Wind hydrogen system

Task and equipment

Information for teachers

Additional information

Similarly to solar energy, wind energy is a regenerative form of energy. It differs in that it has been used by man for centuries, for example, in windmills, in which it is converted to mechanical energy. In recent times, wind power plants have been brought to use for the generation of electric energy. As with solar energy, however, such plants cannot produce it for use when it is required, as generation is wind-dependent. This makes energy storage necessary. A present possibility for this is to convert the energy to hydrogen. The total process is then as follows. The wind energy generates a voltage by means of a generator and the voltage then used to decompose water to hydrogen and oxygen. These can be relatively easily stored and can be converted back to electric energy and water by a fuel cell when energy is required.

Notes on the set up and procedure

The electrolyser and the fuel cell are differentiated by colour marking. The electrolyser is blue, the fuel cell is red.
The maximum permissible values for the electrolyser are 2 V for the voltage and 2 A for the amperage.
Take care that both openings on each side of the electrolyser and the fuel cell are each connected with a piece of tubing again at the end of the experiment, so that the membrane does not dry out. Refer here to Fig. 1 in Set-up.

The values determined in this experiment could vary according to the working accuracy and the dryness or moistness of the equipment, but a meaningful evaluation should always be possible.

It must also be observed that, in contrast to experiment 1, the power supply is on with the pinchcocks open in the first part of experiment 2. This is the only difference between the two experiments. It is to enable the advantages and disadvantages of each possibility to be worked out.

Caution:
Never apply voltage to the fuel cell, as this would then be destroyed.
Use exclusively distilled water in experiments with the electrolyser and fuel cell as otherwise they will be damaged beyond repair.

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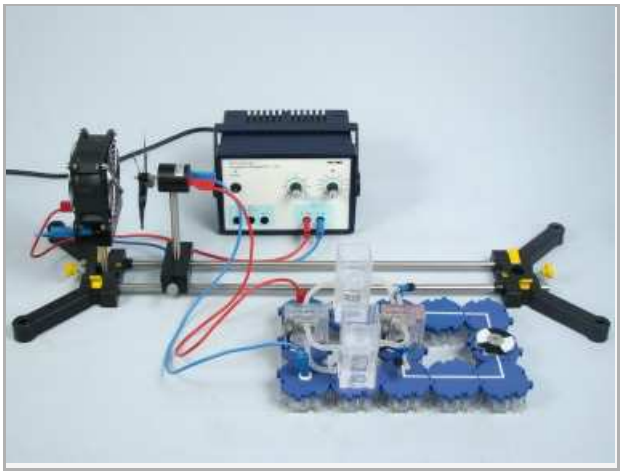
Task

In this experiment, the hydrogen system is to be driven by wind energy.

An examination is to be made on to which extent the hydrogen generated can be used to supply the fuel cell and drive the connected motor.



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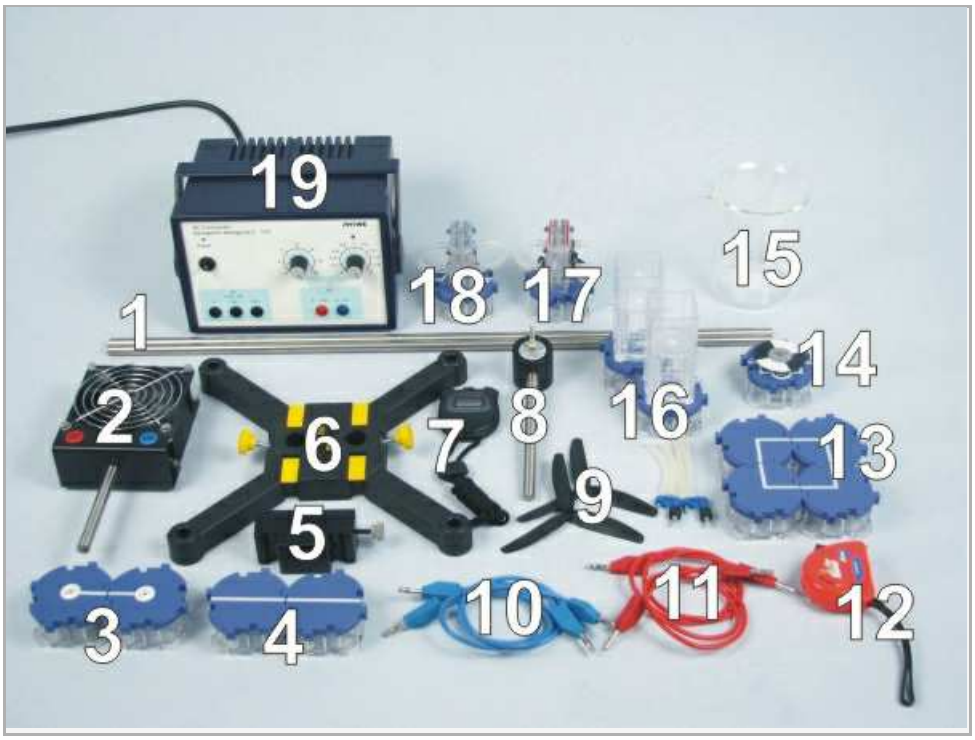
Equipment



