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Research Article

Excess Heat Triggered by Different Current in a D/Pd Gas-loading System

Jian Tian*, Bingjun Shen, Lihong Jin, Xinle Zhao and Hongyu Wang

Clean Energy Technology Lab, Changchun University of Science and Technology, Changchun 130022, People's Republic of China

Xin Lu

School of Science, Changchun University, Changchun 130022, People's Republic of China

Abstract

In order to study the relationship between the triggering current, deuterium pressure and the excess heat, a series of experiments were made in a D/Pd gas-loading system. By comparing the system constants ($k = \Delta T/\Delta P$) in both nitrogen and deuterium atmosphere we found an optimum current (8 A) and a deuterium pressure (9×10^4 Pa) in which the system could release a maximum excess power (more than 80 W). The reproducibility was 16/16 and the excess energy released in the longest experiment was about 300 MJ within 40 days, which was corresponding to 10^4 eV for each palladium atom. Analysis of the palladium surface with a scanning electron microscopy (SEM) and an energy dispersive spectrometer (EDS) revealed that some new surface topographical feature with concentrations of unexpected elements (such as Ag, Sn, Pb and Ca) appeared after the current triggering. The results implied that the excess heat might come from a nuclear transmutation.
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Keywords: Current triggering, Deuterium pressure, D/Pd gas-loading system, Excess heat

1. Introduction

Focardi et al. [1] reported on the existence of a large excess heat production observed in a H/Ni gas-loading system. Rossi [2] developed the method and enlarged the phenomenon into 1 MW power generation device afterwards. In recent days some reported their new achievements in this field and many had skeptics on the demonstration reactor [3–8]. With a curiosity to that event a D/Pd gas-loading system was chosen and a series of similar experiments were made in order to prove if the evidence could be true and if the excess heat could be also occurred in other different system.

*E-mail: tian2281@126.com; tianjian@cust.edu.cn

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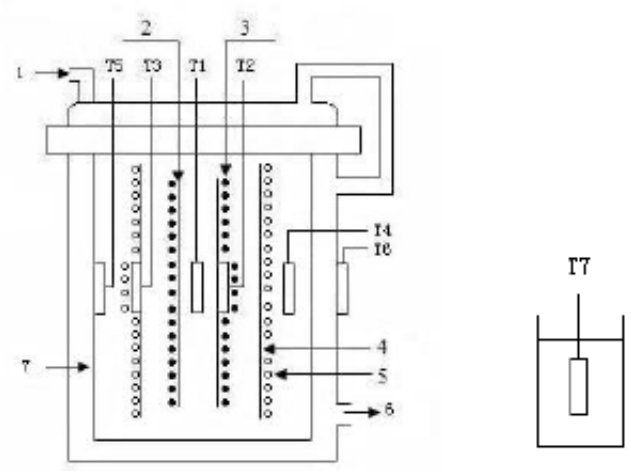


Figure 1. The chamber structure. Here 1 is the inlet of circulating water, 2,4 the ceramic tubes, 3 the Pd wire for triggering, 5 the Pd wire for being triggered, 6 the outlet of circulating water, 7 the double-jacket, the $T_1 - T_7$ Pt100 resistor thermometers were used for taking the temperatures in different positions, T_1 the center of the chamber inside the ceramic tube, T_2 wound on triggering Pd wire, T_3 wound on being triggered Pd wire, T_4 inside the chamber between inner wall and outer wall of the ceramic tube, T_5 inner wall of the chamber, T_6 outside wall of the chamber and T_7 ambient temperature.

