IL NUOVO CIMENTO VOL. 107 A, N. 1 Gennaio 1994
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Anomalous Heat Production in Ni-H Systems.

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(ricevuto il 3 Gennaio 1994; approvato il 12 Gennaio 1994)

Summary. — Evidence for a 50 W anomalous heat production in a hydrogen-loaded nickel rod is reported.

PACS 25.70.Jj – Fusion and fusion-fission reactions.

1. – Introduction.

Since the first claim from Fleischmann and Pons [1] for an anomalous production of heat obtained during an electrochemical experiment, a great number of experiments has been devised and performed, in order to confirm or disprove the effect.

In our opinion, till now, none of the groups involved in these experiments has reached a strong evidence for a consistent anomalous production of heat in a reproducible and controlled way.

At the end of 1989 one of us (FP), in an experiment of low-temperature calorimetry (about 200 K) on deuterated organic compounds in hydrogen atmosphere, suspected an irregular balance of the heat involved.

After several discussions which took place in the following months, we reached the conclusion that the probable responsible for the observed anomaly could have been the nickel support on which the organic sample had been deposited.

In order to investigate the process in detail, we devised a suitable experiment. After some preliminary tests, the final apparatus which will be described below was assembled at the end of 1992 at the Physics Department of Siena University.

2. – Experimental set-up.

In fig. 1 the layout of the experimental set-up is shown.

The reaction chamber is made of stainless steel of 50 mm diameter and 100 mm length. The heater, 1 mm diameter platinum, forming 42 turns of 20 mm diameter, is placed inside the chamber. The chamber contains also either a nickel cylinder or,

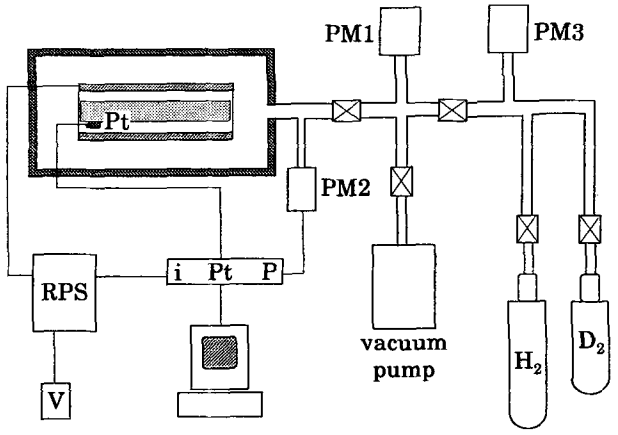

Fig. 1. – Schematic layout of the experiment.

alternatively, an appropriate dummy stainless-steel rod, both having 5 mm diameter and 90 mm length, which are placed in contact with a Pt thermometer (Cryophysics Mod. PT 103).

The chamber can be evacuated by means of a turbomolecular vacuum pump (Leybold-Heraeus Mod. Turbovac 120 K) and filled with hydrogen or deuterium from gas bottles.

The pressure inside the chamber is measured by a piezomanometer (WSE-Waldsee Electronic).

The platinum heater coil is powered by a 300 W d.c. voltage stabilized power supply (Alpha Elettronica Mod.AL 834).

The values of the gas pressure, the heater current and the temperature are continously monitored by a PC (Olidata PC486) operated data logger.

In order to calibrate our experimental apparatus, different measures of the stainless-steel temperature were obtained by varying both the heater input power and the hydrogen pressure (typically from 1 bar to the vacuum).

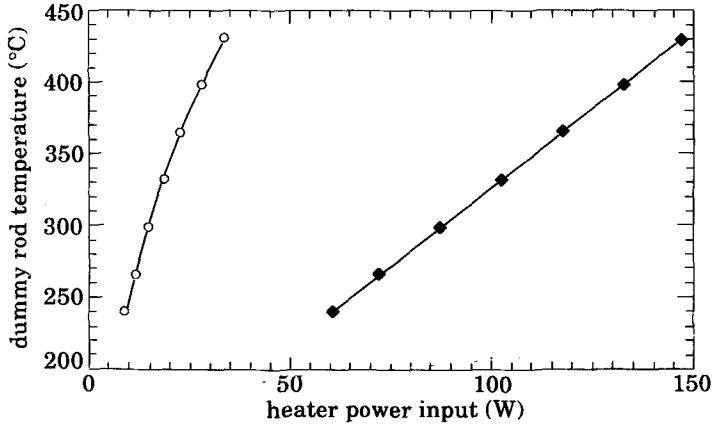

Fig. 2. – Power-temperature relations for the dummy rod at different values of the pressure inside the chamber. ◆ Hydrogen ($p = 570$ mbar), ○ vacuum.

