GA–C23333

DIRECT ENERGY CONVERSION FISSION REACTOR

for the period
December 1, 1999 through February 29, 2000

by

L.C. BROWN

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

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DISCLAIMER

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GENERAL ATOMICS PROJECT 30052
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Nuclear Energy Research Initiative (NERI)
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Technical Progress Report
December 1999 through February 2000

Highlights

- Estimates were made of potential fuel geometry suitable for the quasi-spherical direct energy conversion cell being investigated by Sandia National Laboratories (SNL).
- Scoping calculations were made for the prompt critical pulsed reactor concepts.

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

DEC Fuel Concept. SNL requested that GA provide a fuel concept for the cathode of a direct energy conversion cell. The fuel is to be in the form of a 4-cm diameter electrically conductive spherical shell with minimum fission fragment stopping power. The fuel area density is to be a few mg/cc of U-235. For this requirement, we propose a spherical shell made from 1-mm thick carbon foam with a density of 20 mg/cm^3. This gives a mass per unit area of 2 mg/cm^2. The carbon foam will be open cell with a cell size of about 10 microns. The fuel mass (assumed to be UC_2) will be in addition. The fuel can either be dispersed throughout the foam or sputtered onto the outside of the sphere. Subsequent work by SNL indicates that a volumetrically dispersed fuel is preferable.

The carbon foam sphere will start out as resorcinol-formaldehyde (RF) plastic foam hemi-shells. Two hemi-shells will be glued together and to a small central graphite tube. The assembly would be slowly heated in an inert atmosphere to about 700°C to pyrolyze the RF foam and the glue. The carbonized assembly would then be heated in a high temperature furnace to over 1500°C. The temperature would depend on the desired electrical conductivity and the intended operating temperature. The individual fuel spheres would be strung on a wire or rod in the final assembly.

Since we will not be trying to retain the fission products in the fuel, there is no reason that the fuel cannot run at 2000°C if the center support rod is also graphite. All the thermal energy released in the fuel will radiate to the cooled anode where it can be used in a conventional power cycle.

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Pulsed Reactor. Scoping calculations were made using MathCad for the prompt critical pulsed power reactor concept. These calculations indicate that the pressure in the reactor vessel can reach an extremely high value if the reactor fuel/working fluid is constrained during the pulse. This may be ameliorated by the addition of an expansion volume close coupled to the reactor. Upon the pulse, the liquid will rapidly expand into the additional volume before it passes into the MHD channel. After expansion, the fluid must retain its electrical conductivity. That is, if the fluid is single phase it must be liquid or at least "liquid like". Optimum conditions after the pulse may be near the critical pressure and temperature. At lower pressure or higher temperature, the electrical conductivity may be insufficient for MHD power generation. For an aqueous fuel/working fluid, an expansion volume of twice the liquid volume will result in an average density equal to the critical density.

Preliminary indications are that average power will be limited by the low pulse rate unless the working fluid/fuel is pumped back into the reaction chamber. An increase in pulse rate can be achieved if there are two reaction chambers. The working fluid can be returned to the second reaction chamber while the first chamber is blowing down through the MHD generator.

Scheduled Progress

Development of the pulsed reactor concept is slightly behind schedule. Additional resources are being added and the task will be complete without delaying subsequent tasks.

Planned Next Quarter Activities

DEC fuel concepts will be evaluated, as the need becomes evident.

The preliminary feasibility evaluation of the PR concept will continue.

Schedules and Budgets

All tasks are on schedule as indicated in Table 1 and Figure 1. Expenditures to date and projected expenditures for the rest of Phase 1 are given in Figure 2.

