge tube **12** has opposite ends respectively fitted in associated through holes formed through the first and second isolation plates **14** and **16**.

[0009] The first isolation plate **14** is fixed to an inner peripheral surface of the shell **14** by welding. An O-ring **20** is fitted between the peripheral surface of the second isolation plate **16** and the inner peripheral surface of the shell **10**, taking into consideration thermal expansion of the exhaust gas discharge tubes **12** caused by high-temperature heat of the exhaust gas.

[0010] Hereinafter, operation of the conventional exhaust gas heat exchanger having the above-mentioned configuration will be described.

[0011] Exhaust gas discharged from the engine (not shown) passes through the exhaust gas inlet **2**, exhaust gas discharge tubes **12**, and exhaust gas outlet **4**, in this order.

[0012] As the exhaust gas passes through the exhaust gas discharge tubes **12**, heat transfer occurs between cooling water, which is introduced into the shell **10** through the cooling water inlet **6**, and the exhaust gas tubes **12**.

[0013] Thus, the cooling water is discharged from the shell **10** after absorbing heat from the exhaust gas, and the exhaust gas is discharged after releasing heat to the cooling water.

[0014] In the conventional exhaust gas heat exchanger, which is used in a cogeneration system, however, repeated heat expansion and shrinkage occur due to the high-temperature exhaust gas, so that the O-ring **20** may be worn. When the O-ring **20** is worn, the cooling water leaks toward the exhaust gas outlet **4**, thereby causing essential elements of the cogeneration system, for example, the engine, to be damaged.

## SUMMARY OF THE INVENTION

[0015] The present invention has been made in view of the above-mentioned problems, and it is an object of the invention to provide an exhaust gas heat exchanger for a cogeneration system which includes exhaust gas discharge tubes each having a bellows structure, thereby being capable of preventing the exhaust gas discharge tubes are prevented from being damaged due to thermal deformation thereof, and preventing cooling water from leaking.

[0016] In accordance with the present invention, this object is accomplished by providing an exhaust gas heat exchanger for a cogeneration system comprising: a shell; an exhaust gas path which is defined in the shell to guide exhaust gas to pass through the shell; and a refrigerant path which is defined in the shell to guide a refrigerant to pass through the shell such that the refrigerant heat-exchanges with the exhaust gas path, wherein the exhaust gas path includes exhaust gas passages respectively defined by exhaust gas discharge tubes each including a bellows tube portion formed at at least a portion of the exhaust gas discharge tube to enable the exhaust gas discharge tube to be thermally expanded and shrunken.

[0017] The bellows tube portion may be longitudinally pleated in a longitudinal direction of the exhaust gas discharge tube.

[0018] The bellows tube portion may be pleated in a circumferential direction of the exhaust gas discharge tube.

[0019] The bellows tube portion may include circular pleats.

[0020] The bellows tube portion may include a spiral pleat.

[0021] The exhaust gas heat exchanger may further comprise an exhaust gas inlet and an exhaust gas outlet respectively formed at opposite ends of the shell to allow the exhaust gas to pass through the shell. The exhaust gas discharge tubes may connect the exhaust gas inlet and the exhaust gas outlet.

[0022] Each exhaust gas discharge tube may further include a constant-diameter cylindrical tube portion. The bellows tube portion may be arranged toward the exhaust gas inlet, and the constant-diameter cylindrical tube portion may be arranged toward the exhaust gas outlet.

[0023] The exhaust gas heat exchanger may further comprise a refrigerant inlet and a refrigerant outlet which are formed through a peripheral wall of the shell.

[0024] The exhaust gas heat exchanger may further comprise a first isolation plate and a second isolation plate which are arranged in the shell to isolate the exhaust gas inlet and the exhaust gas outlet from each other, thereby defining the refrigerant path.

