(12) PATENT
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. AU 199728872 B2
(10) Patent No. 706599

(54) Title
High-temperature fuel cell plant and process for operating the same

(51)[6] International Patent Classification(s)
H01M 008/04

(21) Application No: 199728872

(22) Application Date: 1997 .04 .28

(87) WIPO No: WO97/42673

(30) Priority Data

(31) Number	(32) Date	(33) Country
19618331	1996 .05 .07	DE

(43) Publication Date : 1997 .11 .26
(43) Publication Journal Date : 1998 .02 .05
(44) Accepted Journal Date : 1999 .06 .17

(71) Applicant(s)
Siemens Aktiengesellschaft

(72) Inventor(s)
Andreas Stock

(74) Agent/Attorney
SPRUSON and FERGUSON,GPO Box 3898,SYDNEY NSW 2001

OPI DATE 26/11/97 APPLN. ID 28872/97
AOJP DATE 05/02/98 PCT NUMBER PCT/DE97/00868

AU9728872

(51) Internationale Patentklassifikation 6 :
H01M 8/04

A1

(11) Internationale Veröffentlichungsnummer: **WO 97/42673**

(43) Internationales Veröffentlichungsdatum: 13. November 1997 (13.11.97)

(21) Internationales Aktenzeichen: PCT/DE97/00868

(22) Internationales Anmeldedatum: 28. April 1997 (28.04.97)

(30) Prioritätsdaten:
196 18 331.6 7. Mai 1996 (07.05.96) DE

(71) Anmelder (*für alle Bestimmungsstaaten ausser US*): SIEMENS AKTIENGESELLSCHAFT [DE/DE]; Wittelsbacherplatz 2, D-80333 München (DE).

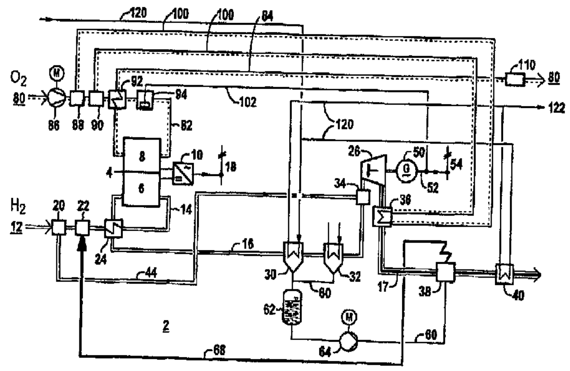
(72) Erfinder; und
(75) Erfinder/Anmelder (*nur für US*): STOCK, Andreas [DE/DE]; Würzburger Strasse 12, D-63639 Flörsbachtal (DE).

(81) Bestimmungsstaaten: AU, CA, JP, US, europäisches Patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Veröffentlicht
Mit internationalem Recherchenbericht.
Vor Ablauf der für Änderungen der Ansprüche zugelassenen Frist. Veröffentlichung wird wiederholt falls Änderungen eintreffen.

(54) Title: HIGH-TEMPERATURE FUEL CELL PLANT AND PROCESS FOR OPERATING THE SAME

(54) Bezeichnung: VERFAHREN ZUM BETREIBEN EINER HOCHTEMPERATUR-BRENNSTOFFZELLENANLAGE UND HOCHTEMPERATUR-BRENNSTOFFZELLENANLAGE



(57) Abstract

This invention concerns a process for operating a high-temperature fuel cell plant (2) which consists of at least one high-temperature fuel cell block (4) with an anode element (6) and a cathode element (8), whereby at least a portion of the anode exhaust gas of the high-temperature fuel cell block (4) is fed as fuel to a gas engine (26) connected to a generator (50) to increase the power generated. This measure provides highly efficient and flexible energy production.

