The Fork in the Road to Electric Power From Fusion

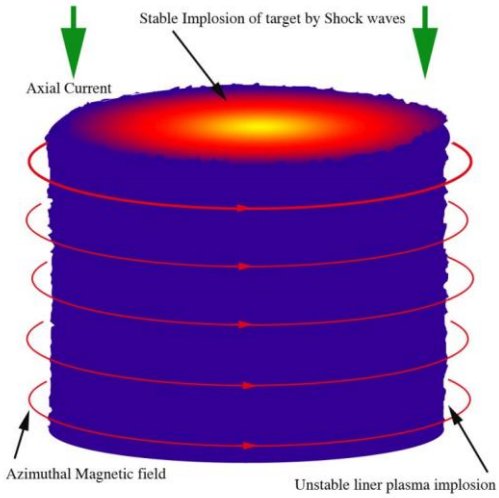
Magneto-Inertial Fusion Technologies, Inc. (MIFTI)

Peter Lobner, 1 February 2021

MIFTI was founded by Gerald Simmons, Hafiz Ur Rahman, and Arshad Mohammad in 2008 in Tustin, CA, as a spinoff from the University of California Irvine, with the goal of developing a staged Z-pinch (SZP, a type of magneto-inertial fusion) Fusion Drive for electric power generation and medical isotope production. MIFTI president, Hafiz Rahman invented and patented SZP. The MIFTI website is here: http://miftec.com/index.html

A staged Z-pinch (SZP) machine is a cylindrical device with an annular plasma shell composed of a high atomic number (Z) material, like argon, krypton, or xenon gas. Pulsed high current is applied to the annular high-Z plasma shell, which implodes and rapidly expands inward, initiating a radial shockwave at the interface with the stagnant low-Z plasma fuel. The shockwave pre-heats the low-Z magnetized plasma and rapidly compresses it to establish fusion conditions along the axial centerline of the device. The low-Z target plasma (deuterium of a deuterium-tritium mixture) is created by a gas puff into the center of the device. An annular gas puff creates the high-Z shell. The use of gas puffs enables this SZP machine to be cycled quickly for the next shot.

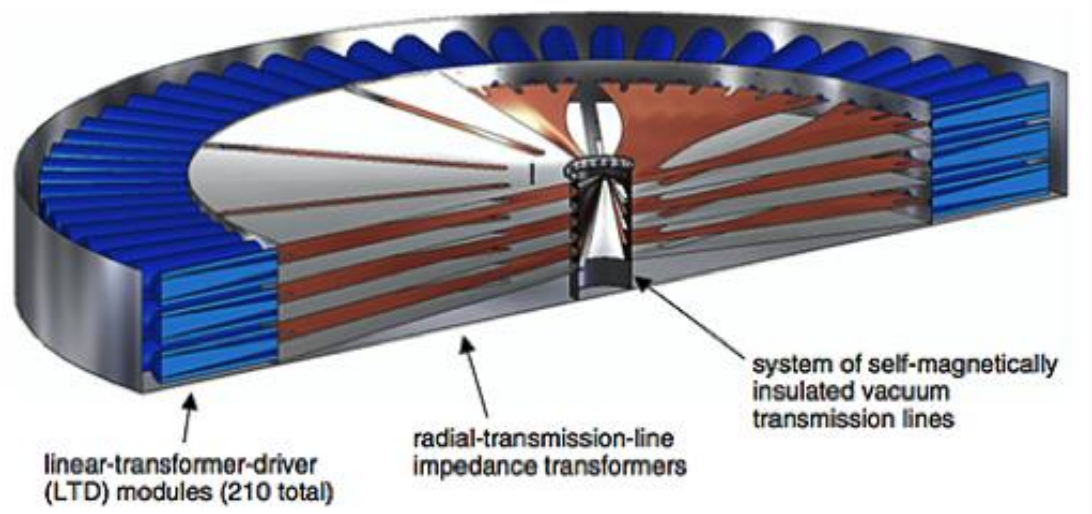
The general arrangement of a staged Z-pinch device is shown in the following diagram.



