Analysis of Patterson Power Cell by TNCF Model

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Abstract

The experimental data of the Patterson Power Cell (PPC) are analyzed in which 3.8 times higher excess power than input power was produced. More recent reports are of the excess energy elevated up to 10^5% of the input energy with good qualitative reproducibility. A model I proposed before, the TNCF model, is used as a basis of the analysis. The result gives an interpretation of PPC data consistent with several data analyzed before on the isotope shift, and on the excess heat and helium production obtained in electrolysis experiments.

1. Introduction

The Patterson Power Cell (PPC) accomplished a good qualitative reproducibility in excess energy generation up to 10^5% of input energy in an electrolysis system with a special Pd cathode and lithium electrolyte in heavy or light water[1].

There are several systems showing large excess energy generation with good qualitative reproducibility. One of those experiments done by Arata et al[2] had been analyzed using TNCF model[3] and the result[4] showed a density of trapped neutrons as high as 10^{15} cm^{-3} in the Pd-black cathode where there had been detected a large amount of helium on the order of $10^{20} \sim 10^{21}$ cm^{-3}.

The model also had been applied to analyze a data[5] showing an isotope shift of Sr in electrolysis of Rb electrolyte in H_2O. The analysis[6] gave a semi-quantitative explanation of the experimental data and a value of the trapped neutron density of the order of 10^7 cm^{-3}.

Another experimental data[7] on the excess energy and helium generation with Li and D_2O combination was analyzed similarly and the result[8] showed a neutron density of $\sim 10^{12}$ cm^{-3}.

An empirical relation between the excess energy Q, D/Pd ratio x in the sample and the electrolyzing current density i had been deduced[9] from data obtained by elaborate experiments. The relation was analyzed by TNCF model and the result[10] showed a qualitative explanation of the relation consistent with other experimental data.

These analyses of various different experiments gave us a consistent understanding of the physics of the cold fusion phenomenon. So, we will try to analyze the excellent apparatus invented by J. Patterson, using microspheres coated with Pd-Ni layers[1]. In an experimental analysis of PPC by D. Cravens[1], he explained the performance of the cell; 1200 beads with 2 micron thickness of all metal layers, an input power of 0.46W, and a thermal output 1.77W ($=1.1 \times 10^{13}$ MeV/s).

The structure of PPC cathode reminds us the Pd-black cathode used by Arata et al[2]. The appropriate form and structure of the cathode material seems to be an essential factor for effective realization of the cold fusion phenomenon, for which it is considered in TNCF model that a necessary condition is the trapping of thermal neutrons. The difference in the two systems is the light and heavy waters used in electrolyte solution. We have to notice that light water is less effective in feeding neutrons to the system from our point of view.

2. Nuclear Reactions Relevant With Patterson Power Cell

In a Pd sample with a large amount of hydrogen atoms, there occurs a fusion reaction between the trapped thermal neutron (with a density N_n cm^{-3}) in Pd lattice and the protons occluded around or in it:

$$n+p=d(1.3\text{ keV})+g\ (2.2\text{ MeV}). \qquad (1)$$

The fusion cross section of this reaction is σ_{np} = 0.6 barns. This reaction feeds deuterium in the sample in addition to that by a preliminary treatment, if any.

When there is PdLi or lithium layer(s) on the surface, there occur following reactions induced by thermal neutrons:

$$n + {}^6\text{Li} = {}^4\text{He}\ (2.1\text{ MeV}) + t\ (2.7\text{ MeV}), \quad Q_l = 4.8\text{ MeV}. \quad (2)$$

$$n + {}^7\text{Li} = {}^8\text{Li} = {}^8\text{Be}\ (1.2\text{ keV}) + e^-\ (13\text{ MeV}) + \nu_e.$$

$^8Be = {}^4He\ (1.6\ MeV) + {}^4He\ (1.6\ MeV),\quad Q'_1 = 16.2\ MeV.$ (3)

The cross sections of the reactions (2) and the first of (3) are $\sigma_{nL6} \sim 1$ and $\sigma_{nL7} = 0.07$ barns, respectively. As is well known, the natural abundance of ^6Li and ^7Li are 7.5 and 92.5 %, respectively.

