The Question of Excess Heat in Nickel-Hydrogen

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Among the objects of our interest, is a focus on metal-hydrogen systems. This metallurgy is of great practical importance for nuclear energy. One of the most significant causes of deterioration of mechanical and technical properties of structural materials is the accumulation of hydrogen in metals as an impurity, leading to metal embrittlement and decreased ductility.

From past experiments we have data about the unusual effects observed in the study of nickel-hydrogen taken in the mid-1990's [2, 3]. In these experiments in a closed metal system, when fine nickel powder was contained with several atmospheres of hydrogen gas and heated to 400-600°C, excess heat of unknown origin was observed.

We decided to re-run these experiments with a slightly modified experimental setup based upon our ideas and opportunities. Below is a brief description of the design of our experiment with a few illustrations, and the results we obtained.

The experiment was limited to measuring the temperature difference ("delta") between the vessels of the same weight and shape, which are shown in Figure 1. In one of the vessels was put "fuel", while the other remained empty.

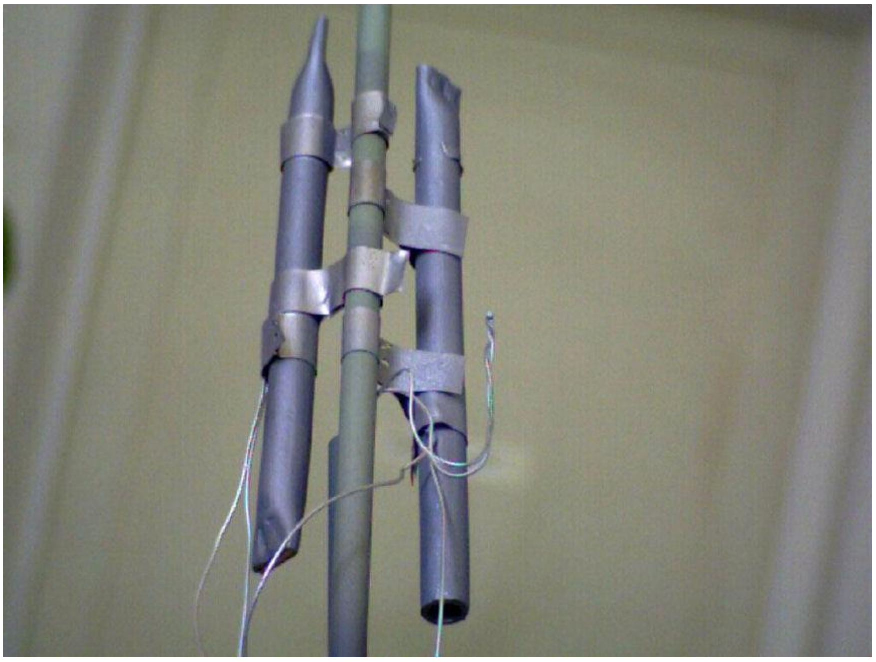

Figure 1: Sealed vessel with the "fuel" (left), and without any "fuel" (right)

The "Fuel" comprised fine nickel powder in which was added, and thoroughly mixed, lithium aluminum hydride powder ($LiAlH_4$) in an amount of 10% by weight. The $LiAlH_4$ was provided to create an overpressure of hydrogen gas inside the sealed volume. The hydrogen is released by heating and is due to decomposition of lithium aluminum hydride.

The temperatures of the sealed reaction vessel and the control vessel were measured using chromel-alumel [k-type] thermocouples, the output of which are used to get the value of the temperature difference ('delta') in two center points. All data was recorded using a digital multimeter (APPA-109M) which transmitted the measurements to a computer for further processing.

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Between the two empty containers, which are shown in Figure 2, the measured temperature "delta" was zero in the entire range of the ambient temperature from 20 to 1200°C.

