LENR: An Off-Grid Stand-alone Energy Source

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Abstract

Energy crisis is slowly building up due to the increase in the amount of energy requirement in every field of human existence. Pollution free energy is in great demand due to the government norms implemented worldwide in reducing global warming. Infinite energy from low radiation reactions are currently being explored into. Nuclear Fusion is one of the methods which produces high energy yield with very low radiation effects. This paper explores into the possibility of Low Energy Nuclear Reactions (LENR) [1] which has the potential to curb the ever increasing energy scarcity. Bubble fusion a type of cold fusion, is highlighted in this paper as a major breakthrough in this research field. This paper intends to revive a research in the field of nuclear fusion reactors in the small form factor structure that could be a possible solution for the existing energy crisis.

Keywords: LENR, Bubble Fusion, Cold Fusion, Sonofusion, Isotope, Helium, Deuterium, Tritium, Muon

I. INTRODUCTION

Energy scarcity is the major threat humans are going to face in the ensuing years. Naturally available resources like petroleum, coal, natural gas and metal ores will be depleted soon due to excess usage and demand. Renewable energy sources too cannot fulfil the huge energy requirements due to the expenditure and frequent maintenance. An alternate source with least threat is a demanding domain. This paper is an instigation towards the concept of off-grid, self-sufficient power sources.

A nuclear fission energy reactor with high capacity energy generation is extremely hazardous to the living organisms causing gene mutation due to the liberation of harmful nuclear radiations caused by catastrophic failures. Nuclear fission based power generation is around 6% of the total energy production in the whole world and contributes to 13-14% of the total electricity generated. The target is to provide energy source based on nuclear fusion reaction that involves hydrogen and its isotopes (deuterium and tritium) which possess zero radiation threat to the human kind. Researchers like Fleischmann and M.S.Pons has opened a path towards the miniaturization of nuclear fusion reactors. The research work (cold fusion)[2] published by them in 1989 which highlighted the proof for sustained nuclear fusion reaction in a small room at room temperature has created so many controversies that embroiled the physics community. Later their work was carried out by several researchers globally and many of them have successfully visualised the results.[3][4]

Bubble fusion experimented by Dr R P Taleyarkhan of Oak Ridge National Laboratory in 2002, is a prototype for compact fusion reactors. He has published evidence for the successful nuclear fusion reaction with his experimental setup by blasting a glass flask filled with liquid rich in deuterium, an isotope of hydrogen, with ultrasonic sound, creating pressure oscillations that led to the implosion of tiny bubbles in the liquid. The fusion process in the deuterium was caused by the violent collapse of the bubble. Because of the presence of bubble, the process was termed as bubble fusion. The fusion reaction was also named as Sonofusion because of the use of ultrasonic sound waves in triggering the reaction. [5]

II. NUCLEAR FUSION

Nuclear reaction which takes place at very high temperature is called thermonuclear reactions. Nuclear fusion is the process in which two lighter nuclei are fused together to form a heavier stable nucleus. In this case a large amount of energy is released because the mass of the single nucleus so formed is less than the sum of the mass of the parent nuclei. Now the mass difference is converted in to energy according to $E=mc^2$.When the two deuterons are brought together, the following reaction takes place with the liberation of 24MeV of energy.[6]

$$ {}_1^2H + {}_1^2H = {}_2^4He + \upsilon \quad (1)[7][8] $$

The technical problem aroused regarding the above process was the possibility of fusing two positively charged nuclei as there would be electrostatic repulsion between them. For fusion to take place the component nuclei must be brought to within a distance of 10^{-12}cm. In order to approach so closely they should be imparted with high energies, so that they may overcome the repulsive force (Coulomb force).

