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Hydrogen recirculation blower for fuel cell system

燃料电池发动机用氢气循环泵

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Hydrogen recirculation blower for fuel cell system

1 Scope

This document specifies the technical conditions, test methods, inspection rules and marking, packaging, transportation and storage requirements for hydrogen recirculation blowers for fuel cell systems (hereinafter referred to as hydrogen blowers).

This document applies to Roots-type hydrogen recirculation blowers for automotive fuel cell systems, and other types of hydrogen recirculation blowers can use this as a reference.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

GB/T 755-2019 Rotating electrical machines - Rating and performance

GB/T 2408-2021 Plastics - Determination of burning characteristics - Horizontal and vertical test

GB/T 2423.3-2016 Environmental testing - Part 2: Testing method - Test Cab: Damp heat, steady state

GB/T 2423.4-2008 Environmental testing for electric and electronic products - Part 2: Test method - Test Db: Damp heat, cyclic (12 h + 12 h cycle)

GB/T 2423.18-2021 Environmental testing - Part 2: Test methods - Test Kb: Salt mist, cyclic (sodium chloride solution)

GB/T 2423.22-2012 Environmental testing - Part 2: Test methods - Test N: Change of temperature

GB/T 2423.56-2018 Environmental testing - Part 2: Test methods - Test Fh: Vibration, broadband random and guidance

GB/T 3836.1-2021 Explosive atmospheres - Part 1: Equipment - General requirements

GB/T 4208 Degrees of protection provide by enclosure (IP code)

provisions of the hydrogen blower product technical documents. According to the working status of the hydrogen blower, it is divided into the following three working modes:

a) Working mode 2.1, the hydrogen blower is not activated (such as sleep mode);

b) Working mode 2.2, the hydrogen blower operates at the minimum steady point;

c) Working mode 2.3, the hydrogen blower operates at the rated point.

6 Technical requirements

6.1 General items

6.1.1 Appearance

Visually inspect the appearance of the product. All appearance parts shall not have rust, dents, or scratches on the surface; the coating shall not peel off; the fasteners shall be firmly connected; the lead wires or terminals shall be intact; the color and marking shall be correct; the handwriting and content of the nameplate shall be clear. The high-voltage warning signs shall comply with the product technical documents.

6.1.2 Dimensions and mass

The dimensions and mass of hydrogen blowers shall comply with the product technical documents.

6.2 Working characteristics and mechanical characteristics

6.2.1 Hydrogen blower performance

Test the performance of the hydrogen blower in accordance with the provisions of 7.2.1.3, and draw the working characteristics diagram shown in B.1 of Annex B. The inlet flow, pressure rise, overall efficiency, pump volumetric efficiency, pump insulation efficiency, etc. of the hydrogen blower shall comply with the product technical documents.

Test the performance of the hydrogen blower at rated point in accordance with the provisions of 7.2.1.4. The deviation rate of the rated inlet flow shall not exceed ±5 %.

6.2.2 Ice-breaking start-up

Test the ice-breaking start-up capability of the hydrogen blower in accordance with the provisions of 7.2.2. The time of ice-breaking start-up of the hydrogen blower shall not exceed 15 s.

6.2.3 Dynamic response

Test the dynamic response of the hydrogen blower in accordance with the provisions of 7.2.3. The load-up time of the hydrogen blower shall not exceed 3 s, and the load-down time shall not exceed 2 s.

6.2.4 Start-up and shutdown response

Test the start-up and shutdown response of the hydrogen blower in accordance with the provisions of 7.2.4. The start-up and shutdown response time of the hydrogen blower shall not exceed 1 s.

6.2.5 Noise

Test the overall noise of the hydrogen blower in accordance with the provisions of 7.2.5. The overall noise of the hydrogen blower shall meet the following requirements, or be determined by consensus between the manufacturer and the user:

a) The noise value at the rated point and the dynamic response point specified in 6.2.3 shall not exceed 75 dB(A);

b) The noise value at the minimum steady point shall not exceed 70 dB(A).

6.2.6 Cooling water channel flow resistance characteristics

For the water-cooled parts of the hydrogen blower (such as hydrogen blower as a whole, pump, motor or controller), the cooling water channel flow resistance shall be tested separately in accordance with 7.2.6. The flow resistance of the cooling water channel shall comply with the provisions of the product technical documents, and the deviation rate of the flow resistance shall not exceed ±10 %.