[0025] The exhaust gas heat exchanger may further comprise at least one flow guide adapted to change the refrigerant path.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0026] The above objects, and other features and advantages of the present invention will become more apparent after reading the following detailed description when taken in conjunction with the drawings, in which:

[0027] **FIG. 1** is a partially-broken perspective view illustrating a conventional exhaust gas heat exchanger;

[0028] **FIG. 2** is a cross-sectional view illustrating the conventional exhaust gas heat exchanger;

[0029] **FIG. 3** is a schematic view illustrating a configuration of a cogeneration system according to a first embodiment of the present invention;

[0030] **FIG. 4** is a partially-broken perspective view illustrating an exhaust gas heat exchanger used in the cogeneration system according to the first embodiment of the present invention;

[0031] **FIG. 5** is a cross-sectional view illustrating an inner configuration of the exhaust gas heat exchanger according to the first embodiment of the present invention;

[0032] **FIG. 6** is a cross-sectional view illustrating an inner configuration of an exhaust gas heat exchanger in a cogeneration system according to a second embodiment of the present invention;

[0033] **FIG. 7** is a cross-sectional view illustrating an inner configuration of an exhaust gas heat exchanger in a cogeneration system according to a third embodiment of the present invention;

[0034] **FIG. 8** is a cross-sectional view illustrating an inner configuration of an exhaust gas heat exchanger in a cogeneration system according to a fourth embodiment of the present invention; and

[0035] **FIG. 9** is a cross-sectional view illustrating an inner configuration of an exhaust gas heat exchanger in a cogeneration system according to a fifth embodiment of the present invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0036] Hereinafter, exemplary embodiments of an exhaust gas heat exchanger and a cogeneration system using the exhaust gas heat exchanger in accordance with the present invention will be described with reference to the annexed drawings.

[0037] **FIG. 3** is a schematic view illustrating a configuration of a cogeneration system according to a first embodiment of the present invention. **FIG. 4** is a partially-broken perspective view illustrating an exhaust gas heat exchanger used in the cogeneration system according to the first embodiment of the present invention. **FIG. 5** is a cross-sectional view illustrating an inner configuration of the exhaust gas heat exchanger according to the first embodiment of the present invention.

[0038] As shown in **FIG. 3**, the cogeneration system according to the first embodiment of the present invention includes an engine **50** to which fuel is supplied, a generator **51** which is driven by the engine **50** to generate electricity, a cooling water heat exchanger **52** which recovers heat from cooling water used to cool the engine **50**, and an exhaust gas heat exchanger **70** which is arranged in an exhaust gas discharge conduit **53** extending from the engine **50** to recover heat from exhaust gas discharged from the engine **50**. The cogeneration system also includes a heat transfer line **54** which transfers the recovered cooling water heat and exhaust gas heat to a cooling and heating apparatus **60**.

[0039] The electricity generated from the generator **51** is used to operate various electronic appliances including the cooling and heating apparatus **60** and illumination devices.

[0040] The waste heat generated from the engine **50**, that is, the heat generated from the cooling water used to cool the engine **50** and the heat generated from the exhaust gas discharged from the engine **50**, is used in the cooling and heating apparatus **60** during a heating operation of the cooling and heating apparatus **60**. In order to outwardly discharge the waste heat generated from the engine **50** during a cooling operation of the cooling and heating apparatus **60**, the cogeneration system also includes a radiator **57** which includes a heat exchanger **55** and a radiating fan **56**.

[0041] The cooling and heating apparatus **60** is of a heat pump type so that it is used not only as a cooling apparatus, but also as a heating apparatus, in accordance with reversal of a refrigerant flow in a refrigerant cycle in the cooling and heating apparatus **60**. As in a typical heat pump type cooling and heating apparatus, the cooling and heating apparatus **60** includes a compressor **61**, a 4-way valve **62**, an outdoor heat exchanger **63**, an expansion device **64**, and an indoor heat exchanger **65**.

[0042] An air preheating heat exchanger **66** is arranged near the outdoor heat exchanger **63** in order to preheat air supplied toward the outdoor heat exchanger **63**, using the waste heat of the engine **50** during the heating operation of the cooling and heating apparatus **60**.

[0043] The air preheating heat exchanger **66** is connected to the cooling water heat exchanger **52** and exhaust gas heat exchanger **70** via the heat transfer line **54**.

[0044] The radiator **57** is arranged in a radiating line **58** connected to the heat transfer line **54**.

[0045] In **FIG. 3**, reference character "P" designates pumps respectively adapted to pump a heat transfer medium such that the heat transfer medium is circulated through desired lines, and reference character "V" designates a valve adapted to change the flow path of the heat transfer medium between the heat transfer line **54** and the radiating line **58**.

