Development of hydrogen energy heater using nano catalyst

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1. Introduction

The Hokkaido Eastern Iburi Earthquake on September 6, 2018 caused a blackout in the whole of Hokkaido, caused by the shutdown of 3 units of the Hokkaido Electric Power Company's Toma-Atsuma Thermal Power Plant, which at that time generated half of the power in Hokkaido. Other power plants also stopped automatically to protect the power generation facilities, which triggered a power outage in Hokkaido as a whole.

Hokkaido Electric Power is on a fairly small scale. It is split among the 10 electric power companies, and it is difficult to supply electric power from other companies, due to the location of the island of Hokkaido. It can be said that Hokkaido's electric power supply is virtually isolated during a crisis. And it can be said there is an urgent need for countermeasures due to the power generation situation in Hokkaido, and new hydrogen energy might be one of the promising countermeasures.

New hydrogen energy is the energy produced by a nuclear fusion reaction. It is a deuterium fusion reaction produced by the catalytic action of metals.

The principle of the fusion reaction is shown in Fig. 1. In this fusion reaction, when two nuclei (deuterium and tritium in the figure) are close enough, the attractive force acting between the nuclei overcomes the repulsive force. To produce new atomic nuclei (helium). This is called a fusion reaction. At this time, energy and a small number of neutrons are generated [(2)].

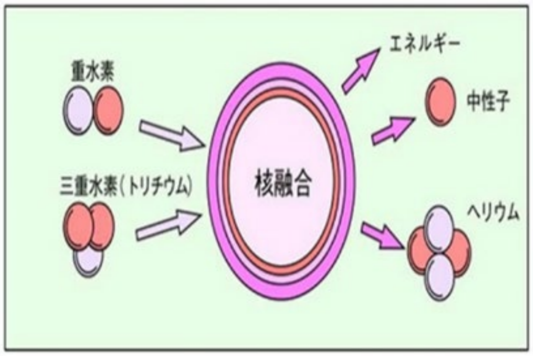

Figure 1. Principle of nuclear fusion. (Deuterium and tritium are shown undergoing fusion to produce energy, neutrons and helium.)

In the present study, by using this new hydrogen energy from fusion, we hope to confirm a new power generation method that may replace conventional power generation methods, such as thermal power, hydropower, nuclear power, wind power, and solar power generation. The purpose is to obtain an input/output ratio of energy two times or more higher than input.

2. Experimental equipment and method

Figure 2 shows a schematic of the experimental equipment. This research project started this year with the installation of equipment and the preparation of the experimental samples. With this method, excess heat is generated by a deuterium gas fusion reaction with metal. This occurs inside a reactor, which is placed inside an insulated box. The reaction is measured with air-flow calorimetry. A blower is installed on the upper part of the box which discharges the heated air. The air temperature is measured with a thermocouple, and the total amount of heat in the discharged air is calculated. The input/output ratio is calculated by comparing input power with the quantity of heat.

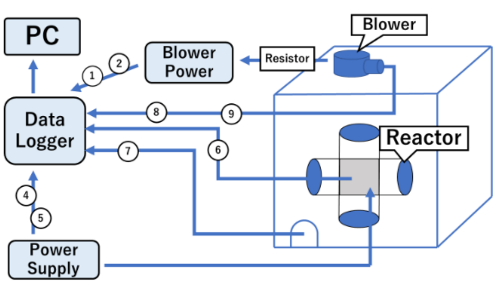

Figure 2. Schematic of equipment.

The reactor chamber is shown on the right, and the control system and measurement system are shown on the left. Shown from the lower left is the power supply, the data logger which is interfaced to personal computer for data collection. A Pirani vacuum gauge was used to measure the pressure inside the chamber.

The surface temperature of the reactor was measured at one location in the center of the reactor cylinder. Since the temperature of the reactor body varies from one place to another, the central part where the temperature is likely to be highest was selected. In addition to the temperature, the blower voltage, current, and chamber heating power were also measured. Input voltage, current, data at one air inlet center and outlet temperature were measured every 5 to 30 seconds, and the thermal power was calculated. The numbers ① to ⑨ in Fig. 2 correspond to the data channels ① to ⑤ in Table 1, and ⑥ to ⑨ in Table 2. The data logger settings are shown in Tables 1 and 2. Note that ① and ② are the current and voltage controlling the blower.

Table 1. Data logger channels ① to ⑤, input power.

Channel	①	②	③	④	⑤
Unit	V	A	Ω	V	A
Meaning	Blower voltage	Blower Amperage	Resistance	Input Voltage	Input amperage

Table 2. Data logger channels ⑥ to ⑨, temperatures.

Channel	⑥	⑦	⑧	⑨
Unit	°C	°C	°C	°C
Meaning	Reactor surface	Inlet	Outlet	Reactor body

In order to capture the heat radiated from the reactor, it is placed in an insulated box, which is shown in Fig. 3. The base of the box is 700 mm × 500 mm, and the height is 700 mm. It is made of acrylic plastic. There is a circular hole 50 mm diameter at the bottom side, and another at the center of the top of the box. The inner surface of the box is insulated with a 10 mm thick layer of Styrofoam covered aluminum foil.

