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(54) Titre : PILE A COMBUSTIBLE ET UTILISATION D'ALLIAGES A BASE DE FER POUR LA PRODUCTION DE PILES A COMBUSTIBLE
(54) Title: FUEL CELL AND USE OF IRON-BASED ALLOYS IN THE CONSTRUCTION OF FUEL CELLS

(57) Abrégé/Abstract:
A fuel cell is provided which includes iron-based alloys for the construction of the solid parts of the fuel cell. The fuel cell includes a membrane electrode unit and solid constructive parts which may include current collectors, a cell frame and a bipolar plate. At least one of these solid constructive parts is made from an iron-based material that preferably has an effective weight percent of iron of greater than or equal to 26.9 percent.

20365-4073

Abstract

A fuel cell is provided which includes iron-based alloys for the construction of the solid parts of the fuel cell. The fuel cell includes a membrane electrode unit and solid constructive parts which may include current collectors, a cell frame and a bipolar plate. At least one of these solid constructive parts is made from an iron-based material that preferably has an effective weight percent of iron of greater than or equal to 26.9 percent.

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Specification

Fuel Cell and Use of Iron-Based Alloys in the Construction of Fuel Cells

The invention relates to a fuel cell that comprises a membrane electrode unit, two current collectors and/or a cell frame or a bipolar plate, whereby at least one solid constructive part is characterized by low weight and high corrosion resistance of the material used.

Up to now, cell frames, bipolar plates, collector plates, and/or other solid constructive parts of fuel cells, in particular of low-temperature fuel cells such as the PEM fuel cell, have been known that are manufactured from graphite or other carbonaceous materials. The thickness of, for example, the plates manufactured therefrom is at least 2 to 2.5 mm, due to the inwrought gas and liquid distribution structure, and despite the low density of the material there thus results a comparatively high weight and large volume of the constructed fuel cells.

In EP 0 629 015 A1, the following alloys or metals are disclosed as materials for bipolar or collector plates: aluminum, titanium or alloys thereof, zirconium, niobium, tantalum, or alloys of these five elements. In addition, it is there disclosed that these elements can be passivated by protective electrically insulating oxides, and that, alternatively to the above-named metals, the plates can also be made of more corrosion-resistant materials such as graphite, high-alloy stainless steel, or nickel-chromium alloys. However, more precise statements concerning the composition of well-suited alloys of these metals have not been known up to now.

For mass production, the carbonaceous materials are too heavy and too expensive in the manufacture of cell frames, current collectors and/or bipolar plates, etc.. In turn, the metals have an excessively high susceptibility to corrosion, and, due to their passivation by oxide layer formation, have excessively high losses during current transport inside the fuel cell.

It is thus the object of the present invention to provide a fuel cell suitable for mass production, in which the collector plates and/or cell frames and/or other constructive parts of the fuel cell are made of a material that

- is economical and corrosion-resistant (even in direct contact with the acid membrane electrolytes), and
- is easily transformable (good deep-drawing quality), and
- has a low contact resistance, and finally
- has a low thickness and, above all, a low weight in the processing into plates, despite the inwrought gas and liquid distribution structure.

The subject matter of the invention is a fuel cell that comprises a membrane electrode unit, two current collectors and/or a cell frame and/or a bipolar plate, whereby the material of at least one of the solid constructive parts is made of an Fe-based material selected from the alloys with the following compositions:

C content	:	0 - 0.06 weight %
Si content	:	0 - 2 weight %
Cr content	:	8.25 - 46.5 weight %
Mo content	:	1.25 - 14.0 weight %
Ni content	:	2.25 - 40.5 weight %
Cu content	:	0 - 4.0 weight %
Mn content	:	0 - 13 weight %
N content	:	0.02 - 1 weight %
Nb content	:	0 - 0.5 weight %
P content	:	0 - 0.09 weight %
S content	:	0 - 0.06 weight %
Fe content	:	remainder to 100 weight %

As an iron-based material, Fe is in principle the main component of the inventively used alloy, whereby the designation 'main component' cannot be defined by percent indications, but rather is regarded relative to the other components.

Moreover, the subject matter of the present invention is the use of an iron-based alloy with one of the above-named compositions in the construction of a fuel cell.

The Fe-based material for the current collectors and/or the cell frame and/or the bipolar plate is preferably selected from the following alloys:

C content	:	0 - 0.03 weight %
Si content	:	0 - 1 weight %
Cr content	:	16.5 - 25.0 weight %
Mo content	:	2.5 - 7.0 weight %
Ni content	:	4.5 - 26.0 weight %
Cu content	:	0 - 2.0 weight %
Mn content	:	0 - 6.5 weight %
N content	:	0.04 - 0.5 weight %
Nb content	:	0 - 0.25 weight %
P content	:	0 - 0.045 weight %
S content	:	0 - 0.03 weight %
Fe content	:	remainder to 100 weight %

Given homogenous alloy element distribution, the relative hole and gap corrosion resistance of a non-rusting steel can be estimated by means of the effective sum (effective sum W = % Cr + 3.3. x % Mo + 30 x % N). In a preferred construction of the invention, the Fe-based material for the at least one solid constructive part is selected of an alloy whose effective sum is $\geq$ 26.9, and particularly preferably one whose effective sum is > 30.