In fig. 2 we show only two data sets: one obtained under vacuum conditions and another with hydrogen pressure of 570 mbar. All the curves obtained for hydrogen pressure values different from zero turned out to be practically independent of the hydrogen pressure in the range of values of interest.

Several measurements showed that the reproducibility range for each curve lies within one degree centigrade.

The plot evidences the effect of the heat conduction of the gas on the central rod equilibrium temperature.

3. – Experimental results.

The experiment was planned to study the behaviour of deuterated nickel samples with respect to any possible anomalous production of heat.

To begin, we used hydrogen as a filling gas for two different purposes:

a) to determine the loading cycle of the gas into the nickel sample and the related thermal chemical-physical effects,

b) to perform, at the same time, a «null experiment».

The gas loading cycle was explored in several runs. We found that the maximum

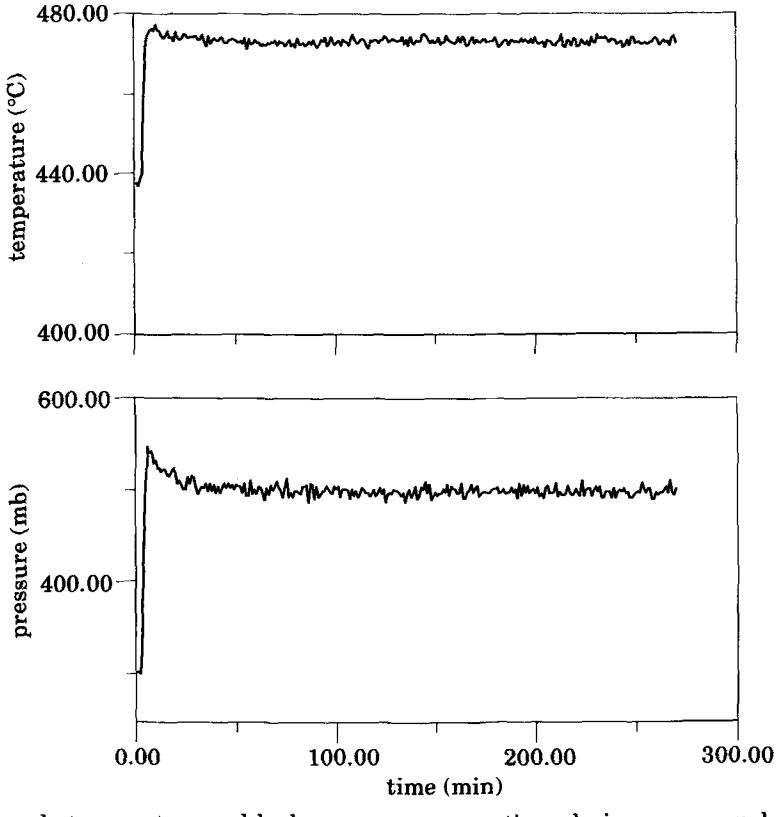

Fig. 3. – Sample temperature and hydrogen pressure *vs.* time, during an «anomalous» loading step.

filling occurred when the nickel temperature was greater than 173 °C and the gas pressure below the atmospheric one. The typical amount of gas loaded in each loading step is of the order of 0.05 l · atm at 400 K.

The loading process showed soon that something was going in an unexpected way. In fact after several loading steps, the gas absorption was accompanied by a strong rise of the rod temperature standing high for such a long time, to render the heat production involved incompatible with any classical theory.

Figure 3 shows the time dependence of nickel temperature and gas pressure during a typical anomalous loading step, performed at fixed heater power input. The temperature increase obtained would require, as shown by the right curve of fig. 2, an extra input power to the coil of about 20 W. Actually due to the voltage stabilization of the heater power supply, and to the rise of the coil resistance with the