(57) Zusammenfassung

Bei einem Verfahren zum Betreiben einer Hochtemperatur-Brennstoffzellenanlage (2), die wenigstens einen Hochtemperatur-Brennstoffzellenblock (4) mit einem Anodenteil (6) und einem Kathodenteil (8) umfaßt, wird zur Erhöhung der Energieerzeugung einem an einen Generator (50) gekoppelten Gasmotor (26) wenigstens ein Anteil des Anodenabgases des Hochtemperatur-Brennstoffzellenblocks (4) als Betriebsmittel zugeführt. Durch diese Maßnahme ist eine hocheffiziente und flexible Energieerzeugung gewährleistet.

Abstract

Process for operating a high temperature fuel cell installation, and high temperature fuel cell installation

In a process for operating a high temperature fuel cell installation (2) comprising at least one high temperature fuel cell block (4) with an anode part (6) and a cathode part (8), at least a portion of the anode off-gas from the high temperature fuel cell block (4) is fed as working medium to a gas motor (26) coupled to a generator (50) in order to increase the energy production. This measure guarantees highly efficient and flexible energy production.

FIG 1

GR 96 P 3308 P

Description

Process for operating a high temperature fuel cell installation, and high temperature fuel cell installation

The invention relates to a process for operating a high temperature fuel cell installation and to a high temperature fuel cell installation.

It is known that, during the electrolysis of water, the water molecules are decomposed by electric current into hydrogen (H_2) and oxygen (O_2). In a fuel cell, this process takes place in reverse. Through the electrochemical combination of hydrogen (H_2) and oxygen (O_2) to form water, electric current is produced with high efficiency. If pure hydrogen (H_2) is used as combustion gas, this takes place without the emission of pollutants and carbon dioxide (CO_2). Even with a technical combustion gas, for example natural gas or coal gas, and with air (which may additionally be enriched with oxygen (O_2)) instead of pure oxygen (O_2), a fuel cell produces considerably less pollutants and less carbon dioxide (CO_2) than other forms of energy production which operate using fossil energy sources.

The technical implementation of the fuel cell principle has given rise to a variety of solutions, and more precisely with different electrolytes and with operating temperatures of between 80°C and 1000°C.

Depending on their operating temperature, fuel cells are divided into low, medium and high temperature fuel cells, which in turn differ through various technical embodiments.

A high temperature fuel cell block (a fuel cell block is also referred to a "stack" in the specialist literature) is generally composed of a multitude of high temperature fuel cells which are of planar construction and are stacked on one another. Fuel cell installations comprising at least one high temperature fuel cell block are, for example, known from the German Patent Applications with the official reference numbers 195 23 973.3, 195 23 972.5 and 195 14 469.4.

A high temperature fuel cell installation is operated with a high constant operating temperature of, for example, in excess of 900°C. For this purpose, in order to achieve the operating temperature before operation or to hold the required operating temperature during brief interruptions to operation, the installation must be supplied with additional heat.

A further problem is to use the working medium efficiently during operation of the high temperature fuel cell block. In order to make it possible to operate the high temperature fuel cell block with high efficiency, the working medium needs to be supplied in excess. Only through an excess of working medium is it possible to guarantee that the active faces of the high temperature fuel cells are provided with enough working medium. An unavoidable consequence of operating the high temperature fuel cell block with excess working medium is that, after the electrochemical reaction has taken place, there is still some working medium present in the off-gas at the outlet of the high temperature fuel cell block. Put another way, the working medium is not fully consumed in the high temperature fuel cell block. Some of it emerges unused, and this impairs efficiency.

Laid-open German Patent Specification 41 37 968 discloses a heat exchange device in which the off-gas from a high temperature fuel cell block is fed to an expansion turbine. In this case, the off-gas from the high temperature fuel cell block contains unconsumed air from the cathode off-gas and unconsumed hydrogen from the anode off-gas. In order to heat the off-gas to the input temperature of the expansion turbine, the off-gas is fed before feeding through a heat exchanger integrated in the high temperature fuel cell block. After having been fed into the turbine, the off-gas is expanded therein. This means that only the heat content of the off-gas is used for the production of energy in the turbine, but not actually the components of the off-gas, for example hydrogen.