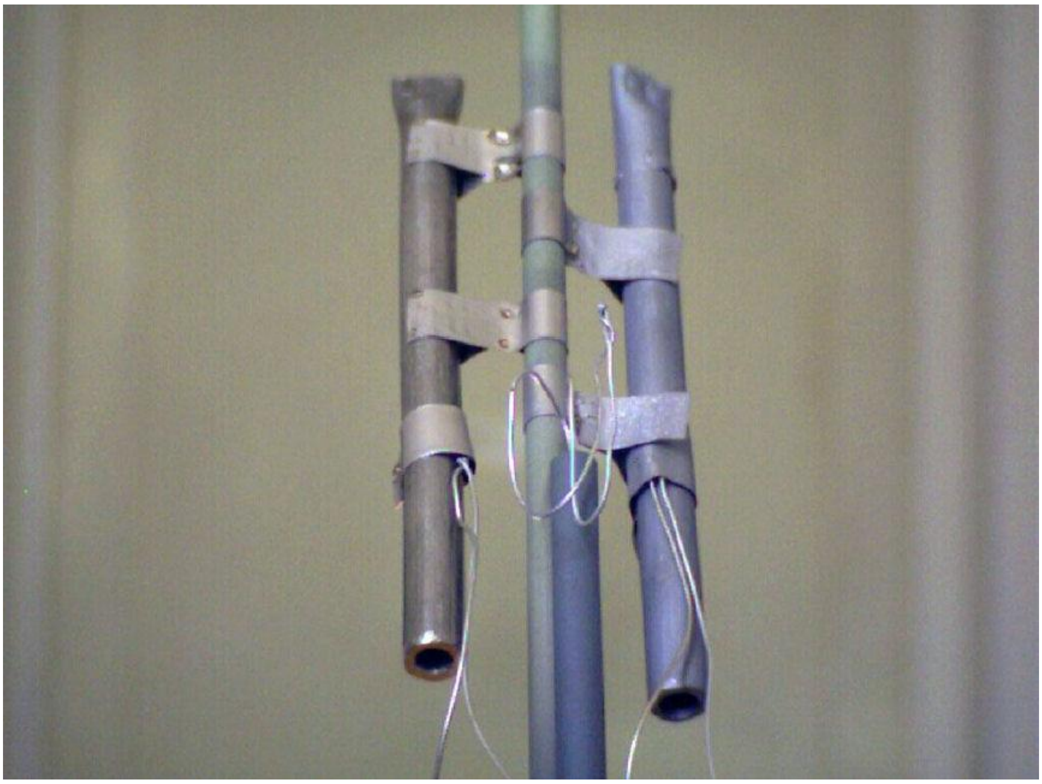

Figure 2: Two vessels without "fuel"

To get rid of external factors that could affect the results of the experiment (e.g. oxidation of the of the vessel material and thermocouples at temperatures above 1000°C in air), the vessels were placed in a programmable vacuum furnace that used oil-free pumping (see Figures 3 and 4). This oven provided a uniform heating at a certain speed, as well as a dwell at a set temperature.

