

Measurement of Excess Heat from a Pons-Fleischmann Type Electrolytic Cell

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ABSTRACT

Two samples of Pd were obtained from Tanaka Kikinzoku Kogyo K. K. (Japan). One sample gave 20 % excess heat before the run was prematurely terminated and the other sample gave no excess heat. The sample giving excess energy contained only 0.8% excess volume while the nonproductive sample had 13.5 % excess volume.

The calorimeter is closed in an energy sense, pressured with D₂, and stirred. Calibration was done before, during and after heat measurement. Four different calibration procedures were used including a blank using a platinum cathode. Temperature gradients were monitored and found to change when excess heat was produced. This change strongly suggests that normal electrolysis releases energy mainly at the anode while excess heat is released mainly at the cathode. The bulk D/Pd ratio was measured during initial charging and was found to reach 0.82. Voltage difference between cathode and reference electrode was measured and indicates that the deuterium concentration gradient is small during initial charging at 0.02A/cm².

Excess volume in each palladium cathode was measured after each study. Heat production is proposed to be prevented if excess volume is too large.

1. Introduction

A computer controlled, sealed, isoperibol-type calorimeter has been constructed and was used to study palladium sheets supplied by Tanaka Kikinzoku Kogyo K. K. (Japan). Single samples of palladium sheet from two different batches were studied[1].

Takahashi has reported[2] the production of excess power that exceeded 100 watts/cm^3 (average $1.7 \times$ input power) from a Pons-Fleischmann-type electrolytic cell using similar material. In addition to this extraordinary energy production, low level neutron emission was measured that was roughly proportional to the magnitude of heat production when cell current was changed but decreased with time.

In addition to using this potentially unique palladium, Takahashi has suggested two procedures for success. The arrangement between the cathode and anode should produce uniform loading with deuterium, and the cathode should be subjected to periodic changes in cell current. He reports that excess energy increased with time when these procedures were used.

In addition to this recent success, excess heat production has also been reported by a significant number of studies[3] using a variety of procedures and calorimeter designs, and these studies found, in most cases, many positive results. Rods of palladium were studied in most of this work in contrast to the plate shaped cathode used here.

A calorimeter design having simplicity of operation and calibration was used in order to counter various objections raised by critics of similar measurements. Active stirring and temperature readings at two levels within the cell were used to eliminate the effect of possible temperature gradients. Four different calibration procedures were used and these were applied before, during and after the production of excess energy. The primary calibration used electrolytic heating of the LiOD electrolyte with a platinum cathode and anode. Except for chemical heat that might be associated with palladium, this method has the same bubble pattern, heat distribution and chemical effects within the electrolyte as would be found in the cold fusion cell. In addition, this method produced a similar calibration constant to that determined when "dead" palladium was used as the cathode. Consequently, most of the objections raised to discount excess heat production are eliminated because they are canceled out by the calibration procedure.

Because the calorimeter contained a recombiner, it could be completely sealed, pressurized with deuterium gas, and the internal pressure could be monitored. In this way, no material entered or left the cell under normal conditions. Significant excess heat was observed using these methods.

This work concentrates on the verification of excess heat and the measurement of various physical and chemical factors that are thought to be associated with excess energy production. No data or theories are pre-

sented about the possible source of heat or associated nuclear products other than to note that no tritium was produced.

2. Methods

2. A. Calorimeter

Figure 1 shows the cathode-anode assembly and Fig. 2 shows a cross-section of the closed, pyrex-glass calorimeter. A teflon plug is held into a standard taper by a spring that allows pressure release should the internal pressure rise above 1.5 atm. Tapered ports through this plug give access for various probes. The calorimeter is attached to a sealed gas handling system that maintains an overpressure of D_2 and allows the pressure to be monitored. An additional sheet of platinum (counter electrode) within the electrolyte provides means to calibrate the cell without disturbing the palladium and to conduct heat generated at the recombiner into the electrolyte. Later in the study, this feature was eliminated without producing a change in the calibration constant. The recombiner is carbon cloth impregnated with teflon and platinum. Active stirring by a teflon covered magnet is used.

Temperature is measured at two points in the surrounding constant temperature jacket and at two points within the interior of the cell, one near the top and the other at the bottom. The difference between the average of the two inner and the two outer temperatures is used to obtain the temperature difference across the glass wall of the cell. After calibration, this difference is used to determine total power production within the cell.

