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Optimization of Output in a Cold Fusion Generator

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Abstract

Progress has been made in the production of excess heat from a cold fusion generator based upon the combination of deuterium ions within a metallic matrix. Drawing from fundamental considerations, this paper identifies for optimization those quantities and methods which would tend to increase the heat production. An analogy to hot fusion is presented, followed by theory of the PONS cell. Methods to increase fusion output are introduced with a detailed theoretical analysis of the effective kinetic temperature generated for deuterium ion under an electric field in a porous material.

1. Introduction: Similarity to Hot Fusion

In a light ion hot fusion reactor, deuterium (D) and tritium (T) are magnetically bottled and interact together to form helium (He) and its isotopes. Two major forces are at work: a electrostatic repulsion force between the two protons, and a short range strong nuclear attraction force between all protons (P) and all neutrons (N). Considering the P and N as "hard balls", the minimum separation distance between nuclei is two times the P radius. The net force is attractive until a larger unstable equilibrium distance and is repulsive after that distance. The quantity of work required to bring the two nuclei together is simply the force from the equilibrium separation distance to infinity integrated over distance. This work is derived from the initial momentum of the ion, which is a function primarily of temperature. Thus, when two ions are on a collision course, fusion will occur when their initial relative velocity exceeds a certain minimum which is sufficient to overcome the electrostatic repulsion force mediated by the strong nuclear attraction force. Clearly, the nuclear attraction force increases linearly with the number of possible nuclear interactions: If a P-P interaction force is arbitrarily set at "1", then a P-D interaction would be set at "2", D-D interaction would be set at "4", D-T at "6", and T-T at "9". As the total amount of charges remains constant, the interaction temperature decreases as the atomic number increases. For example, a D-D reaction may occur at approximately $3x10^8$°K, a D-T reaction at $3x10^7$°K and a T-T reaction at $3x10^6$°K.

2. Theory of Electrolytic "PONS" Cell

The objective of cold fusion is to experience these types of reactions at 300°K. In the PONS type electrolytic cell[REF 1], D gas ions form on the surface of palladium electrode and diffuse into the metal lattice. When two D ions coexist in one metal lattice cell at the same time, and their relative velocity is sufficient to overcome the net electrostatic barrier, then fusion occurs. It is noted that the velocity of the ions in the gas follows a Boltzman probability distribution of velocity curve. Intrinsic in this design is the realization that the electronic fields of the metal lattice shield a major part of the natural electrostatic repulsion of the two ions. That some shielding occurs is undisputed; the extent of the shielding is difficult to calculate and is disputed to be sufficient for the fusion process to occur at essentially room temperature.[REF 2]

3. Methods to Increase Fusion Output

To increase the rate of nuclear fusion increase the probability of reactant contact per unit time or for each reactant contact and/or increase the probability of reaction.[REFS 3]

3.1. To increase the probability of reactant contact, one may:

A. Increase the local density of reactant.

1. One method would be to increase the pressure of the entire system. Practical considerations are the strength of the reactant vessel.

2. A second method would be to preload the metallic lattice with D ions until the ratio of ions to lattice cells reaches a certain fraction.[REF 4] While this method will cause reaction initiation, the D ion concentration will decrease in the steady state.

3. Another method would be to increase the net velocity of the ions through the lattice. Physically increasing the temperature would increase the binary diffusion rate, producing this result. The practical limitation in the PONS (wet) system is not to exceed the boiling point of the water. In a D gas--metal system, one could operate at much higher temperatures, radically increasing the diffusion rate and hence the local density of reactant.[REF 5]

B. Decrease the presence of any nonreacting interfering species

1. The system must be purged of all non-reacting chemicals. The lattice may be internally cleaned of absorbed hydrogen by thermal vacuum outgassing and other methods. The surface of the system must be cleaned continuously with no biological or physical coatings impeding the diffusion of the deuterium ions.[REF 6]

C. Increase the presence of the most highly reacting species. ,

1. As T is more reactive than D, methods to increase the density of T within the lattice would tend to increase reaction rates.

3.2. To increase the probability of reaction, one may:

Given two charged ions, the major obstacle to combination is their mutual electrostatic repulsion. Thus, either decrease the repulsion or give the ions sufficient velocity to break through the repulsion barrier.

A. To decrease the repulsion, surround the positive ion with a dense electronegative field.

1. The field could emanate from the metallic lattice. Thus, selection of a metallic lattice which tends to have a high local electronegativity or high dielectric constant would increase reaction rate.[REF 7] Lattices of palladium, titanium and nickel have been shown to produce excess heat. A lattice of perovskite ceramic have been successful by some researchers.

2. The field could emanate from a singular unusual charged cloud, such as a mu-meson.[REF 8] The mu-meson, an atomic entity with the charge of an electron and 200 times its density, closely surrounds the ion, allowing sufficient shielding for proven fusion at room temperature. However, this atomic entity is short lived and takes more energy to produce that is derived economically from the fusion reaction.

