Ramjet designer's new pitch: safe, cheap fusion reactor

R. Colin Johnson, EE Times, 06/04/2007

There's a way for fusion reactors to sidestep high-temperature plasmas, steam turbines, neutron radiation and even nuclear waste — and still generate inexhaustible nuclear energy for less money than Google's annual electricity bill. That's the position, and latest mission, of physicist Robert Bussard.

In the 1960s, Bussard proposed the ramjet, a paper engine design that would power deep-space vehicles by collecting hydrogen atoms in space and feeding them into a fusion reactor. Now, in a proposal titled "Should Google Go Nuclear?" (video.google.com/videoplay?docid=1996321846673788606), Bussard presents an alternative to thermonuclear fusion. He claims an inertial electrostatic confinement (IEC) reactor can provide fusion power that is simpler, cleaner and cheaper than would be possible under the various routes now being pursued by the Department of Energy.

"Everything [the DOE] is doing is highly radioactive and expensive — measured in tens of billions of dollars, with projected run-out costs of greater than $12 billion, plus another $30 billion over the next 20 or 30 years. The United States has already spent $18 billion [on fusion]," said Bussard. "And there is no end in sight."

By contrast, Bussard estimates startup costs of $200 million for an IEC fusion reactor that would operate at 95 efficiency.

The ramjet, proposed in the 1960s, sought to remove an obstacle to deep-space travel. Traditional spacecraft cannot carry enough fuel to reach distant stars, but the ramjet would harvest particles present even in natural vacuums, using fusion to release energy. Bussard parlayed his ramjet fame into a career working to redirect the nation toward simpler, cleaner, cheaper fusion reactors. He founded Energy Matter Conversion Corp. (EMC2; Santa Fe, N.M.), which initially focused on contract work for the Department of Defense. Lately, Bussard has been courting deep-pocketed corporations to help him build a commercial version of the IEC fusion reactor. He has set up a nonprofit organization, EMC2 Fusion Development Corp. (www.EMC2Fusion.org), to fund the work.

The current, third-generation prototype uses six doughnut-shaped electromagnets to create a cube in which to confine the fusion reactions in a strong magnetic field. The original prototype operated in air and was just centimeters in diameter; the current design operates in a vacuum chamber and measures roughly a cubic yard.

When all six electromagnets are energized, the magnetic fields meld into a nearly perfect sphere. Electrons are injected into the sphere to create a super-dense core of highly negative charge. Given enough electrons, the electrical field can be made strong enough to induce fusion in selected particles. Positively charged protons and boron-11 ions are injected into the sphere and are quickly accelerated into the center of the electron ball by its high negative charge. Protons and boron ions that overshoot the center are pulled back with an oscillatory action of a thousand or more cycles.

If the negative charge of the core is high enough, the positively charged particles will accelerate enough during their oscillations to induce a fusion reaction. The boron-11 collides with a proton to create carbon-12, which then splits into a helium nucleus and a beryllium nucleus. The beryllium particle splits into two more helium nuclei, resulting in a total of three helium nuclei, each of which has almost 3 million electron volts of energy. The force of the final splitting step drives the helium nuclei out of the center of the reactor, where a surrounding electrical grid directly dissipates their energy by generating electricity at a claimed efficiency of 95 percent.