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(71) Applicant: LG–CALTEX OIL CORPORATION [KR/KR]; 20, Yoido–dong Youngdungpo–ku, Seoul 150–721 (KR).

(72) Inventors: HUR, Dong, Soo; LG–Caltex Oil Corporation, 20, Yoido–dong Youngdungpo–ku, Seoul 150–721 (KR). NOH, Joong, Seok; Hanyang Apt. 1–1112, 431, Bukgazwa–dong, Seodaemoon–ku, Seoul 120–130 (KR). NA, Han, Soo; 602–1203, Jeongja–dong, Bundang–ku, Seongnam–shi, Kyungki–do 463–010 (KR). KIM, Gun, Tag; 19–110, Soho–dong, Yocheon–shi, Cheonlanam–do 555–060 (KR). CHOI, Jun, Soo; Keonyoung Villa, 408–303, Madu 1–dong, Ilsan–ku, Koyang–shi, Kyungki–do 411–351 (KR). CHOI, Won, Choon; Soojeong Town Apt., 1–808, Dunsan–dong, Seo–ku, Daejeon–shi 302–173 (KR).

(74) Agent: CHOI, Duk, Kyu; 6th floor, Chunwoo Building, 736, Yoksam–dong, Kangnam–ku, Seoul 135–080 (KR).

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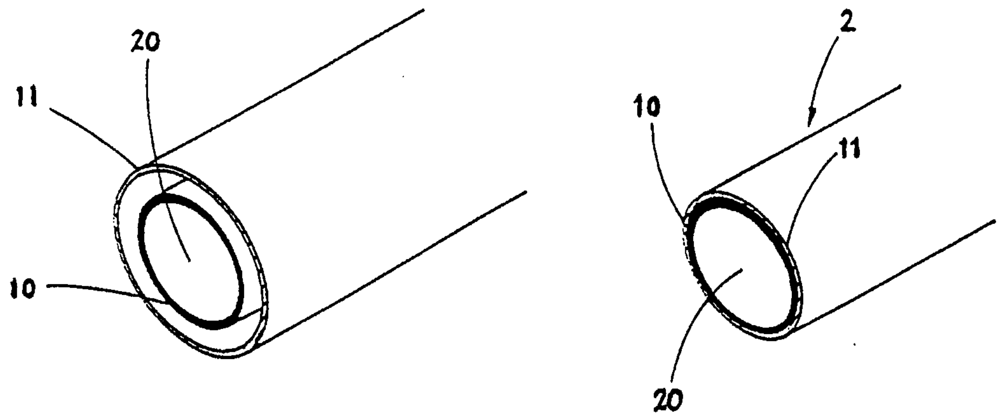
(54) Title: COOLER TUBE FOR COOLING SECTION OF FUEL CELL POWER PLANT AND METHOD FOR PREPARING THE SAME



(57) Abstract

A cooler tube used for the cooling section of a fuel cell power plant system is prepared by inserting a conductive pipe made of copper or stainless steel into a dielectric tube made of a fluorocarbon polymer and shrinking the electric tube on the conductive pipe through a heat treatment so as to stick the dielectric tube fast to the conductive pipe. Examples of the fluorocarbon polymer used for the present invention are PTFE (polytetrafluoroethylene), FEP (fluorinated ethylene–propylene) and PFA (perfluorinated alkoxy tetrafluoroethylene). In case of using a PTFE tube which is dielectric, the heat treatment shall be carried out at a temperature of 320 to 370 °C for 1 to 3 hours so that the ultimate thickness of the PTFE layer on the conductive pipe may be in the range of 0.05 to 0.20 mm.

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Cooler Tube for Cooling Section of Fuel Cell Power Plant and Method for Preparing the Same

Field of the Invention

The present invention relates to a fuel cell power plant system and more particularly to a cooler tube to insert into a cooling section of a fuel cell power plant system.

Background of the Invention

A fuel cell power plant system comprises in the form of a stack of individual cells which have an anode to supply fuel as a reductant and a cathode to supply air as an oxidant.

