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## Science & Technology

# The ideal MHD system: fusion

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At the turn of the next century, the ideal Magnetohydrodynamic system will be in sight, an energy producing process whose combustion products are charged particles that can be directly converted into electrical power by passing them across the lines of force of a magnetic field in an MHD generator. That process is fusion, the nuclear reaction that powers the sun.

Under the required conditions of high temperatures (in the millions of degrees) and pressures, the fusion fuel consisting of the heavy isotopes of ordinary seawater form a plasma and fuse, releasing a tremendous amount of energy and producing as a byproduct neutrons and charged particles.

The first generation fusion plants will use a deuterium-tritium reaction that will produce 77 percent of their energy in the form of neutral particles and most of the remaining energy in alpha particles (positively charged helium).

Advanced fusion fuel systems will use deuterium-deuterium reactions that produce 70 to 80 percent of their energy in the form of charged particles.

There are two basic fusion conceptions under study for direct MHD conversion. The first is the steady-state fusion reaction, typical of the tokamak, mirror, and other major experimental designs. The second is a pulsed fusion design which has important applications for advanced weapons research and which the Soviets have taken a keen interest in. Speculation about the possibility that the Soviets developed an antimissile beam weapon in spring 1977 raised the question of whether pulsed fusion-MHD designs were used to produce huge pulses of electric power.

Steady state fusion power production designs can utilize the closed cycle MHD conversion sytem with an inert gas as the working fluid. The higher fusion temperatures increase the ionization potential and thus the conversion efficiency of systems already designed for lower temperature nuclear reactors.

This coupling of a conventional MHD system to a fusion reactor would use a graphite blanket around the reaction zone to absorb neutron and X-ray energy and to heat a suitable working gas such as helium. Because the graphite does not have to contain fission products and because it maintains good structural properties up to 2,800 degrees Kelvin, such a system should be able to operate at high temperatures for long periods of time.

A helium outlet temperature of 2,500 degrees Kelvin is used to heat and ionize the noble gas for direct conversion in the MHD generator to electric power. Preliminary calculations show an overall cycle efficiency of more than 60 percent.

One design by Brookhaven National Laboratory combines the fusion MHD system with gas turbine or steam boiler cycles that have projected efficiencies of up to 75 percent. They also examined the possibility of producing pulsed power in this system by circulating only the helium coolant-working fluid when the reactor was in between plasma burns.

In pulsed reactions systems the most intriguing ideas have come from the Soviet's Kurchatov Institute by Academician E.P. Velikhov who has investigated bulk pulsed power from fusion reactions. The technique involves induction conversion.

The fusion explosions in Velikhov's dumbbell-shaped reactor chambers are projected to produce 10 billion to 1 trillion joules of energy, the equivalent of 2.5 to 250 tons of TNT. The working fluid is an alkali metal vapor, either lithium, potassium or sodium, which surrounds the thermonuclear charges as an evaporating blanket. The fusion explosion vaporizes the blanket providing the force in the plasma to drive a metal piston from one chamber through the MHD channel to the other chamber (where a second explosion will drive it back). The liquid metal vapor that condenses after the power extraction and temperature drop is recycled through the liquid metal reservoir back to the reactor blanket to be revaporized with the next explosion.

As the piston is pushed through the MHD channel, it is partially slowed down by the magnetic field surrounding the channel and it compresses the magnetic field in the solenoid. The kinetic energy is inductively transferred to the magnet system where the load is attached.

Velikhov has projected that this inductive design would produce an average electrical power of approximately 15 gigawatts with efficiencies greater than steam turbine systems.

Given the efficiency of energy production in MHD systems and the wide-ranging applications to industry—from chemical byproducts for fertilizer production to electricity and high-quality heat for metals processing—there is nothing that does not recommend magnetohydrohynamics as an energy source for today and for the future.



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