Experimental verification for Intermediate Controlled Nuclear Fusion

Leong Ying[1,*], Wei Cai[2], Jerdsay Kadeisvili[3], Chris Lynch[3], Scott Marton[3], Steve Elliot[3] and Yun Yang[3]

[1]Thermo Fisher Scientific, 700 First Street, Hoboken, NJ 07030
[2]Department of Physics, City College of City University of New York, New York, NY 10031
[3]Thunder Fusion Corporation, 150 Rainville Road, Tarpon Springs, FL 34689

*Author to whom correspondence should be addressed:
E-mail: leong.ying@thermofisher.com
Tel: 609 216 3653

Abstract. Results from multiple reaction sequence conducted in a steel reactor vessel are analyzed for the formation of nitrogen from the combination of deuterium with carbon. Thermal analysis further support the excess heat generation through a process described as Intermediate Controlled Nuclear Fusion (ICNF).

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I. INTRODUCTION

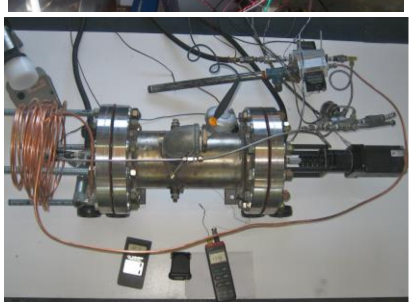
Effort in use of controlled nuclear fusion for a new energy source has lasted for more than 60 years. Most experiments concentrate on fusion of deuterium with tritium creating helium-4 and freeing a neutron (referred to as "hot fusion" in this article). It is interesting to explore possibilities of fusion using other types of nuclei.

The guidelines for the new concept come from nature. As established by chemical analyses of air bubbles in amber, about one hundred millions years ago Earth's atmospheric composition had around 40% nitrogen, while its current percentage is about double that value. Other chemical analyses show that the increase of nitrogen has been gradual. Among all possible origins of a nitrogen synthesis in our atmosphere, the most plausible is generation by lightning, because a quantitative explanation of thunder cannot be achieved with conventional physical and chemical reactions. In fact, a numerical explanation of thunder requires energy equivalent to hundreds of tons of explosives that simply cannot be explained via conventional processes due to the very small cylindrical volume of air affected by lightning and its extremely short duration. Thus it may require nuclear syntheses to account for the very-high energy outputs from thunder.

The first experimental confirmation of nitrogen synthesis from deuterium and carbon without harmful radiation was reported by Santilli [1] and the tests verified independently by a technical team from Princeton Gamma-Tech [2]. These initial tests were conducted in a first-generation pressurized steel vessel called Hadronic Reactor I, which operated with manually adjustable carbon electrodes and filled with 99.999% pure deuterium gas. Five generations of these reactors have been developed to tests various aspects of the fusion process and adaptations for industrializing the equipment. Power was supplied to the 2-in diameter commercial-grade carbon graphite electrodes by a Miller Dimension 1000 AC-DC converter operated at nominally 40VDC and 900A.

Table I lists the main operational features of the five Hadronic Reactors. The second unit integrated a stepper-motor control system for automated adjustments of the arcing electrodes. A jacketed heat-exchanger converted the output heat generation into steam. Reactor III was used for high-pressure tests up to 1000 psi, and for safety reasons housed in a steel cargo container. A remote display console located outside the safety container allowed for automated controls and sensory monitoring of the system. If the carbon anode and cathode come into contact with each other then they can create an electrical short thereby negating any possible fusion reactions. A transparent Pirex tube was constructed for Reactor IV to allow a visual confirmation that an arc was created within these reactors and no fusing of the electrodes occurred. The proceeding results and analysis are experiments conducted on Hadronic Reactor V.