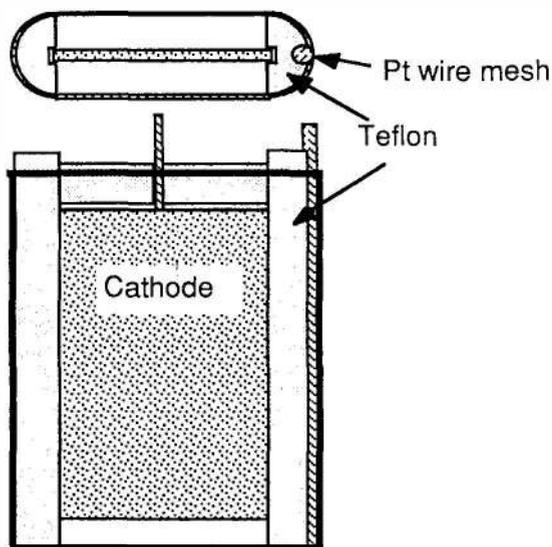


Figure 1. View of cathode-anode assembly.

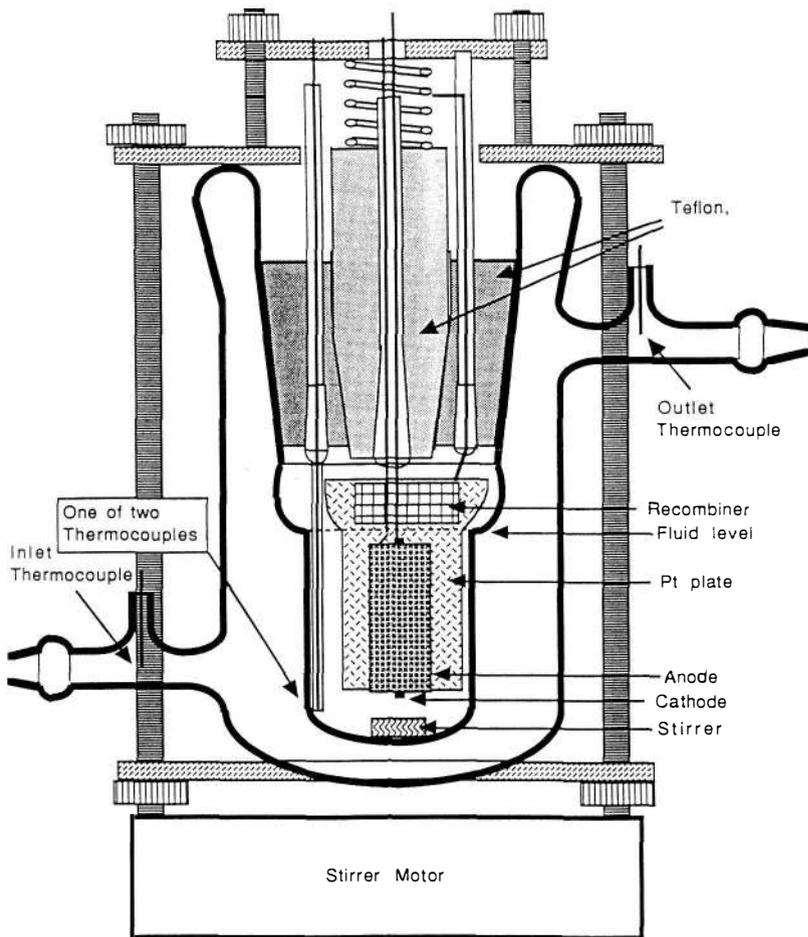


Figure 2. Cross-section of Calorimeter

Calibration is done using four methods.

1. Current is passed through an internal, glass covered, immersion heater to give simple joule heat,
2. A Pt sheet is substituted for the palladium cathode and electrolytic heat is created using the normal anode-cathode configuration.
3. Electrolytic current is passed between the normal Pt anode and a Pt sheet that holds the recombiner.
4. The current is cycled between two values over an extended period of time using either a Pt cathode or an inactive Pd cathode. This technique is called "bivalue" in subsequent discussion.

Several of these methods contribute heat to different positions within the cell, thus testing the effect of potential temperature gradients. The time stability of the calibration is tested by the bivalue mode. A comparison between electrolytic and joule heat tests the effect of heat being produced at the recombiner in the former case. It is important to note that method 2 has the same heat distribution, bubble pattern, and recombiner heat as when palladium is studied. This method is used to calibrate the cell before and after each cell modification. Method 1 is used to detect changes in the calibration constant while palladium is being electrolyzed but is not used to provide an absolute calibration because of a small heat loss through the wires. A small charging current is applied to the palladium electrode during this calibration to prevent loss of deuterium. This additional power is taken into account. Method 4 tests the effects of the *recommended bivalue mode of charging on the calibration constant*. Platinum is used as the cathode or, when excess heat is not being produced, palladium is used. However, this calibration method is less accurate when using palladium because fewer points must be taken in order not to alter the charging conditions too much. Figure 3 compares typical calibrations using methods 1 and 2 and shows typical scatter within data sets as well as the difference between calibrations.

