GA-C23333

DIRECT ENERGY CONVERSION FISSION REACTOR

**for the period
October 1, 2001 through December 31, 2001**

**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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**GENERAL ATOMICS PROJECT 30052
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Direct Energy Conversion Fission Reactor

Nuclear Energy Research Initiative (NERI)
Program DE-FG03-99SF21893
Technical Progress Report
October 1, 2001 through December 31, 2001

Highlights

- The fuel recycle loop of the vapor core reactor model was updated based on information provided by the University of Florida.
- The same loop was expanded to include the fission product species SrF_2 , ZrF_4 , MoF_6 , Xe , CeF_3 and NdF_3 .

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 Fission Electric Cell Reactor

No work was done on the magnetically insulated fission electric cell reactor during this period.

Fission Fragment Magnetic Collimator Reactor

No work was done on the fission fragment magnetic collimator reactor during this period.

Vapor Core Reactor

Modeling of the fuel/coolant loop of the vapor core reactor (VCR) continued. The University of Florida provided additional information on the operating regime for the VCR. The reactor pressure will be 197 atmospheres, rather than the 60 atmospheres used in earlier calculations, and the fuel/coolant composition will be fixed at 10 mole percent UF_4 in helium. These changes have been incorporated into the model. The change in pressure was a simple parameter change in the Aspen Plus model of the recycle loop. The change to operation at fixed coolant composition involved removing an optimization routine and greatly simplified the optimization of the fission product recovery schemes.

Additionally, the MHD generator model was revised to better model the thermodynamics of actual units. A literature review indicated that an isentropic efficiency of 55% should adequately represent an MHD generator. In the past, the MHD generator was modeled using an isentropic efficiency of 97%. Other optimization performed included the removal of the cooling unit after the recuperator,

as it was found the heat removed from the stream did not significantly alter the separation of UF_4 from the helium stream.

Simulation of fission product separation in the recycle loop is continuing. To separate the high vapor pressure fission products, namely Xe, MoF_6 , and ZrF_4 , from the helium stream, three different separation techniques are being considered: gas membrane separation, pressure swing adsorption (PSA), and cryogenic distillation.

In gas membrane separation, low molecular weight (MW) species are separated from high MW species by a selective membrane. The pressure drop across the membrane forces the low MW species to flow through the membrane. Since the fission product flows are a low compared to the helium flow, efficiency will be low unless the pressure drop across the membranes is very small. Further study, focusing on selection of the appropriate type of membrane, will determine if this membrane separation is viable for fission product separation from the VCR coolant.

Pressure swing adsorption (PSA) consists of two (or more) columns in parallel, each one packed with an appropriate fixed-bed adsorbent. It is based on the principle that adsorbents are capable of selectively adsorbing impurities (xenon in this case) under higher pressure and desorbing them under lower pressure. The impurities are first adsorbed in one column under the higher feed-gas pressure until the adsorbent nears saturation. The feed gas is then shifted to the other column and the impurities are desorbed from the first one by switching it to a lower tail-gas pressure and by using a high-purity purge. The impurities are removed continuously by switching the feed-gas flow back and forth between the two columns and “swinging” the pressure level up and down in each column. Typically the desired component (helium in this case) is not adsorbed and is recovered at high purity. PSA looks promising, however, expensive computer codes, such as Adsim, are required to adequately simulate PSA and it has not been determined that leasing Adsim is an optimal use of our resources.

Cryogenic distillation is in our currently working Aspen Plus model. However, cooling the helium recycle stream down to very cold temperatures in order to effect distillation uses a considerable amount of energy.

Previously, the VCR simulation modeled wall heat loss and resultant temperature drop of the reactor and MHD generator outlet streams by adding the amount of heat required to increase the helium recycle stream temperature back up to 1550 K, the inlet temperature of the reactor. This method did not take into account the relative wall cooling areas of the reactor and MHD generator that affect heat loss; therefore, a more accurate model of wall cooling is being investigated.

Planned Next Quarter Activities

We will continue to model the separation of fission products from the VCR fuel/coolant stream. We will incorporate the effects of reactor wall cooling and study heat integration opportunities throughout the simulation.

The analytical model of the cathode structure of the magnetically insulated fission electric cell reactor will be extended to allow calculation of the permitted manufacturing tolerances.

Schedules and Budgets

The status of all tasks of the combined project schedule is indicated in Table 1 and Fig. 1. Expenditures to date and projected expenditures for the rest of Phase 2 are given in Fig. 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 completed
1A(ii).	Review foreign literature	Nov 2000	N/A	Task abandoned due to classification issues
1B.	Identify opportunities for improvement	Mar 2000	Mar 2000	Work completed
1C.	Develop new/alternate concepts	May 2000	May 2000	Work completed
1D.	Characterize/compare alternate concepts	Jun 2000	July 2000	Work completed
1E.	Screen to 3 promising concepts	Jul 2000	Sept 2000	Work completed
1F.	Final (annual) Report for Task 1	Nov 2000	Nov 2000	Work completed
2A.	Preliminary technical specifications for the 3 concepts	Apr 2001		In progress Expected 2/02
2B(i).	Identify critical technology issues	May 2001		In progress Expected 2/02
2B(ii).	Define key experiments	Jun 2001		In progress Expected 4/02
2C.	Compare and assess conceptual definitions	Jun 2001	Nov 2001	Work completed
2D.	Prioritize concepts	Aug 2001	Nov 2001	Work completed
2E.	Final (annual) Report for Task 2	Oct 2001		In progress Expected 2/02
3A.	Preliminary design of most promising concepts	Mar 2002		Initiated 11/01
3B.	Analyze technical performance	Jul 2002		Initiated 11/01
3C.	Analyze economic performance	Jul 2002		Initiated 11/01
3D.	Identify manufacturability issues	Sep 2002		Start expected 4/02
3E.	Perform selected experiments	Sep 2002		Delayed indefinitely
3F.	Complete Phase 3 and project	Oct 2002		
3F'.	Final Report for Phase 3 and project	Oct 2002

Fig. 1. Project Schedule.

Fig. 2. DEC expenditures.