Position No.	Material	Order No.	Quantity
1	Support rod, stainless steel, l = 600 mm, d = 10 mm	02037-00	2
2	Blower, 12V	05750-00	1
3	Junction module, SB	05601-10	2
4	Straight connector module, SB	05601-01	1
5	Slide mount for optical bench	09822-00	1
6	Support base, variable	02001-00	1
7	Digital stop watch, 24 h, 1/100 s & 1 s	24025-00	1
8	Generator with metrical thread axis and nut	05751-01	1
9	Rotor, 2 pieces	05752-01	1
10	Connecting cord, 32 A, 500 mm, blue	07361-04	2
11	Connecting cord, 32 A, 500 mm, red	07361-01	2
12	Measuring tape, l = 2 m	09936-00	1
13	Angled connector module, SB	05601-02	4
14	Motor with indicating disc, SB	05660-00	1
15	Glass beaker DURAN®, short, 400 ml	36014-00	1
16	Gas storage, SB, incl. tubes and plugs	05663-00	2
17	PEM fuel cell for hydrogen/ oxygen operation and	05661-00	1
18	PEM electrolyser, SB	05662-00	1
19	PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13505-93	1
Additional material			
	Distilled water		
	Protective glasses		

Set-up and procedure

Set-up



H: 220 / 270
P: 210 / 220

- Oxygen is a colourless, odourless and tasteless fire-promoting gas. It is a fire hazard on contact with combustible materials.
- Hydrogen is a colourless, odourless and tasteless combustible gas which easily forms explosive mixtures with air. All sources of ignition must therefore be removed prior to starting experiments which involve hydrogen.
- Wear protective glasses.

Setup

Use the variable support base and the two support rods to set up a rail support (Figs. 1 and 2).

Fig. 1

Fig. 2

Fix the blower so in the left part of the support base that the side with the sockets points away from the rail support (Fig. 3).

Fig. 3

Plug the two rotors on the axle of the generator one after the other (Fig. 4).
The 6 vanes should now be equally distanced from each other and the writing should be readable from the front (Fig. 5).

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Fig. 4

Fig. 5

Fit the generator in the slide mount and position it so on the rail support that the distance between generator and blower is 3 cm (Fig. 6).

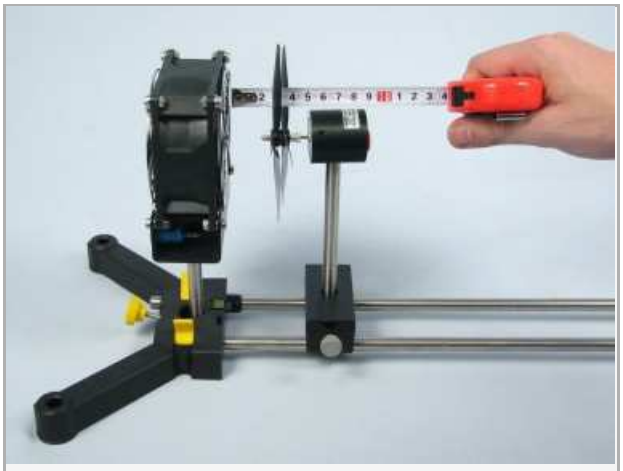

Fig. 6

Connect the blower to the direct voltage output of the power supply (Fig. 7).
The power supply is still switched-off.

Fig. 7

Plug the two junction modules, the two gas storages and the blue-marked PEM electrolyser together as shown in Fig. 8.

Fig. 8

Connect both gas storages to the PEM electrolyser, each with two pieces of tubing. Connect pieces of tubing also to the free ends of each of the gas storages and close both of them with pinchcocks (Fig. 9).

Fig. 9

Plug the fuel cell, motor and connecting modules together as shown in Fig. 10.
Pay attention to polarity. Connect the positive side of the motor to the positive side of the fuel cell.