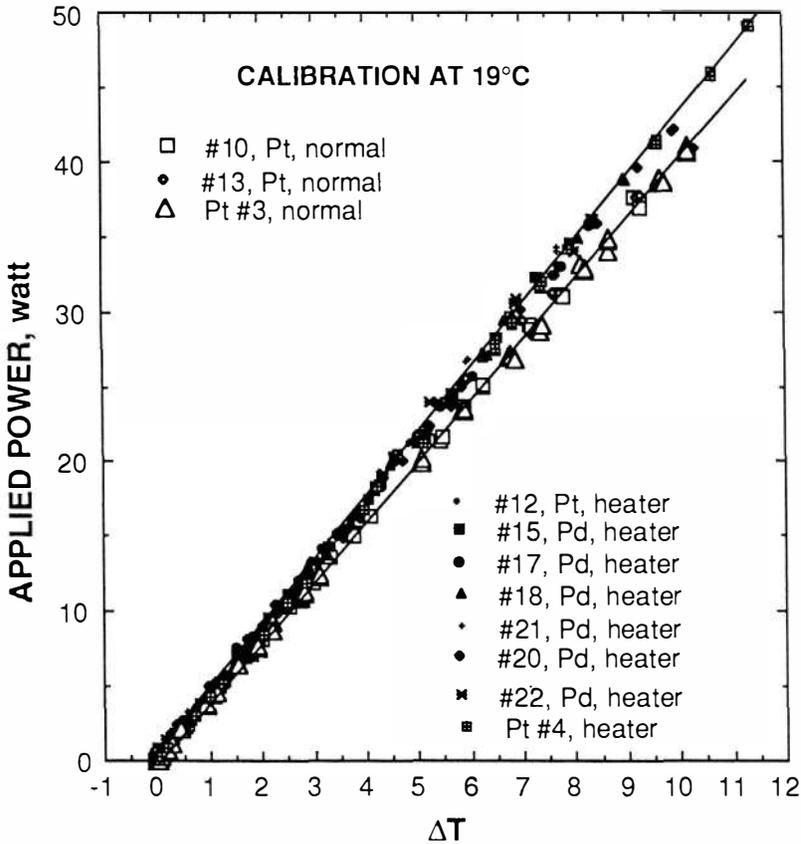


Figure 3. Comparison between calibrations using normal electrolysis with a Pt cathode and the immersion heater. Linear least-squares fits to the data are shown. Jacket temperature is near 19°C, and the electrolyte is 0.3 N LiOD.

Figure 4 compares the slope of lines shown in Figure 3 with values obtained using the bivalence mode at various jacket temperatures.

The product of current flowing through the cell times the voltage across the cell, measured where the wires enter the active region of the calorimeter, is used as the applied power. The difference between total power and applied power is taken as excess power. Many measurements of excess power under a variety of applied currents and calibrations give uncertainties of ± 1 W at 40 W of applied power and ± 0.3 W when the applied power is near zero. Therefore, excess power is not claimed unless the value is above 1 W.

