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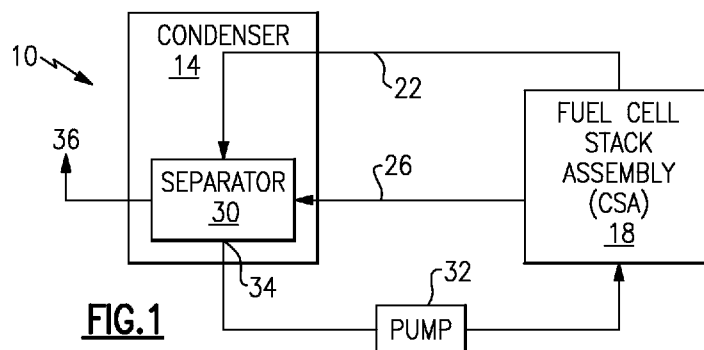
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- (54) Title:** CONDENSER FOR A FUEL CELL SYSTEM



- (57) Abstract:** An exemplary condenser system for a fuel cell includes a mixing device configured to receive a first fluid that includes an emulsifier and a second fluid from a fuel cell. The mixing device is configured to introduce some of the second fluid to the first fluid to form a microemulsion.

CONDENSER FOR A FUEL CELL SYSTEM

1. Technical Field

[0001] This disclosure relates generally to a fuel cell system. More particularly, this disclosure relates to removing a fuel cell byproduct from the fuel cell system.

2. Description of Related Art

[0002] Fuel cell assemblies are well known. Some fuel cells include a polymer electrolyte membrane (PEM) positioned between electrodes that contain a platinum catalyst. One of the electrodes operates as an anode while the other operates as a cathode. These two electrodes and the PEM are positioned between separator plates. These separator plates commonly have anode flow fields for moving fuel adjacent to the anode and cathode flow fields on the opposite side for moving oxidant. The plates are often known as bipolar plates. Some PEM fuel cells utilize porous, carbon bipolar plates and other fuel cells use solid, instead of porous, carbon bipolar plates. The bipolar plates often separate gas within the fuel cell. The porous plates are kept filled with liquid to minimize gas communication between the opposite sides of the plates. Both types of fuel cells typically include a gas-diffusion layer located between each electrode and the bipolar plates.

[0003] As known, fuel cells generate thermal and liquid byproducts (i.e., heat and water). Some of these byproducts move away from the fuel cell as water vapor. Coolant circulates through the fuel cell to remove other remaining byproducts. Many fuel cell systems incorporate a condenser that condenses the water vapor to generate a condensate and another separate condenser or heat exchanger that removes thermal byproducts from the coolant. Excessive condensate can undesirably block channels within the condenser, which can degrade the performance of some condensers to varying degrees. Further, the condensate may freeze and damage the condenser or other portions of the fuel cell system.

SUMMARY

[0004] An exemplary condenser system for a fuel cell includes a mixing device configured to receive a first fluid that includes an emulsifier and a second fluid
5 from a fuel cell. The mixing device is configured to introduce some of the second fluid to the first fluid to form a microemulsion.

[0005] An exemplary fuel cell arrangement includes a condenser, a fuel cell, and a fluid path. The fluid path is operative to circulate a fluid between the condenser and the fuel cell. The condenser adds a byproduct of the fuel cell to the fluid.

10 [0006] An exemplary method of removing a byproduct from a fuel cell includes the steps of condensing a fuel cell byproduct to generate a condensate, introducing the condensate to another fluid, and carrying the condensate through the fuel cell using a microemulsion in the fluid.

[0007] The various features and advantages of this disclosure will become
15 apparent to those skilled in the art from the following detailed description. The drawings that accompany the detailed description can be briefly described as follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Figure 1 is a partial schematic illustrating an example system
20 designed according to an embodiment of this invention.

[0009] Figure 2 is a cross-sectional schematic view of a second fluid path of the Figure 1 system.

[0010] Figure 3 is a partial schematic illustrating another example system designed according to an embodiment of this invention.

DETAILED DESCRIPTION

[0011] Referring to Figure 1, an example fuel cell system 10 includes a condenser 14 and a fuel cell stack assembly (CSA) 18. A first fluid path 22 is operative to communicate a fluid byproduct from the CSA 18 to the condenser 14. A second fluid

path 26 is operative to communicate a coolant between the CSA 18 and the condenser 14. A pump 32, or similar pressure increasing device, facilitates communicating the coolant.

[0012] In this example, the fluid byproduct exiting the CSA 18 along the first fluid path 22 is water vapor. The condenser 14 condenses the fluid byproduct in a known manner to provide a condensate. A separator 30 within the condenser 14 separates the condensate from the vapor portions of the fluid byproduct. In this example, the condensate is introduced to the coolant at 34, and the vapor is exhausted from the condenser 14 at 36. Thus the condenser 14 acts as a mixing device that introduces the condensate to the coolant. The example condenser 14 also removes thermal energy from the coolant within the second fluid path 26. That is, the coolant releases thermal energy at the condenser 14.