TABLE I. Experimental Hadronic Reactors and their main operational features

Reactors	Photo Images	Features
I		• 12 in diameter x 24 in length welded vessel. • 100 psi pressure rating. • Manually adjusted electrode.
II		• Automatic control of arcing electrodes. • Jacketed cooling system for steam generation.
III		• High-pressure operations up to 1000 psi. • Remote industrial console for auto-control and sensory monitoring.
IV		• 12 in diameter x 24 in length vessel. • Automatic control of arcing electrodes. • Transparent Pirex tube for visual confirmation of arc generation.
V		• 12 in diameter x 24 in length welded vessel. • 300 psi pressure rating. • Automatic control of arcing electrodes.

II. EXPERIMENTAL RESULTS

Hadronic Reactor V was constructed of welded stainless steel with bolted end plates with seals rated up to 300psi. A stationary carbon graphite anode was mounted to one of the end plates. A moveable cathode of the same carbon graphite rod was position-controlled by a stepper motor operated by the automatic controls of the arc. Power was supplied to the electrodes by a AC-DC converter and the input power monitored by a wattmeter. Automatic logging was taken of the various sensors such as temperature and pressure mounted on the reactor. Radiation levels were continuously monitored by external detectors. The reactor chamber was first evacuated with a vacuum pump and then flushed with deuterium gas supplied by AirGas Specialty Gases of Cinnaminson (NJ) and guaranteed to be 99.999% pure. Following the flushing, the reactor was pressurized to 100psi. ICNF reactions were activated by powering up the arc for two minutes. Sample bottles were taken of the internal gases before and after each reaction. A total of five separate experimental tests were conducted and the analyzed results presented in the following sections.

A. Gas Analysis

Gas chromatography was used to analyze the gas contents before and after initiation of ICNF reactions. Figure 1 illustrates the reduction of deuterium after the proceeding reactions measured using a Gas Chromatographer with Thermal Conductivity Detection (GC-TCD). Figure 2 the corresponding increase in nitrogen after the reactions measured using a Gas Chromatographer Mass Spectrometer equipped with Infra-Red Detector (GC-MS/IRD).

FIG 1. Confirmation of the decrease of deuterium following the activation of the arc obtained via a GC-TCD instrument.

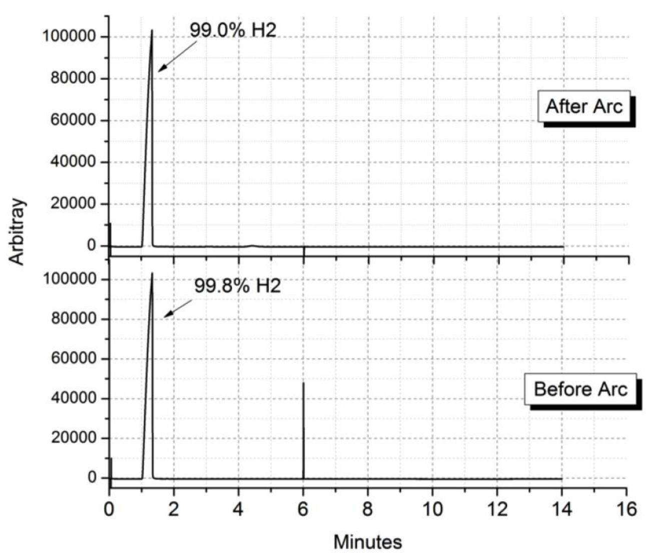
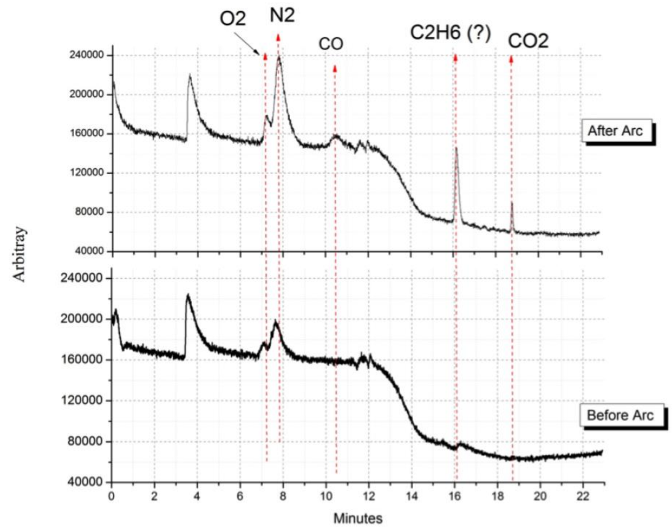


FIG. 2. Confirmation of the increase of nitrogen following the activation of the arc obtained via a GC-MS/IRD instrument.