[0046] As shown in **FIGS. 4 and 5**, the exhaust gas heat exchanger includes a shell **71**, an exhaust gas path which is defined in the shell **71** to guide exhaust gas to pass through the shell **71**, and a refrigerant path **72** which is defined in the shell **71** to guide a refrigerant to pass through the shell **71** such that the refrigerant heat-exchanges with the exhaust gas path.

[0047] The shell **71** is arranged in the exhaust gas discharge conduit **53** through which the exhaust gas from the engine **50** is discharged. An exhaust gas inlet **73** and an exhaust gas outlet **74** are formed at opposite ends of the shell **71**, respectively, such that the exhaust gas inlet **73** and exhaust gas outlet **74** communicate with the exhaust gas discharge conduit **53** to allow the exhaust gas to be introduced into the shell **71** and then to be discharged from the shell **71**.

[0048] The exhaust gas path includes a plurality of exhaust gas passages respectively defined by exhaust gas discharge tubes **80** which are arranged between the exhaust gas inlet **73** and the exhaust gas outlet **74**.

[0049] A refrigerant inlet **75** and a refrigerant outlet **76** are formed through a peripheral wall of the shell **71** to allow the refrigerant to be introduced into the shell **71** and then to be discharged from the shell **71**.

[0050] A first isolation plate **77** and a second isolation plate **78** are arranged at the exhaust gas inlet **73** and the exhaust gas outlet **74**, respectively, to isolate the interior of the shell **71** from the exhaust gas inlet **73** and exhaust gas outlet **74**, and thus, to define the refrigerant path in the shell **71**.

[0051] The first and second isolation plates **77** and **78** are fixed to an inner peripheral surface of the shell **71** by welding. A plurality of connecting holes **79** are formed through each of the first and second isolation plates **77** and **78**. Opposite ends of each exhaust gas discharge tube **80** are connected to associated ones of the connecting holes **79** of the first and second isolation plates **77** and **78**.

[0052] A flow guide is arranged in the shell **71** to change the refrigerant path for an enhancement in heat transfer efficiency.

[0053] The flow guide includes at least one lower flow guide **81** upwardly protruded from the bottom of the shell **71** in the interior of the shell **71**, and at least one upper flow guide **82** downwardly protruded from the top of the shell **71** in the interior of the shell **71**.

[0054] In the illustrated case, the flow guide includes two lower flow guides **81** and one upper flow guide **82**. The lower flow guides **81** are spaced apart from each other in a flow direction of the exhaust gas, and the upper flow guide **82** is arranged between the lower flow guides **81**.

[0055] A plurality of through holes are formed through each of the lower and upper flow guides **81** and **82**, to allow the exhaust gas discharge tubes **80** aligned with the through holes to extend through the through holes, respectively.

[0056] Each exhaust gas discharge tube **80** includes a bellows tube portion **83** to be thermally expandable and shrinkable, thereby preventing the exhaust gas discharge tube **80** from being damaged due to thermal deformation thereof caused by the heat of the exhaust gas.

[0057] The bellows tube portion **83** has circular pleats arranged in a longitudinal direction of the bellows tube portion **83** to enable the bellows tube portion **83** to be easily extended and shrunken in the longitudinal direction.

[0058] The opposite ends of each exhaust gas discharge tube **80** are fitted in associated ones of the connecting holes **79** formed through the first and second isolation plates **77** and **78**, respectively, and are fixed to the first and second isolation plates **77** and **78** around the associated connecting holes **79** by welding, respectively.

[0059] It is preferred that the portions of each exhaust gas discharge tube **80** to be fitted in the associated connecting holes **79** have a circular cross-section corresponding to that of the connecting holes **79**.

[0060] Also, it is preferred that each exhaust gas discharge tube **80** be made of steel use stainless (SUS).

[0061] Hereinafter, operation of the exhaust gas heat exchanger in the cogeneration system having the above-described configuration according to the first embodiment of the present invention will be described.

[0062] Electricity generated from the engine **50** during operation of the engine **50** is supplied to the cooling and heating apparatus **60**, and high-temperature exhaust gas discharged from the engine **50** during the operation of the engine **50** passes through the exhaust gas heat exchanger **70** arranged in the exhaust gas discharge conduit **53**.

[0063] That is, the exhaust gas discharged from the engine **50** is introduced into the shell **71** through the exhaust gas inlet **73** of the shell **71**, and is then discharged from the shell **71** through the exhaust gas outlet **74** after passing through the exhaust gas exhaust tubes **80**.