The stack of cells is heated by reaction heat from the fuel cell power plant system. The heated stack of cells needs to keep an adequate temperature between 180℃ and 210℃, which in turn to keep the temperature of the stack between 180℃ and 210℃ needs to cool down. For this purpose the stack of the fuel cell power plant comprises a plurality of the cooling sections, and the cooling section, which is cooled by a water cooling system or an air cooling system, cools down the stack of individual cells. The cooling method of the air cooling system is that air introduces to the cooling system of the stack by using a blower, U.S. Patent No. 4,276,355 teaches a technique by this method.

The cooling method by the water cooling system uses water or a liquid cooling fluid instead of air. Advantages of the water cooling system are that it is easy to use the heated water, passing through the cooling section of the stack, and that the size of the cooling system of a fuel cell power plant system can be smaller.

The cooling method by the water cooling system achieves a cooling effect by inserting a plurality of cooler tubes into the cooling section and then passing water or a liquid coolant through the passageways of the cooler tubes.

U.S. Patent No. 3,964,930 discloses a fluid cooling system of a fuel cell power plant system. In this cooling system, it discloses the cooler tube which is coated with a dielectric material such as PTFE (polytetrafluoroethylene) in the internal or external surface of a conductive pipe to be able to operate at 2,000V for 40,000 hours. The U.S. patent teaches a fuel cell stack having a cooler means including a plurality of cooler tubes on which a dielectric material such as a fluorocarbon polymer is coated

Up to the present, the cooler tube using for the cooling section of a water cooling fuel cell has been produced by coating with a dielectric material such as PTFE to a conductive pipe such as copper or stainless steel.

However, the conventional cooler tubes still have serious problems in view of a corrosion by an electrolyte in a fuel cell, and a perfect dielectric property. In other words, a perfect dielectric property of a cooler tube is required, because a high current and a high voltage are applied between the cooler tubes inserted into the cooling section. Also, in case of having flaws, such as a pin-hole, in a portion of the surface coated with a dielectric material, the cooler tube can be corroded by electrolyte solution such as a phosphoric acid. Accordingly, in case of coating the cooler tube with a dielectric material, it should absolutely be free of pin-hole on the surface.

As disclosed in U.S. Patent No. 3,964,930, since the conventional coating method of a conductive pipe comprising copper or stainless steel can make flaws such as a pin-hole on the coated surface, it may cause a serious result in dielectric property and corrosion problem. Therefore, in this case it requires a high level coating skill, and a perfect and strict examination of the coated surface should be carried out. Also, in order to coat with a dielectric material, such as PTFE, to the conductive pipes are required very expensive expenses.

The present inventors developed a cooler tube which is capable to prevent any flaw on the coated surface, which might occur on the surface of the conventional cooler tube.

Objects of the Invention

An object of the present invention is to provide cooler tubes inserted into a cooling section of a fuel cell power plant system, which have a perfect dielectric property so as to protect the system from a high current and a high voltage.

Another object of the present invention is to provide cooler tubes to perfectly prevent corrosion of the cooler tubes by an electrolyte solution such as a phosphoric acid in the stack of a fuel cell.

A further object of the present invention is to provide a method to prepare cooler tubes, which have a perfect dielectric property and an anticorrosive property, by sticking a dielectric tube fast to a conductive pipe through heat treatment after inserting the conductive pipe into the dielectric tube, and which take a low cost of preparation.

The foregoing and other objects of the present invention will be achieved in the following description.

Summary of the Invention

The cooler tube using for the cooling section of a fuel cell power plant system is prepared by inserting a conductive pipe made of copper or stainless steel into a dielectric tube made of a fluorocarbon polymer and shrinking the electric tube on the conductive pipe through a heat treatment so as to stick the dielectric tube fast to the conductive pipe.

Examples of the fluorocarbon polymer used for the present invention are PTFE (polytetrafluoroethylene), FEP (fluorinated ethylene-propylene) and PFA (perfluorinated alkoxy tetrafluoroethylene).

In case of using a PTFE tube which is dielectric, the heat treatment shall be carried out at a temperature of 320 to 370℃ for 1 to 3 hours so that the ultimate thickness of the PTFE layer on the conductive pipe may be in the range of 0.05 to 0.20 mm.

