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University of Nevada, Las Vegas Advanced Accelerator Applications University Participation Program: Quarterly Report, First Quarter Year 2 (March 2002 to May 2002)

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Quarterly Report
First Quarter Year 2 (March 2002 to May 2002)

University of Nevada, Las Vegas
Advanced Accelerator Applications
University Participation Program

October 17, 2002

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ACRONYMS

AAA	Advanced Accelerator Applications
ADTTA	Accelerator-Driven Transmutation Technology and Applications Conference
AMUSE	Argonne Model for Universal Solvent Extraction
ANL	Argonne National Laboratory
ANS	American Nuclear Society
ASME	American Society of Mechanical Engineers
BNL	Brookhaven National Laboratory
CE	Civil and Environmental Engineering
COE	UNLV College of Engineering
DCC	Dose Conversion Coefficients (refer to UNLV Task 7)
DOE	U.S. Department of Energy
DOE-NE	DOE Office of Nuclear Energy, Science, and Technology

ECE	Electrical and Computer Engineering Department
EENF	Environmental Evaluation Notification Form
EMIL	Electron Microanalysis and Imaging Laboratory
FEI	Transmission Electron Microscope Vendor
FY02	Fiscal Year 2002
HRC	Harry Reid Center for Environmental Studies
IAEA	International Atomic Energy Agency
ICAPP	International Congress on Advanced Nuclear Power Plants
INPE	Institute of Nuclear Power Engineering, Obninsk, Russia
IYNC	International Youth Nuclear Congress
IPPE	Institute of Physics and Power Engineering, Obninsk, Russia
ISTC	International Science and Technology Center
ISU	Idaho State University
JEOL	Transmission Electron Microscope Vendor
KRI	Khlopin Radium Institute, St. Petersburg, Russia
LANL	Los Alamos National Laboratory
LANSCE	Los Alamos Neutron Science Center
LBE	Lead Bismuth Eutectic
LBNL	Lawrence Berkeley National Laboratory
LEDA	Low Energy Demonstration Accelerator
MCNPX	Monte Carlo Neutron Photon with extremely high-energy libraries code
MSE	Material Sciences and Engineering
NEPA	National Environmental Policy Act
NERAC	Nuclear Energy Research Advisory Committee
QTR	Quarterly Technical Review
SEM	Scanning Electron Microscope
SLLF	State Legislative Leaders Foundation
SMC	Student Mini-Conference
SOW	Statement of Work
TC	Target Complex
TEM	Transmission Electron Microscope
UNLV	University of Nevada, Las Vegas
UPP	University Participation Program
URHPPA	Utilization and Reliability of High Power Proton Accelerators
VPR	Vice Provost for Research
WBS	Work Breakdown Sheet

1. INTRODUCTION

This Quarterly Report is a primary deliverable from the University of Nevada, Las Vegas (UNLV) Advanced Accelerator Applications (AAA) University Participation Program (UPP) Director to the U.S. Department of Energy (DOE) as described in the UNLV AAA proposal[1], and Statement of Work for the First Quarter Year 2 [2].and AAA FY02 Work Package[3].

The UNLV AAA UPP Director implements the program's administration using staff from the Harry Reid Center for Environmental Studies (HRC) to ensure that work conducted under the UNLV AAA UPP meets program objectives. The UNLV AAA program consists of four components: Program Support, Research Infrastructure Augmentation, International Collaboration, and Student Research. Further information about the activities and reports discussed in this document can be viewed on the UNLV AAA program's website at <http://aaa.nevada.edu>.

1.1 Chronology of Events

Mar. 4, 2002	AAA Program Conference Call
Mar. 5, 2002	Task 7 Second Quarter Report submitted to UNLV AAA Director
Mar. 6, 2002	UNLV faculty visit FEI TEM demonstration facility
Mar. 8, 2002	UNLV February Actual Expenditures submitted to DOE
Mar. 8, 2002	Task 9 First and Second Quarter Reports submitted to UNLV AAA Director
Mar. 8, 2002	Students and faculty meet to discuss the formation of a UNLV Student Section of the American Nuclear Society
Mar. 11, 2002	AAA DOE-NE/UNLV Program Conference Call
Mar. 11, 2002	Reprocessing, Transmutation, and Waste Management Presentations to Paul Newman during his visit to UNLV
Mar. 11, 2002	Candidate Presentation and Interview for EMIL Scientist: Bill Shannon
Mar. 12, 2002	AAA Graduate Student Seminars, Hydrogen Embrittlement and High-Temperature Deformation – Tasks 4 and 10
Mar. 13, 2002	Candidate Interview for ECE Professorship: Dr. Grave
Mar. 14, 2002	Task 2 Third Quarter Report submitted to UNLV AAA Director
Mar. 14-17, 2002	UNLV hosted the State Legislative Leaders Foundation Meeting, Energy Demands of America's Future
Mar. 15, 2002	Candidate Presentation and Interview for EMIL Scientist: Dr. Fairhurst
Mar. 15, 2002	UNLV SOW and FY02 Work Packages submitted to DOE
Mar. 18, 2002	AAA DOE-NE/UNLV Program Conference Call
Mar. 18, 2002	AAA Program Conference Call
Mar. 19, 2002	Draft LBE Experimental Plan submitted to UNLV AAA Director
Mar. 19, 2002	AAA Graduate Student Seminar, Neutron Multiplicity – Task 6
Mar. 20, 2002	UNLV AAA Finance Advisory Committee meets and recommends renewal of four tasks for second year funding and two new tasks of the seven new