2. Experimental

2.1. Materials and apparatus

Figures 1 and 2 show the schematic of the experimental system. Figure 1 is a reaction chamber that made up of stainless steel with a double-jacket structure, where the circulating water could flow through. It has internal dimension of diameter = 100 mm and hight = 240 mm with a useful capacity of about 1.9 L. Two Pd wires were 99.98% in purity (made by General Research Institute of Nonferrous Metals, Beijing), one of them was for being triggered with the dimension of 0.5 mm in diameter and 210 cm in length ($V = 4.1 \times 10^{-1}$ cm^3) . And the other was for triggering with the same size in diameter and 400 cm in length ($V = 7.854 \times 10^{-1}$ cm^3). In order to monitor the temperature at different positions continuously, Seven Pt100 resistor thermometers were placed inside and outside the reaction chamber. The chamber structure as shown in Fig. 1,

The apparatus connected to the reaction chamber is shown as in Fig. 2,

2.2. Calibration

Two palladium wires for triggering and being triggered were placed, respectively, in the reaction chamber. At the beginning some natural nitrogen gas was introduced into the chamber by four steps of $P_{N_2} = 20$, 1×10^4, 5×10^4 and 9×10^4 Pa. In each step, an initial current of 1 A and at a regular increase ($\Delta I = 1$ A) were passed through the triggering Pd wire. The maximum current was 8 A. Then the relation between the temperature increases and different input power was obtained. The same process was done exactly when the nitrogen was replaced by deuterium. The promising result was occurred in $P_{N_2/D_2} = 9 \times 10^4$ Pa and calibration were shown in Figs. 3 and 4.

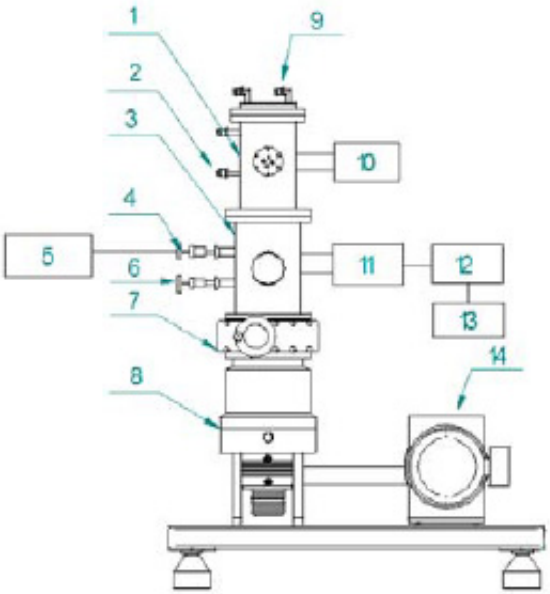


Figure 2. The apparatus connected to the reaction chamber. Here 1 is the chamber, 2 the inlet and outlet for circulation water around the chamber, 3 the transition chamber, 4 the D_2 needle valve, 5 the D_2 generator, 6 the air-released valve, 7 the gate valve, 8 the turbo-molecular pump, 9 the inlet and outlet mouth for water circulation on the top, 10 the DC power supply, 11 the vacuum gauge, 12 the Keithley 2700 multifunction date-inquisition meter, 13 a computer for data recording and controlling, 14 the mechanical pump.

2.3. Current triggering

From the data, the correlation between input power and $k = \Delta T/\Delta P$ [3] on being triggered Pd wire in N_2 and D_2 were fitted. The fitting curves were as shown as in Fig. 4. From this we can see that the value of k in N_2 atmosphere was

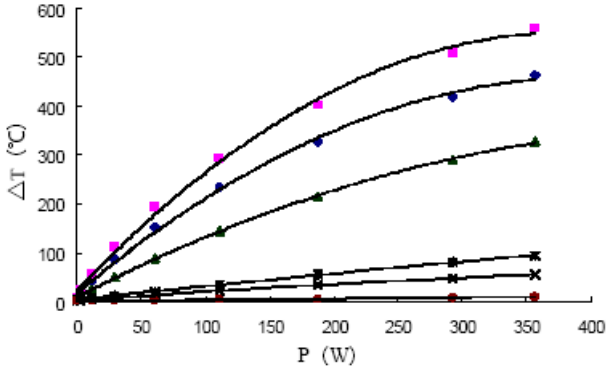


Figure 3. Calibration curves: temperature (relative to the T_7) vs. power under N_2 environment at 9×10^4 Pa. (T_1( ), T_2( ), T_3(N), T_4(×),T_5( ) and T_6(●)).