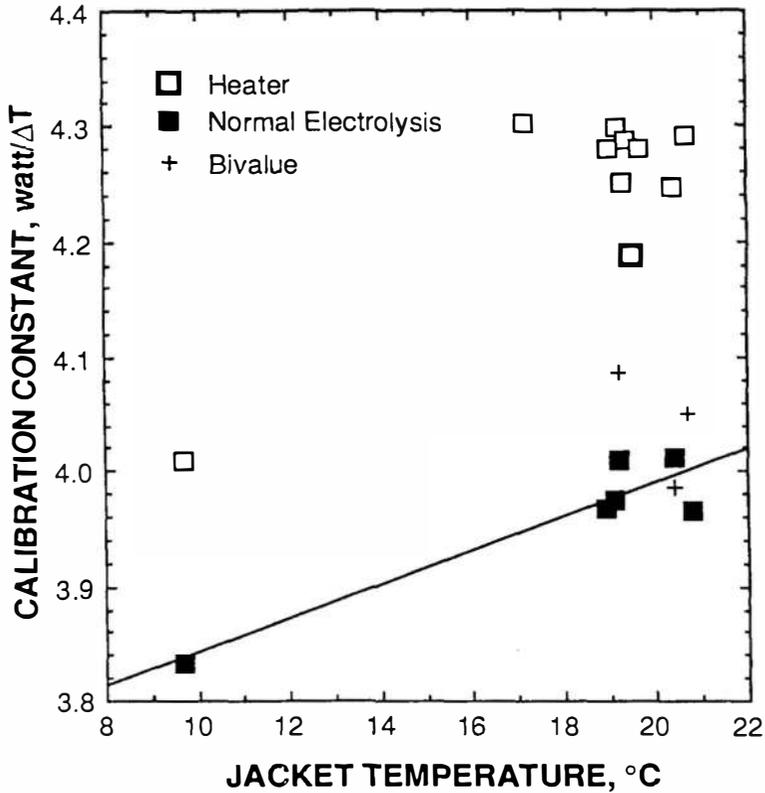


Figure 4. Effect of jacket temperature on the calibration constant when calibration is done using the immersion heater, normal electrolysis with a platinum cathode and bivalence using a palladium cathode.

2. B. Additional Measurements

The D/Pd ratio is measured during initial charging using the system volume, the decrease in D_2 pressure within the system, and the weight of the palladium cathode. Figure 5 shows this quantity as a function of time for Pd sample #1. Up to ≈ 150 min, nearly every deuterium atom released by electrolysis dissolves in the palladium. The apparent decrease in deuterium composition after 650 min is not thought to be real. The charging behavior of Pd sample #2 shows a lower efficiency for deuterium dissolution.

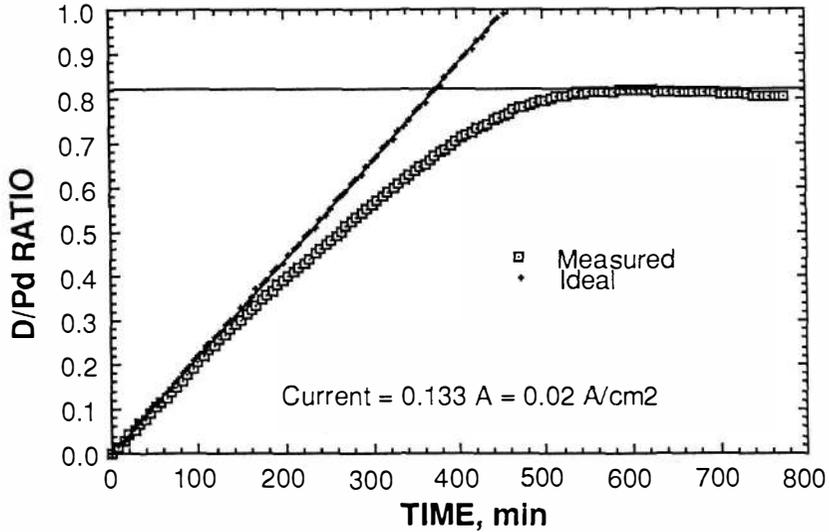


Figure 5. D/Pd ratio as a function of time during the initial charging of Pd #1. The ideal line shows the expected composition if every atom of electrolyzed D dissolved in the palladium.

An exterior platinum electrode is connected, using an electrolyte bridge, to a capillary located about 0.5 mm from the cathode surface. The voltage between this electrode and the cathode is monitored and found to change by 0.34 V when the cathode changed from pure Pd to PdD_{0.82}.

The volume of the cathode is measured using a micrometer. The measured change in volume when the deuteride formed is compared to the expected change based on the known lattice parameter change. Samples of palladium deuteride always show a variable volume that is in excess of the expected value[4] owing to cracks and other distortions to the lattice. The palladium that produced excess heat had an excess volume of 0.8% while the palladium that did not produce excess heat had an excess volume of 13.5% at D/Pd=0.75.

3. Results

After initial charging, the sample is ramped for 64 hr between 0.133 A and 2.77 A using various cycle times. No excess heat is observed at 0.133 A. After bivalued charging between 0.133 A and 2.77 A was initiated, excess heat between 1 and 2 W is seen at 2.77 A after 30 additional hours. After a total time of 159 hr the cell was opened to repair the recombiner that had stopped working at 145 hr. During this repair, the cathode was

exposed to air for 47 min. After reassembly, the cell was calibrated and the bivalence mode was resumed. The resulting excess heat is plotted in Fig. 6. After about 5 hr, a small burst of heat is observed which is typical of earlier behavior. This is followed by a steady increase over the next 55 hr. A calibration using the immersion heater was run between 304 hr and 312 hr while 1.0 A was applied to the cathode. Periodically, excess power measurements are made at various lower currents. Not only is the excess absent at 2.0 A and below, but these periodic interruptions do not seem to alter the steady rise once 2.8 A is resumed. At 295 hr, the recombiner began to fail again, owing to attack by lithium from the electrolyte, and the measured excess power is seen to decrease.

