GA-C23333

DIRECT ENERGY CONVERSION FISSION REACTOR

**for the period
March 1 through May 31, 2000**

**by
L.C. BROWN**

**Prepared under
Nuclear Energy Research Initiative (NERI)
Program. DE-FG03-99SF21893
for the U.S. Department of Energy**

DATE PUBLISHED: JUNE 2000

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

GA-C23333

DIRECT ENERGY CONVERSION FISSION REACTOR

**for the period
March 1 through May 31, 2000**

**by
L.C. BROWN**

**Prepared under
Nuclear Energy Research Initiative (NERI)
Program. DE-FG03-99SF21893
for the U.S. Department of Energy**

**GENERAL ATOMICS PROJECT 30052
DATE PUBLISHED: JUNE 2000**

Direct Energy Conversion Fission Reactor

Nuclear Energy Research Initiative (NERI)
Program DE-FG03-99SF21893
Technical Progress Report
March through May 2000

Highlights

- The fuel concept for the magnetically insulated quasi-spherical fission electric cell was refined.
- A short critique was written for UF_4 recycle system of the vapor core reactor concept.
- Calculations made, by SNL, for the pulsed reactor concept indicate that the aqueous concept originally proposed should be superior to the liquid metal fast reactor concept.

Introduction

Direct energy conversion is the only potential means for producing electrical energy from a fission reactor without the Carnot efficiency limitations. This project was undertaken by Sandia National Laboratories, Los Alamos National Laboratories, The University of Florida, Texas A&M University and General Atomics to explore the possibilities of direct energy conversion. Other means of producing electrical energy from a fission reactor, without any moving parts, are also within the statement of proposed work. This report documents the efforts of General Atomics. Sandia National Laboratories, the lead laboratory, provides overall project reporting and documentation.

Current Quarter Accomplishments

Magnetically insulated quasi-spherical fission electric cell. Recent SNL optimizations of the fission electric cell indicate that the cathode should be 5.4-mm diameter thin shell of fissile material instead of the 4-cm diameter of the original concept. While the smaller cell size does lead to other problems, the new cathode size is in the range of shells being developed for inertial fusion targets. Obtaining the desired low areal fuel density of 0.43mg/cm^2 will be a challenge but should be realizable. Several different approaches can be envisioned based on each of two starting concepts: foam shells and depolymerizable mandrels.

Polymer foams can be made over a wide range of densities and pore sizes and polymer foam shells are being developed for inertial fusion energy applications. An organo-uranium compound could be incorporated into the polymer system used to make foam shells. The uranium foam shells could be used “as-is” or the foam could be pyrolyzed to make a carbon-uranium carbide foam. Alternatively, uranium or uranium carbide could be sputtered onto polymer foam shells or onto carbon foam shells. Using a polymer with low thermal stability, it may be possible to sputter uranium carbide onto and into the foam thus coating the individual foam fibers with uranium carbide. After pyrolysis of the polymer, this would leave a structure comprised of thin uranium carbide tubes.

The majority of inertial confinement fusion targets are presently made by coating various materials on spherical shells of poly alpha-methyl styrene (PAMS). PAMS has a low thermal stability and depolymerizes to the gaseous monomer below its softening temperature. Any material coated onto the PAMS mandrel is left as a spherical shell. The desired areal density of uranium corresponds to a thickness of less than half a micron. It may be possible to make a 5-mm diameter by 0.5-micron wall shell, but it will be very fragile and difficult to handle. The structural integrity can be improved by laying down a structural web of thicker deposits under or over the fuel layer. The structural web should not cover a significant fraction of the total area.

Vapor Core Reactor – Direct Energy Conversion. A short critique was written of the UF_4 condensation system. Vapor pressure calculations were made for conditions at the cyclone inlet (0.4 atm) and at the outlet of the cyclone heat exchanger (2×10^{-6} atm). A significant quantity of UF_4 remains in the vapor leaving the cyclone and plates out in the downstream heat exchanger. The plate-out can be turned into an advantage by incorporating this heat exchanger into the purification system. Two heat exchangers would be operated in parallel. UF_4 and the less volatile impurities would be plated out into one heat exchanger while the other was vaporizing the UF_4 and concentrated impurities into the remainder of the purification system.

Pulsed Reactor. A preliminary criticality and kinetic analysis was completed for the prompt-burst liquid reactor core concept at SNL. High pulse power was indicated for low fuel concentration and large reactor diameter but not for high fuel concentration and small reactor diameter. This confirmed our original assumptions. The required rate of reactivity insertion was much less than originally assumed so reactivity control will be much simpler than previously assumed and close to the original simple concept. A reactivity and pulse control system similar to that used for TRIGA reactors should be adequate. A small number of control rods are used to control the overall reactivity and one poison rod is ejected from the reactor pneumatically to initiate the pulse. The poison rod is returned to the core by gravity. Figure 1 shows the original concept, the high reactivity insertion rate concept and the final concept.

A similar analysis was carried out for a liquid core fast reactor indicated that the combination of low critical mass, high pulse power and low insertion rate could not be simultaneously achieved. From this preliminary assessment, the aqueous solution core appears to be the better choice.

Scheduled Progress

Development of the pulsed reactor concept is slightly behind schedule.

Planned Next Quarter Activities

The final report for Phase will be written.

Schedules and Budgets

Status of all tasks of the combined project schedule is indicated in Table 1 and Figure 2. Expenditures to date and projected expenditures for the rest of Phase 1 are given in Figure 3.

A. Basic Concept

B. Pulsed Reflector

C. Pulsed Control Rod

Fig. 1. Pulsed reactor: (A) Original concept, (B) High reactivity insertion rate concept, (C) Low reactivity insertion rate concept.

Table 1. Summary of NERI Tasks – Phases 1-3

Identification Number	Milestone/ Task Description	Planned Completion Date	Actual Completion Date	Comments
1A(i).	Preliminary critical review of previous work	Jan 2000	Jan 2000	Work complete
1A(ii).	Review foreign literature	Jan 2000		Work behind schedule
1B.	Identify opportunities for improvement	Mar 2000	Feb 2000	Work complete
1C.	Develop new/alternate concepts	May 2000		Work slightly behind schedule
1D.	Characterize/compare alternate concepts	Jun 2000		Work begun and ahead of schedule
1E.	Screen to 3 promising concepts	Jul 2000		Work begun and ahead of schedule
1F.	Final (annual) Report for Task 1	Aug 2000		Work not begun
2A.	Identify and develop 3 concepts	Feb 2001		Phase 2
2B.	Identify critical technology issues	Mar 2001		Phase 2
2C.	Compare and assess conceptual designs	May 2001		Phase 2
2D.	Identify most promising concept	Jul 2001		Phase 2
2E.	Final (annual) Report for Task 2	Aug 2001		Phase 2
3A.	Preliminary design of most promising concept	Feb 2002		Phase 3
3B.	Analyze technical performance	Jun 2002		Phase 3
3C.	Analyze economic performance	Jun 2002		Phase 3
3D.	Identify manufacturability issues	Apr 2002		Phase 3
3E.	Perform selected experiments	Jun 2002		Phase 3
3F.	Final (annual) Report for Task 3	Aug 2002		Phase 3