6.2.7 Hydrogen gas circuit sealing

Test the hydrogen gas circuit sealing in accordance with 7.2.7. The leakage of the hydrogen gas circuit shall not exceed 0.1 mL/min.

6.2.8 Cooling water channel sealing

For the water-cooled parts of the hydrogen blower (such as hydrogen blower as a whole, pump, motor or controller), test the cooling water channel sealing in accordance with 7.2.8. The leakage of the cooling water channel shall not exceed 1 mL/min.

6.2.9 Hydrogen gas circuit cleanliness

Test the hydrogen gas circuit cleanliness of the hydrogen blower in accordance with 7.2.9. The hydrogen gas circuit cleanliness shall comply with the following provisions, or be determined by consensus between the manufacturer and the user:

a) The total mass of metal particles with a diameter of 0 μm ~ 200 μm per square meter of hydrogen circuit surface area shall not exceed 40 mg;

The high-voltage operating range of the hydrogen blower at full power shall comply with the provisions of the product technical documents.

6.3.3 Insulation resistance

Test the insulation resistance of the motor and controller in accordance with 7.3.3.

The insulation resistance of the motor and controller shall comply with the provisions of 5.1.4 in GB/T 18488-2024.

6.3.4 Withstand voltage

Test the withstand voltage of the motor and controller in accordance with 7.3.4.

The withstand voltage of the motor and controller shall comply with the provisions of 5.1.5 in GB/T 18488-2024.

6.3.5 Low-voltage input range

Test the low voltage in accordance with 7.3.5.

The low-voltage input range of the controller shall comply with the provisions of 4.2 code C or F in GB/T 28046.2-2019.

6.3.6 Safety grounding inspection

Inspect the grounding characteristics of the motor and controller in accordance with 7.3.6, which shall comply with the provisions of 5.3.1 of GB/T 18488-2024.

6.3.7 Controller protection function

Inspect the controller protection function in accordance with 7.3.7. The controller shall have protection functions for overvoltage, undervoltage, overtemperature, overspeed and communication interruption faults.

6.3.8 Controller support capacitor discharge time

Test the controller support capacitor discharge time in accordance with 7.3.8. The passive discharge time shall not be greater than 5 min, and the active discharge time shall not be greater than 3 s.

6.3.9 High-voltage cable

The high-voltage cable shall have a 360° shielding layer and a heat-resistant temperature of not less than 150 ℃.

6.3.10 Electromagnetic compatibility

Test the electromagnetic compatibility of the hydrogen blower in accordance with 7.3.9, which shall meet the following requirements:

a) For the tests of 7.3.9 a), b), c), and d), the limits of different frequency bands shall comply with the provisions of the hydrogen blower manufacturer;

b) For the tests of 7.3.9 e), f), g), h), i), and j), the functional characteristics of the hydrogen blower during and after the test shall comply with the provisions of the manufacturer.

6.3.11 Rotational speed control accuracy

Test the rotational speed control accuracy of the hydrogen blower in accordance with 7.3.10, which shall be less than 100 r/min or 0.2 % of the maximum rotational speed (whichever is greater).

6.4 Environmental adaptability

6.4.1 General inspection items

After all environmental adaptability tests are completed, the hydrogen blower is restored to normal state and shall meet the following requirements:

a) Visually check that there are no cracks and damage on the outer surface of the hydrogen blower, and the bolts are not loose;

b) The air cavity sealing complies with the provisions of 6.2.7;

c) The cooling water channel sealing complies with the provisions of 6.2.8;

d) The insulation resistance complies with the provisions of 6.3.3;

e) Visually check that there is no leakage of lubricating oil (if any) and coolant (if any);

f) The hydrogen blower can operate stably at rated point for not less than 1 h;

g) Compared with before the start of the test, the rated flow deviation rate measured in f) does not exceed 5 %.

6.4.2 Low-temperature storage

Carry out the low-temperature storage test in accordance with 7.4.1.

The insulation resistance re-measured in the chamber shall comply with the provisions of 6.3.3.

After the test is completed, the hydrogen blower is restored to normal state and shall comply with the provisions of 6.4.1.

Carry out the steady damp heat test in accordance with 7.4.7.