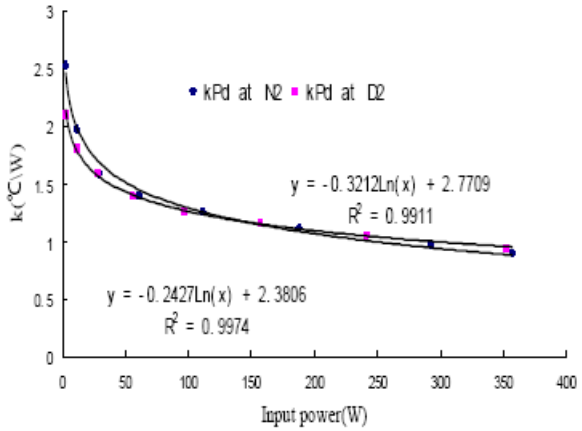


Figure 4. The fitting curve of input power and k under N2( ),D2( ) environment at 9×10^4 Pa.

higher than that in the D_2 when input power was less than 150 W. But when the input power was more than 150 W, the value of k in D_2 was higher than that in the N_2 at high temperature. And with the input power is increasing, the difference between k in D_2 and k in N_2 became larger. However, taking into account the specific circumstances of laboratory equipment and the palladium wire, the triggering current of 8.0 A and $P_{D_2} = 9 \times 10^4$Pa were chosen in the whole experiment. The triggering result is shown in Fig. 5.

The drawing in Fig. 5 is only the first four times' triggering in our experiment. The total was as many as 16 times.

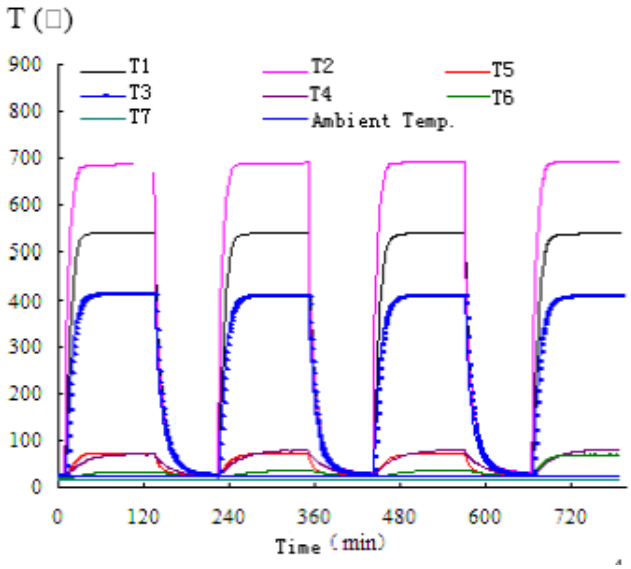


Figure 5. Current triggering results at 8 A in $P_{D_2} = 9 \times 10^4$Pa.

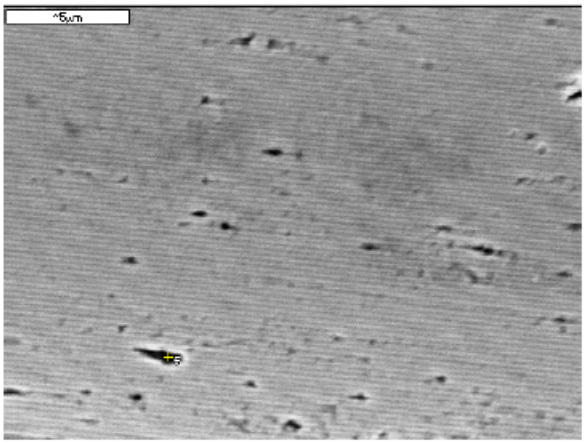


Figure 6. SEM of palladium wire before triggering (400×).

There were 80–90 W excess power in these experiments. The longest one was lasted for 40 days. It looked like the experiment could keep going on as long as possible.