In case of using a FEP tube which is dielectric, the heat treatment shall be carried out at a temperature of 170 to 270℃ for 1 to 3 hours so that the ultimate thickness of the FEP layer on the conductive pipe may be in the range of 0.05 to 0.20 mm.

In case of using a PFA tube which is dielectric, the heat treatment shall be carried out at a temperature of 250 to 310℃ for 1 to 3 hours so that the ultimate thickness of the PFA layer on the conductive pipe may be in the range of 0.05 to 0.20 mm.

Brief Description of the Drawings

The present invention will be more fully understood by reference to the following detailed description of the preferred embodiment of the present invention when read in conjunction with the accompanying drawings.

Fig. 1 is a schematically perspective view of a cooling section of a fuel cell power plant system, which shows a plurality of cooler tubes inserted into the cooling section;

Fig. 2 is a schematic view that shows an unheated state wherein a conductive pipe is placed into a dielectric tube; and

Fig. 3 is a schematic view of a close adhesion state that a dielectric tube has shrunk to a conductive pipe by a heat treatment of the dielectric tube and conductive pipe of Fig. 2.

Detailed Description of the Preferred Embodiments

Fig. 1 is a schematically perspective view of a cooling section of a fuel cell power plant system, which shows a plurality of cooler tubes inserted into the cooling section.

A conventional fuel cell power plant system comprises a plurality of stacks having cooling sections. A plurality of cooler tubes are installed to pass through the cooling section **1**. A liquid such as water could be fluidized through these passageways **20** in the cooler tubes **2.** The cooling section **1** and the cooler tubes **2** of a fuel cell power plant system can easily be understood by an ordinary skilled person in the art.

As disclosed in U.S. Patent No. 3,964,930, the cooler tubes **2** are prepared by a conventional coating method using a fluorocarbon polymer material, such as PTFE, to coat the internal or external surface of a conductive pipe of copper or stainless steel material.

The present invention does not adopt the conventional coating method which coats a dielectric material on a conductive pipe. The cooler tubes using for cooling sections of the fuel cell power plant system of the present invention are prepared by inserting a conductive pipe made of copper or stainless steel into a dielectric tube made of a fluorocarbon polymer and shrinking the dielectric tube on the conductive pipe through a heat treatment so as to stick the dielectric tube fast to the conductive pipe.

Fig. 2 is a schematic view that is an unheated state wherein a conductive pipe **10** is placed into a dielectric tube **11**.

A conventional conductive pipe may be used as a conductive pipe in the present invention. The inner or outer diameters and thicknesses of the conductive pipes are manifold and these can be easily understood an ordinary skilled person in the art.

The dielectric tube **11** is made of a fluorocarbon polymer material and representative examples of the fluorocarbon polymer are PTFE, FEP and PFA. The inner diameter of the dielectric tube **11** shall be a little larger than the outer diameter of the conductive pipe **10** to be inserted into the dielectric tube, and this can be easily understood an ordinary skilled person in the art. The thickness of a dielectric tube may be chosen in the range of 0.07 to 0.22 mm, which will be a little larger than the thickness after shrinking by heat treatment. In other words, since heat treatment reduces the thickness of the dielectric tube a little, the thickness of a dielectric tube prefers in the range of 0.07 to 0.22

mm to get a thickness in the range of 0.05 to 0.2 mm after heat treatment.

In case of using a PTFE dielectric tube, it shall be treated by heat at a temperature of 320 to 370℃ for 1 to 3 hours, thereby becoming the thickness of a PTPE layer in the range of 0.05 to 0.2 mm in the ultimate cooler tube. If a PTFE dielectric tube is treated over 370℃, it will start melting, and if below 320℃, it will become a state not to shrink perfectly.

In case of using a FEP dielectric tube, it shall be treated by heat at a temperature of 170 to 270℃ for 1 to 3 hours, thereby becoming a thickness of a FEP layer in the range of 0.05 to 0.2 mm in the ultimate cooler tube. If a temperature of heat treatment of a FEP dielectric tube is over 270℃, it will start melting, and if below 170℃, it will become a state not to shrink perfectly.