In a particularly preferred construction, the Fe-based material is additionally surface-treated in order to reduce the contact resistance. Gold plating, or also treatment e.g. with titanium nitride, are possibilities for such surface treatments. However, the surface treatment can also be realized by coating with conductive polymer plastics. In principle, all known surface treatments can be used here for the lowering of the contact resistance with the same or improved corrosion resistance.

'Solid constructive part' refers here to e.g. cell frames, current collectors and/or collector plates, bipolar plates, terminating and/or pole plates, or some other constructive part, such as a frame element, etc., that is usefully constructed from a material whose shape is stable under normal conditions. These can be square, round, tubular, and other constructive parts that can have arbitrary stamped or otherwise formed surface structures, in which either a cooling medium or a reaction medium then flows, or into which the membrane electrode unit is also clamped. Finally, it can also be a sealing element. In practice, an axial channel or a tension rod, or a part of an axial channel or of a tension rod, can also be made of the inventively used material.

In other words, any additional construction material of a fuel cell can be selected from the inventively named alloys, except for the polymer electrolyte membrane and the two electrodes adjacent to this membrane.

The design in the patent DE 44 42 285 for the construction of a fuel cell provides for the use of production methods suitable for mass production, such as stamping and pressing, on the materials. The inventively named Fe-based materials are suitable for such processing techniques.

For use as plates with a gas and/or liquid distribution structure, the inventively used Fe-based materials have a small thickness from 20 to 300 μm, preferably 50 to 200 μm, and particularly preferably approximately 100 μm. For use as pole or terminating plates, or other applications, in some circumstances entirely other plate thicknesses are useful. According to the solid constructive part for which the alloy is used according to the invention, the weight reduction of the fuel cell achieved according to the invention increases naturally with the thickness of the part.

In the fuel cells specified in the above-cited patent, both the pole plates and also the terminal plates and the frame elements can be made from the materials, resulting in a considerable reduction in weight in relation to the prior art.

In the following, the invention is further specified on the basis of alloys that are preferably used:

Alloy **1.4539** (material numbers)

C content	:	0 - 0.02 weight %
Cr content	:	19.0 - 21.0 weight %
Mo content	:	4.0 - 5.0 weight %
Ni content	:	24.0 - 26.0 weight %
Cu content	:	1.0 - 2.0 weight %
N content	:	0.04 - 0.15 weight %
Fe content	:	remainder to 100 weight %

Alloy **1.4462:**

C content	:	0 - 0.03 weight %
Cr content	:	21.0 - 23.0 weight %
Mo content	:	2.5 - 3.5 weight %
Ni content	:	4.5 - 6.5 weight %
N content	:	0.08 - 0.2 weight %
Fe content	:	remainder to 100 weight %

Alloy **1.4439:**

C content	:	0 - 0.03 weight %
Cr content	:	16.5 - 18.5 weight %
Mo content	:	4.0 - 5.0 weight %
Ni content	:	12.5 - 14.5 weight %
N content	:	0.12 - 0.22 weight %
Fe content	:	remainder to 100 weight %

Alloy **1.4565:**

C content	:	0 - 0.03 weight %
Cr content	:	23.0 - 25.0 weight %
Mo content	:	3.5 - 4.5 weight %
Ni content	:	16.0 - 18.0 weight %
Mn content	:	5.0 - 6.5 weight %
N content	:	0.4 - 0.5 weight %
Nb content	:	0 - 0.10 weight %
Fe content	:	remainder to 100 weight %

Alloy **1.4529:**

C content	:	0 - 0.02 weight %
Si content	:	0 - 1 weight %
Cr content	:	19.0- 21.0 weight %
Mo content	:	6.0 - 7.0 weight %
Ni content	:	24.0 - 26.0 weight %
Cu content	:	0.5 - 1.5 weight %
Mn content	:	0 - 2.0 weight %
N content	:	0.1 - 0.25 weight %
P content	:	0 - 0.03 weight %
S content	:	0 - 0.015 weight %
Fe content	:	remainder to 100 weight %

and alloy **1.3964:**

C content	:	0 - 0.03 weight %
Si content	:	0 - 1 weight %
Cr content	:	20.0 - 21.5 weight %
Mo content	:	3.0 - 3.5 weight %
Ni content	:	15.0 - 17.0 weight %
Mn content	:	4.0 - 6.0 weight %
N content	:	0.2 - 0.35 weight %

Nb content: 0-0.25 weight %

P content: 0-0.025 weight %

S content: 0-0.001 weight %

Fe content: remainder to 100 weight %.