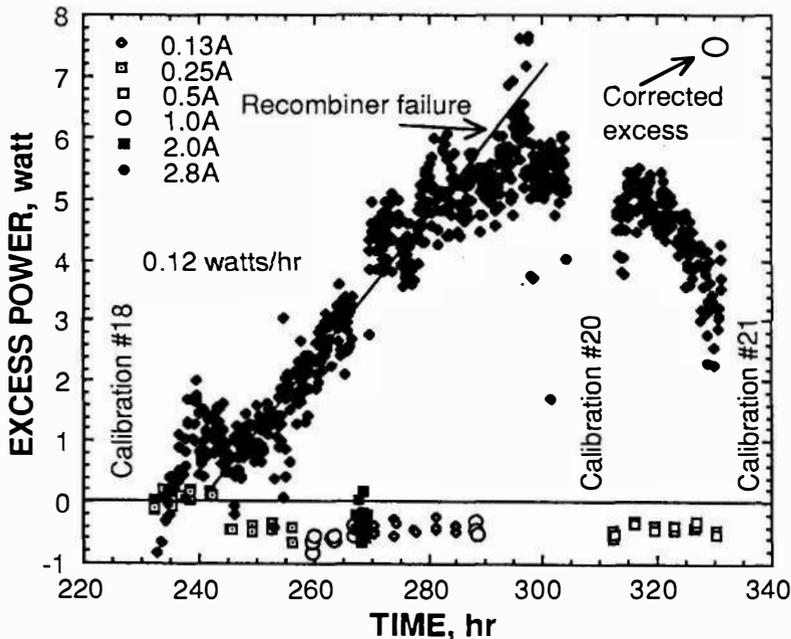


Figure 6. Excess power at various cell currents during Phase 2. The "corrected excess" value is the maximum excess power expected if the recombiner had worked properly.

If no oxygen is being recombined in the cell at 330 hr, 4.3 watts ($2.8 \text{ A} \times 1.54 \text{ V}$) must be added to the measured excess to give the actual excess power. When this is done, the value falls on the upward trend created by earlier data. Thus, the upward trend in power generation apparently is continuing up to the time when the cell is again turned off. After repair, heat at the 2-3 W level is observed for 6 hrs before additional problems re-

quire the experiment to be terminated.

4. Conclusions

Excess power has been made in an electrolytic cell using palladium similar to that used by A. Takahashi (Japan). After 90 hr of electrolysis, small amounts of excess heat were observed. After the cathode was exposed to air for 47 min and electrolyzed for ≈ 30 additional hours, excess power started to increase and reached $\approx 20\%$ of applied power (≈ 7.5 watts) before the study had to be interrupted. This power increased with time only while the palladium was electrolyzed at 0.42 A/cm^2 . No measurable excess power was seen at or below 0.38 A/cm^2 . This excess is about 75% of the amount expected at 0.42 A/cm^2 as proposed by Storms[3] based on a variety of calorimetric measurements. The excess heat originates from a different position within the cell than does electrolytic heat. This position is proposed to be the palladium cathode. The palladium produced heat in spite of being exposed to air after loading with deuterium, being placed in liquid nitrogen for a short time, and the electrolyte being saturated with CO_2 . However, no excess was produced after deloading to $\text{D/Pd}=0.73$ had occurred. The bivalued mode of charging, as used by Prof. Takahashi, does not appear to be a requirement for continued heat production once production starts. The palladium (Pd#1) that produced excess heat loaded to $\text{D/Pd}=0.82$ and the deuteride contained no significant excess volume. On the other hand, the palladium (Pd#2) that failed to show excess power loaded to only $\text{D/Pd}=0.75$ and had 13.5% excess volume. One explanation is that the second piece of palladium contained internal defects that caused the formation of cracks during loading with the result that a sufficiently high D/Pd ratio could not be achieved.

References

- [1] More detail about this work can be found in the March 1993 issue of Fusion Technology.
- [2] A. Takahashi, T. Iida, T. Takeuchi and A. Mega, "Excess Heat and Nuclear Products by $\text{D}_2\text{O/Pd}$ Electrolysis and Multibody Fusion", Submitted to Applied Electromagnetics in Materials, 1992.
- [3] E. Storms, "Review of Experimental Observations About the Cold Fusion Effect", Fusion Tech. **20** (1991) 433.
- [4] E. Storms and C. Talcott-Storms, "The Effect of Hydriding on the Physical Structure of Palladium and on the Release of Contained Tritium", Fusion Tech. **20**, (1991) 246.