	proposals submitted for funding
Mar. 21, 2002	Candidate Interview for ECE Professorship: Dr. Melkonian
Mar. 21, 2002	Task 3 Second Quarter Report submitted to UNLV AAA Director
Mar. 21, 2002	Task 11 First Quarter Report submitted to UNLV AAA Director
Mar. 21, 2002	Task 12 First Quarter Report submitted to UNLV AAA Director
Mar. 24, 2002	Task 4 Third Quarter Report submitted to UNLV AAA Director
Mar. 24, 2002	Task 10 Second Quarter Report submitted to UNLV AAA Director
Mar. 25, 2002	AAA DOE-NE/UNLV Program Conference Call
Mar. 25, 2002	AAA Program Conference Call
Mar. 25-26, 2002	UNLV faculty visit JEOL TEM demonstration facility
Mar. 26, 2002	Task 6 First Quarter Report submitted to UNLV AAA Director
Mar. 26, 2002	UNLV AAA Fourth Quarter Report submitted to DOE
Mar. 27, 2002	Task 1 Third Quarter Report submitted to UNLV AAA Director
Mar. 27, 2002	Task 8 Second Quarter Report submitted to UNLV AAA Director
Mar. 28, 2002	AAA Program Management and Controls Conference Call
Apr. 1, 2002	AAA DOE-NE/UNLV Program Conference Call
Apr. 1, 2002	AAA Program Conference Call
Apr. 2, 2002	AAA Graduate Student Seminars, Criticality during Separations and Neutron Transport in a Target – Tasks 11 and 12
Apr. 4, 2002	UNLV AAA Finance Director and accounting staff attend AAA Program Management Integrated Training at LANL
Apr. 5, 2002	Technical presentation and discussion with Congresswoman Berkley's Legislative Director
Apr. 5, 2002	Inaugural meeting of the UNLV Student Section of the American Nuclear Society, speaker David Stahl on the Yucca Mountain Materials Program
Apr. 7, 2002	UNLV March Actual Expenditures submitted to DOE
Apr. 8, 2002	AAA Program Conference Call
Apr. 8, 2002	Physics faculty discussion on potential AAA-sponsored professorships
Apr. 9, 2002	AAA Seminar and faculty meetings, Physics of Radioactive Waste Transmutation, Massimo Salvatores, Argonne National Laboratory
Apr. 11, 2002	UNLV March Actual Expenditures submitted to DOE
Apr. 11, 2002	UNLV director attends AAA Program Management Integrated Training at ANL
Apr. 15, 2002	DOE-NE formally approves the proposals recommended by the UNLV Finance Advisory Committee – six tasks for $900,937 worth of funding starting summer term 2002
Apr. 16, 2002	AAA Graduate Student Seminar, Systems Engineering Model of Chemical Separations Process – Task 8
Apr. 16-20, 2002	IYNC 2002 Conference, Daejeon, Korea. Two papers presented by UNLV AAA graduate student and faculty.
Apr. 19, 2002	Task 11 Report distributed: "Fission and Thermal Effects in Curium Separated from Spent Nuclear Fuel"

Apr. 22, 2002	AAA DOE-NE/UNLV Program Conference Call
Apr. 22, 2002	AAA Program Conference Call
Apr. 23, 2002	AAA Graduate Student Seminar, Dose Conversion Coefficients – Task 7
Apr. 24, 2002	UNLV AAA Infrastructure Committee recommends $150,000 for three items: flow visualization equipment for Task 3, startup package support for new ECE professor, and machining equipment to support a number of AAA tasks
Apr. 25, 2002	AAA Program Management and Controls Conference Call
Apr. 25, 2002	Task 1 distributed two conference papers on Melt Casting of Metallic Fuel Pins to ASME02 and ICAPP02
Apr. 25, 2002	LBE Infrastructure Subcommittee Conference Call
Apr. 26, 2002	Infrastructure Seminar, JEOL TEM representatives
Apr. 29, 2002	AAA DOE-NE/UNLV Program Conference Call
Apr. 29, 2002	AAA Program Conference Call
Apr. 29, 2002	UNLV AAA Program Call for Proposals for Fall 2002 Distributed
Apr. 30, 2002	Task 11 Second Quarter Report submitted to UNLV AAA Director
Apr. 30, 2002	Task 12 Second Quarter Report submitted to UNLV AAA Director
Apr. 30, 2002	UNLV meetings on Accelerator Research with John McGill, General Atomics
Apr. 30, 2002	AAA Graduate Student Seminar, Modeling of Corrosion in LBE Systems – Task 5
May 1, 2002	Kemal Pasamehmetoglu (LANL) visits UNLV to discuss with AAA collaborations with faculty and administrators
May 2, 2002	Task 6 Second Quarter Report submitted to UNLV AAA Director
May 2, 2002	Infrastructure Subcommittee meeting to discuss machining equipment and access policy
May 4-7, 2002	Nikolay Salnikov (INPE President) and Irina Vorobieva (INPE Director of International Affairs) visit UNLV to discuss collaboration with UNLV faculty and administrators.
May 6, 2002	AAA DOE-NE/UNLV Program Conference Call
May 6, 2002	AAA Program Conference Call
May 6-8, 2002	Eric Pitcher (LANL) visits UNLV to add MCNPX libraries and help students with modeling
May 7, 2002	UNLV April Actual Expenditures submitted to DOE
May 7-8, 2002	Ning Li (LANL) visits UNLV to collaborate with students and faculty on tasks related to his AAA area
May 12-16, 2002	UNLV director participates in the Third International Workshop of Utilization and Reliability of High Power Proton Accelerators, Santa Fe, NM
May 13, 2002	AAA DOE-NE/UNLV Program Conference Call
May 13, 2002	AAA Program Conference Call
May 17, 2002	LBE Infrastructure Subcommittee on ISTC Target meeting to update progress on Target transport and UNLV acceptance