The triton with 2.7 MeV generated in the reaction (2) above fuses with a deuteron with a cross section $\sigma_{td}\Omega$ barn until the triton lose energy down to 0.1 MeV:

$t + d = {}^4He(3.5\ MeV) + n\ (14.1\ MeV).\quad Q_2 = 17.6\ MeV.$ (4)

The neutron with 14.1 MeV generated in the reaction will make interaction with other particles; 1) The elastic collision with a proton to accelerate it to higher energy with a cross section $\sigma_{np} \sim 0.5 - 5$ barns (at 1 MeV),

$$n + p = n' + p'. \quad (5)$$

2) The elastic collision with a deuteron to accelerate it to higher energy with a cross section $\sigma_{np} \sim 0.5 - 5$ barns (at 1 MeV),

$$n + d = n' + d'. \quad (6)$$

3) The disintegration of a deuteron duplicating neutron with a cross section $\sigma_{npn} = 0.2$ barns

$$n + d = n' + p + n''. \quad (7)$$

The accelerated deuteron in the reaction (6) can fuse with another deuteron with a cross section $\sigma_{dd} \sim 0.1$ barns for the deuteron energy E_d larger than 1 MeV (1 MeV $< E_d$):

$d + d = {}^3He(0.82\ MeV) + n\ (2.45\ MeV),\ Q_3 = 3.27\ MeV$ (8)

$= t\ (1.01\ MeV) + p\ (3.02MeV)\ \ Q'_3 = 4.03MeV.$ (9)

A series of reactions written above will work in cold fusion phenomenon, together.

3. Estimation of excess power in PPC

Let us assume a stationary existence of trapped neutrons with a density N_n in the metal plate (thickness $\delta = 2\ \mu m$) on the surface of the microsphere with a diameter 1 mmø. Also we assume a presence of $PdLi_x$ (or $NiLi_x$) alloy and Li metal layer with a thickness δ' on the outer surface of the metal plate. The volume v of the metal plate on the surface is, then, $v = 1.3 \times 10^{-6}\ cm^3$. Therefore, total volume V of the metal plate on the surfaces of 1200 microspheres is $V = 1.6 \times 10^{-3}\ cm^3$.

The deuterium content in natural water is known to be 0.015%. Considering a possible enhancement by preliminary treatment and by the reaction (1), we write the density of deuterium in the sample as $\eta\rho_d$ with an enhancement factor η (≥ 1) where $\eta =$ there are no enhancements.

Then, the number of events per unit time (quency) of reactions (2) and (3) denoted by ν_l ν'_l, respectively, are expressed as follows:

$$\nu_1 = 0.35 N_n v_n \rho_{Li6} \delta' S \sigma_{nL6}$$
$$\nu'_1 = 0.35 N_n v_n \rho_{Li7} \delta' S \sigma_{nL7} \quad (10\text{-}11)$$

In these relations, $0.35 N_n v_n$ is the neutron density ($cm^{-2}s^{-1}$), δ' and S are the thickness and area of the PdLi (NiLi) alloy layer. The factors and σ_{nL7} are the fusion cross sections of the the neutron with ^6Li and ^7Li, respectively. When a stitutional alloy PdLi is formed, then PLi = PL PLi7 = $3.4 \times 10^{22}\ cm^{-3}$, while the density of hy gen ρ_H in palladium is $6.8 \times 10^{22}\ cm^{-3}$ when H/P

When a reaction (2) occurs, the triton gener there induces the reaction (4) with a frequency

$$\nu_2 = P_l \nu_l, \quad (12)$$
$$P_1 = \eta \rho_d \sigma_{td} \delta_t \quad (13)$$

In the relation (13), δ_t is a length in which triton runs with energy more than 0.1 MeV, η i amplification factor of deuterium in the sampl explained above.