Figure 3: The programmable vacuum furnace

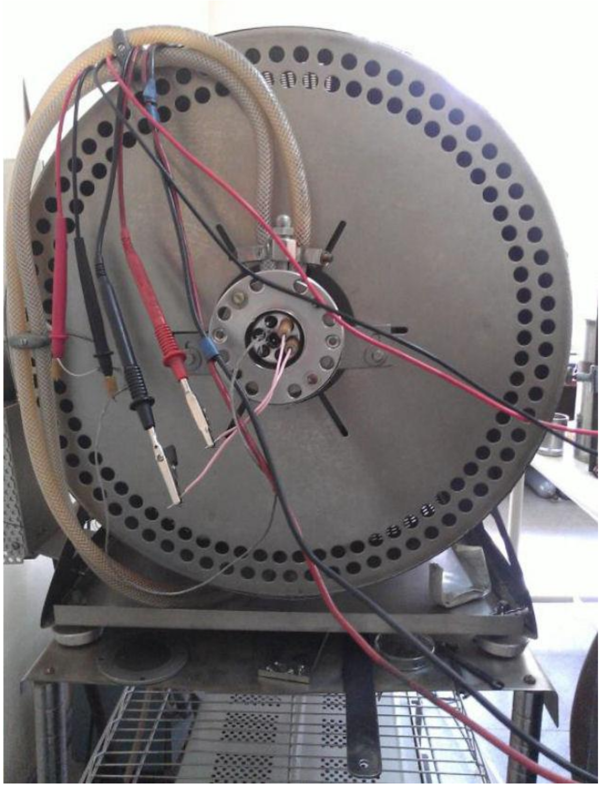

Figure 4: The flange with the connections to the thermocouples

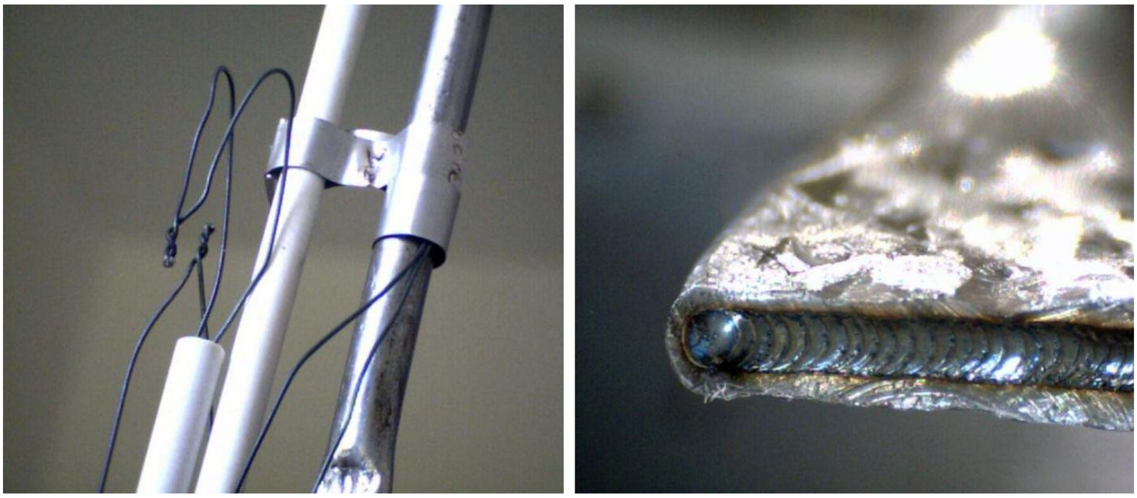

Figure 5: Appearance elements of the product design to the start of the experiment

After loading the "fuel", this vessel was sealed by electron beam welding (Figure 5).

The results are presented in Figure 6. Graph (a) shows how the furnace temperature is varied over time. Within four hours the furnace rose linearly from room temperature to 1200°C. This was followed by hours of dwell at this temperature, and then the oven was turned off and began to cool naturally, without forced cooling.

Plot (b) shows the temperature difference ("delta") of two vessels versus time; one of which was loaded with the "fuel", and the other remained empty. This plot is time synchronous with the change in temperature of the furnace shown in the curve at the top.

Plot (c) shows how the temperature "delta" changes depending upon the surrounding temperature of the furnace. Compared to the temperature difference ("delta") of the vessels while the furnace temperature increased, when the furnace temperature slowly declined from 1200°C to 600°C, the temperature difference ("delta") showed a small decline (about 10%).

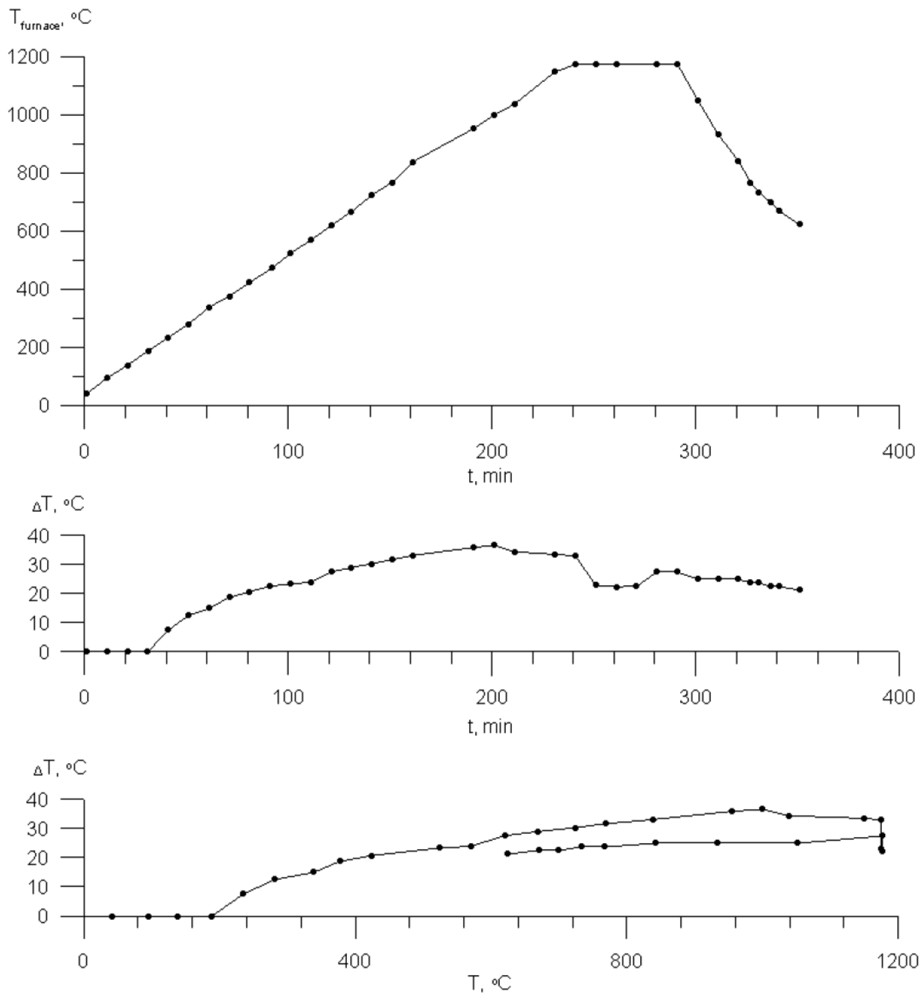

Figure 6: a) The temperature in the furnace as a function of time; b) the "delta" temperature of the vessels depending on the versus time; c) the temperature difference ("delta") of the vessels depending on versus the temperature in the furnace.