In case of using a PFA dielectric tube, it shall be treated by heat at a temperature of 250 to 310℃ for 1 to 3 hours, thereby becoming thickness of a PFA layer in the range of 0.05 to 0.2 mm in the ultimate cooler tube. If a temperature of heat treatment of a PFA dielectric tube is over 310℃, it will start melting, and if below 250℃, it will become a state not to shrink perfectly.

In the present invention heat treatment may carry out in a conventional oven.

Fig. 3 is a schematic view of an adhesion state that the dielectric tube 11 has shrunk to the conductive pipe 10 by heat treatment of the dielectric tube and conductive pipe of Fig. 2.

The present invention shows a superior effect by shrinking a dielectric tube on the external surface of a conductive pipe through a heat treatment. Accordingly, the cooler tube according to the present invention is absolutely free of pin-hole on the surface. However, in case that the external surface of a conductive pipe is directly coated with a dielectric material, a defect such as pin-hole could occur on the coated surface, and the defect could cause a serious problem corroding the conductive pipe. In the present invention, since it is treated by heat using an already prepared dielectric tube, it may prepare a perfect cooler tube with no defect.

Also, the cooler tube of the present invention may cut down the preparation cost much more than that of the conventional coating method.

The cooling tube using for a fuel cell power plant system should be satisfactory in the effect of heat transfer. To show a satisfactory effect of heat transfer, the thickness of the shrunk dielectric tube had better be thin. However, if the thickness of the shrunk dielectric tube is very thin, the dielectric tube will be able to be damaged during the heat treatment. As a result, the thickness of the shrunk dielectric tube prefers in the range of 0.05 to 0.2 mm in consideration of an anti-corrosion property, a dielectric property and a heat conductivity, Among the used dielectric materials of the present invention, PTFE has the highest heat conductivity and PFA has the lowest heat conductivity.

The invention may be better understood by reference to the following examples which are intended for purpose of illustration and are not to be construed as in any way limiting the scope of the present invention, which is defined in the claims appended

Example

The following examples 1 to 18 in the Table were treated under the condition of the individual heat treatment, inserting each of the conductive pipes into each of the dielectric tubes. Each of the measurement of the thickness of the dielectric tubes after shrinking shows in the following table.

Table

Examples	Conductive Tube		Dielectric Tube			Heat Treatment		Thickness
	Material	D_o(mm)	Material	D_i(mm)	Th.(mm)	Temp.(℃)	Hrs	(mm)
1	S.S.	9.525	PTFE	11.938	0.22	345	1	0.2
2	Cu	6.230	PTFE	9.906	0.22	345	2	0.19
3	S.S.	9.525	PTFE	31.750	0.15	345	2	0.13
4	S.S.	6.35	PTFE	22.225	0.15	335	2	0.14
5	Cu	9.525	PTFE	11.938	0.09	335	1	0.08
6	S.S.	6.35	PTFE	9.906	0.07	345	1.5	0.05
7	S.S.	9.525	PTFE	11.938	0.07	340	1	0.06
8	S.S.	9.525	FEP	11.176	0.21	255	2	0.2
9	Cu	9.525	FEP	12.700	0.17	245	2	0.16
10	S.S.	6.350	FEP	9.525	0.15	255	2.5	0.13
11	S.S.	9.525	FEP	12.700	0.15	245	2.5	0.14
12	Cu	6.350	FEP	9.525	0.07	255	1	0.05
13	S.S.	6.350	FEP	7.874	0.07	245	1.5	0.05
14	S.S.	9.525	PFA	12.700	0.20	295	3	0.17
15	S.S.	9.525	PFA	12.700	0.15	285	1	0.12
16	Cu	9.525	PFA	12.700	0.10	295	1.5	0.08
17	S.S.	6.350	PFA	9.525	0.10	295	3	0.07
18	S.S.	6.350	PFA	9.525	0.07	280	1	0.06

notes) Thickness: thickness of dielectric tube layer after heat treatment
Do: outer diameter of conductive tube
Di: inner diameter of dielectric tube
Th: thickness of dielectric tube
Temp.: temperature of heat treatment
Hrs: hours of heat treatment
S.S: stainless steel
Cu: copper

As showed in the above Table, when heat treatment was completed, it may know that the dielectric tube is shrunk and a thickness of the shrunk dielectric tube is reduced a little.