May 17, 2002	UNLV ANS Student Section holds second meetings, speaker Doug Nousen, Counter Intelligence Officer, Nevada Operations Office
May 20, 2002	Summer Term starts, four Tasks renewed, two new Tasks start research
May 20, 2002	AAA DOE-NE/UNLV Program Conference Call
May 20, 2002	AAA Program Conference Call
May 22, 2002	LBE Infrastructure Subcommittee on ISTC Target Conference Call to update progress on Target transport and UNLV acceptance
May 24, 2002	AAA Seminar and faculty meetings, IAEA Health Physics Division, Christian Schmitzer, Austrian Research Center
May 28, 2002	ISTC Target arrives at UNLV from LANL
May 28, 2002	AAA Graduate Student Prospectus Presentation to Thesis Committee, Steven Curtis, Task 6, Health Physics Department
May 28, 2002	Ka-Ngo Leung (LBNL) presents AAA seminar and holds discussions with faculty on Development and Applications of Compact Neutron Generators
May 29, 2002	AAA Program Management and Controls Conference Call

1.2 Overall Program Schedule

The First Quarter Year 2 milestones and deliverables for the UNLV AAA University Participation Program are shown in Figures 1 to 4.

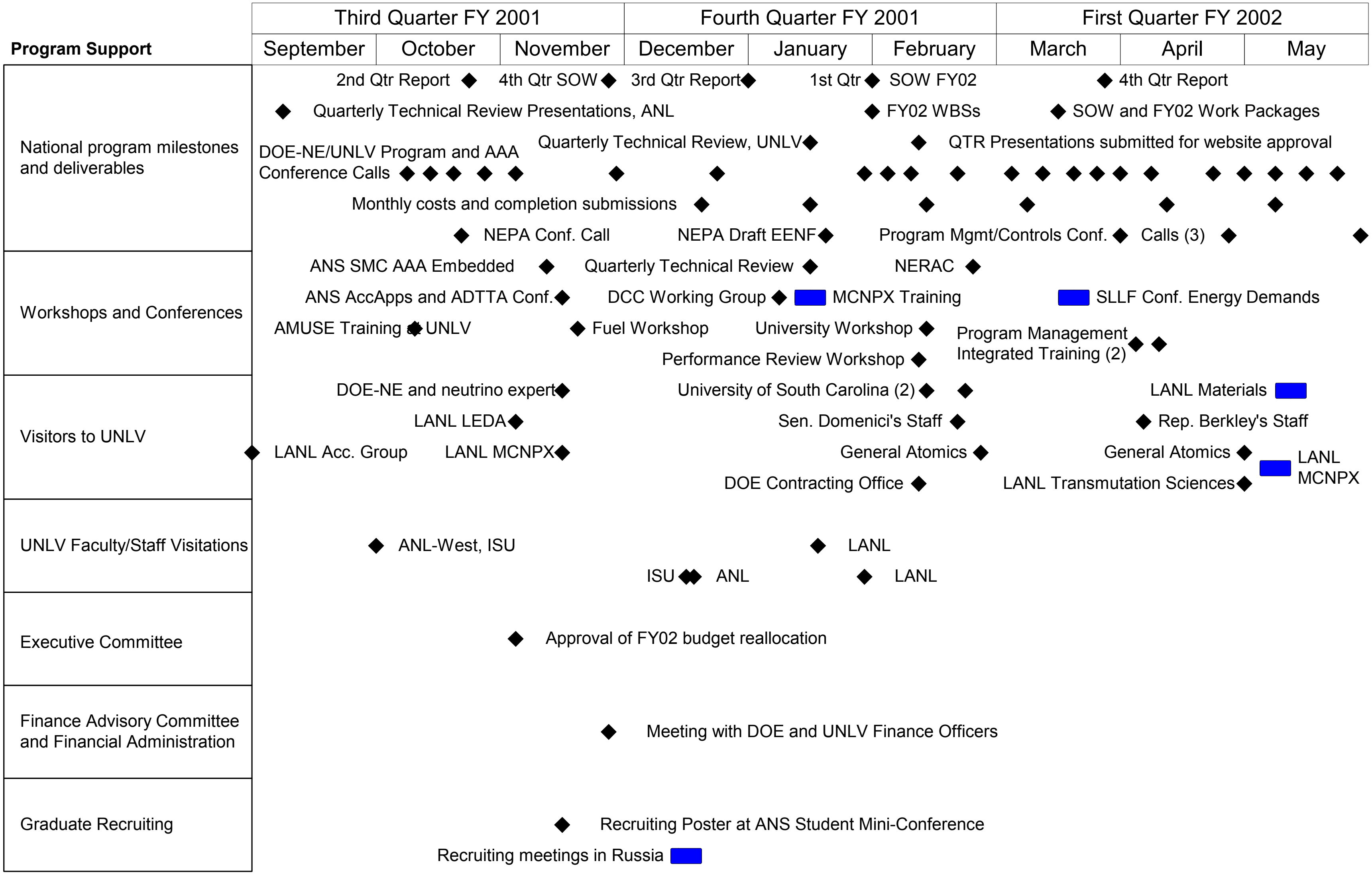

Figure 1. Milestones and Deliverables of Program Support for the UNLV AAA University Participation Program through the First Quarter Year 2.