The object of the invention is to provide a process for operating a high temperature fuel cell installation, in which efficient and flexible energy production is guaranteed. A further object is to provide a high temperature fuel cell installation having high efficiency.

The former object is achieved according to the invention by a process for operating a high temperature fuel cell installation comprising at least one high temperature fuel cell block with an anode part and a cathode part. In order to increase the energy production, a gas motor coupled to a generator is provided, the motor being fed at least a portion of the anode off-gas from the high temperature fuel cell block.

This process proves efficient since all of the working medium, unless consumed in the fuel cell block and therefore not present in the anode off-gas, is available to the gas motor as working medium for obtaining further energy. At the same time, the process proves flexible since the gas motor does not always need to be provided with the same amount of working medium from the anode off-gas at every operating time. If, at a particular operating time, there is not enough working medium in the anode off-gas to operate the gas motor, then the missing portion of working medium can be fed separately to the gas motor.

Preferably, water is withdrawn from the anode off-gas before feeding into the gas motor. In other words, the water produced during the electrochemical reaction in the high temperature fuel cell block is withdrawn from the anode off-gas, so that the working medium is present in a form which can be exploited by the gas motor. Together with the water, the anode off-gas also has some of its heat content withdrawn. The temperature of the anode off-gas, that is to say the working medium for the gas motor is therefore reduced on the way from the high temperature fuel cell block to the gas motor.

In particular, a working medium for the anode part may be supplied with water in the form of water vapor before the feeding.

In a further refinement, a portion of the electric current produced with the generator is used to heat a working medium when the high temperature fuel cell block is being started up. For example, the working medium provided for the high temperature fuel cell block in normal operation may at the start be fed directly via a bypass to the gas motor, the energy of which is therefore used for electrically heating the high temperature fuel cell block. The high temperature fuel cell block may consequently be started up with the gas motor, which forms part of the overall high temperature fuel cell installation.

In particular, a working medium for the anode part and/or cathode part of the high temperature fuel cell block may be heated with the heat dissipated by the gas motor.

The latter object is achieved according to the invention by a high temperature fuel cell installation having at least one high temperature fuel cell block comprising an anode part and a cathode part. In order to increase the energy production, a gas motor coupled to a generator is provided, the gas motor being connected to the discharge path of the anode part of the high temperature fuel cell block.

Preferably, at least one water precipitator is provided in the discharge path of the anode part. The water removed from the anode off-gas by at least one water precipitator may, for example, be fed via a feed water tank to a steam generator, the water subsequently evaporated being fed back to the working medium for the anode part of the high temperature fuel cell block. By virtue of this, even the water from the anode off-gas can be fed for reuse in the high temperature fuel cell block.

In particular, at least one heat exchanger may be arranged in the discharge line of the gas motor.

In a further refinement, a steam generator is provided in the discharge line of the gas motor. Using the steam generator, the water from the off-gas of the anode part of the high temperature fuel cell block is evaporated for reuse in the cathode part.

Preferably, the generator is connected to a heating device arranged in the feed path of the cathode part. A fraction of the electric current produced in the generator is used to heat the working medium for the cathode part.

In particular, the generator may be connected to an electrical network in order to feed it with electric current. The current may be fed to a load via the electrical network.

For further explanation of the invention, reference will be made to the illustrative embodiment in the drawing, the single figure of which schematically represents a high temperature fuel cell installation.

According to the figure, a high temperature fuel cell installation 2 comprises a high temperature fuel cell block 4 which is divided into an anode part 6 with anode gas spaces (not shown in detail) and a cathode part 8 with cathode gas spaces (not further shown). The high temperature fuel cell block 4 is preferably composed of a multitude of high temperature fuel cells (not further shown) of planar design.

An invertor 10, which converts the direct current produced by the high temperature fuel cell block 4 into alternating current for an electrical network 18, is connected to the high temperature fuel cell block 4.