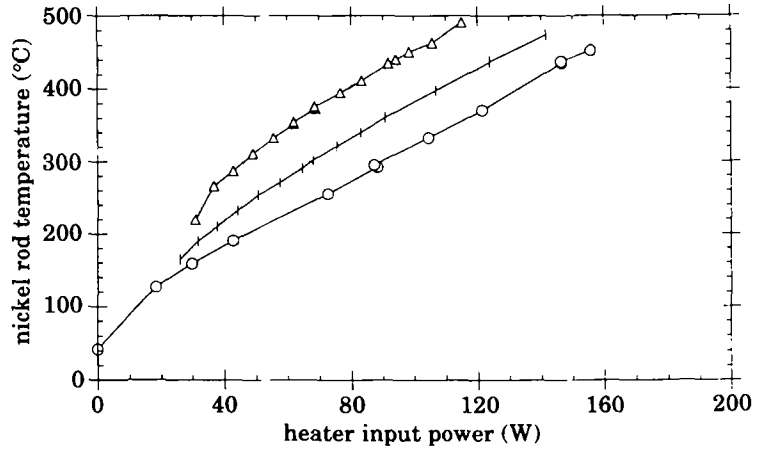

Fig. 4. – Temperature *vs.* heater-power curves family for a loaded nickel sample at different values of power «imbalance». ○ 0 W, —|— 20 W, △ 50 W. The dummy rod and the unloaded Ni rod are represented by the 0 W lower «imbalance» curve.

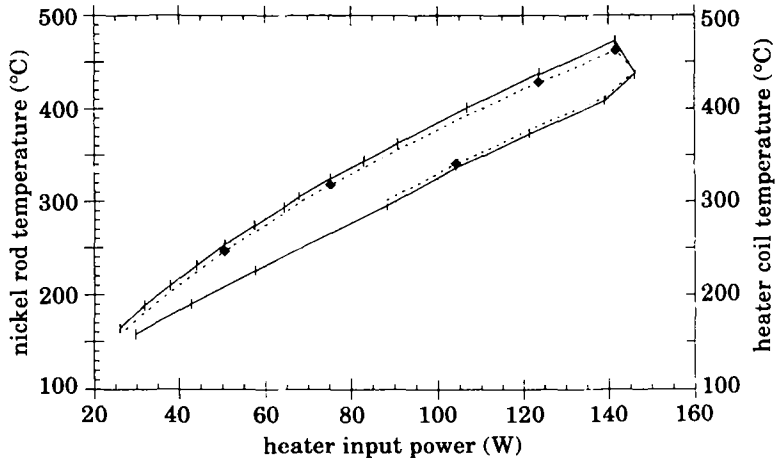

Fig. 5. – Heater coil and nickel rod cycles in the (W, T) diagram, at 20 W power «imbalance». —|— rod temperature, ◆ coil temperature.

temperature, the electrical input power decreases. Therefore, to justify the produced increase of temperature we need to invoke the existence of an internal power source. With repeated cycles we were able to push such power «imbalance» up to about 50 W.

A family of curves showing the nickel temperature *vs.* the external input power, for two values of the power «imbalance», is reported in fig. 4.

Figure 5 shows the values of the heater coil and nickel rod temperatures in the phase-space diagram (W, T) obtained for one cycle at 20 W power «imbalance». The cycle is counterclockwise and starts from the lower part of the curve. From that figure it can be immediately seen that in the lower part of the curve there is a heat transfer from the coil to the nickel, whereas in the upper one the process is reversed. This gives evidence for an internal (to the nickel) heat source.

4. – Discussion and conclusions.

Up to now we are not able to formulate any consistent model which comprehends the phenomenon. Nevertheless we can state a few standpoints on the basis of the measurements performed.

i) The system can be reliably controlled, as the curves of fig. 4 show, allowing for different working points.

ii) The system has been maintained at a mean «power imbalance» of 44 W for a period of twenty-four days (corresponding to about 90 MJ), after that it has been stopped. This amount of energy is beyond that produced in any known chemical reaction involving H_2 and Ni, being at least three orders of magnitude larger.

iii) From fig. 4 it appears that the power required to maintain the unloaded Ni sample at a fixed temperature can be up to twice the one required for the loaded Ni. This power «imbalance» can be considered the «gain» of the system.

iv) No penetrating radiation (neutrons, γ-rays) was detected above the background level during the process.

These four points are all we can state so far on the basis of the work done. Work is now in progress to verify as a possible candidate for the heat generation the reaction (p, D), where D is that naturally contained in hydrogen.

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Thanks are due to S. Bottari, E. Corsi, A. Marchini and A. Pifferi for their invaluable technical support.

REFERENCES

[1] M. FLEISCHMANN, M. HAWKINS and S. PONS: *J. Electroanal. Chem.*, **261**, 301 (1989).