Calorimetric investigation of anomalous heat production in Ni-H systems

K.P. Budko[1] and A.I. Korshunov[2]

[1]*Moscow Institute of Physics and Technology, Moscow, Russia, email: kpb@lcard.ru*

[2]*Institute for Problems in Mechanics, Russian Academy of Sciences, Moscow, Russia, email: fallex@inbox.ru*

It has been stated that Ni-H systems could produce excess heat during rather long periods of time. We have performed experimental calorimetric investigation of this phenomenon. The experimental setup consisted of ceramic reactor with nickel powder inside it, 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 ^{o}C. Different methods of input power supply were used in order to investigate possible effects of high amplitude magnetic pulses. The experimental runs lasted from 4 to 50 hours. Experiments didn't show any evidence of excess heat within the accuracy of measurement.

Introduction.

Since Fleischmann and Pons in 1898 claimed that it is possible to maintain 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 fact 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 works of recent years metal usually presents in solid phase and hydrogen in gaseous one and the process of gas loading/unloading is used for triggering the reaction. Some suppose that nuclear reactions mainly take place on the surface of the metal [16], that is why metal powders with micro- and nanometer grain size are commonly used in experiments. Also almost every researcher of LENR agree that some sort of catalyst required for reaction to start. Recent investigations showed that lithium aluminium 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 system. To obtain reliable results we used calorimetric system. We also investigated possible catalytic effects of LAH and high amplitude magnetic pulses using different methods of input power supply.

Experimental setup

The calorimetric system is shown on fig. 1. Reactor capsule (6) made of stainless steel with two plugs at both ends which are fixed by a super kanthal wire. Inner diameter of capsule is 11 mm and length (without plugs) is 50 mm, working volume is 4.75 cm^3. Reactor is placed into cylindrical gas chamber (5) made of dural with outer diameter of 20 mm and length of 120 mm. Heater coil of nichrome wire is wound on the ceramic tube which is tightly placed inside dural 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 Watts. Outer shell of calorimeter is covered with thermal insulation (4) made of mineral wool and cement. There are three thermosensors, one of them (7) is a thermocouple of TXA-type and it measures the temperature of reactor and the other two (11) and (2) are integral thermosensors ADT7310 measure input and output temperature of flowing water. 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 calculation 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. For measuring pressure in reactor zone integrated silicon sensor MPX5700AP (14) is used. Practically in all experimental runs maximum pressure was no more than 2.5 atm. The input power is calculated by direct numerical multiplication of current by voltage in run-time mode. For this purpose device (8) on the basis of

STM32 controller and high-speed 14-bit ADCs (10 MHz) was constructed and used. The output power data were obtained from thermocouples readings and values of water flow in the pump.