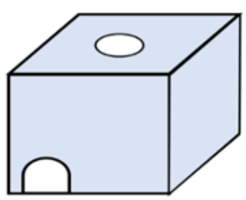

Figure 3. Schematic of insulated box.

However, this insulation cannot completely contain the heat. Therefore, the experiment is conducted by calibrating with a resistance heater (a calibration heater) which is stepped through different power levels. The calibration heater is placed in box in the same environment as the reactor. As a result, the amount of heat dissipated from the adiabatic box is obtained from the input/output measurement of the calibration heater, and the accuracy of the data is improved with a correction factor based on this ratio.

Figure 4 shows that the air outlet of the blower is attached to a plastic pipe with a round cross section, which is 200 to 300 mm long. The blower outlet is square, which complicates the measurement of the air flow rate, so the air is channeled into the circular pipe to simplify the calculation.

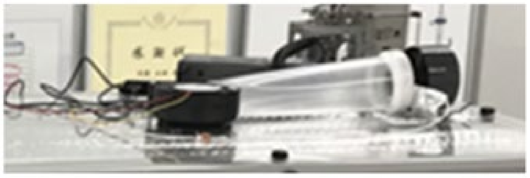

Figure 4. Blower.

Using the input values from Table 1 and Table 2, heat is calculated from the temperature and air volume measured at the air outlet.

Input power to the blower in watts (W) is sent to the data logger

The values in columns ① and ② are obtained from resistors and used in equation (1).

$$Blower_{input}\ (\mathrm{W}) = ((①\times ②)-(②)^2/3 \quad (1)$$

Where "①" means spreadsheet column 1, blower voltage.

The pressure N_p (Pa) of the gas in the reactor is expressed by equation (2) using the value in the data logger and the conversion coefficient 1330 of the output voltage.

$$Np = (③) \times 1330 \quad (2)$$

The input value W_{in} (W) to the reactor body is expressed by Eq. (3) using the voltage and current values in columns ④ and ⑤ and the conversion factor 32 for the current and voltage output of the power source.

$$Win = (④ \times ⑤) \times 32 \quad (3)$$

The temperature difference T (in degrees Celsius) between the blower outlet and the box inlet temperature is expressed by Eq. (4) by subtracting the change in the air temperature coming out of the blower, that is, the temperature difference between the air inlet (column ⑦) and outlet (⑧).

$$T = ((⑧)-(⑦)-(-0.31 \times \exp(-(\text{Blower Input})/1.83))-0.3755) \quad (4)$$

The constant pressure air specific heat Hc (J/°C) is expressed by Eq. (5) using the air temperature from the blower outlet and column ⑧.

$$Hc = 987 + 0.066 \times (⑧) \quad (5)$$

Equation (6) shows the weight of air per second (kg/s), which is obtained from volume of air computed from the wind speed at the blower outlet.

$$\text{Air weight} = (⑰) \times 0.0035 * (3.5 \times \exp(-((⑧) + 273.2)/201.3) + 0.415) \quad (6)$$

The thermal energy W_{out} (W) from the air outlet is expressed by Eq. (7) using the temperature difference ΔT between the box inlet and the blower outlet, the constant pressure air specific heat H_c, and the weight of air.

$$W_{out} = \text{Outlet-inlet temperature} \times \text{Specific heat of air} \times \text{Weight of air} \quad (7)$$

The heat generation W_{out} taking into account the heat recovery rate is expressed in Eq. (8), using an approximate value for the heat recovery rate.

$$W_{out}(\text{corrected}) = (W_{out})/(0.98 - 5.0811 \times 10^{-4} \times (⑨)) \quad (8)$$

3. Experimental results and discussion

3.1. Study of excess heat due to deuterium

The input/output ratio values when the reactor was heated stepwise from 72 W to 1000 W were measured, and the total output was calculated from the calibration. That is to say, by adding the amount of heat dissipated estimated by comparing measured heat losses above 750 W measured with the calibration heater. The relationship between the amount of heating and the input/output ratio of the reactor is shown in Fig. 5. As shown in Fig. 5, excess heat was confirmed at all input power levels. At 345 W to 750 W, excess heat over 40% was recorded. The variations in the temperature indicate that under these conditions it is difficult to control the temperature.