The anode part 6 is assigned an anode path 12 for supplying it with a working medium, for example hydrogen (H_2) or a mixture of combustion gas and reaction vapor, this anode path 12 comprising a feed path 14 and a discharge path 16. Before feeding into the anode part 6, the working medium is referred to as "working medium for the anode part 6", and after it has left the anode part 6, it is referred to as "anode off-gas of the anode part 6".

A gas splitter 20, a mixing chamber 22 and a heat exchanger 24 are successively arranged, in that order in the flow direction, in the feed path 14 of the anode part 6 of the high temperature fuel cell block 4. A gas motor 26 is connected to the discharge path 16 of the anode part 6 of the high temperature fuel cell block 4. The term "gas motor" is in this context intended to mean a device for converting the chemical energy contained in the working medium (anode off-gas) into mechanical energy. A generator 50, which converts the mechanical energy produced in the gas motor 26 into alternating current, is coupled to the gas motor 26. The alternating current is delivered to an electrical network 54 via a line 52.

The off-gas from the gas motor 26 is discharged by a discharge line 17 from the high temperature fuel cell installation 2. A heat exchanger 36, a steam generator 38 and a further heat exchanger 40 are successively arranged, in that order in the flow direction, in the discharge line 17.

Two water precipitators 30, 32 and a mixing chamber 34 are successively arranged, in that order in the flow direction, in the discharge path 16 of the anode part 6.

The working medium for the anode part 6 is fed into the anode part 6 of the high temperature fuel cell block 4 via the feed path 14. This being the case, the working medium firstly flows through the gas splitter 20, in which a fraction of the working medium is diverted from the feed path 14 via a line 44 and fed directly into the mixing chamber 34 arranged upstream of the gas motor 26 in the discharge path 16 of the anode part 6. Operation of the gas motor 26 is therefore guaranteed even if not enough working medium is present in the anode off-gas of the anode part 6 of the high temperature fuel cell block 4. In the heat exchanger 24, the working medium for the anode part 6 is heated by the anode off-gas.

After the electrochemical reaction has taken place in the high temperature fuel cell block 4, the anode off-gas is discharged from the high temperature fuel cell block 4 via the discharge path 16. In the water precipitators 30 and 32, a large portion of the process water produced during the reaction in the high temperature fuel cell block 4 is removed together with a fraction of the heat content of the anode off-gas.

After the process water has been removed from the anode off-gas, the cooled anode off-gas passes as working medium via the mixing chamber 34 into the gas motor 26. In the latter, the working medium, i.e. the anode off-gas, is burnt to produce mechanical energy.

In the steam generator 38, the process water removed by the water precipitators 30, 32 from the anode off-gas is evaporated. For this purpose, the process water from the water precipitators 30, 32 is fed to the steam generator 38 via a line 60, in which a feed water tank 62 and a pump 64 are arranged. The feed water tank 62 is in this case used as a reservoir for the process water. The latter is fed in the required quantity to the steam generator 38 by the pump 64.

The water vapor produced in the steam generator 38 is fed via a line 68 to the mixing chamber 22 which is arranged in the feed path 14 of the anode part 6. The water vapor is therefore mixed with the working medium for the anode part 6 in order to heat this medium.

The heat obtained in the water precipitator 30 and in the further heat exchanger 40 can be fed via a line 120 carrying a heat-exchange medium into a local hot water network 122 (not shown in detail).

The cathode part 8 of the high temperature fuel cell block 4 is assigned a cathode path 80 which comprises a feed path 82 and a discharge path 84. A compressor 86, a gas splitter 88, a mixing chamber 90, a heat exchanger 92 and an electrical heating device 94 are successively arranged, in that order in the flow direction, in the feed path 82 of the cathode part 8.

The working medium for the cathode part 8 is fed to the cathode part 8 via the feed path 82. This being the case, the working medium, for example air or air enriched with oxygen (O_2), is fed into the gas splitter 88 via the compressor 86.