The hydrogen blower shall not have obvious deterioration of the external surface quality and rust that affects normal operation.

After the test is completed, the hydrogen blower shall be restored to normal state and shall comply with the provisions of 6.4.1.

6.4.9 Protection degree

Carry out the waterproof and dustproof test in accordance with 7.4.8.

The protection degree of the hydrogen blower shall meet the protection requirements of IP67 or higher degree specified in GB/T 4208.

After the test is completed, the hydrogen blower shall be restored to normal state and shall comply with the provisions of 6.4.1.

6.4.10 Salt spray test

Carry out the salt spray test in accordance with 7.4.9.

After the test is completed and the normal state is restored, the engraved mark shall be clearly visible and comply with the provisions of 6.4.1.

6.4.11 Random vibration

Carry out the random vibration test in accordance with 7.4.10.

After the test is completed, the hydrogen blower shall be restored to normal state and shall comply with the provisions of 6.4.1.

6.4.12 Mechanical shock

Carry out the mechanical shock test in accordance with 7.4.11.

After the test is completed, the hydrogen blower shall be restored to normal state and shall comply with the provisions of 6.4.1.

6.5 Safety and prohibited substances

6.5.1 High-voltage safety

All high-voltage connectors shall have connection terminals for judging the high-voltage interlocking function and shall meet the safety requirements of 5.1 in GB 18384-2020.

6.5.2 Combustion characteristics

The horizontal combustion performance and vertical combustion performance of the exposed plastic parts in the hydrogen blower shall meet the HB level specified in 8.4 and the V-0 level specified in 9.4 of GB/T 2408-2021 respectively.

6.5.3 Explosion-proof safety

The non-metallic parts of the hydrogen blower enclosure shall comply with the provisions of Clause 7 of GB/T 3836.1-2021 for Class IIC equipment, the metal parts of the enclosure shall comply with the provisions of 8.3 of GB/T 3836.1-2021, and the cable entry device of the hydrogen blower shall comply with the provisions of 16.3 of GB/T 3836.1-2021. The hydrogen blower shall also comply with the manufacturer's other requirements for explosion-proof safety.

6.5.4 Prohibited substances

Test the prohibited substances in accordance with 7.5. Prohibited substances for hydrogen blowers shall meet the requirements of GB/T 30512, and asbestos shall not be detected.

6.6 Durability

6.6.1 Start-shutdown durability

Carry out the start-shutdown cycle durability test of the hydrogen blower in accordance with 7.6.1.

After the test is completed, the hydrogen blower shall be restored to normal state and shall comply with the provisions of 6.4.1. The total mass of impurities in the outlet filter shall be less than 50 mg.

After the test, the components of the hydrogen blower shall be disassembled and confirmed. There shall be no abnormal phenomena such as wear, breakage, deformation, looseness, etc. that affect the function.

6.6.2 Temperature cycle durability

Carry out the temperature cycle durability test in accordance with 7.6.2.

After the test is completed, the hydrogen blower shall be restored to normal state and shall comply with the provisions of 6.4.1. The total mass of impurities in the outlet filter shall be less than 50 mg.

After the test, the components of the hydrogen blower shall be disassembled and confirmed. There shall be no abnormal phenomena such as wear, breakage, deformation, looseness, etc. that affect the function.

6.6.3 Variable load cycle durability

The performance of the hydrogen blower shall be carried out on a special test bench that can adjust the working conditions and measure the corresponding parameters. The test bench shall comply with the provisions of 7.1.

The test medium is hydrogen. According to working mode 2.3, set the inlet pressure and inlet temperature of the hydrogen blower. The pressure deviation shall not exceed ±5 kPa, and the temperature deviation shall not exceed ±5 ℃.

7.2.1.2 Test preparation

Carry out test preparation as follows:

a) Install the hydrogen blower on the test bench, and the installation method shall comply with the provisions of the product technical documents;

b) Set the coolant flow and temperature according to the requirements of the product technical documents;

c) Use nitrogen to purge the gas circuit of the hydrogen blower;

d) Operate the hydrogen blower to working mode 2.3, check that there shall be no gas leakage, liquid leakage, current leakage, etc. at each connection part, and there shall be no abnormal sound during the operation of the hydrogen blower;

e) After the coolant temperature stabilizes, start the test.

