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Research Article

Calorimetric Investigation of Anomalous Heat Production in Ni–H Systems

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Abstract

It has been claimed that Ni–H systems produce excess heat for long periods of time. We have performed experimental calorimetric investigations of this phenomenon. The experimental setup consisted of a ceramic reactor with nickel powder inside it, a heater, hydrogen loading system and calorimeter. Nickel powders with different grain size were used because of their large surface area. Hydrogen pressure varied from 0.5 to 2.5 atm. Temperature varied from 25 to 800°C. Different methods of input power were used in order to investigate possible effects of high amplitude magnetic pulses. The experimental runs lasted from 4 to 50 h. Experiments did not show any evidence of excess heat within the accuracy of measurement.

Keywords: Calorimeter, Cold fusion, Hydrogen, LENR, $LiAlH_4$, Nickel

1. Introduction

Since Fleischmann and Pons in 1989 claimed that it is possible to produce low energy nuclear reactions (LENR) in palladium during heavy water electrolysis practically at room temperature [1] researchers all over the world have been searching for evidence of that phenomenon in different metal–hydrogen systems. Nowadays, the most promising systems for LENR are palladium–hydrogen (deuterium) and nickel–hydrogen (deuterium) [2–15]. In the majority of experimental work of recent years, the metal is usually in solid bulk phase and hydrogen is in the gaseous phase. The process of gas loading/unloading is used to trigger the reaction. Some people suppose that nuclear reactions mainly take place on the surface of the metal [16], which is why metal powders with micro- and nanometer grain size are commonly used in experiments. Almost every LENR researcher agrees that some sort of catalyst is required for

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reaction to start. Recent investigations showed that lithium aluminum hydride ($LiAlH_4$) could be used as a catalyst [17,18]. It is assumed that one of the possible sources of excess energy is the fusion of lithium and hydrogen.

The main goal of our work was an experimental investigation of possible anomalous thermal effects in nickel–hydrogen systems. To obtain reliable results we used a calorimetric system. We also investigated possible catalytic effects of LAH and high amplitude magnetic pulses using different methods of input power.

2. Experimental Setup

The calorimetric system is shown in Fig. 1. It is a reactor capsule (6) made of stainless steel with plugs at both ends which are fixed by a super kanthal wire. The inner diameter of capsule is 11 mm and length (without plugs) is 50 mm. The working volume is 4.75 cm^3. The reactor is placed into a cylindrical gas chamber (5) made of duralumin with an outer diameter of 20 mm and length of 120 mm. A heater coil of super kanthal wire is wound on the ceramic tube which is tightly placed inside the duralumin chamber. With coil resistance of 15 Ω and currents up to 4.5 A it is possible to vary input power from 0 to 300 W. The outer shell of the calorimeter is covered with thermal insulation (4) made of mineral wool and cement. There are three thermosensors, one of them (7) is a K-type thermocouple and it measures the temperature of the reactor, and the other two (11) and (2) are integral temperature sensors (Analog Devices, ADT7310), that measure the input and output temperature of flowing water. The water pump has an adjustable flow rate. Since the total hydraulic resistance of the system is unknown, the flow value was obtained during simple calibration tests by measuring the total mass of water pumped over a certain period of time. All wires were routed through the holes which were then filled with epoxy glue. To measure pressure in the reactor zone, an integrated silicon sensor (NPX, MPX5700AP) (14) is used. In practically all experimental runs the maximum pressure was no more than 2.5 atm. The input power is calculated by direct multiplication of current by voltage in run-time mode. For this purpose, a device (8) based on an STM32 controller and high-speed 14-bit ADCs (10 MHz) was constructed and used. The output power