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

ID	Task Name	Duration	Start	Finish
1	**Critical Review of Previous |**	**284d**	**8/1/99**	**8/31/00**
2	Preliminary Critical Reviev	110d	8/1/99	12/31/99
3	Review of Foreign Literatu	153d	12/1/99	6/30/00
4	ID Opportunities to Improv	92d	10/7/99	2/11/00
5	Develop Concepts for DE	109d	11/1/99	3/30/00
6	Characterized, Compare,	62d	2/3/00	4/28/00
7	Screening ID	86d	4/1/00	7/31/00
8	Task 1 Report	1d	8/31/00	8/31/00
9	**Conceptual Design & R&D N**	**261d**	**9/1/00**	**8/31/01**
10	ID Three Concepts from T	109d	9/1/00	1/31/01
11	ID Critical Tech Issues anc	45d	12/15/00	2/15/01
12	Characterize, Compare &	42d	2/1/01	3/30/01
13	ID Most Promising Conce	67d	3/15/01	6/15/01
14	Task 2 Report	1d	8/31/01	8/31/01
15	**Preliminary Design & Perfor**	**260d**	**9/3/01**	**8/30/02**
16	Develop Prelim Design for	109d	9/3/01	1/31/02
17	Analyze Perform. Of Prelii	66d	3/1/02	5/31/02
18	Perform Econ Analysis of	66d	3/1/02	5/31/02
19	ID Key Manuf Issues for P	85d	12/3/01	3/29/02
20	Perform Selected Experin	152d	11/1/01	5/31/02
21	Task 3 Report	1d	8/30/02	8/30/02