In the gas splitter 88, at least a fraction of the working medium for the cathode part 8 is diverted from the feed path 82 of the cathode part 8 and fed via a line 100 through the heat exchanger 36. It is then fed back via the mixing chamber 90 to the feed path 82. Since the heat exchanger 36 is connected downstream of the gas motor 26 in the discharge line 17 for the off-gas from the gas motor 26, the working medium for the cathode part 8 diverted from the feed path 82 is heated by the off-gas from the gas motor 26. The waste heat of the off-gas from the gas motor 26 is therefore advantageously used to heat the working medium for the cathode part 8.

The undiverted fraction of the working medium passes directly via the line 82 into the mixing chamber 90, where it is recombined with the diverted fraction. The working medium for the cathode part 8 is then heated in the heat exchanger 92 and in the electrical heating device 94. In the heat exchanger 92, the working medium for the cathode part 8 is heated by the cathode off-gas, and in the electrical heating device 94 it is electrically heated for starting up the high temperature fuel cell block 4. In this case, the electrical heating device 94 is supplied with current from the generator 50 assigned to the gas motor 26. The electrical heating device 94 is in this case supplied with current via a line 102 from the line 52.

The cathode off-gas is firstly fed via the discharge path 84 of the cathode path 8 through the heat exchanger 92, where it heats the working medium for the cathode part 8. It is then fed to a local heat-using system 110 (not shown in detail).

On the one hand, therefore, the gas motor 26 is operated using the anode off-gas from the high temperature fuel cell block 4 and on the other hand the gas motor 26 is used for starting up the high temperature fuel cell block 4. The process water obtained during the electrochemical reaction in the high temperature fuel cell block 4 is fed in the form of water vapor to the working medium for the anode part 6 in order to heat it. Further, the current produced by the gas motor 26 and the generator 50 is used to operate the electrical heating device 94 for heating the working medium for the cathode part 8 of the high temperature fuel cell block 4. In addition, the heat of the off-gas from the gas motor 26 preheats the working medium for the cathode part 8 of the high temperature fuel cell block 4.

It is therefore possible for the start-up process of the high temperature fuel cell installation 2 to be carried out merely using components which are provided in the high temperature fuel cell installation 2.

Patent Claims

1. A process for operating a high temperature fuel cell installation (2) comprising at least one high temperature fuel cell block (4) with an anode part (6) and a cathode part (8), at least a portion of the anode off-gas from the high temperature fuel cell block (4) being fed as working medium to a gas motor (26) coupled to a generator (50) in order to increase the energy production, and water and heat energy are withdrawn from the anode off-gas before feeding into the gas motor (26).

2. The process as claimed in claim 1, characterized in that the anode part (6) is supplied with a working medium to which water in the form of water vapor is fed before the feeding.

3. The process as claimed in claim 1 or 2, characterized in that a portion of the electric current produced with the generator (50) is used to heat a working medium when the high temperature fuel cell block (4) is being started up.

4. The process as claimed in one of claims 1 to 3, characterized in that a working medium for the anode part (6) and/or cathode part (8) of the high temperature fuel cell block (4) is heated with the heat dissipated by the gas motor (26).

5. A high temperature fuel cell installation (2) having at least one high temperature fuel cell block (4) comprising an anode part (6) and a cathode part (8) as well as a gas motor (26) coupled to a generator (50) in order to produce energy, the gas motor (26) being connected to the discharge path (16) of the anode part (6) of the high temperature fuel cell block (4), and at least one water precipitator (30, 32) being arranged in the discharge path (16) of the anode part (6).

6. The high temperature fuel cell installation (2) as claimed in claim 5, which has at least one heat exchanger (36, 40) in the discharge line (17) of the gas motor (26).

7. The high temperature fuel cell installation (2) as claimed in claim 6, which has a steam generator (38) in the discharge line (17) of the gas motor (26).