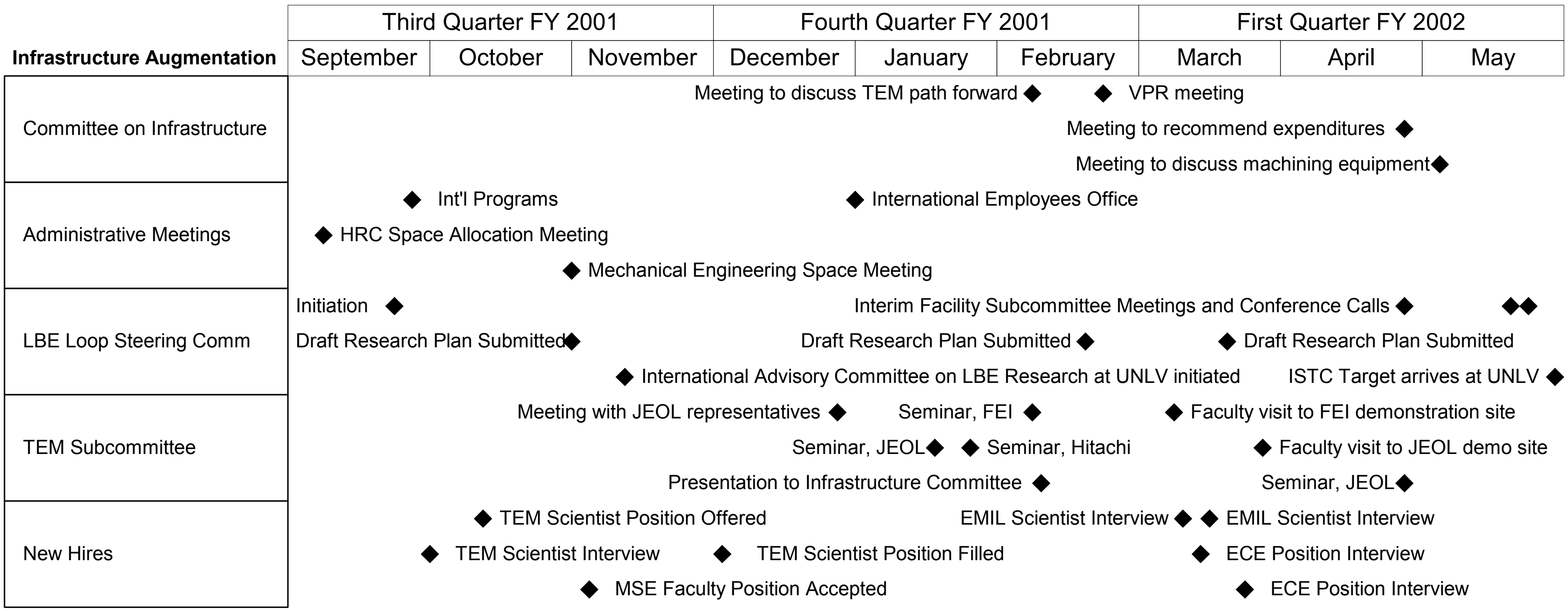

Figure 2. Milestones and Deliverables of Research Infrastructure Augmentation for the UNLV AAA University Participation Program through the First Quarter Year 2.