3. The field could emanate from point defects in a metallic lattice. Local defects show a remarkable concentration of electric field which could lead to local fusion generation at that point. However, the immense quantity of local heat generated by such fusion events would tend to cause disruption of the point defect, and self-extinguishment of the reaction. Perhaps this method could account for some of the irregular times of occurrences of fusion reported by some authors. Selection of a metal with many point defects and grain boundaries may enhance this method of increasing reaction rate.

4. The field could emanate from an artificial external source.

A. An electron cloud could be generated similar to that in old-styled radio tubes and the D gas would be placed within that cloud.

B. Selective bombardment of D within the metal lattice with high energy focused electromagnetic waves would increase the field density.

B. To increase the velocity of contact, certain steps could be taken.

1. Increase the individual temperature of the ion. There is a severe limitation on this method by the wet ion-metal system over that of gas ion-metal system.

2. Accelerate the ion by placing it within an electric field.

A. The electric field could be placed across the metal or ceramic in a binary gas-metal/ceramic system. From electron transport theory inside a metal, consider the movement of an ion of charge "Q" along a free path across a pore diameter "A" under the influence of an electric field, "E". Consider that the ion's velocity at its point of origin at the entry to one side of the pore is zero, and that the ion subsequently loses all electric field induced momentum by impaction at the other side of the pore. Letting "V_f" be the final ion velocity, "m_i" being the mass of the ion, "t_f" be the total flight time, "a" being the acceleration, "T_k" being the effective kinetic temperature, and "k" being Boltzman's constant. The effective kinetic temperature "T_k" is defined conventionally as the equivalent gas temperature of a set of ions moving at an average velocity "V_f". The equations governing the motion of this ion would be:

$$Q \cdot E = m_i \cdot a\ ,\quad A = .5 \cdot a \cdot t_f^2\ ,\quad v_f = a \cdot t_f\ ,\quad .5 \cdot m_i \cdot v_f^2 = 1.5 \cdot k \cdot T_k\ ,\quad T_k = \frac{2 \cdot A \cdot Q \cdot E}{3 \cdot k}$$

Question: For an electric field of 5×10^5 Volts/meter, and a pore size of 10 microns, what would be the effective kinetic temperature?

$$T_k = \frac{2 \cdot 10^{-5} \cdot 1.6 \cdot 10^{-19} \cdot 5 \cdot 10^5}{3 \cdot 1.38 \cdot 10^{-23}} = 3.9 \cdot 10^4\,K$$

This magnitude of electric field cannot be supported in a metal. It can be supported in a semiconductor with the properly chosen material properties. Even allowing for other inefficiencies in the accelerating flight path due to field interaction with the lattice ions, an electric field could produce, at room temperature, an effective kinetic temperature, which, magnified by shared lattice electronegative field, would allow light ion fusion. Like the electron beam hitting the interior of a television tube, the total quantity of energy transferred to the ion is small compared to the overall thermal energy of the lattice, and therefore that overall lattice temperature does not substantially rise due to the electric field alone. Certain researchers have observed transient fusion effects which are difficult to repeat. These effects could well be due to lattice defects, which are themselves lost due to the intense local energy generated at a point at the site of ion fusion. Current research in our laboratory utilizes an apparatus with these electric fields.

Placement of any electric field across a metal is difficult as its resistivity is low, leading to excess current flow. Alternatively, an electric field could be placed on an insulator, essentially creating a capacitor. One might construct an ion-insulator system. In a capacitor, there is a large surface charge and no movement of electrons within the material. The insulator may not be able to provide the proper amount of local electron sharing required to local electrostatic shielding, although some research groups have noted positive results for certain high temperature ion-ceramic systems.

B. The electric field could be placed upon a semiconductor. Thus, one would have a ion-semiconductor system. Many natural materials, such as germanium and silicon, are semiconductor by nature, and may allow both the presence of the electric field and the proper amount of internal electrostatic shielding for fusion to occur.

C. The electric field could be directly acting upon the ion.

1. One method is to produce deuterium ions by electric or X-ray ionization and then accelerating them in an electric field in vacuum, letting them impact a metallic lattice system. The ion would gain sufficient velocity but only at the surface of the metal, as the ion would transfer much of its kinetic energy to the lattice upon contact, essentially losing all of it within a few atomic layer depths. Further, the impact itself would tend to damage the surface of the lattice.

2. Another method is to accelerate the ion by electric field and increase the ion density through magnetic pinch effect to increase the reaction rate.

4. THE PROOF IS IN THE PUDDING

The public will accept cold fusion as a viable energy source when they can see a totally closed system producing usable power. It is good for individual researchers to produce sophisticated calorimeter results of excess heat production, but unless this heat can be translated into usable power, and the power utilized to prime, sustain and power the instrumentation for the reaction, the public will remain skeptical.

We have experimented with a novel design to extract heat from a boiling reaction chamber and convert it directly to electricity. In this design, a matched heat pipe is connected to a metallic thermal reservoir, itself connected to thermoelectric modules with cooling fins. At present, the unit efficiency is low, on the order of 1.5-2%, but better convection cooling, a higher reaction temperature, and a lower cooling temperature will increase this figure substantially. Obvious advantages are no observable moving parts, no danger of overload, and no necessity of continuous adjustment or calibration.

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