Schematic of staged Z-pinch. Source: MIFTI

MIFTI explains the process: “Basically, staging resets the clock on the energy accumulation in a fusible target, allowing it to be accumulated more efficiently and with greater power than using a conventional approach. Studies on experimental systems, using a microsecond implosion time, coupled with theoretical and computational analysis, provide solid evidence for the success of staging, and the potential for scaling this concept to fusion conditions.” Implosion radial velocity is on the order of 30 – 50 cm/microsecond.

MIFTI SZP device. Source: MIFTI



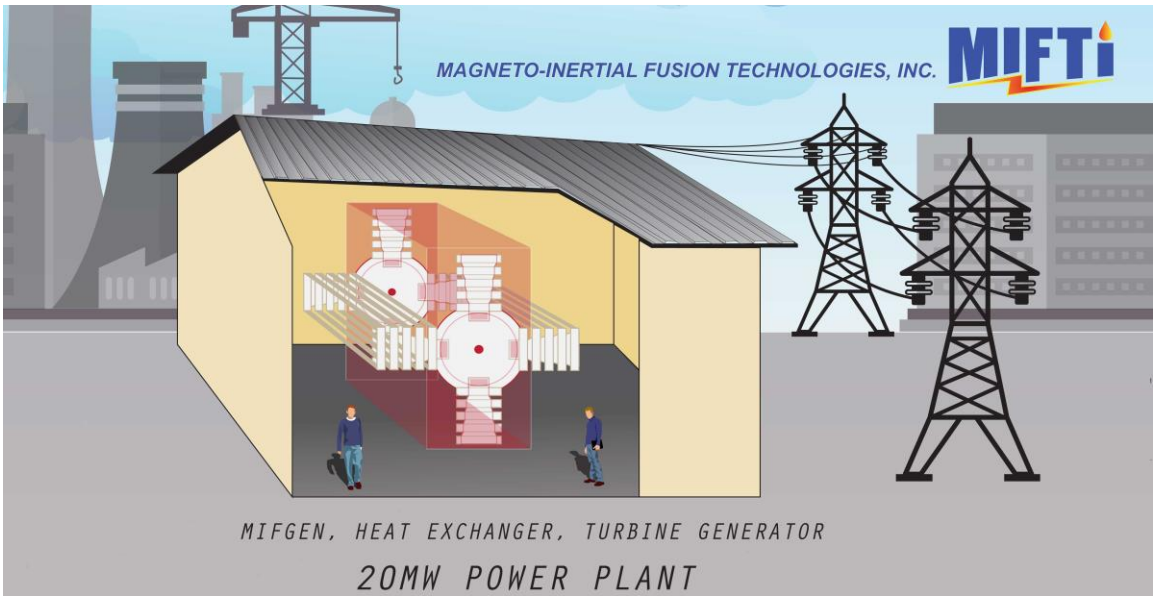
MIFTI SZP device cross-section. Source: United Nuclear

MIFTI participated in the DOE ARPA-E ALPHA program and claims that they have overcome instability problems in Z-pinch machines. In 2018, MIFTI tested their SZP "Reaction Cell" on the 1 million ampere Zebra machine at the University of Nevada, Reno National Terawatt Facility (UNR/NTF), generating 10 billion D-D neutrons per pulse. In 2020, SZP testing was scheduled on the L3 Harris 4 million-ampere device. The US Air Force MACH-2 simulation code predicted these tests were likely to achieve 1 trillion D-D neutrons per pulse or better.