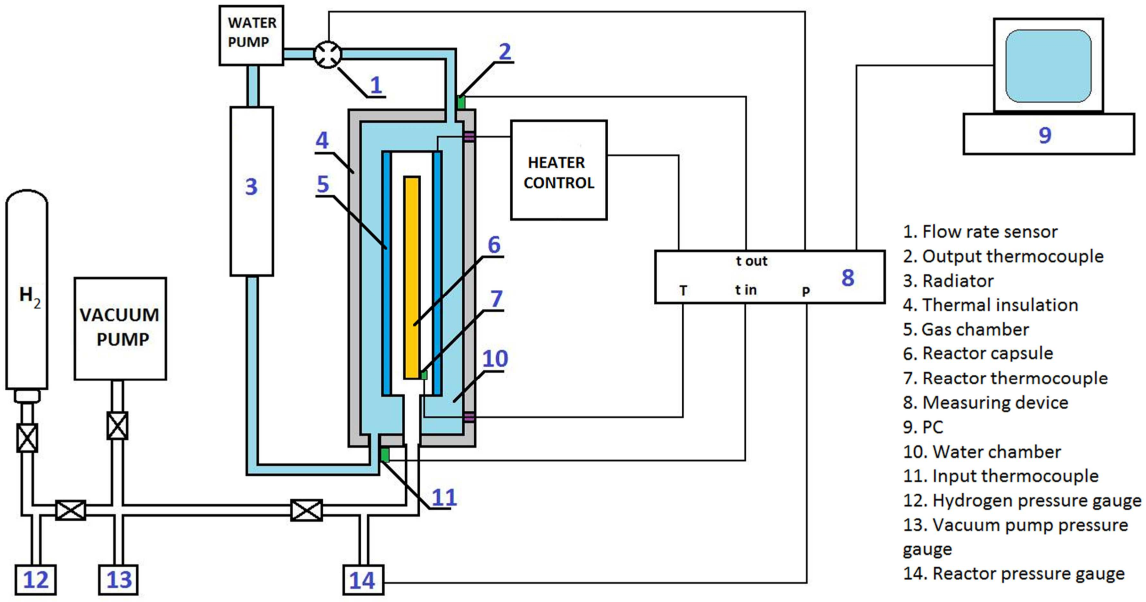

Figure 1. Schematic of calorimetric system

Two different types of nickel powders were used as a fuel: micro-nickel with grain size about 10-20 μm and nano-nickel with grain size about 60-80 nm. Usually we used different mixtures of these nickel powders and aluminium oxide powder (Al_2O_3, grain size about 5 μm). The last was mainly used as a spacer and allowed us to vary surface area of the fuel and to prevent nickel powder from sintering at high temperatures. Typical amount of fuel mixture was about 10 grams. 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 usually comprised periods of heating (1 to 120 minutes) and pauses between them (1 to 60 minutes) when heater is turned off. In order to investigate possible effects of alternating magnetic field several types of input power supply were used: DC, DC pulses and AC. In second case duration and of pulses pauses between them varied from 100 μs to 1 s. In case of AC frequency varied from 10 to 20000 Hz. Schematic diagrams of input power modes are shown on fig. 2. Number of turns of heater coil N=100, its inductance is 27 μH. Since pulse rise time is about 10 μs, it is possible to obtain $dH/dt \approx 3.75*10^8$ A/(m*s).

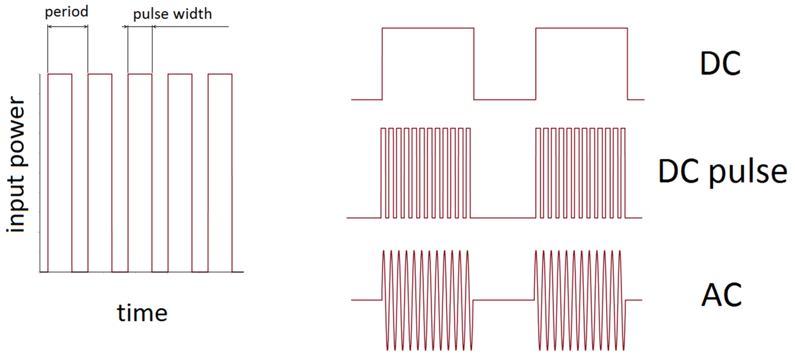

Figure 2. Schematic diagrams of different input power modes

To calibrate the calorimetric system and to determine radiation losses we loaded empty reactor capsule with hydrogen to some pressure and then turned on some constant power supply for 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%.

Results

The experimental runs lasted from 4 to 50 hours. Initial hydrogen pressure varied from 0.5 to 1.5 atm. With fuel mixtures containing only nickel and Al_2O_3 maximum pressure usually didn't exceed 2.5 atm., but when mixtures with $LiAlH_4$ were used maximum pressure often exceeded 3 atm. and we had to open gas valve at the beginning of the first cycle to relieve the pressure to an acceptable value. During heating cycles temperature of reactor reached 800 ^oC. An example of typical run with DC-mode and 10 g of nanoNi + 1g of $LiAlH_4$ as a fuel is presented in figure 3. As it can be seen pressure follows the temperature with some delay. The whole system is rather inert. Calculation of the COP performed using equilibrium values of input and output power taken from the end of each pulse. Thus using calorimetric data we couldn't notice any fast single events of extra heat generation. It was possible to notice them only from temperature data, but accurate analyzing of all experimental data didn't reveal any extra heat events.