For further verification the sample bottles taken of the gases before and after arc activation were sent to an independent laboratory Oneida Research Services in Whitesboro (NY). Figure 3 list the results of the analyzed masses for reaction 1 before (N1B) and after (N1A). Before initiation of the arc (N1B) the analyzed masses (in atomic mass units) show only a few conventional molecular species. However, after (N1A) the data show the creation by the arc of considerable number of new species, some of which are ordinary molecules but others can only be accounted for by Santilli magnecules [3]. Nitrogen (N_2) and Carbon Monoxide (CO) have the same 28amu, and therefore there is the possibility that the increased nitrogen counts may be due in part from the contribution from CO. This factor can be excluded by the analytical measurements shown in figure 2 that differentiates the quantity of N_2 contents from CO.

FIG. 3. Chromatographic data analyzed by Oneida Research Laboratories.

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PACKAGE TYPE: MAGNEGAS CYLINDER

Sample	a.m.u.	N1B	N1A
Mass	2	90,209	175,752
Mass	3	51,898	790,291
Mass	4	8,443,180	6,625,830
Mass	5	169	1,461
Mass	6	10,687	6,709
Mass	7	0	0
Mass	8	0	0
Mass	9	0	0
Mass	10	0	0
Mass	11	0	0
Mass	12	0	21,180
Mass	13	0	3,242
Mass	14	6,075	23,851
Mass	15	60	24,896
Mass	16	2,582	71,708
Mass	17	1,768	50,718
Mass	18	8,386	238,735
Mass	19	1,720	32,348
Mass	20	8,507	155,124
Mass	21	0	1,568
Mass	22	0	1,532
Mass	23	0	0
Mass	24	0	293
Mass	25	0	679
Mass	26	0	3,809
Mass	27	0	6,202
Mass	28	58,724	199,947
Mass	29	415	7,877
Mass	30	487	8,891
Mass	31	0	4,712
Mass	32	13,321	12,235
Mass	33	0	1,079
Mass	34	0	1,763
Mass	35	0	665
Mass	36	0	1,912
Mass	37	0	846
Mass	38	0	1,814
Mass	39	0	3,455
Mass	40	682	3,118

Sample	a.m.u.	N1B	N1A
Mass	41	0	4,387
Mass	42	0	5,525
Mass	43	0	10,054
Mass	44	187	122,917
Mass	45	0	2,332
Mass	46	0	1,289
Mass	47	0	136
Mass	48	0	181
Mass	49	0	131
Mass	50	0	852
Mass	61	0	0
Mass	62	0	207
Mass	63	0	171
Mass	64	0	235
Mass	65	0	278
Mass	66	0	665
Mass	67	0	123
Mass	68	0	0
Mass	69	0	0
Mass	70	0	0
Mass	71	0	0
Mass	72	0	91
Mass	73	0	0
Mass	74	0	169
Mass	75	0	0
Mass	76	0	405
Mass	77	0	217
Mass	78	0	493
Mass	79	0	601
Mass	80	0	1,060
Mass	81	0	1,260
Mass	82	0	2,857
Mass	83	0	3,780
Mass	84	0	10,524
Mass	85	0	661
Mass	86	0	0
Mass	87	0	0
Mass	88	0	0
Mass	89	0	0
Mass	90	0	0
Mass	91	0	429
Mass	92	0	283

Table II summarizes the analyzed mass contents for deuterium and nitrogen for all 5 reactions. The results clearly demonstrate a decrease in deuterium and increase in nitrogen contents after each subsequent ICNF reaction.