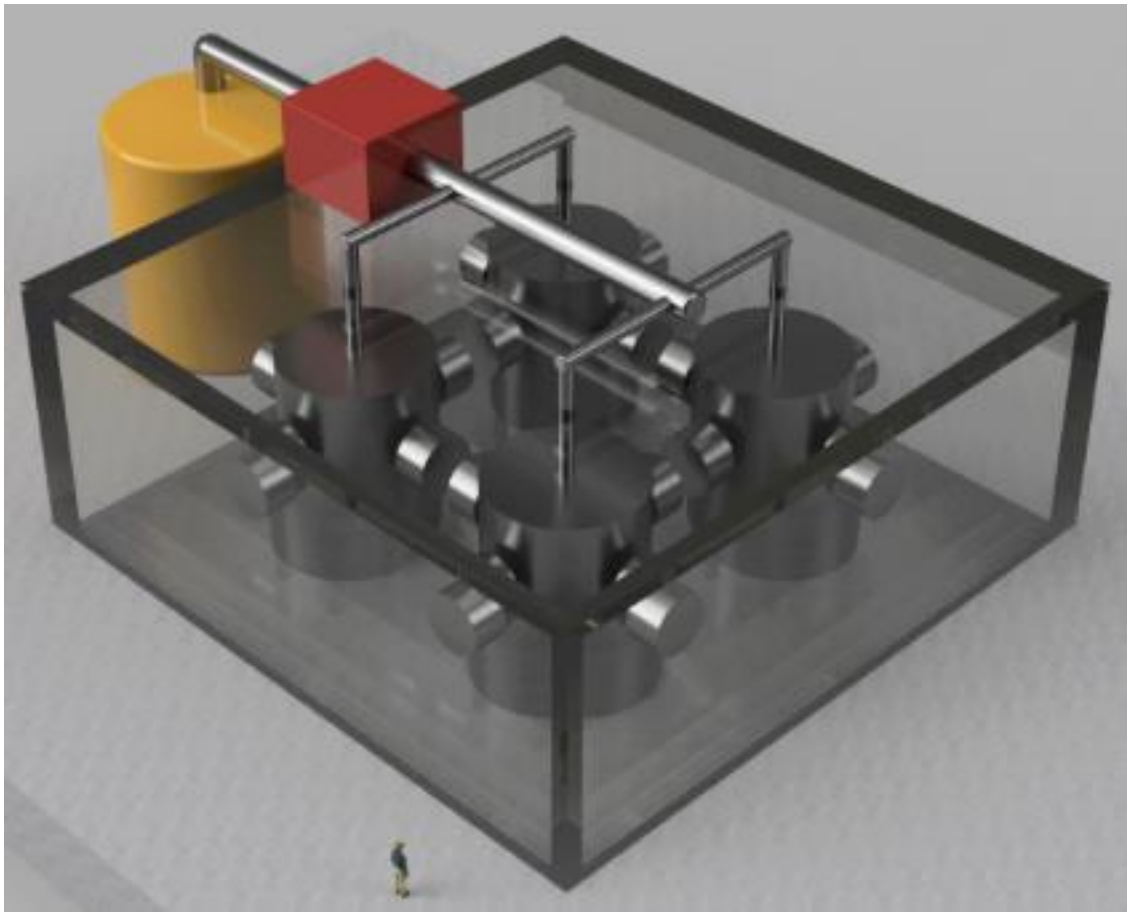
MIFTI has designed a 10 million ampere machine called the Staged Z-Pinch LTD-X (linear transformer driver-X), which is designed to provide significant net energy gain (Q > 1.0) for production of electric power or medical isotopes. An SZP device has the potential to produce a Q in the range from 10 to 50.

Using readily available deuterium (D) as fuel, MIFTI estimates that the deuterium in one gallon of seawater can produce the equivalent energy of 300 gallons of gasoline. This would be about 10.1 MWh (@ 33.7 kWh per gallon).

MIFTI believes their near-term electric power generation market is for a 1–10 MWe modular fusion power unit for off-grid applications. Modules could be aggregated to deliver 100 MWe to the grid.



MIFGEN 20 MWe small power plant concept. Source: MIFTI



Conceptual design of a multi unit MIFTI SZP fusion reactor building. Source: Bechtel / Woodruff ARPA-E fusion power plant costing study.