3. Results and Discussion

3.1. Calculation for excess heat

The main purpose of this experiment was to investigate whether the excess heat could also appear in D/Pd gas-loading system by current triggering as in Focardi's H/Ni system. The next was whether the excess energy obtained in the system could be higher than chemical heat triggered by different electric current when deuterium atoms were charged into metal

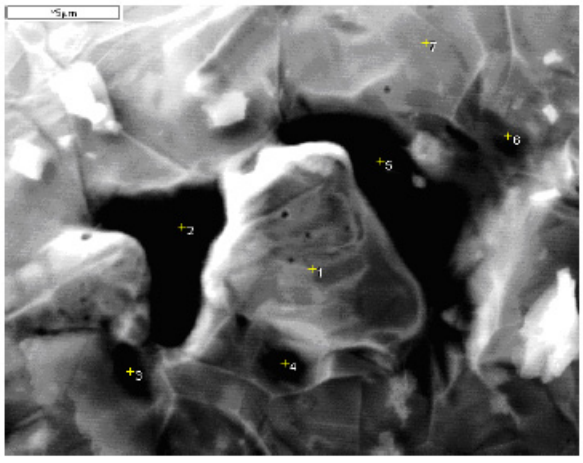


Figure 7. SEM of palladium wire after triggering (400×).

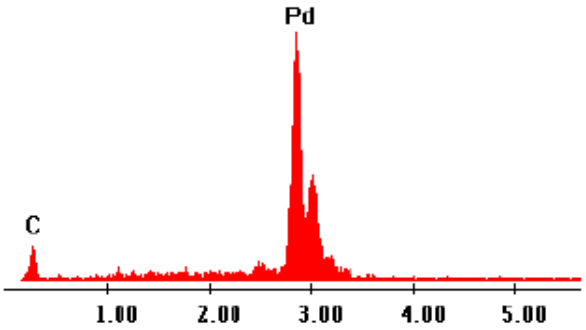


Figure 8. EDS of Pd origin sample before triggering.

palladium lattice. Let P_{i} be the electrical power supplied into the reaction chamber. At the thermal equilibrium the difference between the T_6 and T_7 could be measured. If k is the system heat equilibrium constant, which was determined by the rise of temperature with a unit power input into the system, the following relation must be verified:

$$P\mathrm{i} = k(\mathrm{T}_6 - \mathrm{T}_7). \tag{1}$$

If some kind of physical–chemical process occur into the system and palladium wire is the related enthalpy variation, the following relation holds:

$$P\mathrm{i} + \sum_{i=1}^{n} \frac{\mathrm{d}Hi}{\mathrm{d}t} = C\frac{\mathrm{dT}_5}{\mathrm{d}t} + k(\mathrm{T}_6 - \mathrm{T}_7), \tag{2}$$

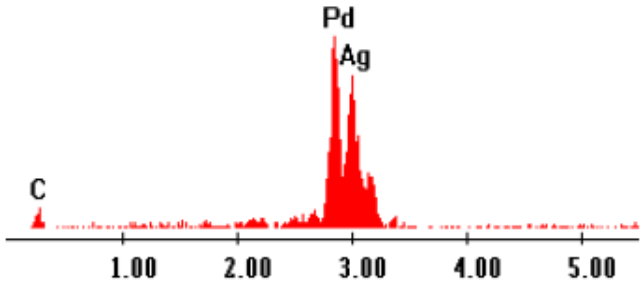
where C is the heat capacity. Equation (2) is valid if the characteristic times of the heat exchanges inside the reaction chamber are shorter than $\tau c = C/k$ (chamber time constant). If all the physical–chemical processes last for a limited period before stopping, Eq. (2) reduces to Eq. (1). In the case for which one process excess heat power (P_{o}) does not stop and $P_{\mathrm{o}} = \mathrm{d}Hi/\mathrm{d}t \rightarrow$ constant, on assuming quasi-stationary conditions, that is, the temperatures of the chamber remain practically constant during a few chamber time constants. The excess heat power can be calculated by using Eq. (3).