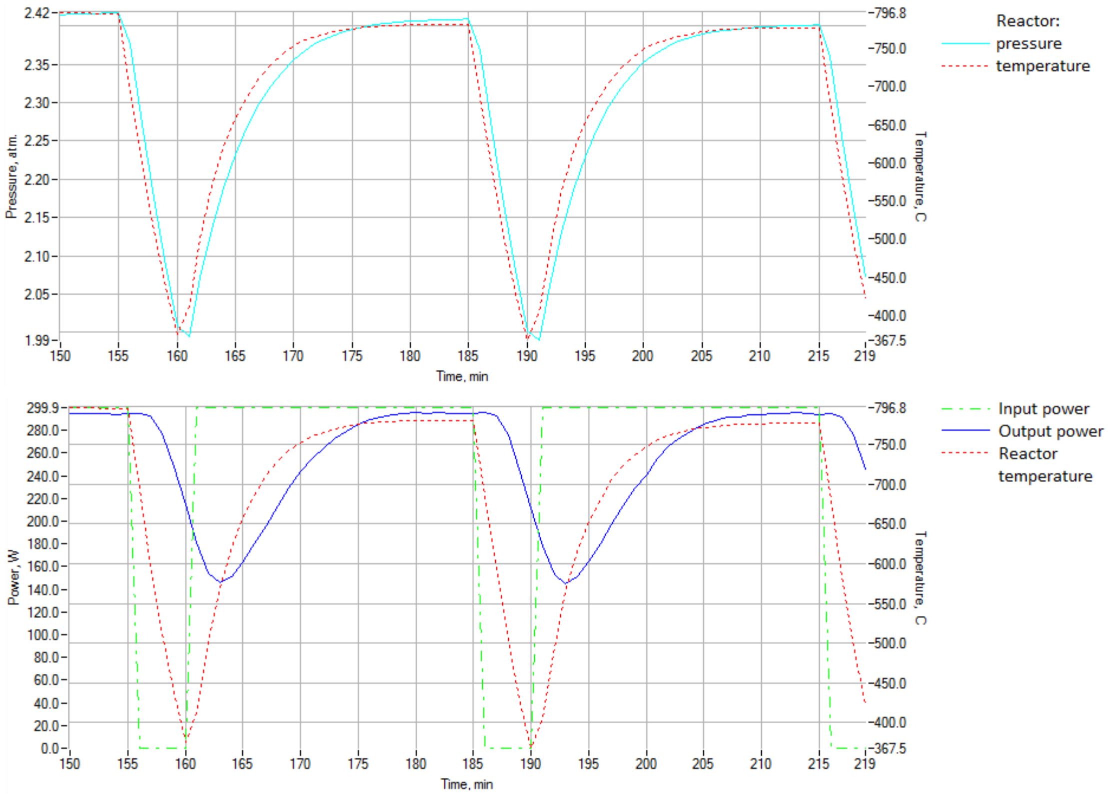

Figure 3. Fragment of typical experimental run. (DC mode, 10 g of nanoNi and 1g of $LiALH_4$).

Main results for different fuel mixtures presented in table 1. Every experiment presented in this table except of final four (14-17) was conducted three times with different power supplies: 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 7 different power supply 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 20000 Hz. Average COP for every single experiment was calculated on the basis of all runs. It can be seen that COP in all experiments doesn't 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 generation of large amounts of hydrogen, especially in those experiments where more than 1 g of $LiAlH_4$ was taken. Any influence of alternating magnetic field on output power wasn't found: no matter what kind of power supply was used, the final results depended only on total value of input electric power.

Table 1. Results of calorimetric experiments

Experiment #	Fuel type	Ni mass, g	Al_2O_3 mass, g	$LiAlH_4$ mass, g	Period/ Pulse width, min/min	Experiment time, hours	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

Conclusion

The calorimetric experiments with two types of nickel powders and hydrogen didn't show any evidence of excess heat within the accuracy of measurement. Possible catalytic effect of $LiAlH_4$ was not found. Possible influence of alternating magnetic field wasn't noticed: 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 ^oC) and high pressures (up to 100 kPa). Also using of deuterium instead of hydrogen could be more fruitful in order to attain extra heat generation. We didn't investigate that but are going to this in future experiments.