TABLE II. Deuterium and nitrogen by volume before and after initiation of the arc for the five analyzed reactions.

	Deuterium		**Nitrogen**	
Reactions	**Before**	**After**	**Before**	**After**
1	991,893	949798	3,610	14,994
2	991,356	947,056	3,741	15,008
3	990,845	966,806	4,170	6,554
4	992,839	979,263	2,683	4,471
5	987,880	982,062	5,567	6,554

The above analysis of experimental data suggests the following fusion:

$$D(2, 1, 1+, 2.0141) + C(12, 6, 0+, 12.0000) + TR \rightarrow N(14, 7, 1+, 14.0030) + \Delta E , \quad (1)$$

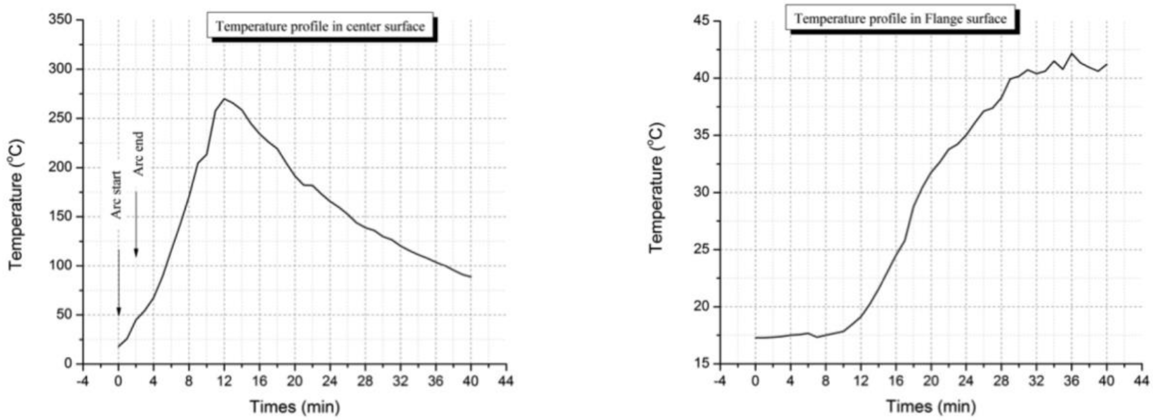
with $\Delta E = 0.0111\ u = 10.339$ MeV, the resulting positive energy due to the mass difference between the product (nitrogen) and the fuels (deuterium and carbon). The numbers in the bracket of Eq. (1) are, separately, the atomic number, the nuclear charge, the nuclear angular momentum with parity, and the atomic mass. Electric arc acts as the trigger (TR) mechanism.

The following thermal analysis of the temperature with time in reaction shows that the excess heat beyond input energy is produced, which supports existence of fusion reaction.

B. Thermal Analysis

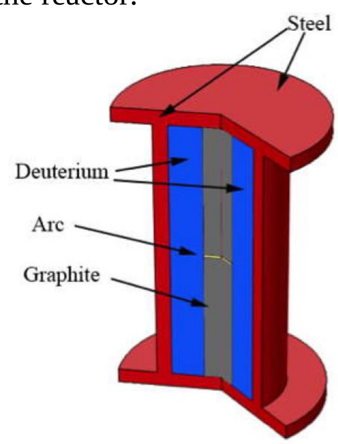
Figure 4 illustrates the temperature profile of the reactor measured on the center of the cylindrical body and at one end of the solid end plates.

FIG. 4. Temperature profiles of Hadronic Reactor V.