With the inventively proposed alloys, fuel cells suitable for mass production can be manufactured economically, and a light and compact construction can thereby be realized. In addition, the inventively cited materials have a comparatively high resistance to corrosion, even given direct contact of the plates and/or of the frame elements with the acid electrolytes. In addition, they have a good deep drawing quality, and are also well able to be transformed. Finally, they have a low contact resistance, which can be further optimized by corresponding surface treatment.

In accordance with one aspect of this invention, there is provided a fuel cell comprising a membrane electrode unit and a plurality of solid constructive parts selected from a group consisting of a plurality of current collectors, a cell frame, and a bipolar plate, at least one of the solid constructive parts comprising a Fe-based material comprising the following composition:

Cr content: 8.25-46.5 weight %

Mo content: 1.25-14.0 weight %

Ni content: 2.25-40.5 weight %

N content: 0.02-1 weight %

Fe content: remainder to 100 weight %, wherein the Fe-based material comprises an effective sum greater than or equal to 26.9, and effective sum is defined as Pitting Resistance Equivalent (PRE).

In accordance with another aspect of this invention, there is provided a method of constructing a fuel cell comprising solid constructive parts, the method comprising the step of fabricating the solid constructive parts from an Fe-based alloy comprising the composition:

Cr content: 8.25-46.5 weight %

Mo content: 1.25-14.0 weight %

Ni content: 2.25-40.5 weight %

N content: 0.02-1 weight %

Fe content: remainder to 100 weight %, wherein the Fe-based material comprises an effective sum greater than or equal to 26.9, and effective sum is defined as Pitting Resistance Equivalent (PRE).

CLAIMS:

1. A fuel cell comprising a membrane electrode unit and a plurality of solid constructive parts selected from a group consisting of a plurality of current collectors, a cell frame, and a bipolar plate, at least one of the solid constructive parts comprising a Fe-based material comprising the following composition:

Cr content: 8.25-46.5 weight %

Mo content: 1.25-14.0 weight %

Ni content: 2.25-40.5 weight %

N content: 0.02-1 weight %

Fe content: remainder to 100 weight %,

wherein the Fe-based material comprises an effective sum greater than or equal to 26.9, and effective sum is defined as Pitting Resistance Equivalent (PRE).

2. The fuel cell of claim 1, wherein the Fe-based material further comprises the following composition:

Cr content: 16.5-25.0 weight %

Mo content: 2.5-7.0 weight %

Ni content: 4.5-26.0 weight %

N content: 0.04-0.5 weight %

Fe content: remainder to 100 weight %.

3. The fuel cell of claim 1, wherein the Fe based material further comprises the following composition:

C content: 0-0.03 weight %

Si content: 0-1 weight %

Cu content: 0-2.0 weight %

Mn content: 0-6.5 weight %

Nb content: 0-0.25 weight %

P content: 0-0.045 weight %

S content 0-0.03 weight %

Fe content: remainder to 100 weight %.

4. The fuel cell of claim 1, wherein the Fe-based material is surface treated.

5. The fuel cell of claim 1, wherein the fuel cell is a PEM fuel cell.

6. A method of constructing a fuel cell comprising solid constructive parts, the method comprising the step of fabricating the solid constructive parts from an Fe-based alloy comprising the composition:

Cr content: 8.25-46.5 weight %

Mo content: 1.25-14.0 weight %

Ni content: 2.25-40.5 weight %

N content: 0.02-1 weight %

Fe content: remainder to 100 weight %,

wherein the Fe-based material comprises an effective sum greater than or equal to 26.9, and effective sum is defined as Pitting Resistance Equivalent (PRE).

7. The method of claim 6, wherein the Fe-based material further comprises the following composition:

Cr content: 16.5-25.0 weight %

Mo content: 2.5-7.0 weight %

Ni content: 4.5-26.0 weight %

N content: 0.04-0.5 weight %

Fe content: remainder to 100 weight %.

8. The method of claim 6, wherein the Fe-based material further comprises the following composition:

C content: 0-0.03 weight %

Si content: 0-1 weight %

Cu content: 0-2.0 weight %

Mn content: 0-6.5 weight %

Nb content: 0-0.25 weight %

P content: 0-0.045 weight %

S content: 0-0.03 weight %

Fe content: remainder to 100 weight %.

9. The method of claim 6, wherein the Fe based material is surface treated.

10. The method of claim 6, wherein the fuel cell is a PEM fuel cell.