$$P_{\mathrm{o}} = P_{\mathrm{i}} - \frac{\mathrm{T}_6 - \mathrm{T}_7}{k}. \tag{3}$$

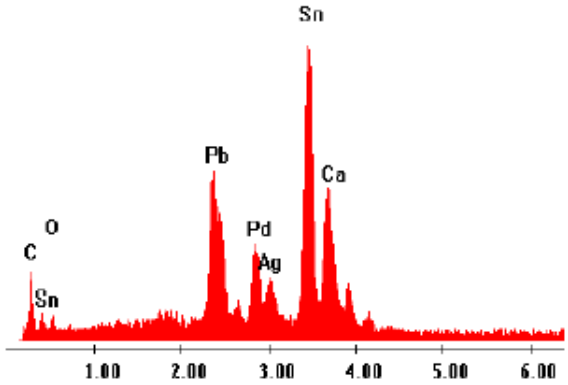
According to Eq. (3), the excess heat power could be calculated as in Table 1.

Table 1. 8 A Current triggering results in $P_{\mathrm{D}_2} = 9 \times 10^4$ Pa

Triggering	P_{input} (W)	Loading ratio	Equilibrium temperature ($^{\mathrm{o}}$C)	Excess heat power (W)
0	–	0.094	23.959 ± 0.003	–
1	416.875 ± 0.011	0.018	409.138 ± 0.022	90.629 ± 0.002
2	416.689 ± 0.015	0.029	407.166 ± 0.037	88.380 ± 0.015
3	416.778 ± 0.019	0.092	406.408 ± 0.156	87.399 ± 0.019
4	416.71 ± 0.004	0.032	405.532 ± 0.022	88.217 ± 0.004



(a) Element Ag was found (point 2)



(b) Element Pb, Sn, Ca were found (point 5)

Figure 9. EDS of Pd sample after triggering.

The longest triggering experiment lasted for 40 days. The average excess heat power was more than 87 W, the total excess heat energy was about 300 MJ, which was corresponding to 1.8×10^4 eV/atom Pd. Apparently it was more than the energy for each Pd atom released in a chemical process.

3.2. SEM and EDS analysis

The SEM image of original Pd wire before triggering was shown in Fig. 6. From this many scratches on Pd wire surface could be seen due to its industrial production. The SEM of Pd wire charged by deuterium for 5 times was given in Fig. 7. Where many small cavities on Pd wire surface occurred. Comparison to Figs. 6 and 7, Pd wire had an apparently morphological difference in the surface before and after deuterium loading and current triggering. Because a certain number of deuterium atoms went into the Pd lattice, many cavities formed on the surface. These cavities or channels, made it easy that deuterium atoms charged into the Pd lattice. This is the reason why deuterium charging repeatedly into Pd became more easily afterwards.

The original Pd wire was analyzed with an EDS (Fig. 8). The result indicated that the purity of sample was of nearly 100×. The EDS analysis of palladium wire after being triggered was shown in Fig. 9. It is very clear that new

elements of Ag, Pb, Sn and Ca were appeared after the triggering process. Also it is necessary to invested how they did form on the palladium surface or inside the body. These elements might be produced during some transmutation process.

4. Conclusions

Being triggered by current large amount of excess heat could be produced in D/Pd gas-loading system as same as in H/Ni system. Under the condition of bellowing an atmosphere, the higher of deuterium pressure, the larger of triggering current, the better the triggering effect. By this way even larger excess heat could be obtained under some other conditions (such as 2 atm, 500°C). The reproducibility of our experiments was good as 16/16 in the conditions of 8 A triggering current and 9×10^4 Pa deuterium pressure. 300 MJ excess energy was obtained within 40 days, which was corresponding to the energy of 1.8×10^4 eV for each Pd atom. This is clear that gratitude was much higher than the energy for each Pd atom released in a chemical process. And on the surface of Pd after being triggered some new elements were found by SEM and EDS analysis. This phenomenon needs further studies and its origin might come from a nuclear transmutation process.

Acknowledgement

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