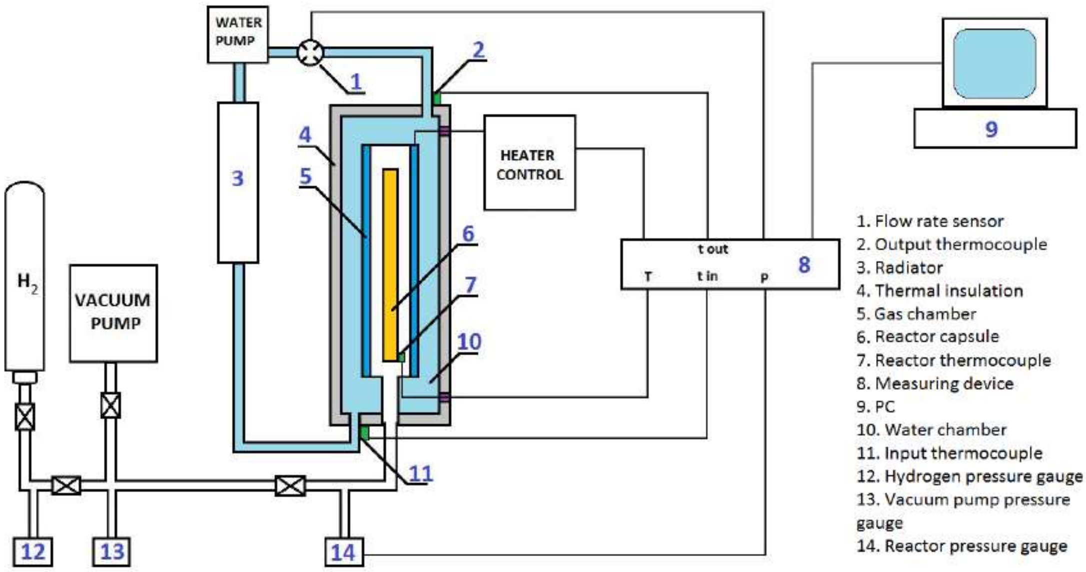

Figure 1. Schematic of calorimetric system.

data were obtained from thermocouples readings and values of water flow in the pump.

Two different types of nickel powders were used as fuel: micro-nickel with a grain size of about 10–20 μm, and nano-nickel with a grain size of about 60–80 nm. Usually we used different mixtures of these nickel powders and alumina powder (Al_2O_3, grain size about 5 μm). The latter was mainly used as a spacer and allowed us to vary the surface area of the fuel and to prevent nickel powder from sintering at high temperatures. The typical amount of fuel was about 10 g. All fuel mixtures were prepared in a normal atmosphere without annealing. Also, in some experiments small amounts of $LiAlH_4$ in powder form were added to the fuel in order to investigate its catalytic effect.

The experimental run was usually comprised of periods of heating (1–120 min) and pauses between them (1–60 min) when the heater was turned off. In order to investigate possible effects of alternating magnetic field several types of input power were used: DC, DC pulses and AC. In the second case, the duration and of pulses pauses between them varied from 100 μs to 1 s. In the case of AC, the frequency varied from 10 to 20 000 Hz. Schematic diagrams of input power modes are shown in Fig. 2. The number of turns of the heater coil was $N = 100$, and its inductance is 27 μH. Since pulse rise time is about 10 μs, it is possible to obtain $\mathrm{d}H/\mathrm{d}t \approx 3.75 \times 10^8$ A/ms.

To calibrate the calorimetric system and to determine radiation losses, we loaded an empty reactor capsule with hydrogen to a given pressure and then turned on constant power for a rather long period of time until all measured parameters reached equilibrium. Performing this procedure for different pressures and different modes and values of input power, we obtained equilibrium temperature levels and values of energy losses, which were no more than 6%.

3. Results

The experimental runs lasted from 4 to 50 h. Initial hydrogen pressure varied from 0.5 to 1.5 atm. With fuel mixtures containing only nickel and Al_2O_3, the maximum pressure usually did not exceed 2.5 atm., but when mixtures with $LiAlH_4$ were used, maximum pressure often exceeded 3 atm. and we had to open a gas valve at the beginning of the first cycle to reduce the pressure to an acceptable value. During heating cycles the temperature of reactor reached 800°C. An example of typical run with DC-mode and 10 g of nanoNi + 1g of $LiAlH_4$ as a fuel is shown in Fig. 3. As can be seen, pressure follows the temperature with some delay. The whole system is rather inert. The COP was calculated using equilibrium values of input and output power taken from the end of each pulse. Using calorimetric

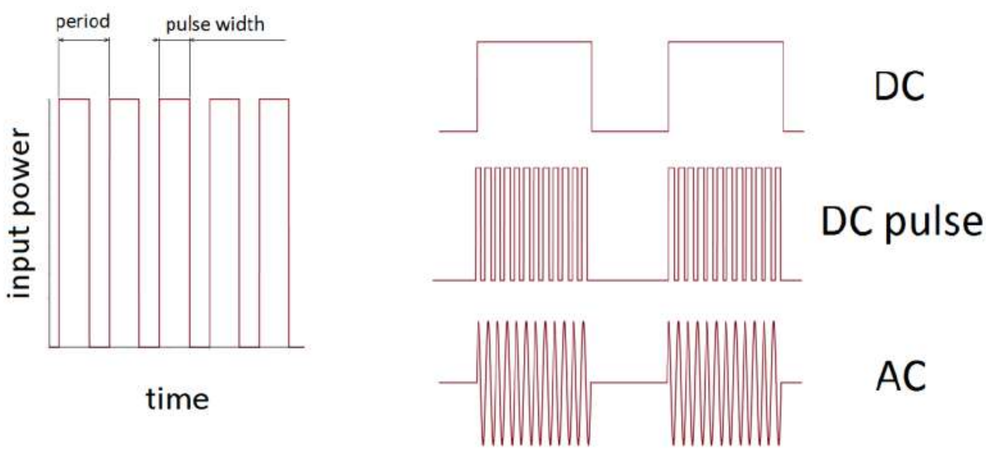

Figure 2. Schematic diagrams of different input power modes.