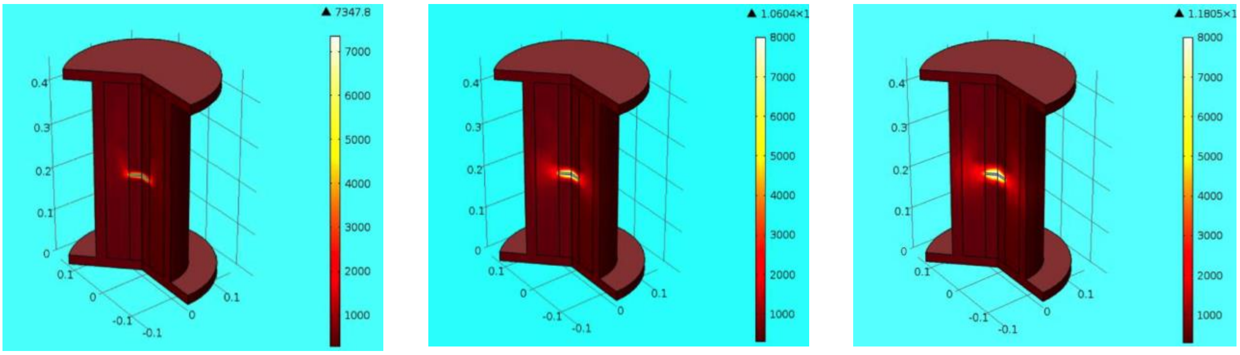
To estimate the amount of excess heat generated by the fusion reactions, the measured thermal profiles were compared to computer simulated results for the reaction process. Figure 5 is a schematic view of the interior of Hadronic Reactor V used for the heat simulations.

FIG. 5. Computer simulation of the reactor.



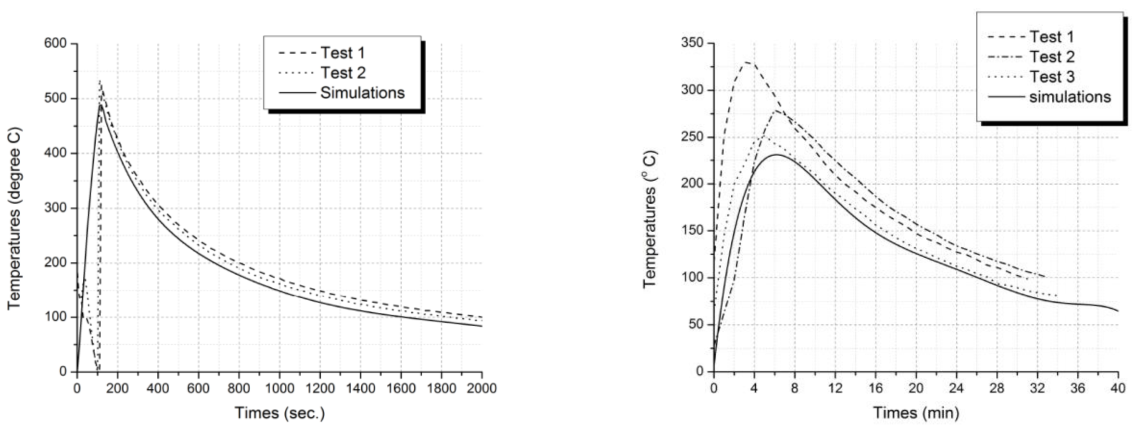
Computational Fluid Dynamics (CFD) is used to solve the thermal equations via numerical methods and algorithms. Computers are used to perform the calculations required to simulate the interaction of gases and solids while the surfaces are defined by boundary conditions. Figure 6 illustrates the simulated temperature distribution inside the reactor at time 20s, 60s and 120s after the start of the arc.

FIG. 6. Simulated temperature distributions inside the reactor.



A wattmeter was used to measure the average power consumption of the reactor at 4.8MJ. The thermal CFD simulation assumed that this was the only source of heat generated by the electric arc. Figure 7 shows the comparisons between the simulated temperature profiles against that measured at the interior and exterior of the reactor. Best fitting is defined by best matching of peak time of temperature, which is realized by selecting the value of heat conductivity of deuterium gas. The analysis indicates ~10% of excess heat generated above that of the electrical input power of the arc, which is the proposed contribution from the fusion energy.