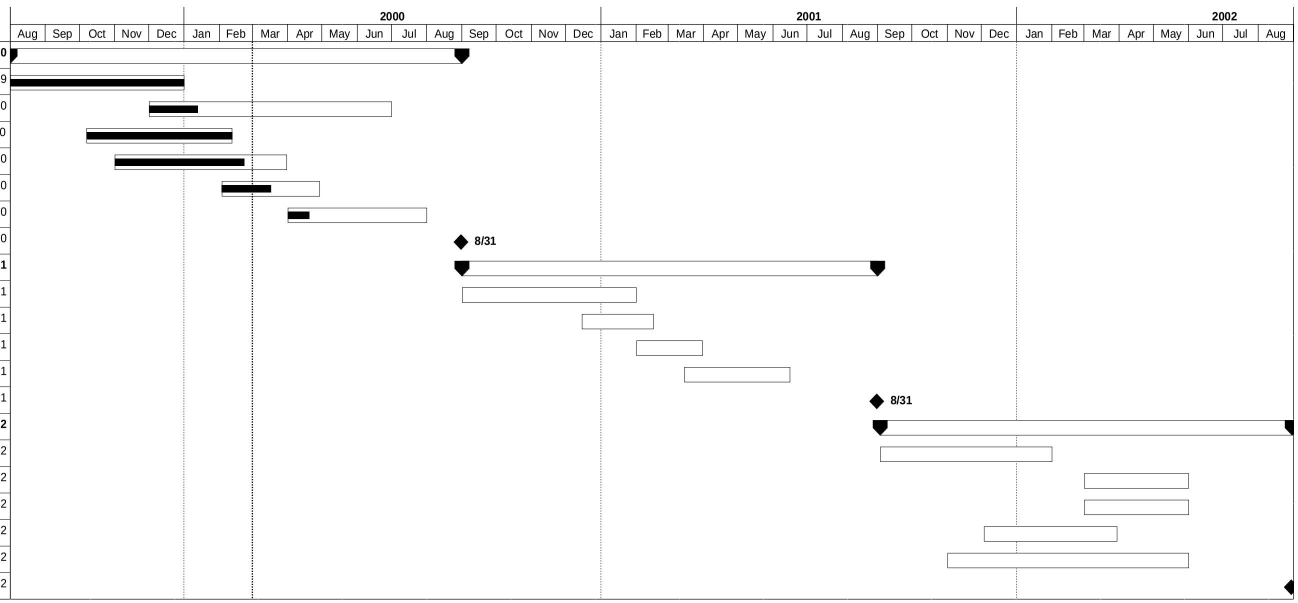

Figure 2. Project Schedule

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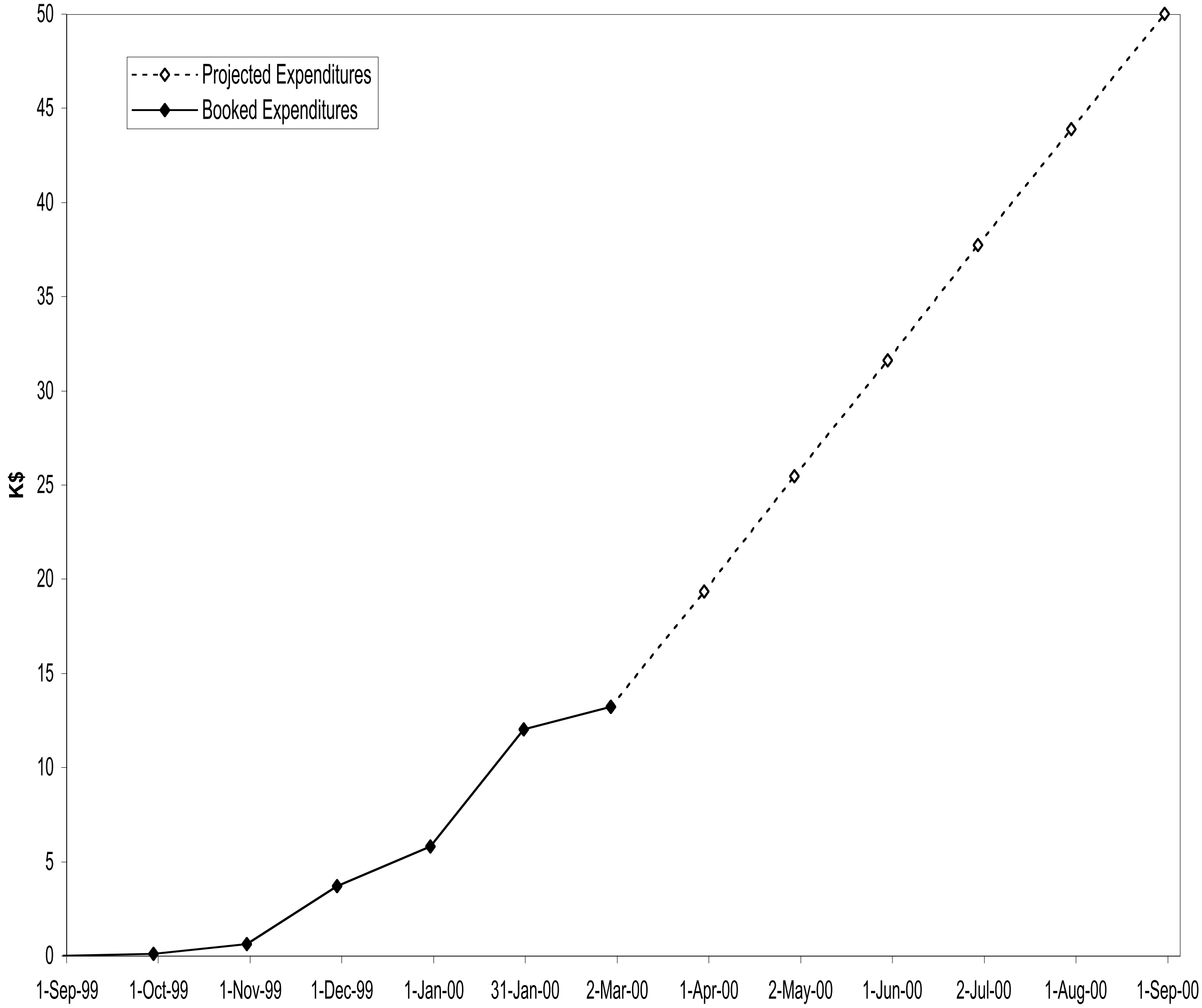

Figure 2. Spending Profile