[0064] During the flow of the exhaust gas, cooling water which is a refrigerant is introduced into the shell **71** through the refrigerant inlet **75**. Accordingly, heat exchange occurs in the shell **71** between the cooling water and the exhaust gas discharge tubes **80**.

[0065] That is, as the cooling water comes into contact with the exhaust gas discharge tubes **80**, the cooling water absorbs the heat of the exhaust gas transferred to the exhaust gas discharge tubes **80** through which the exhaust gas passes. As a result, the exhaust gas discharge tubes **80** are cooled by the cooling water.

[0066] The cooling water is discharged from the shell **71** through the refrigerant outlet **76** after absorbing heat from the exhaust gas discharge tubes **80**, and is supplied to the air preheating heat exchanger **66** via the heat transfer line **54**.

[0067] Thus, the cooling water preheats outdoor air introduced into the cooling and heat apparatus **60** while passing through the air preheating heat exchanger **66**, using the heat absorbed from the exhaust gas discharge tubes **80**, in order to achieve an enhancement in heating capability.

[**0068**] Meanwhile, each exhaust gas discharge tube **80** has an increased thermal contact area contacting the cooling water by virtue of the thermally expandable and shrinkable bellows tube portion **83** included in the exhaust gas discharge tube **80**. Accordingly, an enhancement in thermal efficiency is achieved.

[**0069**] Since repeated thermal expansion and shrinkage of each exhaust gas discharge tube **80** is enabled, it is possible to reduce damage of the exhaust gas discharge tube **80**.

[**0070**] Since the first and second isolation plates **77** and **78** are fixed to the inner peripheral surface of the shell **71** by welding, it is possible to effectively prevent leakage of the cooling water.

[**0071**] When the cooling and heating apparatus **60** operates in cooling mode, the flow path of the cooling water is changed to communicate with the radiating line **58** connected to the heat transfer line **54** because it is unnecessary to supply waste heat. In this case, the waste heat is discharged to the atmosphere through the radiator **57**, or is supplied to and used in a water heater, a hot water supplier, or other systems.

[**0072**] **FIG. 6** is a cross-sectional view illustrating an inner configuration of an exhaust gas heat exchanger in a cogeneration system according to a second embodiment of the present invention.

[**0073**] As shown in **FIG. 6**, the exhaust gas heat exchanger according to the second embodiment of the present invention includes a shell **90** which is provided, at opposite ends thereof, with an exhaust gas inlet **91** and an exhaust gas outlet **92**, respectively, and an exhaust gas discharge tubes **93** which are arranged in the shell **90** to connect the exhaust gas inlet **91** and exhaust gas outlet **92**, thereby defining an exhaust gas path. Each exhaust gas discharge tube **93** includes a bellows tube portion **94** to be thermally expandable and shrinkable, thereby preventing the exhaust gas discharge tube **90** from being damaged due to thermal deformation thereof caused by the heat of the exhaust gas. The bellows tube portion **94** has a pleat extending spirally in a longitudinal direction of the bellows tube portion **94** to enable the bellows tube portion **94** to be easily extended and shrunken in the longitudinal direction, and to achieve an enhancement in the heat transfer of the bellows tube portion **94** with cooling water. Other configurations of the exhaust gas heat exchanger according to the second embodiment of the present invention are identical to those of the first embodiment of the present invention, so no detailed description thereof will be given.

[**0074**] **FIG. 7** is a cross-sectional view illustrating an inner configuration of an exhaust gas heat exchanger in a cogeneration system according to a third embodiment of the present invention.

[**0075**] As shown in **FIG. 7**, the exhaust gas heat exchanger according to the third embodiment of the present invention includes a shell **100** which is provided, at opposite ends thereof, with an exhaust gas inlet **101** and an exhaust gas outlet **102**, respectively, and an exhaust gas discharge tubes **103** which are arranged in the shell **100** to connect the exhaust gas inlet **101** and exhaust gas outlet **102**, thereby defining an exhaust gas path. Each exhaust gas discharge tube **103** includes two portions, namely, a bellows tube portion **104** and a constant-diameter cylindrical tube portion **105**. Other configurations of the exhaust gas heat exchanger according to the third embodiment of the present invention are identical to those of the first embodiment of the present invention, so no detailed description thereof will be given.