The repulsive energy between the deuterium atoms can be calculated by the following formula

$$U \equiv E_P = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{d_{12}} = \frac{1}{4\pi * 8.8541853 * 10^{-12}} * \frac{(1.602 * 10^{-19})^2}{4 * 10^{-15}} =$$
$$= 5.7664 \text{ x } 10^{-14}[J] = 5.7664 \text{ x } 10^{-14} \text{ x } 6.242 \text{ x } 10^{18} \text{ [eV]} = 3.599 \text{ x } 10^{5} \text{ [eV]} \qquad (2)[9]$$
$$= 360keV$$

The calculated value of energy is equivalent to a temperature of 3600 million degree Celsius. So the only practical way of fusing the two nuclei is to raise their temperature to excessively high value. This thermonuclear reaction[6] results in the generation of enormous amount of energy in the range of MeV. The possible reactions with hydrogen isotope, deuterium that is abundant in nature can be as follows.

$${}_1^2H + {}_1^2H = {}_1^1p + {}_1^3H \quad (+4.0MeV) \qquad (3)[8]$$
$${}_1^2H + {}_1^2H = {}_0^1n + {}_2^3He \quad (+3.3MeV) \qquad (4)[8]$$
$${}_1^2H + {}_2^3He = {}_1^1p + {}_2^4He \quad (+18.3MeV) \qquad (5)[8]$$

An excess amount of 17.9MeV is generated during the fusion reaction which can be utilized as a viable energy source.
Another possible fusion reaction is between deuterium and tritium (heavy isotope of hydrogen) is as follows that leads to the liberation of 17.5MeV energy.[6]

$${}_1^2D + {}_1^3T = {}_2^3He + 3.5MeV + {}^1n + 14MeV = {}_2^3He + {}^1n + 17.5MeV \qquad (6)[9][10]$$

Since tritium is not easily available due to its high instability, it can be synthesized from lithium.

$${}_3^6Li + {}^1n = {}_1^3T + {}_2^4He + 4.6MeV \qquad (7)[7]$$

The mass of two hydrogen atoms is a bit higher than that of helium atoms, and this mass difference gets converted to large amount of energy according to Einstein's mass energy conversion formula.

III. COLD FUSION

The required temperature for triggering the fusion reaction is 3600 million degree Celsius. The maximum attained level is 150 million degree Celsius and to maintain that temperature level is perilous. The fusion reaction can be triggered at room temperature too, using various techniques. This category of reactions is termed as cold fusion reactions. Cold fusion is a field of condensed matter nuclear science (CMNS). It is also termed as Low Energy Nuclear Reaction (LENR)/Lattice Assisted Nuclear Reactions (LANR)/Low Energy Nano Scale Reactions (LENSR).[11][8][12][6]

One of the prospects suggested by McNally is based on the combination of isotopes (D) in the thick density. The density levels dealt ranges from 10^{14} D/cm^3 to 10^{26} D/cm^3. The possibility of pycnonuclear fusion is very high if the isotope concentration is above 10^5g/cm^3. The D+D or D+T fusion ignition in this case can occur at any temperature. The fusion reaction in this case is temperature independent.[2][8][10]

The findings based on the requirements for sustained oscillations includes the presence of reactants along with the mass-energy of the compound nuclei in which excess energy appearing as the triggering energy for the formation of compound nuclei. The condition for the same is that the projectile and the target nuclei must be in the nuclear force range for a time span in the range of several microseconds. Also for a compound nucleus reaction to occur it needs large interaction between the nucleons in the above specified time span.[4][13][6]

The nuclear mass energy resonance of input nuclei and output compound nuclei required for sustained fusion reaction is based on the possession of threshold levels (excitation levels) in which net excess energy is within the level width of excited states. The possible reaction is

$${}_1^2H + {}_1^3H = {}_2^5He + 16.7MeV \quad (8)[7][11]$$

Thus D+T = ${}_2^5He^*$(16.70 MeV)[10] which occurs 60KeV below the 16.76 MeV excitation state in ${}_2^5He^*$ and has a maximum cross section of 5 barns at 60KeV centre of mass energy of D+T.

The concept of cold fusion is an extract in the journey of finding a clean, reliable and immutable energy source that could revolutionize the world and would solve our energy problem. [3]