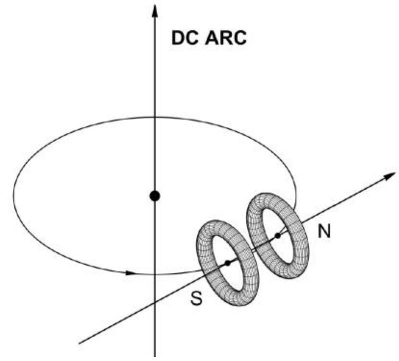
FIG. 7. Comparison of the thermal profiles based on CFD simulations and actual measured interior and exterior temperature of the reactor.



III. REACTION THEORY

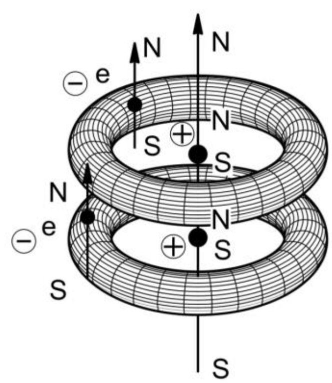
In ICNF it is proposed that the exposure of the inner nucleus is achieved by the polarization of orbital atomic electrons into toroids caused by intense magnetic field (order of ~10^{12} Gauss) in the atomic vicinity of electric arcs [4-6] as conceptually illustrated in Figure 8.

FIG. 8. Conceptual rendering of polarization of orbiting atomic electrons via strong magnetic fields generated in the atomic vicinity of an electric arc.



Temperatures at core region of the Hadronic Reactors are estimated at 10^5 K, which is much lower than the temperature in hot fusion experiments. The latter require temperatures up to 10^9 K in order to supply sufficient kinetic energy to overcome Coulomb repulsions. This is why hadronic fusion described in these experiments is termed "intermediate" (or warm) fusion. In the experimental setup, carbon ions are produced by the arc and limited to the core region of intense magnetic field. The deuterium gas inside the vessel is highly pressured, which may reduce the escape rate of deuterium ions from the core reaction region and magnetic confinement by the arc made more efficient. Figure 9 illustrates the conceptual magnecules. The toroidal polarization of the electron orbital allows for the bonding of polarized atoms with opposing magnetic polarities. The magnetic attractions overcome possible Coulomb repulsions due to atomic charges since the atoms are neutral.

FIG. 9. Santilli magnecules as prelude to hadronic fusion.



On the theoretical basis of ICNF, a main conceptual argument is that nuclear fusions can only occur under contact among extended nucleons. Quantum mechanics has been experimentally confirmed to be correct when particles are far from each other, for example, a proton and an electron in a hydrogen atom. There is no clear evidence confirming that quantum mechanics is accurate in describing motion of extended nucleons in a nucleus. Quantum mechanics allows only kinetic energy and potential energy terms existing in Hamiltonian. Hadronic mechanics [7] adds a non-linear, non-local and non-potential interaction, which plays an important role when nucleons are physically close to each other in a 10^{-13} cm region. The resulting non-Hamiltonian character of nuclear reactions then mandates a non-unitary theory, which also satisfies the physical requirements of invariance under transform of the system. Hadronic mechanics has achieved a representation of many characteristics, such as the composition of the Deuteron, the most elemental fusion, the synthesis of neutrons inside stars according to Rutherford's historical conception as compressed hydrogen atoms (electrons totally compressed inside protons).

IV. CONCLUSION

The experimental measurements presented in this article for the nuclear fusion of deuterium and carbon into nitrogen appears to confirm Santilli's Intermediate Controlled Nuclear Fusion process. When suitably selected to verify all nuclear conservation laws, two light natural stable isotopes termed hadronic fuels do admit laboratory fusion into a third isotope with the release of energy in the form of heat due to the well-known mass-defect. The process is achieved in a pressure vessel triggered by an internal electric arc submerged within the hadronic fuels. The fusions are made possible by the controlled exposure of nuclei out of their electron clouds due to the polarizing effects of the intense magnetic field generated by the arc. Hadronic fusions are fully controllable via control of the electric power, the pressure, the fuel flow and other mechanical means. No harmful radiations are observed outside the confines of the Hadronic Reactors.

ACKNOWLEDGMENTS

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