[0013] The example fuel cell system 10 has a coflow arrangement. That is, the fluid byproduct communicates along the first fluid path 22 from the CSA 18 to the condenser 14 and the coolant moves along a separate fluid path 26 from the CSA 18 to the condenser. In another example, the fuel cell system 10 has a counterflow arrangement, which includes another path (not shown) for communicating fluid, such as air or water, between the CSA 18 and the condenser 14.

[0014] Referring now to the Figure 2 schematic with continuing reference to Figure 1, an example coolant 28 moving within the second fluid path 26 is a water and oil microemulsion. The coolant 28 includes an emulsifier 38 joining an aqueous phase fluid 42 to an oil phase fluid 46. At least some of the aqueous phase fluid 42 is the condensate portion of the fluid byproduct from the separator 30.

[0015] Joining the aqueous phase fluid 42 to the oil phase fluid 46 with the emulsifier 38 forms a swollen micelle 50, which allows the oil phase fluid 46 to carry the aqueous phase fluid 42. The coolant 28 includes droplets of the aqueous phase fluid 42 distributed throughout the oil phase fluid 46 relatively evenly, which limits the ability of the droplets of the aqueous phase fluid 42 to combine and form larger droplets.

[0016] The emulsifier 38 is characterized by its ability to form a microemulsion with the aqueous phase fluid 42 and the oil phase fluid 46.

Microemulsions, which are sometimes referred to as micellar solutions, are typically clear, bright, and transparent, as the swollen micelle 50 is smaller than the wave length of visible light, or less than 0.1 micron in this example. Thus, there is little or no perceivable diffraction of light through the swollen micelle 50. Microemulsions are also
5 characterized by their relatively long term storage stability. That is, microemulsions are often able to maintain a single phase at ambient temperatures, whereas macroemulsions, or other types of emulsions, tend to separate over time at ambient temperatures. Microemulsions are known, and a person skilled in the art with the benefit of this disclosure would understand how to select the emulsifier 38.

10 [0017] The example CSA 18 produces thermal byproducts in addition to the fluid byproduct. Both byproducts exit the CSA 18 as water vapor moving toward the condenser 14 along the first fluid path 22. The condenser 14 condenses the water vapor to generate a condensate 42, a type of aqueous phase fluid 42. The separator 30 within the condenser 14 separates the condensate 42 from the water vapor and mixes the
15 condensate 42 directly into the coolant 28 moving along the second fluid path 26 at 34. The emulsifier 38 within the coolant 28 joins condensate 42, with the oil phase fluid 46. The oil phase fluid 46 carries the condensate 42 from the condenser 14 to the CSA 18. Carrying the condensate 42 away from the condenser 14 prevents the condensate 42 from blocking channels within the condenser 14.

20 [0018] The aqueous phase fluid 42 within the coolant 28 returning to the CSA 18 absorbs thermal byproducts from the CSA 18 and releases them at the condenser 14. In other words, the microemulsion of the coolant 28 facilitates using the byproduct condensate 42 for cooling the CSA 18 to reduce the impact of the thermal byproduct (i.e., heat) in the CSA 18.

25 [0019] After introducing sufficient amounts of the fluid byproduct at 34, the coolant 28 may become saturated. That is, there are insufficient emulsifiers remaining in the coolant 28 that are able to join any additional aqueous phase liquid 42 to the oil phase fluid 46. As known, such saturated solutions develop characteristics of a two phase solution, such as visible separation between the oil phase fluid 46 and the aqueous
30 phase fluid, a cloudier solution, and a higher viscosity.

[0020] The saturation point is also known as the cloud point. In some examples, the cloud point provides a visual cue indicating that the coolant 28 is saturated. Typically, an operator calibrates or adjusts the amount of the fluid byproduct that mixed directly into the second fluid path 26 at 34 to avoid the cloud point. In one example, the operator adjusts the condenser 14 to remove less heat from the water vapor and generate less of the condensate 42. Condensing less condensate 42 provides less condensate 42 for mixing directly into the second fluid path 26. A person skilled in the art and having the benefit of this disclosure would be able to calibrate the fuel cell system 10 to avoid the cloud or saturation point.

[0021] Referring to Figure 3 with continued reference to Figure 2, another example embodiment 100 combines the fluid byproduct or aqueous phase liquid 42 with the coolant 28 apart from the condenser 14 at a mixing device 134. In this example, the condenser 14 receives a mixture of the fluid byproduct (i.e., water vapor) together with the coolant 28 at a single inlet port 54. The example mixing device 134 provides a space to combine the fluid byproduct or aqueous phase liquid 42 apart from the condenser 14.