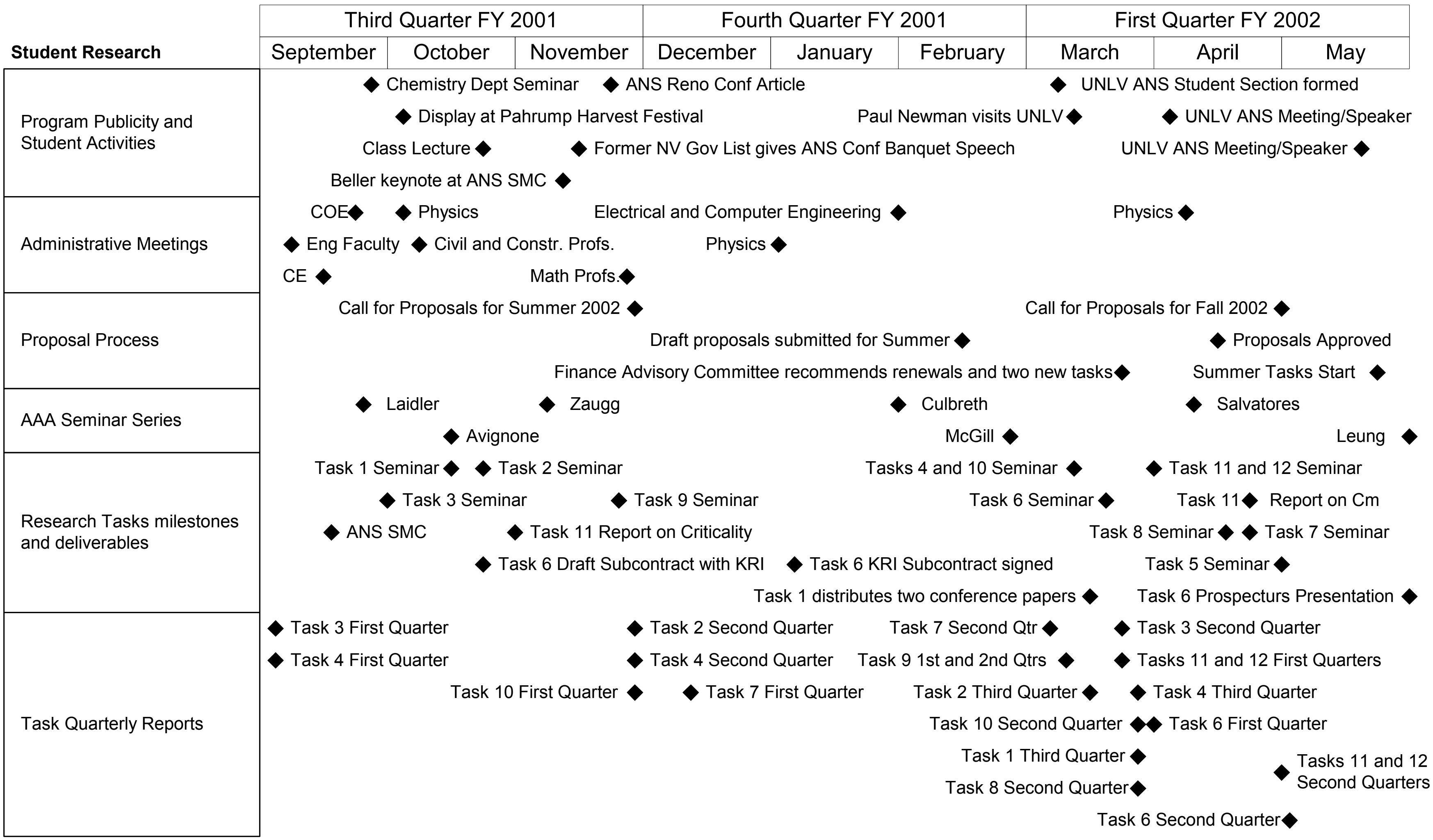

Figure 3. Milestones and Deliverables of Student Research Tasks for the UNLV AAA University Participation Program through the First Quarter Year 2.

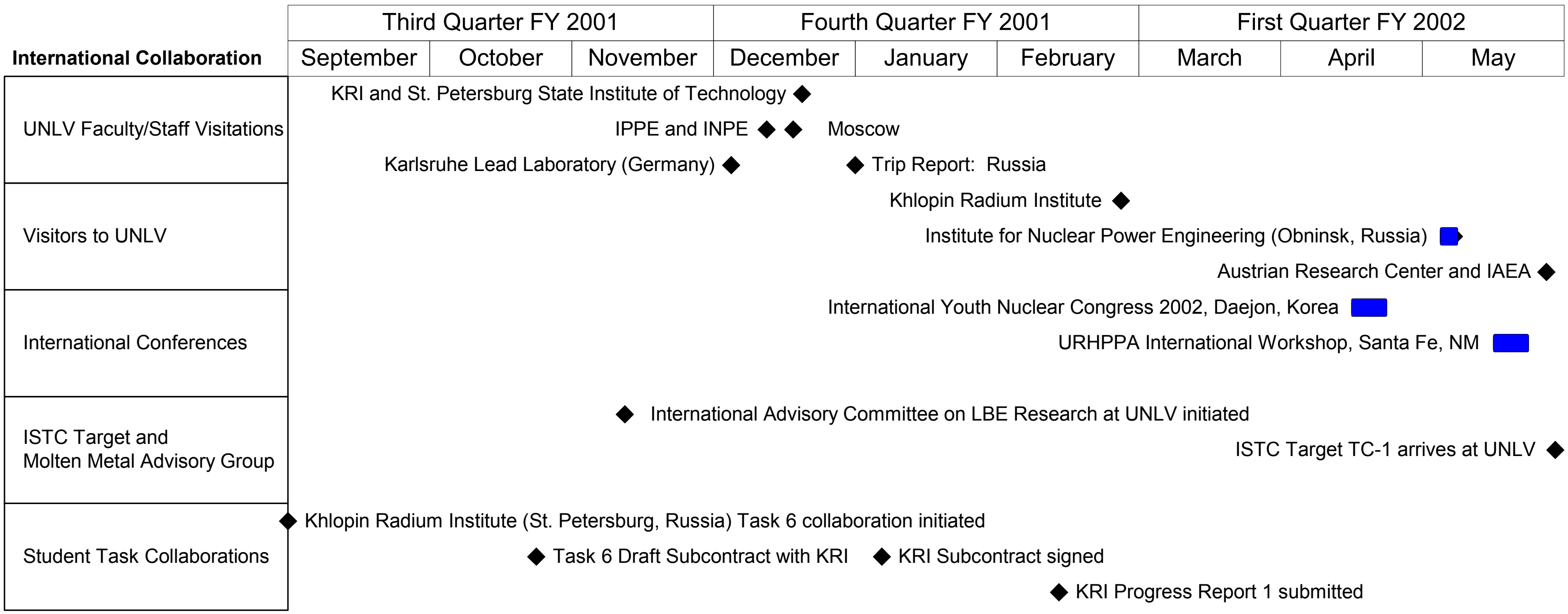

Figure 4. Milestones and Deliverables of International Collaboration for the UNLV AAA University Participation Program through the First Quarter Year 2.