Based on the temperature difference between the two vessels, *dT*, and using the Stefan-Boltzmann law, which determines the dependence of blackbody radiation power on the temperature, the total radiated power density of each vessel is proportional to the fourth power of its Kelvin temperature, *T*.

The law relating the radiated power per unit area, *U*, to the Kelvin Temperature, *T*, and Stephan-Boltzman constant, *σ*, is given by equation (1):

$$U = \sigma T^4 \quad (1)$$

To determine the power of the radiating source, the Stephan-Boltzmann result is multiplied by the surface area of the vessel, *S*, and its emissivity, *ε*:

$$U = \sigma T^4 S \varepsilon \quad (2)$$

Differentiating (2) with temperature gives:

$$dU = 4 \sigma T^3 S \varepsilon dT \quad (3)$$

Where *S* is the area of the surface of the radiating object; *ε* is the emissivity of the emitting material; and *σ* is the Stefan-Boltzmann constant, which can be expressed in terms of fundamental constants by integrating over all frequencies of Planck's formula:

$$\sigma = \frac{8\pi^5 k^4}{15 c^3 h^3}$$

Where *h* = Planck's constant, *k* = Boltzmann's constant, *c* = the speed of light.

Numerically, the Stefan - Boltzmann constant is:

$$\sigma = 5.670367x10^{-8}\ \frac{joule}{sec\ m^2\ K^4}$$

Substituting the experimental parameters taken in this experiment into the formulas given here; and taking into account the degree of blackness of the container material - stainless steel ($\varepsilon \approx 0.8$) - we find that our fueled vessel, at a temperature difference of 25°C and an ambient temperature of 1200°C, continuously emits about 21 watts of thermal power [more than that of the empty vessel].

Subsequent to the first test of 360 minutes, a second test was conducted the following week without disturbing the apparatus.   The peak temperature for the second test was 1178°C and the duration of the second test was 100 hours.   During this time the "delta" remained constant (around 25°C), and according to our estimates for the entire test period, the vessel with the fuel produced more than 2 kWH of excess thermal energy.

Upon disassembly, the appearance of the original, and spent "fuel" (ash), which is in the form of a speckled rod having a diameter of about 3 mm, is shown in Figure 7.

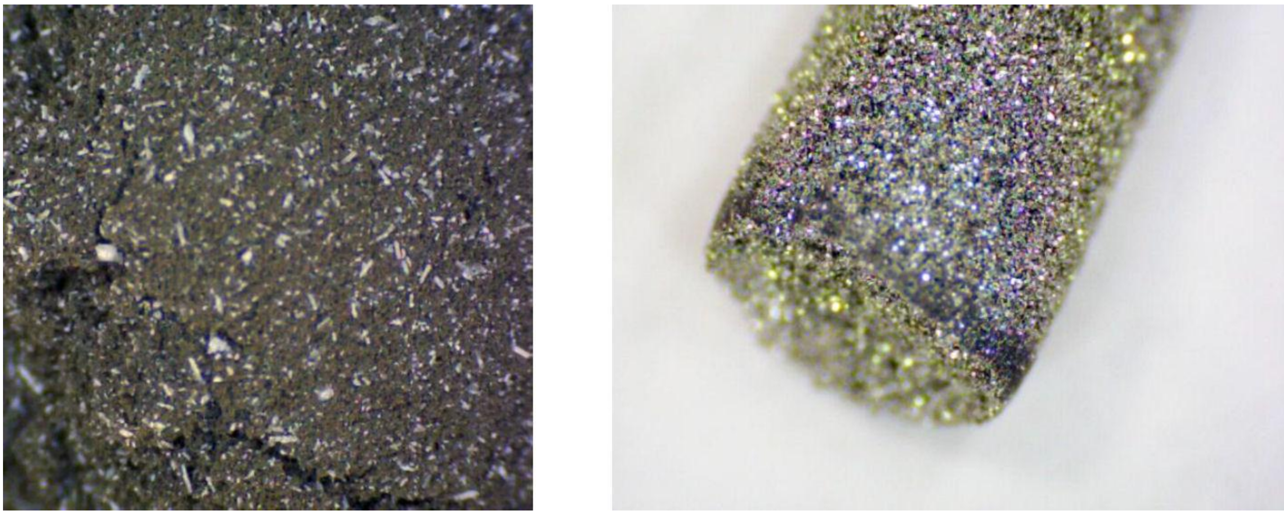

Figure 7:   Appearance of the original (left) and spent "fuel" (ash)

Our experiments have shown convincingly that excess heat was actually produced in the nickel-hydrogen system.

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