7.2.1.3 Working characteristic diagram (map) test

Carry out the hydrogen blower working characteristic diagram test according to the following steps:

a) Fix the hydrogen blower rotational speed, adjust the throttle opening so that the hydrogen blower outlet pressure reaches the set value, and then record the data specified in 7.1.5. During the test, the value of each measuring point shall be stable for at least 3 min after the control parameter reaches the specified value. Each point is measured 5 times, and the average value (or the average value within 1 min after stabilization) is taken when calculating;

b) Gradually change the valve opening, and the hydrogen blower outlet pressure increases from small to large until the upper pressure limit is reached;

c) After completing one rotational speed line, continue to test the next rotational speed line until the map is completed. The rotational speed line shall not be less than 7 and include the minimum rotational speed and rated rotational speed, and the rotational speed interval shall not be greater than 15 % of the maximum rotational speed;

d) After the test is completed, turn off the hydrogen blower and the test bench.

7.2.1.4 Rated point performance test

Carry out the rated point performance test of the hydrogen blower according to the following steps:

a) Fix the rotational speed of the hydrogen blower to the rated rotational speed, and the deviation shall not exceed the provisions of 6.3.11;

b) Adjust the throttle so that the pressure rise is equal to the rated value, and the deviation shall not exceed (-2 kPa, +2 kPa);

c) Make the hydrogen blower operate stably at the rated point for at least 10 min. The inlet flow is the average value of 10 min of stable operation;

d) After the test is completed, turn off the hydrogen blower and the test bench.

7.2.1.5 Data processing

According to the parameters measured in the test, calculate the parameters such as hydrogen blower inlet flow, pressure rise, controller input power, hydrogen blower overall efficiency according to Annex A. Refer to Annex C for data collation, and refer to Annex B for drawing the corresponding hydrogen blower working characteristic diagram.

7.2.2 Ice-breaking start-up

It is allowed to use external heating and other methods included in the product range to achieve ice-breaking start-up.

7.2.2.1 Test preparation

Carry out test preparation as follows:

a) Install the hydrogen blower on the test bench, and the installation method shall comply with the provisions of the product technical documents;

b) Install a humidity sensor at the inlet of the hydrogen blower;

c) The external heating function within the product range can be turned on.

7.2.2.2 Test steps

Carry out the ice-breaking start-up test according to the following steps:

a) Start the hydrogen blower to working mode 2.3 (the inlet pressure, inlet temperature, rotational speed, etc. of the hydrogen blower shall comply with the provisions of working mode 2.3). Pass saturated wet steam into the hydrogen blower inlet, observe the humidity at the hydrogen blower inlet; if the relative

e) Rapidly reduce the load of the hydrogen blower until it reaches the rotational speed corresponding to working mode 2.2, and continuously record the corresponding parameters of the hydrogen blower.

7.2.3.3 Data processing

Issue the start command according to 7.2.3.2 c), and the time it takes for the hydrogen blower rotational speed to reach the set rotational speed is taken as the load-up time of the hydrogen blower.

Issue the start command according to 7.2.3.2 e), and the time it takes for the hydrogen blower rotational speed to reach the set rotational speed is taken as the load-down time of the hydrogen blower.

NOTE: The calculation of dynamic response selects the difference between the time before the rotational speed reaches stability after overshoot and the time when the command is issued.

7.2.4 Start-up and shutdown response

7.2.4.1 Test preparation

Carry out test preparation as follows:

a) Install the hydrogen blower on the test bench, and the installation method shall comply with the provisions of the product technical documents;

b) Set the coolant flow and temperature according to the requirements of the product technical documents.

7.2.4.2 Test steps

Carry out the start-up and shutdown response test according to the following steps:

a) After the coolant temperature stabilizes, the hydrogen blower is stabilized in working mode 2.2 for 5 min, then the throttle opening is fixed and the blower is shut down;

b) The test bench sends a start command to the hydrogen blower and loads it to working mode 2.2, and continuously record the corresponding parameters of the hydrogen blower;

c) After the hydrogen blower stabilizes in working mode 2.2, the test bench sends a shutdown command to the hydrogen blower, and continuously record the corresponding parameters of the hydrogen blower.

7.2.4.3 Data processing

The time from issuing the start command according to 7.2.4.2 b) to the hydrogen blower reaching the set rotational speed is taken as the start-up time of the hydrogen blower.

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