2. PROGRAM SUPPORT

The primary deliverables for the Program Support component are quarterly and annual reports. These reports detail the progress on each administrative task and the milestones and deliverables generated during the appropriate period. Other than this report, the only other documents provided to DOE for the First Quarter Year 2 are the following:

- UNLV AAA University Participation Program Revised Statement of Work for the First Quarter, FY02, March 18, 2002.
- UNLV AAA University Participation Program Fourth Quarter Report, March 26, 2002.

The following are the individuals involved in the day-to-day administration of the UNLV AAA UPP during the First Quarter Year 2.

UNLV AAA UPP Executive Committee:

Anthony Hechanova	Director
Gary Cerefice	Deputy Director (Harry Reid Center for Environmental Studies)
Malcolm Nicol	Deputy Director (College of Sciences)
William Culbreth	Deputy Director (College of Engineering)

UNLV Student Support Staff:

Christina Crossan	Undergraduate, Health Physics Department
Demian Gitnacht	Undergraduate, Health Physics Department
Cheryl Gustafson	Undergraduate, Kinesiology Department
Ingrid James	Undergraduate, School of Social Work

UNLV AAA UPP Affiliates:

Pattie Baldwin (HRC)	Director of Finance
Denis Beller (LANL)	AAA UPP Intercollegiate Programs Coordinator
Ning Li (LANL)	AAA UPP International Programs Coordinator
Thomas Ward (DOE)	Senior Science Adviser
John Knoten (HRC)	Webmaster

2.1 UNLV AAA UPP Meetings and Committees

This section describes the motions of committees that were active during the First Quarter Year 2.

Finance Advisory Committee:

Dr. Anthony Hechanova, Chair
Dr. Gary Cerefice (Harry Reid Center)
Prof. Malcolm Nicol (College of Sciences)
Prof. William Culbreth (College of Engineering)
Dean Paul Ferguson (UNLV Administration)
Vice Provost for Research Stephen Rice (UNLV Administration)

The Finance Advisory Committee met July 25 to discuss and recommend proposals starting fall term 2001. Ten proposals were submitted and eight were recommended for final submission to DOE-NE.

The Finance Advisory Committee met March 20, 2002 to discuss and recommend proposals starting summer term 2002. Eleven proposals were submitted, four of the proposals were second-year renewals and seven of the proposals were new. Denis Beller representing the DOE-NE Program Advisory Committee gave a briefing of the DOE-NE program mission prioritizations. The four renewals and two new proposals were recommended for funding. DOE-NE approved the recommendations on April 15, 2002.

Infrastructure Committee:

Dr. Anthony Hechanova, Chair
Dr. Gary Cerefice (Harry Reid Center, Point of Contact)
Prof. Malcolm Nicol (College of Sciences, Point of Contact)
Prof. William Culbreth (College of Engineering, Point of Contact)
Prof. Dennis Lindle (College of Sciences, Interface Science Program)
Prof. Allen Johnson (College of Sciences, Chemistry)
Prof. Brendan O'Toole (College of Engineering, Mechanical Engineering)
Prof. Robert A. Schill, Jr. (College of Engineering, Electrical Engineering)
Mark Pippenger (College of Engineering, Electronics Technician)

The Infrastructure Committee is responsible to advise the Executive and Finance Committees on matters related to the development of user laboratories and the hiring of AAA faculty and staff. The Committee met April 24, 2002 to discuss three requests. Their recommendations were as follows:

- $31,000 to purchase flow visualization equipment for Prof. Robert Schill, Jr. and Prof. Mohamed Trabia's niobium cavity project (UNLV AAA UPP Task 3).
- $50,000 in support of Dr. Biswajit Das's (Electrical and Computer Engineering) startup package (Fall 2002 potential start date) with another $50,000 provided using FY03 funds if they are available.

- $69,000 contribution to support machining capability on campus. These funds will be available to an ad hoc committee commissioned by the UNLV administration to identify and procure machining equipment to address the needs of the campus research community.

LBE Loop Steering Committee

Subcommittee to Develop a Research Plan

Prof. Samir Moujaes, Chair (College of Engineering, Department of Mechanical Engineering)
Dr. Gary Cerefice (Harry Reid Center)
Prof. John Farley (College of Sciences, Physics Department)

The LBE Loop Steering Committee established a subcommittee to develop (in collaboration with potential collaborators) a research plan to help in the design of the facility. A draft LBE Experimental Plan with input from collaborators at LANL was submitted to the UNLV AAA UPP Director on March 19, 2002.

Subcommittee to Develop an Interim LBE Facility

Dr. Anthony Hechanova, Chair (UNLV AAA UPP Director)
Dr. William Culbreth (Associate Dean, College of Engineering)
Prof. Samir Moujaes, (College of Engineering, Department of Mechanical Engineering)
Dr. Gary Cerefice (Harry Reid Center)
Prof. John Farley (College of Sciences, Physics Department)
Mr. Courtney Kerr (UNLV Environmental Health & Safety)

The LBE Loop Steering Committee forms the basis of a subcommittee to develop (in collaboration with potential collaborators, mainly at LANL) an interim LBE facility to house the ISTC Target and allow preliminary LBE research to be conducted while a long-term facility is being investigated by the UNLV administration. The Subcommittee met three times (May 2, 17, and 22) including two conference calls with collaborators at LANL to prepare UNLV to accept the ISTC Target that arrived May 28, 2002 from LANL. The ISTC Target had two accelerometers on it that indicated sideways motion greater than 6 g when it arrived at UNLV. In the future, the Subcommittee will work with LANL and the insurance company to resolve this situation.