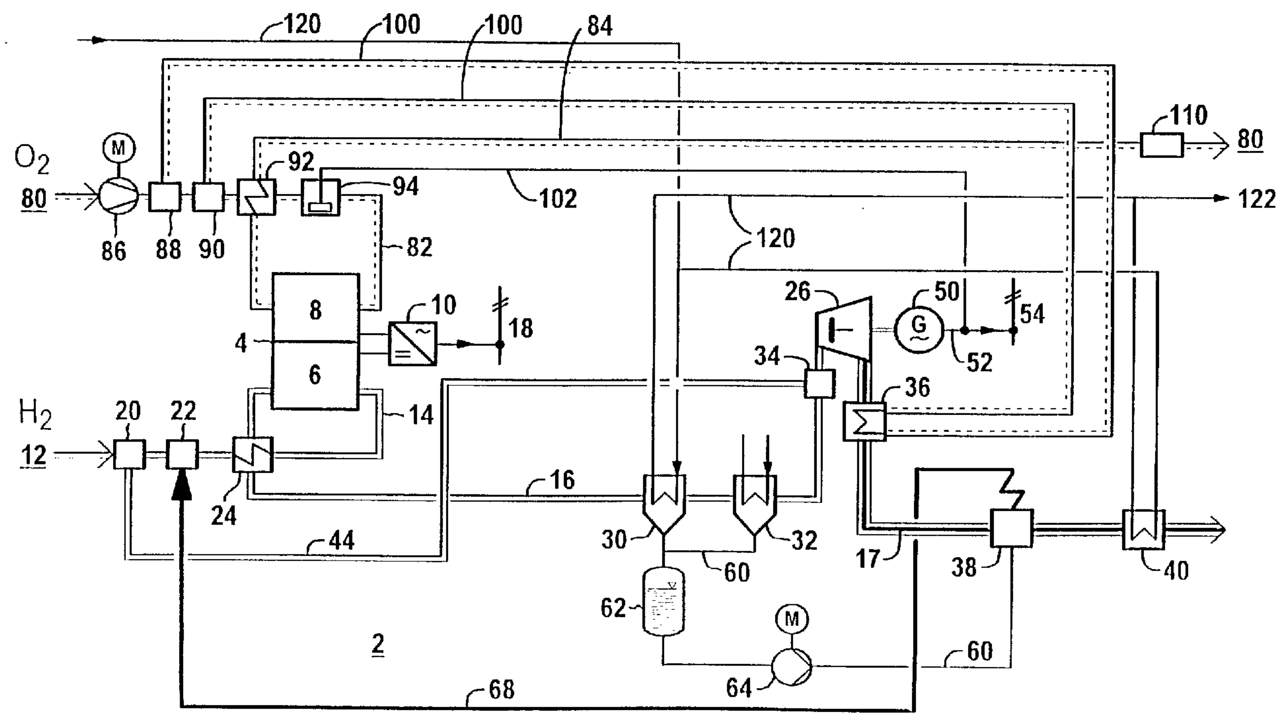
8. The high temperature fuel cell installation (2) as claimed in claim 6 or 7, characterized in that an electrical heating device (94) arranged in the feed path (82) of the cathode part (8) is connected to the generator (50).

9. The high temperature fuel cell installation (2) as claimed in one of claims 5 to 8, characterized in that the generator (50) is connected to an electrical network (54) in order to feed it with electric current.

10. A process for operating a high temperature fuel cell installation (2) substantially as herein described with reference to Fig. 1.

11. A high temperature fuel cell installation (2) substantially as herein described with reference to Fig. 1.

DATED this Sixteenth Day of October 1998
Siemens Aktiengesellschaft
Patent Attorneys for the Applicant
SPRUSON & FERGUSON


O2
80
M
86
88
90
92
94
82
120
100
100
84
102
120
110
80
122
8
6
4
10
18
14
H2
12
20
22
24
44
16
26
50
G
52
54
34
36
30
32
60
62
M
64
60
68
17
38
40
2