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Possibility analysis on energy breakeven of Z-pinch & accelerator-based fusions

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Abstract

Energy breakeven is the key to utilize fusion energy. This paper predicts Z-pinch based fusion breakeven is possible in near future as long as it is available of a better pulse DC power supply with high voltage and tremendous current than prior LTD (Linear Transformer Driver), but accelerator-based fusion hopeless forever.

Introduction

Z-pinch machine is the proud big science equipment of Sandia national laboratories of USA. Although incredible huge investments have been sunk for long time endeavor, it is still the most concern of science community that whether such a monster machine is possible to realize breakeven for commercial fusion energy production.

Also many accelerator-based fusion projects have been conducted all over the world, but same question of energy breakeven is pending.

Hereby I offer my analysis on this issue.

Z-pinch fusion

Nowadays, LTD-based (Linear Transformer Driver) high voltage and high current pulse power supply is used in Z-pinch machine (**ref. 1 & 2**). It can reach **5.4MV, MA & TW** level.

According to the **Sandia Lab**'s science paper, their highest neutron yield of **Z**-pinch can reach **60** million **neutrons per joule** energy input.

As no neutron will be wasted, even unluckily not captured by any nucleus, it can still release max **0.78MeV** via **β** decay to proton with some not claimable loss in neutrino within about **15** minutes.

Almost all neutrons can be captured after cooling to room temperature, and every capture event can produce energy about **7MeV** in average by recoil or gamma photons.

If well designed, the ensuing events can continue to generate energy by beta or alpha decay or delayed other events, during which, about **8MeV** can be reasonably assumed. Here the ensuing fission event is ruled out, unless fission isotope **U-235** is used, though its energy can be many folds higher.

So, total **15MeV** in average can be optimistically induced by one thermal neutron.

No neutron is released in cold state, if Z-pinch induces **D+T** reaction, extra innate **17.6MeV** should be added to the total, else if **D+D** then **4MeV**, so total is **15 + 17.6 = 32.6MeV** per neutron for the former, and **15 + 4 = 19MeV** for the latter.

Now it is ready to assess **Sandia Lab**'s potential efficiency of nuclear energy generation:

For simplicity and rough estimation, take **30MeV** per neutron, we find:

The specific efficiency = output/input =

$$(60*10^{6})*(30*10^{6})*(1.602*10^{-19})J/1J \approx 0.0003 = 0.03\%$$

The result means **99.97%** input is converted to non-nuclear dissipation, and obviously indicates the efficiency is far away to the breakeven.

For meaningful breakeven, the nuclear energy output should be far more than or commeasurable to the conventional thermal dissipation.

If the neutron yield can be increased to **1000** times of current quote **60** million per joule, then the specific efficiency will be **30%**, i.e. the overunity = **1.3**, it hence exhibits some commercial potential.

The deep **Z**-pinch research shows the neutron yield grows cubically as a function of the electric current. So if the prior **Z**-pinch max current can be increased **10** times, then the increased **1000** times neutron yields can make breakeven point occur.

According to ohm's law, the best direct way of increasing current is to increase voltage as high as possible, so increasing current Z-pinch voltage to **10** times above can theoretically meet the breakeven condition, however unluckily prior art of high voltage generation already touches the ceiling.

With the fast development of state-of-art post-LTD pulse power supply technology, such as the dielectric blade comb piston mechanic-electric bi-direction conversion technology (**ref. 3 & 4**), the promising future of Z-pinch fusion is looming clear and more clear!

Why accelerator-based fusion most likely hopeless of breakeven?

Nowadays high energy physics can accelerate particles to the energy order of magnitude **GeV** even **TeV**, however it will consume huge input energy, because the accelerated relativistic particles usually fly in almost light speed.

It is only good for special purposes such as medical isotopes synthesis, educational demonstration etc. and never a decent choice for commercial energy generation, because the extreme high input does spoil the breakeven.

From the view of aforementioned analysis, the extreme high voltage power supply is capable to catalyze fusion reaction and reach breakeven point, because there is no particles long distance relativistic speeding, but local extreme pinching in situ, so the input energy is mainly and efficiently used for overcoming the coulomb barrier.

Although prior art **GeV/TeV** acceleration realizable, it does not imply **GV** or **TV** voltage order of magnitude power supply a reality, because the said **GeV/TeV** is not acquired via direct applying high voltage to the main **2** electrodes, but via bunching **RF** cavities or other means. So it is not feasible to modify it to adapt commercial reactor.

Some fusion devices look like not accelerator-based, but in fact, they are!

For example, the so-called **fusor** is just a device that uses an electric field to heat ions to conditions suitable for nuclear fusion.

Philo Farnsworth is the original designer, and many improvements have been done by other scientists in past decades. The famous is the Polywell version of Robert Bussard.

Basically those fusors use the low pressure fuel deuterium or mix of deuterium and tritium in gas phase. Although fuel is dielectric media, however the **Paschen's law** undercuts significantly the dielectric strength, then the dielectric media have to be used in conductor state with the transient fuel charged particles accelerated up to **100KeV** for higher cross section of wanted fusion reaction. This obviously falls in the accelerator-based fusion category that dooms low efficiency and hopeless to achieve breakeven.

Do not be obsessed by Dr. Brian Naranjo or Dougar Jabon observation of nuclear fusion driven by a pyroelectric crystal (**ref. 5 & 6**). They just used the dielectric material **$LiTaO_3$** as high voltage generator of circca **100KV** to accelerate deuteron, thus also fall in same hopeless category.

Conclusion

Z-pinch based commercial fusion reactor is worth to wait for, but accelerator based one including fusors, etc. are doomed to be hopeless of energy breakeven.

Cited publications:

1. Zhou Lin et al. **Design of a 5-MA 100-ns linear-transformer-driver accelerator for wire array Z-pinch experiments**. PHYSICAL REVIEW ACCELERATORS AND BEAMS, Vol. 19, Iss. 3, March 2016; DOI: 10.1103/PhysRevAccelBeams.19.030401
2. Mazarakis, et al. **Linear Transformer Drivers (LTD) for high voltage, high current rep-rated systems**. In *Proceedings of the 2010 IEEE International Power Modulator and High Voltage Conference, IPMHVC 2010*, 5958297, pp. 69-74, 2010 IEEE International Power Modulator and High Voltage Conference, IPMHVC 2010, Atlanta, GA, United States, 23-27 May. DOI: 10.1109/IPMHVC.2010.5958297
3. *Yanming Wei, **Dielectrodynamics and its applications**, April, 2017, Researchgate DOI: 10.13140/RG.2.2.29374.69448 or* viXra:1704.0386

4. *USPTO Application* ***US15/267,122****, filing date: 2016-09-15,* ***Dielectric blade comb piston unlimited voltage generator, fusor and more****.*

5. *Brian Naranjo et la.* ***Observation of nuclear fusion driven by a pyroelectric crystal****, DOI: 10.1038/nature03575*

6. *V.D. Dougar Jabon, et la.* ***Catalitically Induced D-D Fusion in Ferroelectrics****, Dec. 1997, Brazilian Journal of Physics, DOI: 10.1590/S0103-97331997000400014*