IV. METHODOLOGIES AVAILABLE IN COLD FUSION REACTIONS

A. Cold Fusion With Fusion Cell [14]

The fusion cell designed by Pons and Fleishmann[15][1] (Figure-1) consist of a container filled with heavy water electrolyte which is a rich source of deuterium. Two electrodes are submerged in to the heavy water and are powered to undergo the process of electrolysis, in which the heavy water molecules would split to form deuterium gas and oxygen. The cathode is made of palladium and is having the property to absorb deuterium gas due to its large lattice space. The possible hypothesis to explain this is the classical oscillator behavior of deuterium ions in palladium lattice. The high chemical potential energy of D^+ ions overcomes the electrostatic repulsive force existing between the ions which seriatim prevent them from amalgamation. This quantum mechanical tunneling between D^+ ions, force them to fuse and hence release prodigious amount of heat which in turn increases the fluid temperature of electrolyte. The possible reactions can be[16][17][14]

$$^{2}_{1}D + ^{2}_{1}D = ^{3}_{1}T + 1MeV + ^{1}_{1}H + 3MeV = ^{3}_{1}T + ^{1}_{1}H + 4MeV \quad (9)[8][15][9]$$

$$^{2}_{1}D + ^{2}_{1}D = ^{3}_{2}He + 0.8\,MeV + ^{1}n + 2.5MeV = ^{3}_{2}He + ^{1}n + 3.3MeV \quad (10)[8][15][9]$$

$$^{2}_{1}D + ^{2}_{1}D = ^{4}_{2}He + \gamma \quad (11)[8][15]$$

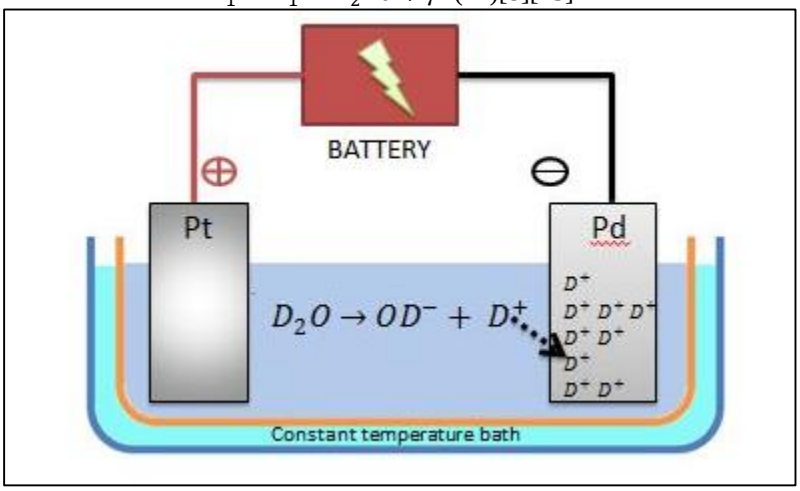


Fig. 1: fusion cell designed by Pons and Fleishmann[14]

B. Muon Catalyzed Fusion (μCF)[18]

Muons are catalysts that stimulate the cold fusion reaction. They have a mass 200 times higher than a normal electron and ten times lower than proton, but possess similar charge of electron. It is naturally synthesized when cosmic rays hit air molecules at the top of the atmosphere. The synthesis rate over sea level is approximately 1muon/cm^2 per minute coming from the sky.[18] When muons are injected to deuterium gas, it displaces one of the electron and hence reducing the equilibrium bond distance between the deuterons. This results in quantum tunnelling and hence nuclear fusion.

C. Sono Fusion[19]

Sonofusion / bubble fusion[20] proposed by Dr R P Taleyarkhan of Oak Ridge National Laboratory is a prototype for compact fusion reactors. The system (Figure-2) involves a glass chamber filled with liquid rich in deuterium (deuterated acetone, C3D6O) that is deprived of free air (vacuum). The chamber is encircled with Lead Zirconate Titanate (PZT) patch with which a high frequency oscillation will be induced to the chamber and in effect to the electrolyte. This creates pressured oscillation that results in bubble formation in the size range of 10nm which eventually grows to μm range and implodes in the presence of neutrons (neutron induced nucleation) from external pulsed neutron generator (neutrister)[21]. Hence the reaction was termed as Acoustic Inertial Confinement Fusion.[7][20][19]