Fig. 10

Now connect the two components as shown in Fig. 11.
Take care again here that the fuel cell, electrolyser and motor have the same polarity on the left side, and the same polarity on the right side.

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Fig. 11

Have about 250 ml of distilled water filled into your 400 ml glass beaker.
Use this water to fill each of the gas storages up to the lower mark from above (Fig. 12).

Caution: Use only distilled water.

Fig. 12

Open the pinchcocks while holding the free end of the tubing high up, so that water flows down into storage without spillage of water (Fig. 13).

Fig. 13

Clamp the tubing tight again and connect the free ends of it to the fuel cell (Fig. 14).
The two additional pieces of tubing are intended to prevent any water that possibly emerges from reaching the contacts.

Fig. 14

Connect the two junction modules to the connecting sockets of the rotor with the polarity: Red is the positive pole, blue is the negative pole (Fig. 15).

Fig. 15

The experimental set-up should now be as shown in Fig. 16.

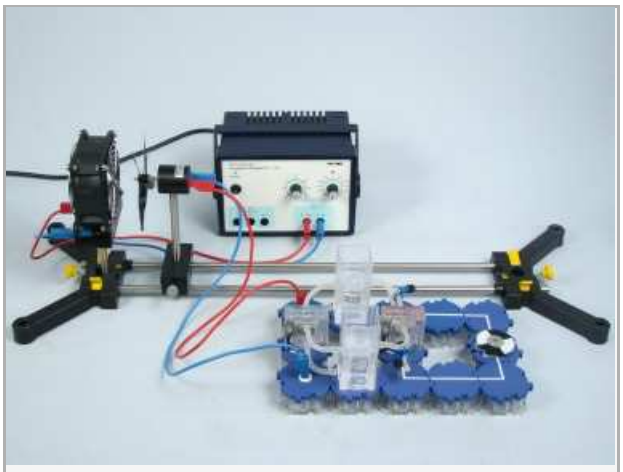

Fig. 16

Procedure

Experiment 1

Note the filling level in each gas storage prior to the start under Result - Observations 1.
Switch the power supply on and start the stop watch (Fig. 17).

Fig. 17

Switch the power supply off after 5 minutes and note the filling level in each gas storage under Result - Observations 2.

Open the pinchcock on the oxygen side of the fuel cell (take notice of the marking of the fuel cell and the electrolyser).
Determine the length of time over which the motor runs when you now open the pinchcock on the hydrogen side.
Note this time under Result - Observations 3.

Experiment 2

Switch the power supply on again and start the stop watch with the pinchcocks still open.
Observe the behaviour of the motor for 5 minutes and note your observations under Result - Observation 4 and describe what happened in the electrolyser and the two gas storages in this same time period under Result - Observations 5.

Switch the power supply off after these 5 minutes and observe if the motor runs and, if so, for how long. Note your results under Result - Observations 6.

Emptying gas storage:
With the power supply switched off, remove the cable, connecting modules and fuel cell with motor. Make sure that the pinchcocks are closed and then grip the two gas storages, one in each hand. Do not remove the electrolyser. Lift up one gas storage above the beaker and tip the contents out over one corner into the beaker (Fig. 18).

Fig. 18

Proceed in exactly the same way with the second gas storage.

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Report: Wind hydrogen system

Result - Observations 1

How much gas was in the gas storages to start with?

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Result - Observations 2

How much gas was in each of the gas storages after 5 minutes?

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Result - Observations 3

How long did the motor run after you opened the pinchcock on the hydrogen storage tubing?

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Result - Observations 4

How did the motor behave during the 5 minutes that the pinchcock was open?

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Result - Observations 5

What could be seen in the electrolyser and the gas storage during the 5 minutes?

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Result - Observations 6

Did the motor still run? If yes, for how long?

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Evaluation - Question 1

How much gas was produced in 5 minutes and why was such a reading not possible the second time?

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Evaluation - Question 2

How can it be explained that with open pinchcocks the motor does start to run somewhat later but not immediately?

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Evaluation - Question 3

Why does the motor run longer when the pinchcocks are open than when they are closed after the power supply has been switched off?

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Evaluation - Question 4

Which properties from experiments 1 and 2 are meaningful for actual usage and which are not?

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Evaluation - Question 5

Which advantages and disadvantages are offered by wind energy compared to solar energy?

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Evaluation - Supplementary problem 1

Which forms of regenerative energy are there and what are original energy sources?

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