[0022] After the condenser 14 condenses the fluid byproduct to provide the condensate 42, the separator 30 separates and adds the condensate 42 to the coolant 28. The coolant 28 carries the condensate 42 from the condenser 14 to the CSA 18. The aqueous phase fluid 42 within the coolant 28 returning to the CSA 18 absorbs thermal byproducts to remove them from the CSA 18. The separator 30 exhausts the vapor portions from the condenser 14 at 36.

[0023] Features of this disclosure include removing condensed water from the condenser 14 to limit blocking of channels within the condenser 14. Another feature is simplifying the fuel cell system 10 to reduce the number of condensers within the fuel cell system 10 because a single condenser 14, rather than multiple condensers, is used to remove thermal energy from the water vapor and the coolant 28.

[0024] Although a preferred embodiment has been disclosed, a worker of ordinary skill in this art may recognize that certain modifications are possible and come

within the scope of this disclosure. For that reason, the following claims should be studied to determine the true scope of legal protection coverage.

CLAIMS

We claim:

- 5 1. A mixing device arrangement for a fuel cell, comprising:
a mixing device configured to receive a first fluid that includes an emulsifier and a second fluid from a fuel cell, wherein the condenser is configured to introduce at least a portion of the second fluid to the first fluid to form a microemulsion.
- 10 2. The arrangement of claim 1, wherein the mixing device includes a single inlet port configured to receive the first fluid together with the second fluid.
3. The arrangement of claim 1, including a separator within the mixing device configured to separate a condensate of the second fluid and to introduce the condensate
15 to the first fluid.
4. The arrangement of claim 1, wherein the mixing device is configured to communicate the first fluid to the fuel cell.
- 20 5. The arrangement of claim 1, wherein the second fluid comprises a fuel cell byproduct.
6. The arrangement of claim 5, wherein the fuel cell byproduct comprises water.
- 25 7. The arrangement of claim 1, wherein the mixing device is configured to at least partially condense the second fluid to a condensate and to introduce the condensate to the first fluid.
8. The arrangement of claim 1, wherein the mixing device comprises a condenser.

30

9. A fuel cell arrangement, comprising:

a condenser;

a fuel cell; and

5 a fluid path operative to circulate a fluid between the condenser and the fuel cell, wherein the condenser adds a byproduct of the fuel cell to the fluid.

10. The system of claim 9, wherein the fluid comprises an emulsifier that carries the byproduct of the fuel cell with the fluid to form a microemulsion.

10 11. The system of claim 9, including a second fluid path operative to communicate the byproduct of the fuel cell to the condenser.