References

[1] *M. Fleischman, S. Pons, M. Hawkins.* Electrochemically induced nuclear fusion of deuterium. J. Electroanal. Chem. 1989. V. **261 (2)**, p. 301.

[2] *S. Focardi, R. Habel, F. Piantelli.* Anomalous heat production in Ni-H systems. Nuovo Cimento A. 1994. V. **107**, p. 163

[3] *S. Focardi, V. Gabbani, V. Montalbano, F. Piantelli and S. Veronesi.* Large excess heat production in Ni-H systems. Nuovo Cimento. 1998. V. **111A**, 11, p. 1233

[4] *A. Rossi.* Method and apparatus for carrying out nickel and hydrogen exothermal reaction. U.S. Patent 20110005506 A1, January 13, 2011.

[5] *A. Rossi.* Fluid heater. U.S. Patent 9115913 B1, August 25, 2015.

[6] *Y. Sasaki et al.* Anomalous Heat Generation in Charging of Pd Powders with High Density Hydrogen Isotopes (I) Results of Absorption Experiments using Pd Powders. 15th International Conference on Condensed Matter Nuclear Science, Rome, Italy, 2009.

[7] *Y. Sasaki et al.* Deuterium Gas Charging Experiments with Pd Powders for Excess Heat Evolution (I) Results of Absorption Experiments using Pd Powders. 9th Meeting of Japan CF-Research Society, Shizuoka, Japan, 2009.

[8] *A. Takahashi et al.* Deuterium Gas Charging Experiments with Pd Powders for Excess Heat Evolution (II) Discussions on Experimental Results and Underlying Physics. 9th Meeting of Japan CF-Research Society, Shizuoka, Japan, 2009.

[9] *A. Kitamura, T. Nohmi, Y. Sasaki, Y. Taniike, A. Takahashi, R. Seto and Y. Fujita.* Anomalous Effects in Charging of Pd Powders with High Density Hydrogen Isotopes. Physics Letters A. 2009. V. **373(35)**, pp. 3109–3112.

[10] *D. Kidwell et al.* Does Gas Loading Produce Anomalous Heat? 15th International Conference on Condensed Matter Nuclear Science, Rome, Italy, 2009.

[11] *F. Celani. et al.* Deuteron Electromigration in Thin Pd Wires Coated With Nano-Particles: Evidence for Ultra-Fast Deuterium Loading and Anomalous, Large Thermal Effects. International Conference on Condensed Matter Nuclear Science, Washington, DC, 2008.

[12] *F. Celani et al.* Towards a High Temperature CMNS Reactor: Nano-coated Pd Wires with D_2 at High Pressures. 15^{th} International Conference on Condensed Matter Nuclear Science, Rome, Italy, 2009.

[13] X. *Li et al.* Progress in Gas-Loading D/Pd System—The Feasibility of a Self-sustaining Heat Generator. 10^{th} International Conference on Cold Fusion, 2003.

[14] *F. Celani et al.* Observation of macroscopic current and thermal anomalies, at high temperature, by hetero-structures on thin and long Constantan wires under H_2 gas. 19^{th} International Conference on Condensed Matter Nuclear Science, Padua, Italy, 2015.

[15] *G.H. Miley, K.-J. Kim, E. Ziehm, T. Patel, B. Stunkard.* Progress in Development of an LENR Power Cell for Space. Proceedings of Nuclear & Emerging Technologies for Space (NETS) 2015 Albuquerque, NM, February 23-26. 5134, pp. 325 -335

[16] *E. Storms.* An Explanation of Low-energy Nuclear Reactions (Cold Fusion). J. Condensed Matter Nucl. Sci. 2012. V. 9, Pp. 1–22.

[17] *A. Parkhomov, E. Belousova.* Researches of the heat generators similar to high temperature Rossi reactor. 19^{th} International Conference on Condensed Matter Nuclear Science, Padua, Italy, 2015.

[18] *G. Levi, E. Foschi, H. Essen.* Observation of abundant heat production from a reactor device and of isotopic changes in the fuel. 2014. http://www.infinite-energy.com/images/pdfs/ECatReport2.pdf