[**0076**] In this case, it is preferred that the bellows tube portion **104** have circular pleats arranged in a longitudinal direction of the bellows tube portion **104**, and be provided at a portion of the exhaust gas discharge tube **103** exposed to a higher temperature than the remaining portion of the exhaust gas discharge tube **103**.

[**0077**] Since the exhaust gas discharged from the engine **50** passes through the exhaust gas inlet **101**, each exhaust gas discharge tube **103**, and exhaust gas outlet **102**, in this order, the temperature of the exhaust gas inlet **101**, into which the exhaust gas from the engine **50** is first introduced, is higher than that of the exhaust gas outlet **102**. Accordingly, the bellows tube portion **104** is provided at the portion of the exhaust gas discharge tube **103** arranged at the side of the exhaust gas inlet **101**, and the constant-diameter cylindrical tube portion **105** is provided at the portion of the exhaust gas discharge tube **103** arranged at the side of the exhaust gas outlet **102**.

[**0078**] **FIG. 8** is a cross-sectional view illustrating an inner configuration of an exhaust gas heat exchanger in a cogeneration system according to a fourth embodiment of the present invention.

[**0079**] As shown in **FIG. 8**, the exhaust gas heat exchanger according to the fourth embodiment of the present invention includes a shell **110** which is provided, at opposite ends thereof, with an exhaust gas inlet **111** and an exhaust gas outlet **112**, respectively, and an exhaust gas discharge tubes **113** which are arranged in the shell **110** to connect the exhaust gas inlet **111** and exhaust gas outlet **112**, thereby defining an exhaust gas path. Each exhaust gas discharge tube **113** includes two portions, namely, a bellows tube portion **114** and a constant-diameter cylindrical tube portion **115**. The bellows tube portion **114** has a pleat extending spirally in a longitudinal direction of the bellows tube portion **114**. Other configurations of the exhaust gas heat exchanger according to the fourth embodiment of the present invention are identical to those of the third embodiment of the present invention, so no detailed description thereof will be given.

[**0080**] **FIG. 9** is a cross-sectional view illustrating an inner configuration of an exhaust gas heat exchanger in a cogeneration system according to a fifth embodiment of the present invention.

[**0081**] As shown in **FIG. 9**, the exhaust gas heat exchanger according to the fifth embodiment of the present invention has the same configuration as that of the first embodiment of the present invention, except that the exhaust gas heat exchanger includes a plurality of exhaust gas discharge tubes **120** each having a bellows tube portion which is formed at at least a portion of the exhaust gas discharge tube **120**, and is provided with straight pleats extending in a longitudinal direction of the exhaust gas discharge tube **120** while being arranged in a circumferential direction of the exhaust gas discharge tube **120**. Accordingly, no further detailed description will be given of the exhaust gas heat exchanger according to the fifth embodiment of the present invention.

[0082] The above-described exhaust gas heat exchanger in the cogeneration system according to the present invention provides various effects.

[0083] That is, since at least a portion of each exhaust gas discharge tube in the exhaust gas heat exchanger according to the present invention has a bellows tube structure such that the exhaust gas discharge tube is thermally expandable and shrinkable, it is possible to prevent the exhaust gas discharge tube from being damaged due to repeated thermal expansion and shrinkage thereof caused by hot exhaust gas passing through the exhaust gas discharge tube. Accordingly, an enhancement in durability is achieved.

[0084] Since each exhaust gas discharge tube includes a bellows tube portion, the contact are of the exhaust gas discharge tube contacting cooling water is increased, thereby achieving an enhancement in heat transfer efficiency.

[0085] Since each exhaust gas discharge tube is thermally expandable and retractable, the first and second isolation plates can be fixed to the inner peripheral surface of the shell by welding. Accordingly, it is possible to effectively prevent leakage of cooling water.

[0086] In addition, it is possible to dispense with an O-ring which is required in conventional cases. Accordingly, it is possible to use the exhaust gas heat exchanger under a higher temperature condition, and thus, to achieve an enhancement in reliability.

[0087] Although the preferred embodiments of the invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

What is claimed is:

**1**. An exhaust gas heat exchanger for a cogeneration system comprising:

a shell;

an exhaust gas path which is defined in the shell to guide exhaust gas to pass through the shell; and

a refrigerant path which is defined in the shell to guide a refrigerant to pass through the shell such that the refrigerant heat-exchanges with the exhaust gas path,

wherein the exhaust gas path includes exhaust gas passages respectively defined by exhaust gas discharge tubes each including a bellows tube portion formed at at least a portion of the exhaust gas discharge tube to enable the exhaust gas discharge tube to be thermally expanded and shrunken.