12. The system of claim 11, wherein the second fluid path joins the first fluid path outside of the condenser.

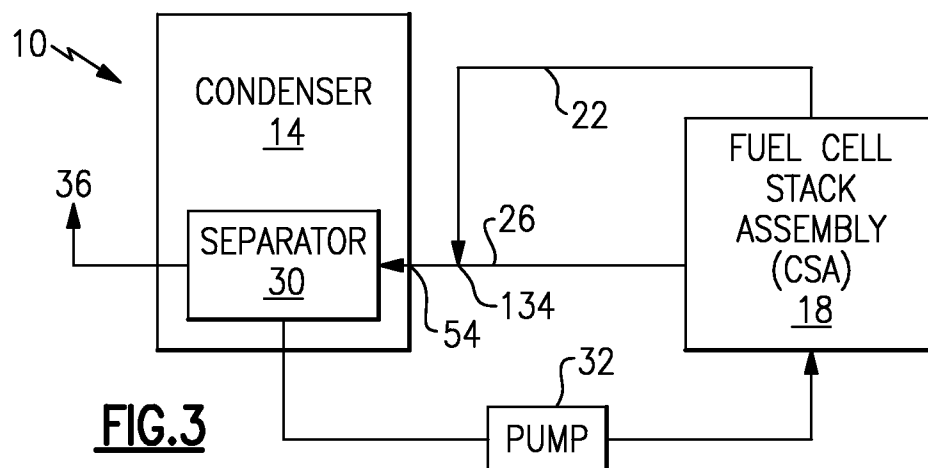
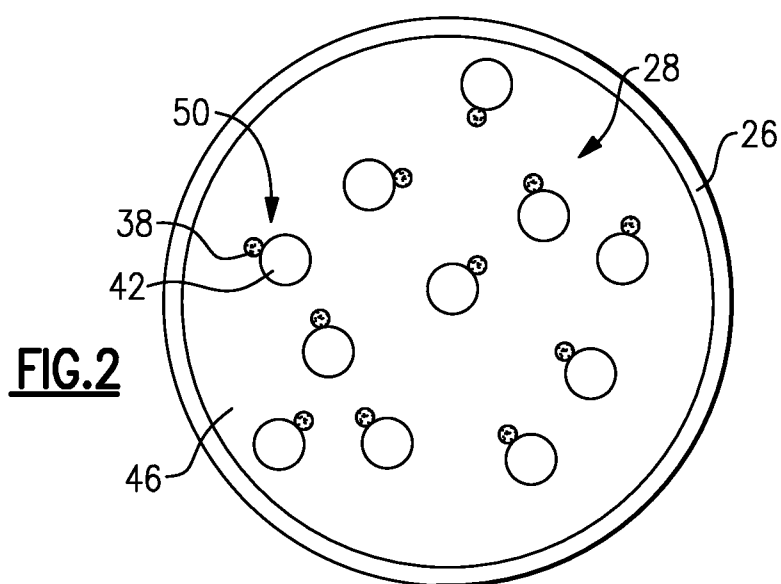
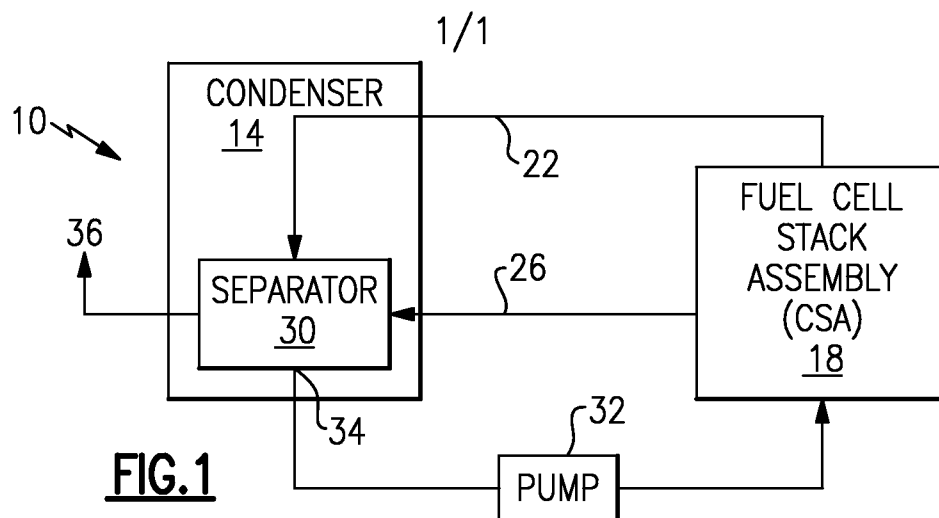
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13. The system of claim 9, wherein the byproduct of the fuel cell comprises water.

14. The system of claim 9, wherein the condenser comprises a separator that separates a liquid phase from a gas phase and removes exhausts the gas phase from the
20 fluid path.

15. The system of claim 9, wherein the byproduct is a condensate.

16. A method of removing a byproduct from a fuel cell, comprising the steps of:
condensing a fuel cell byproduct to generate a condensate;
introducing the condensate to a fluid; and
carrying the condensate through the fuel cell using a microemulsion in
5 the fluid.
17. The method of claim 16, wherein an emulsifier holds the fluid and the condensate to form a microemulsion.
- 10 18. The method of claim 16, including moving the fluid from the fuel cell to a condenser that performs the condensing, the fluid moved together with the fuel cell byproduct and introduced to the condenser at a single inlet port.
- 15 19. The method of claim 16, including absorbing a thermal byproduct of the fuel cell with the condensate.
20. The method of claim 19, including circulating the fluid between the condenser and the fuel cell.



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2009/030810**A. CLASSIFICATION OF SUBJECT MATTER****H01M 8/04(2006.01)i, B01F 5/00(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 9: H01M, H02M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS (KIPO internal) and keywords "mixing device, condenser, fluid, emulsifier, microemulsion, condensate, byproduct, fuel cell, and similar terms"**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2006-0141331 A1 (Reiser et al.) 29 June 2006 See abstract, Figures 2 and 4, paragraphs [0031], and claim 1	9, 13
A	US 2005-0130004 A1 (Blunk et al.) 16 June 2005 See abstract, Figures 1-2, paragraphs [0019] to [0020] and [0028] and [0030] to [0034] and [0041] and [0042] to [0044] and [0048], and claim 1	1-20
A	US 6835480 B2 (Dykeman et al.) 28 December 2004 See abstract, Figure 1, column 5, lines 39-55 and column 6, lines 42-45 and column 6, line 63 to column 7, line 4, and claims 1-13	1-20
A	US 6365291 B1 (Margiott) 02 April 2002 See abstract, Figures 1-2, column 7, lines 3-67 and column 8, lines 39-43 and column 13, line 66 to column 14, line 28, and claims 1, 10	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2009/030810

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