Other Committees:

Conference Committee: Anthony Hechanova (Chair) and Kathy Lauckner (Co-Chair) worked with Denis Beller to plan UNLV's participation in national conferences. The two conferences that will be supported by UNLV AAA UPP are the AccApp03 embedded topical meeting (June 1-5, 2003) in San Diego, CA and the ANS Student Conference/AAA University Workshop (April 2-5, 2003) in Berkeley, CA.

Finance Oversight: HRC Finance Director Patricia Baldwin and Anthony Hechanova provided timely monthly actual expenditure reports to DOE/BREI and participated in monthly Program Management and Controls conference calls (last Thursday of each month).

Information Management Committee: Anthony Hechanova (Chair), Gary Cerefice, and John Knoten. Weekly meetings were held to maintain and update the UNLV AAA UPP website at <http://aaa.nevada.edu> and the AAA library.

Search Committees:

- Research Scientist B, College of Sciences (Dean Frederick Bachhuber, Point of Contact) – The offer to the top candidate was not accepted by the candidate and the position was not filled. A new search is anticipated during fall term 2002.

- Research Scientist D, Department of Geosciences (Rod Metcalf, Dept. Chair, Point of Contact) – Two candidates were interviewed by UNLV AAA UPP directors and an offer was made to the top candidate. The candidate, Dr. Robert Fairhurst, accepted the offer and is anticipated to start June 1, 2002.

- Professor, Electrical and Computer Engineering Department (Rama Venkat, Dept. Chair, Point of Contact) – Two candidates were interviewed by UNLV AAA UPP directors and an offer was made to the top candidate. The candidate, Dr. Biswajit Das, accepted the offer and is anticipated to start fall term 2002 or spring term 2003.

2.2 Workshops, Conferences, and Collaboration Meetings

State Legislative Leaders Foundation Conference, March 14-17, Las Vegas, Nevada – The conference was titled "Under Our Own Power: What States Can Do to Ensure Stable, Secure, and Affordable Energy" and included legislative leaders from 22 states as well as corporate and congressional leaders. The purpose of the meeting was to inform state legislators (who are predominantly untrained in technical matters) about energy issues. Marvin Fertel gave the presentation on nuclear energy.

International Youth Nuclear Congress, April 16-20, Daejeon, Korea – UNLV has been an active participant with the IYNC since it was founded in 1998. The IYNC meetings give students and young nuclear professionals an opportunity to network and learn about global nuclear issues. UNLV students and professors gave two papers on AAA projects Task 1 and Task 5.

Research collaboration meetings are encouraged and arranged to help enhance communication networking and develop collaborative graduate student research projects. Research collaboration meetings were held between UNLV faculty and the following groups:

- Argonne National Laboratory: Massimo Salvatores (April 9, 2002)
- Los Alamos National Laboratory: Kemal Pasamehmetoglu (May 1, 2002), Eric Pitcher (May 6-8, 2002), and Ning Li (May 7-8, 2002)
- Lawrence Berkeley National Laboratory: Ka-Ngo Leung (May 28, 2002)
- Congresswoman Shelley Berkley's Staff: Legislative Director visit to UNLV (April 5, 2002)
- Austrian Research Center: Christian Schmitzer (May 24, 2002)
- DOE-NE and UNLV Directors' Conference Calls: March 4, 11, and 18; April 1, 8, 22, and 29; and May 6, 13, 20, telephone conferencing between John Herczeg and staff and Anthony Hechanova; followed by telephone conferencing with AAA program representatives.

2.3 UNLV AAA UPP Website, Information Management, and Seminars

The UNLV AAA UPP website <http://aaa.nevada.edu> was maintained in the First Quarter Year 2 by HRC webmaster John Knoten. This website contains relevant information for internal UNLV communications, networking with outside groups, and for general public access. A library housed at the HRC was maintained that contains materials supplied by the national laboratories and other sources related to the AAA.

The following seminars were presented during the First Quarter Year 2:

"Hydrogen-Induced Embrittlement of Lead in Spallation-Neutron-Target Systems" and "Development of a Mechanistic Understanding of High-Temperature Deformation of EO-823 for Transmutation Applications" Research team of Profs. Ajit Roy and Brendan O'Toole, UNLV Mechanical Engineering Department, AAA Student Seminar, March 12, 2002.

"Neutron Multiplicity Measurements of AAA Target/Blanket Materials," Steven Curtis, UNLV Health Physics Department, AAA Student Seminar, March 19, 2002.

"Nuclear Criticality Analyses for the Transmuter Fuel Fabrication and Reprocessing Process" and "Radiation Transport Modeling of Beam-Target Experiments for the AAA Project" Research team of Prof. William Culbreth, UNLV Mechanical Engineering Department, AAA Student Seminar, April 2, 2002.

"Physics of Radioactive Waste Transmutation," Massimo Salvatores, Argonne National Laboratory, April 9, 2002.