It is apparent from the above that many modifications and changes are possible without departing from the spirit and scope of the present invention.

What is claimed is:

1. A cooler tube using for the cooling section of a fuel cell power plant system, which comprises:

a conductive pipe; and

a dielectric tube layer of a fluorocarbon polymer material having a thickness of 0.05～0.2 mm as shrunk and adhered on the external surface of the conductive pipe by heat treatment.

2. The cooler tube according to claim 1 wherein said conductive pipe is made of copper or stainless steel.

3. The cooler tube according to claim 1 wherein said fluorocarbon polymer material is selected from the group consisting of PTFE, FEP and PFA.

4. A method for preparing a cooler tube using for the cooling section of a fuel cell power plant system, which comprises:

providing a dielectric tube of which the inner diameter tube is larger than the outer diameter of a conductive pipe;

inserting said conductive pipe into said dielectric tube; and

carrying out a heat treatment of said conductive pipe and said dielectric tube, whereby said dielectric tube is shrunk and adhered on the external surface of said conductive pipe.

5. The method for preparing a cooler tube according to claim 4 wherein said conductive pipe is copper or stainless steel.

6. The method for preparing a cooler tube according to claim 4 wherein said fluorocarbon polymer material is PTFE.

7. The method for preparing a cooler tube according to claim 6 wherein the step of said heat treatment is performed at a

temperature of 320～340℃ for 1～3 hours.

8. The method for preparing a cooler tube according to claim 4 wherein said fluorocarbon polymer material is FEP.

9. The method for preparing a cooler tube according to claim 8 wherein the step of said heat treatment is performed at a temperature of 210～230℃ for 1～3 hours.

10. The method for preparing a cooler tube according to claim 4 wherein said fluorocarbon polymer material is PFA.

11. The method for preparing a cooler tube according to claim 10 wherein the step of said heat treatment is performed at a temperature of 280～295℃ for 1～3 hours.

12. The method for preparing a cooler tube according to claim 4 wherein said shrunk dielectric tube layer has a thickness of 0.05～0.2 mm.

13. A use of a dielectric tube for preparing a cooler tube using for a fuel cell power plant system, which is made of a fluorocarbon polymer material, and has a thickness of 0.05～0.2 mm after shrinking on the surface of a conductive pipe by a heat treatment.

14. The use of a dielectric tube according to claim 13 wherein said fluorocarbon polymer material is selected from the group consisting of PTFE, FEP and PFA.