**2**. The exhaust gas heat exchanger according to claim 1, wherein the bellows tube portion is longitudinally pleated in a longitudinal direction of the exhaust gas discharge tube.

**3**. The exhaust gas heat exchanger according to claim 1, wherein the bellows tube portion is pleated in a circumferential direction of the exhaust gas discharge tube.

**4**. The exhaust gas heat exchanger according to claim 2, wherein the bellows tube portion includes circular pleats.

**5**. The exhaust gas heat exchanger according to claim 2, wherein the bellows tube portion includes a spiral pleat.

**6**. The exhaust gas heat exchanger according to claim 4, further comprising:

an exhaust gas inlet and an exhaust gas outlet respectively formed at opposite ends of the shell to allow the exhaust gas to pass through the shell,

wherein the exhaust gas discharge tubes connect the exhaust gas inlet and the exhaust gas outlet.

**7**. The exhaust gas heat exchanger according to claim 6, wherein:

each of the exhaust gas discharge tubes further includes a constant-diameter cylindrical tube portion;

the bellows tube portion is arranged toward the exhaust gas inlet; and

the constant-diameter cylindrical tube portion is arranged toward the exhaust gas outlet.

**8**. The exhaust gas heat exchanger according to claim 6, further comprising:

a refrigerant inlet and a refrigerant outlet which are formed through a peripheral wall of the shell.

**9**. The exhaust gas heat exchanger according to claim 8, further comprising:

a first isolation plate and a second isolation plate which are arranged in the shell to isolate the exhaust gas inlet and the exhaust gas outlet from each other, thereby defining the refrigerant path.

**10**. The exhaust gas heat exchanger according to claim 8, further comprising:

at least one flow guide adapted to change the refrigerant path.

**11**. A cogeneration system comprising:

an engine;

a generator which is driven by the engine to generate electricity;

an exhaust gas heat exchanger which is arranged in an exhaust gas discharge conduit extending from the engine to recover heat from exhaust gas discharged from the engine; and

an air conditioner which receives the recovered heat from the exhaust gas heat exchanger,

wherein the exhaust gas heat exchanger includes a shell, and exhaust gas discharge tubes arranged in the shell, each of the exhaust gas discharge tubes including a bellows tube portion formed at at least a portion of the exhaust gas discharge tube.

**12**. The cogeneration system according to claim 11, wherein the bellows tube portion is longitudinally pleated in a longitudinal direction of the exhaust gas discharge tube.

**13**. The cogeneration system according to claim 11, wherein the bellows tube portion is pleated in a circumferential direction of the exhaust gas discharge tube.

**14**. The cogeneration system according to claim 12, wherein the bellows tube portion includes circular pleats.

**15**. The cogeneration system according to claim 12, wherein the bellows tube portion includes a spiral pleat.

**16**. The cogeneration system according to claim 14, wherein:

the exhaust gas heat exchanger further comprises an exhaust gas inlet and an exhaust gas outlet respectively formed at opposite ends of the shell to allow the exhaust gas to pass through the shell,

the exhaust gas discharge tubes connect the exhaust gas inlet and the exhaust gas outlet.

**17**. The cogeneration system according to claim 16, wherein:

each of the exhaust gas discharge tubes further includes a constant-diameter cylindrical tube portion;

the bellows tube portion is arranged toward the exhaust gas inlet; and

the constant-diameter cylindrical tube portion is arranged toward the exhaust gas outlet.

**18**. The cogeneration system according to claim 16, wherein the exhaust gas heat exchanger further comprises a refrigerant inlet and a refrigerant outlet which are formed through a peripheral wall of the shell.

**19**. The cogeneration system according to claim 18, wherein the exhaust gas heat exchanger further comprises a first isolation plate and a second isolation plate which are arranged in the shell to isolate the exhaust gas inlet and the exhaust gas outlet from each other, thereby defining the refrigerant path.

**20**. The cogeneration system according to claim 18, wherein the exhaust gas heat exchanger further comprises at least one flow guide adapted to change the refrigerant path.

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