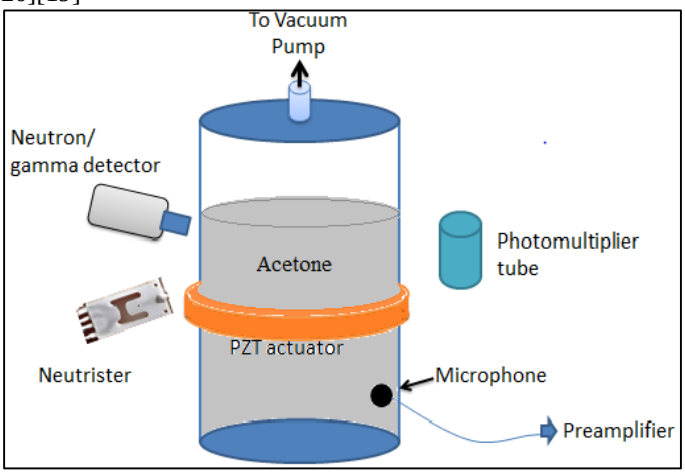
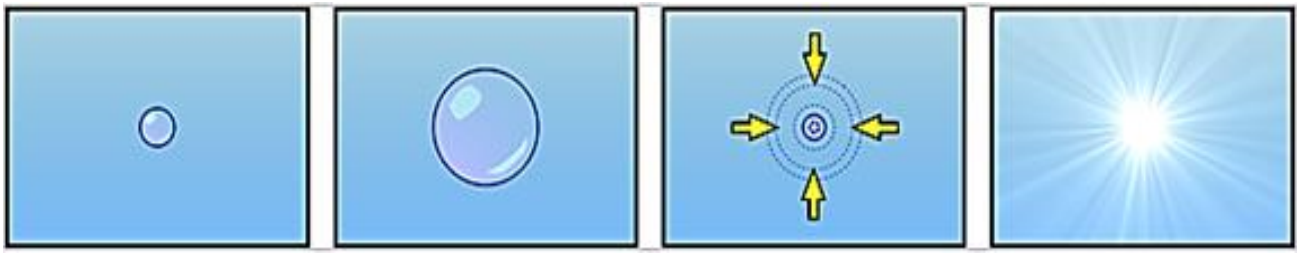


Fig. 2: Taleyarkhan's experimental setup on SBSL[19]

The Single-Bubble Sonoluminescence (SBSL) experiment by Dr. Taleyarkhan experienced series of light pulses in spectrum ranging from gamma ray to ELF [22]along with a series of bubble imploding sounds and shock waves in the medium. The bubble implosion simulated by hydrodynamic shock code observed significant amount of energy generation but insufficient for an industrial system. To overcome this limitation Sato and Sugai proposed Multi-Bubble Sonoluminescence (MBSL) reactions.[23]



(a) (b) (c) (d)

Fig. 3: [19](a) apparition of bubble; (b) slow expansion; (c) quick and sudden contraction; (d) purported fusion event.

The replication of SBSL experiment was done by multiple researchers of which the cardinal work was done at UCLA. But these procedures lacked so many features that were present in the actual set up and raised comments that counters Taleyarkhan's experimental outcome. But Taleyarkhan's collaborator Richard T L Jr, a professor at Renssetter Polytechnic Institute in Tray commented on these allegations highlighting the need of Tyrex glass flask and the ceramic piezo electric ring attached to the glass to generate the acoustic shock in the medium which results in successful implosions. They have proven the presence of neutrons during the implosions which are an evidence of nuclear fusion reaction. The nuclear fusion reaction is generally uncontrollable.[23][19]

Tadahika Mizuno, a Japanese nuclear chemist and former assistant professor in atomic power environmental material program at Hokkaido University, conducted an extraordinary 10 day long heat-after-death incident in 1991. He performed a new fusion experiment with closed cell and produced about 114MegaJoules of energy during the entire experiment. The active material in the cell was 100 grams of palladium and produced energy 27 times greater than an equivalent mass of chemical cell. After 8 months of preparations Mizuno and one of his graduate students (Ohmori) conducted the experiment at 100 degree Celsius and 10 atmospheres of pressure and constituted proof of tritium, excess heat and transmutation. The major problem with cold fusion researcher is the endless guerrilla war with other scientist/institutions to stop the research.[12]

V. CONCLUSION

The energy scarcity is skyrocketing day by day. Global warming caused by the conventional energy resources is damaging the planet. Cold fusion reactions using naturally available resources promise a great future. These types of reactions also give out least amount of radiation and can be conducted in small setup. Research in this field is to be geared up as this could be the source of infinite energy which will wipe out the traditional high pollution energy resources. .

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