Fig. 1

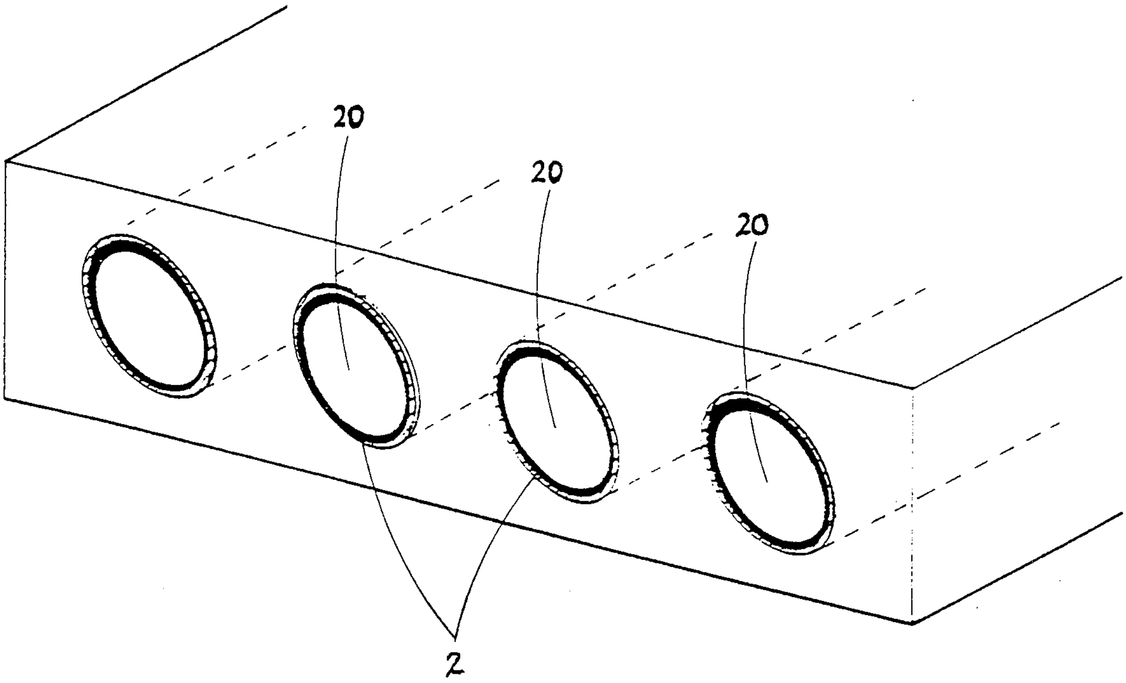


Fig. 2

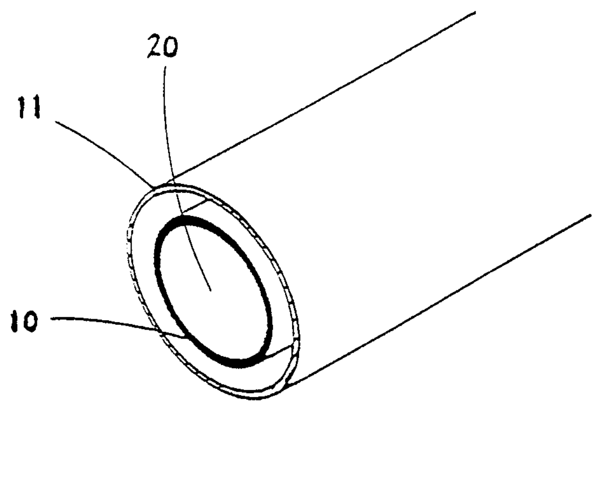
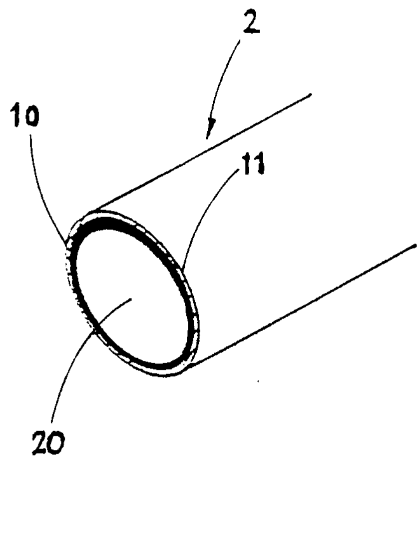


Fig. 3



INTERNATIONAL SEARCH REPORT

International application No.
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A. CLASSIFICATION OF SUBJECT MATTER

IPC⁶: F 16 L 13/00, 9/147, 11/12; H 01 M 8/04; G 03 G 5/02

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B. FIELDS SEARCHED

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IPC⁶: F 16 L 9/14, 9/147, 9/18, 11/12, 13/00, 25/00, 58/00, 58/02; H 01 M 8/04; G 03 G 5/02

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 786 086 A (GUTHRIE et al.) 22 November 1988 (22.11.88), totality.	1-6
X	EP 0 435 598 A2 (XEROX CORPORATION) 03 July 1991 (03.07.91), totality.	1,3,4,6
X	US 4 258 939 A (KARLEN) 31 March 1981 (31.03.81), totality.	1,4
X	US 3 964 930 A (REISER) 22 June 1976 (22.06.76), totality, cited in the application.	1-6

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Date of the actual completion of the international search	Date of mailing of the international search report
04 November 1997 (04.11.97)	20 November 1997 (20.11.97)

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