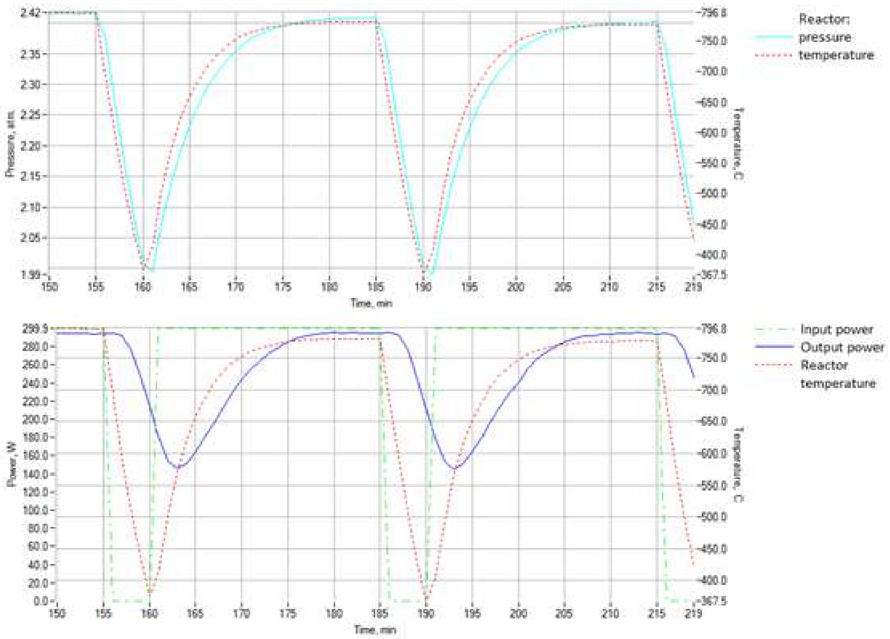

Figure 3. Segment of typical experimental run (DC mode, 10 g of nanoNi and 1 g of $LiALH_4$).

data with this method, we did not observe any fast single events of excess heat generation. It was possible to detect such events only from temperature data, but accurate analyzing of all experimental data did not reveal any excess heat.

Table 1. Results of calorimetric experiments

Experiment No.	Fuel type	Ni mass (g)	Al_2O_3 mass (g)	$LiAlH_4$ mass (g)	Period/ Pulse width (min/min)	Experiment time (h)	Average COP
1	Nano-Ni	10	–	–	35/30	12	0.956
2	Nano-Ni	5	5	–	35/30	12	0.958
3	Nano-Ni	2	8	–	35/30	12	0.953
4	Nano-Ni	5	5	1	60/40	24	0.959
5	Nano-Ni	10	–	1	60/40	24	0.941
6	Nano-Ni	5	–	5	45/40	24	0.954
7	Micro-Ni	10	–	–	60/40	50	0.951
8	Micro-Ni	7.5	2.5	–	60/40	50	0.953
9	Micro-Ni	5	5	–	60/40	50	0.958
10	Micro-Ni	2.5	7.5	–	60/40	50	0.944
11	Micro-Ni	5	5	1	45/40	12	0.948
12	Micro-Ni	10	–	1	45/40	12	0.946
13	Micro-Ni	7	–	3	45/40	12	0.951
14	Nano-Ni	8	2	–	40/30	8	0.935
15	Nano-Ni	8	2	2	40/30	8	0.928
16	Micro-Ni	8	2	–	40/30	8	0.931
17	Micro-Ni	8	2	2	40/30	8	0.934

The main results for different fuel mixtures are presented in Table 1. Every experiment presented in this table except of final four (14–17) was conducted three times with different power profiles: DC, DC pulses with period of 200 μs and duration of 100 μs and AC with frequency 20 kHz. The last four (14–17) were conducted for seven different power modes: DC, DC pulses with duration of 100 μs, 1 ms, 1s and period of 200 μs, 1 ms and 1 s, AC with frequencies 50, 1000 and 20 000 Hz. Average COP for every single experiment was calculated on the basis of all runs. It can be seen that the COP in all experiments does not exceed 1. Also, there is no obvious relation between COP and fuel type. The only notable consequence of using $LiAlH_4$ as a catalyst was the generation of large amounts of hydrogen, especially in those experiments where more than 1 g of $LiAlH_4$ was used. No influence of an alternating magnetic field on output power was found: no matter what kind of power supply was used, the final results depended only on total value of input electric power.

4. Conclusion

The calorimetric experiments with two types of nickel powders and hydrogen did not show any evidence of excess heat within the accuracy of measurement. A possible catalytic effect of $LiAlH_4$ was not found. Possible influence of an alternating magnetic field was not observed: total output power depended only on total input power.

Many researchers agree that low energy nuclear reactions can occur in the range of high temperatures (>1200°C) and high pressures (up to 100 kPa). Also, using deuterium instead of hydrogen could be more fruitful to attain extra heat generation. We did not investigate these possibilities, but we are going to in future experiments.

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