MIFTI acknowledges that the potential exists for their SZP machine to be used to produce aneutronic (no neutrons) fusion reactions using advanced fuels. MIFTI explains:

> "Virtually all studies, to date, on fusion using Z-pinches has involved the use of deuterium and tritium fuels, which produce over 80% of its nuclear energy in the form of high energy neutrons. Neutrons are not preferred, since they induce radioactivity in the surrounding structure, and cannot be directed efficiently into an energy converter. With advanced fuels, for example; deuterium and helium-3, or hydrogen and boron-11, the nuclear reaction produces over 80% of its output in the form of charged particles that can be captured and directed into an efficient energy converter."

After a D-D or D-T fueled SZP fusion reactor has been developed and commercialized, it will be interesting to see if MIFTI develops an aneutronic SZP fusion reactor.

Funding

MIFTI is funded by private capital and public-private partnership funding.

- October 2015: $5.1 million award under the DOE ARPA-E ALPHA program
- May 2017: $1.6 million from Strong Atomics, a venture fund managed by Malcom Handley

MIFTEC, a division of MIFTI, will be responsible for the medical isotope business. In April 2019, US Nuclear Corp. acquired a 10% stake in MIFTEC and exclusive manufacturing and sales rights for the medical isotope generators in North America and Asia, and also acquired a smaller stake in MIFTI.

For more information

- "Staged Z-Pinch Target For Fusion," ARPA-E ALPHA, 2015: https://arpa-e.energy.gov/technologies/projects/staged-z-pinch-target-fusion
- Rachel Lerman, "Helion Energy takes in $10.6M for fusion energy," The Seattle Times, 7 July 2015: https://www.seattletimes.com/business/helion-energy-takes-in-106m-for-fusion-energy/
- Frank Wessel, "Staged Z-Pinch," MIFTI, presentation at the Dense Z-Pinch Conference, 14 August 2017: https://www.researchgate.net/publication/321951364_Staged_Z-Pinch
- C. L. Nehi, et al., "Retrospective of the ARPA-E ALPHA Fusion Program," Journal of Fusion Energy, 38_506 – 521, 2019: https://www.osti.gov/servlets/purl/1572943
- "US Nuclear Signs Agreement to Acquire an Interest in a Leading Fusion Power Developer and Rights to Manufacture and Sell Fusion Power Generators for the Electric Power Grid,"

US Nuclear Corp, 23 April 2019: https://www.globenewswire.com/news-release/2019/04/23/1807900/0/en/US-Nuclear-Signs-Agreement-to-Acquire-an-Interest-in-a-Leading-Fusion-Power-Developer-and-Rights-to-Manufacture-and-Sell-Fusion-Power-Generators-for-the-Electric-Power-Grid.html

- "Nuclear Fusion Z-Pinch Progress with Staged Z-Pinch LTD 10MA Generator," EnergyCentral, 14 October 2019: https://energycentral.com/c/ec/nuclear-fusion-z-pinch-progress-staged-z-pinch-ltd-10ma-generator
- "US Air Force MACH2 Code Tests US Nuclear and MIFTI Progress Towards Goals of Producing Medical Isotopes and Electric Power," US Nuclear press release, 12 May 2020: https://apnews.com/press-release/newmediawire/f9fddc55a3aa23c17d2420371df4cd84

Patents

- Patent US9839111B2, "Staged Z-pinch for the production of high-flux neutrons and net energy," filed, 30 July 2010, granted 5 December 2017, assigned to UC California: https://patents.google.com/patent/US9839111B2/en?inventor=Hafiz+Ur+Rahman&oq=+inventor:(Hafiz+Ur+Rahman)
- Patent US8837661B2, "Radionuclide production using a Z-pinch neutron source," filed 23 July 2010, granted 16 September 2014, assigned to UC California: https://patents.google.com/patent/US8837661B2/en?inventor=Hafiz+Ur+Rahman&oq=+inventor:(Hafiz+Ur+Rahman)