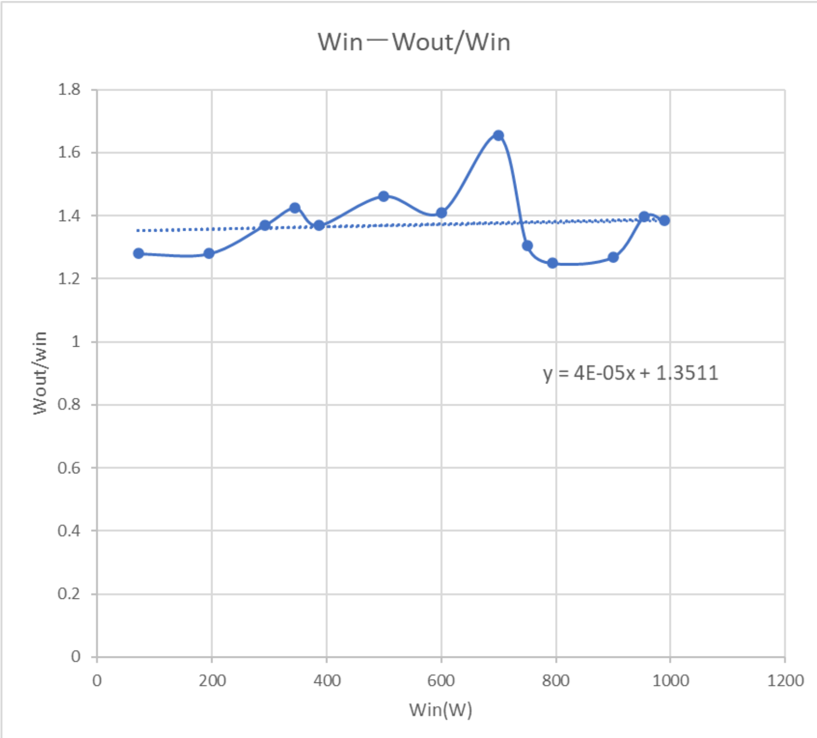

Figure 5. Relationship between the amount of reactor heating and the input/output ratio.

With the current experimental equipment, in measurements up to 1000 W, we observed definite excess heat, albeit with a rough trend with a great deal of variation. If we increase input power, we can predict from the trend so far with this method that it will be difficult to produce an input/output ratio of 2 or more.

We think the first future task should be to find the optimum concentration of deuterium from the viewpoint of quantum mechanics by controlling the gradient of heat generation, and keeping it high.

Second, a single layer of Ni is laid inside the chamber as a Nano metal catalyst, but we will consider increasing this to two layers, to increase the reaction probability.

Third, we try a different metal than the catalyst currently used to examine whether there is a more efficient metal.

Fourth, deuterium is generally not widely available, and it will take some time to obtain it. It has been confirmed that a similar reaction occurs with hydrogen, but in the current chamber, deuterium has been used. Since the deuterium has soaked into the reactor walls, it is not possible to perform experiments with pure hydrogen alone. Therefore, we need prepare a new reactor. We might grind away a layer of the inside of the existing chamber. However, it is not clear how much deuterium was absorbed, and there is uncertainty about whether this might reduce the margin of safety somewhat, so it is better to prepare a new reactor.

3.2. Measurement of radiation dose

Table 6 shows the unit conversion based on the radiation dose in the laboratory on the day of the experiment and the value written in the Sapporo Shimbun newspaper. Table 7 shows the average monthly radiation dose. The figures in Table 6 shown in red represent radiation doses that were higher, either in reactor, or higher ambient doses. As can be seen in Table 7, the radiation level in Sapporo is nearly the same all year around. The normal value reported in the Hokkaido Shimbun is 0.17 ~ 0.91 mSv/y (the units have been converted into milliSievert per year). Based on these two facts, we conclude there may be very slight radiation but it is too small to affect the human body. Although it cannot be ignored, as long as it is observed when this experiment is performed, it is considered so low that experiment can be safely performed. However, in the future, it will be necessary to closely cooperate with external institutions to ensure safety. To be specific regarding radiation, we will continue to use Dosimetry badges Chiyoda Techno Co., Ltd. These badges are clipped to the shirt, and they measure the amount of radiation the body is exposed to.

4. Conclusion

As a result of this experiment, we conclude that the equipment did produce excess heat. Although the target energy input/output ratio of 2 was not reached, we conclude that it is theoretically possible to reach this ratio.

Acknowledgment

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References

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(2) In search of fusion energy (1) -Fundamental basics of fusion: http://www.fusion.qst.go.jp/reading5/pamphlet/PDF/shousasshi-1.pdf

(3) Hokkaido Shimbun

Table 6 Comparison of radiation dose between the laboratory and Sapporo (3) (mSv/y)

Date	chamber	Sapporo city
Oct. 16	0.25	0.31
Oct. 17	0.30	0.40
Oct. 18	0.32	0.32
Oct. 21	0.26	0.32
Oct. 23	0.38	0.31
Oct. 24	0.34	0.32
Oct. 25	0.29	0.31
Oct. 28	0.33	0.31
Oct. 29	0.29	0.32
Oct. 30	0.32	0.38

Table 7 Comparison of average monthly radiation dose (mSv/y)

	October	November	December
Chamber	0.31	0.36	0.34
Sapporo	0.30	0.35	0.32