The neutron with energy 14.1 MeV generate the reaction (4) induces the reactions (8), (9) others through elastic collisions (5) and (6). t we can write down the excess power E by these actions, as follows:

$$E = \nu_1 Q_1 + \nu'_1 Q'_1 + \nu_2 Q_2 + P_1(Q_3 + Q'_3), \quad (1$$

$$E = \nu_1 (Q_1 + \frac{\nu'_1}{\nu_1} Q' + P_1 Q_2) + P_1(Q_3 + Q'_3). \quad (1$$

Here, Q_s and Q'_s are the whole energies in sample and in solution, respectively, generated cessively by a neutron produced in the reaction

The experimental data[1] (D. Cravens) shows output power of 1.77 W using 1200 microsphere the cell. Therefore, we equate this equation with x 10^{13} MeV/s. Then, putting values of parame given above into this equation, we obtain a rela between N_n and δ_1: (16)

$$N_n(1.3 + 3.1x10^{-5}\delta_1\eta) + P_1(Q_3 + Q'_3) = 1.1x10^{13}(M$$

1) If we keep only the first term on the left glecting all reactions following the $t - d$ reaction we obtain a relation which determines the densit trapped neutrons in the sample in this case:

$N_n = 8.5 \times 10^{12}$ (cm^{-3}). (17)

Inclusion of the energy terms with X, Q_s and Q'_s will reduce the value of the neutron density by at least one order of magnitude. This value of the neutron density is similar to that in the case of Pd-D system analyzed before[7] and seems a reasonable one.

2) In the experiment with light water, a problem in TNCF model is the supply of trapped thermal neutrons. Without initial deuterons in the system, the only the source of deuterons is the reaction (1) with a considerable cross section 0.6 barns. to keep enough density of neutrons as 10^{13} cm^{-3} as estimated above to produce observed excess energy, we have to rely on the other neutron sources, e.g. preliminary occlusion of deuterons in the sample to make η large.

The neutron generating reaction (8) may be half the total reactions (8) and (9) generating energy. Borrowing data from previous estimation[8] in Pd + D_2O + LiOH system that the energy produced by reactions initiated by the neutron with 14.1 MeV was $P_1(Q_s + Q'_s) \sim 26$ MeV, we have the number v_3 of reaction (8) generating a neutron, $v_3 \times P_1 Q_s/Q_3 \sim 13/3.27 = 4$ s^{-1} ($Q_s \sim Q'_s$ assumed).

This value is not absurd if we consider the result of a model calculation given before[11] and gives a possibility to supply enough neutrons necessary for the cold fusion phenomenon.

Let us investigate an optimum situation where $\eta = 6.8 \times 10^3$ (every hydrogen isotope is deuterium); then, we have $P_1 = 0.07$. Therefore, the total number of neutrons produced in successive reactions initiated by the 14.1 MeV neutron becomes $P_1 v_3 \sim 0.5$. This result means that it is not sufficient to keep the neutron density constant if only the gain by reactions (4) and (8) is assumed to compensate the loss in the reaction (2). It is possible, however, to add the reactions (7), and (3) followed by ^{4}He – *d* interaction for breeding of neutrons. Therefore, we can hope that the neutron balance is maintained scarcely in the optimum case where all the occluded hydrogen isotope is deuterium.

Our model predicts that even in the lithium electrolyte it is difficult to realize steady heat production by cold fusion with pure hydrogen.

4. Conclusion

We don't have enough information about PPC, even with the outstanding reported results. With the limited detailed information, I have tried to analyze the data of PPC using the TNCF model to test its ability. The result shows that it is necessary to have fairly high density of deuterium in Pd cathode to maintain cold fusion phenomenon steadily in Pd–H_2O–LiOH system if the TNCF mechanism is responsible for the observed excess energy. To initiate the high excess power generation in the operation of PPC with light water, it might be necessary to have a preliminary occlusion of deuterium in the cathode.

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