"Development of a Systems Engineering Model of the Chemical Separations Process" Research team of Prof. Yitung Chen, UNLV Mechanical Engineering Department, AAA Student Seminar, April 16, 2002.

"Development of Dose Conversion Coefficients for Radionuclides Produced in Spallation Neutron Sources" Research team of Prof. Mark Rudin, UNLV Health Physics Department, AAA Student Seminar, April 23, 2002.

3. RESEARCH INFRASTRUCTURE AUGMENTATION

The goal of the Research Infrastructure Augmentation component of the UNLV AAA UPP is to augment the research staff and facilities at UNLV to increase the ability of the university to perform AAA research. The following sections describe progress made in infrastructure augmentation.

3.1 New Hires

Research Scientist A, Harry Reid Center — Dr. Longzhou Ma began December 1, 2001. All of Dr. Ma's time is devoted to AAA and his principal responsibilities are the design, development, and establishment of a Transmission Electron Microscopy User Facility.

Research Scientist B, College of Sciences — The search committee has completed their process and their top candidate was offered a faculty position, however, the candidate turned down the offer. The position was not yet filled by the end of the First Quarter Year 2; a new search will commence probably during fall term 2002.

Research Scientist C, College of Engineering — Dr. Ajit Roy began July 1, 2001. Half of Dr. Roy's time is devoted to AAA and he is a principal involved in developing a Materials Performance Laboratory.

Research Scientist D, Department of Geosciences and Harry Reid Center — The search committee for a SEM technician has been completed and an offer was made and accepted by the top candidate Dr. Robert Fairhurst. The candidate is expected to begin June 2002.

Research Professor, College of Engineering — The UNLV AAA UPP was involved in the search of a new faculty member in the Electrical and Computer Engineering Department. The search was completed and an offer was made and accepted by the top candidate Dr. Biswajit Das. The candidate is expected to begin fall term 2002 or spring term 2003.

3.2 New Equipment and Facilities

Four new user facilities are under development in the First Quarter Year 2.

Materials Performance Laboratory (MPL): This facility is under development in existing space in the College of Engineering complex. About $230,000 of equipment for AAA tasks is being set up in the facility, which is expected to be complete by mid-year 2002.

Transmission Electron Microscopy (TEM) User Facility: This facility is to be built in existing space at the Harry Reid Center. The first step in the development of the facility was to hire a TEM expert, Dr. Longzhou Ma (Research Scientist A, see Section 3.1) to aid in the selection of a TEM, and the design, development, and operation of the new TEM User Facility. Last quarter a number of TEM vendors visited UNLV to meet with faculty and staff to determine the most appropriate system for UNLV's infrastructure needs. This quarter UNLV faculty and staff visited the sites of two candidate vendors: FEI and JEOL (March 6 and March 25, respectively).

Lead Bismuth Eutectic Loop User Facility: The LBE Loop Steering Committee's Subcommittee submitted a revised draft research plan on March 19, 2002. The ISTC Target was accepted at UNLV on May 28, 2002 and is in a safe holding area while insurance issues are resolved (the two accelerometers were out of position, indicating acceleration greater than 6 g in two directions). A second Subcommittee was formed to set up an interim facility in the College of Engineering Complex while a permanent and tailor-made facility is designed and developed as part of the Harry Reid Center for Environmental Studies. The Molten Metal Advisory Group will meet next quarter to discuss and recommend future direction for the ISTC Target and LBE facility.

Electron Microscopy and Imaging Laboratory (EMIL): The UNLV AAA program at the recommendation of the Infrastructure Committee financially supports already existing facility within the College of Sciences that contains optical microscopes and a Scanning Electron Microscopy (SEM) by paying for some service contracts. In addition, the UNLV AAA Program cost-shares Dr. Robert Fairhurst (newly hired as Research Scientist D) with the UNLV Geosciences Department. Dr. Fairhurst's responsibilities will include operation and maintenance of the SEM and TEM facilities.

4. RESEARCH PROJECTS

The Student Research component is the core of the UNLV AAA UPP with steadily increasing funds as the program evolves and capability expands.

The following 14 tasks comprise the student research component of the UNLV AAA University Participation Program. 4 tasks began in the summer term 2001, 8 tasks began in the fall term 2001, and 2 new tasks began in summer term 2002. Quarterly progress reports from the tasks are included as appendices.

Task	Title	UNLV Department National Collaborator Annual Cost (# of Students)	Technical Area
1	Design and Analysis for Melt Casting Metallic Fuel Pins Incorporating Volatile Actinides	Mech. Engineering Dept Argonne National Laboratory $141k (2 Grads)	Fuels
2	Modeling, Fabrication, and Optimization of Niobium Cavities	Electrical & Comp Eng Dept Los Alamos National Lab $161k (3 Grads)	Accelerator

3	Experimental Investigation of Steel Corrosion in Lead Bismuth Eutectic: Characterization, Species Identification, and Chemical Reactions	Physics Department Los Alamos National Lab $190k (2 Grads)	Transmutation Sciences
4	Hydrogen-Induced Embrittlement of Candidate Target Materials for Applications in Spallation-Neutron-Target Systems	Mech. Engineering Dept Los Alamos National Lab $146k (2 Grads)	Transmutation Sciences
5	Modeling Corrosion in Oxygen Controlled LBE Systems with Coupling of Chemical Kinetics and Hydrodynamics	Mech. Engineering Dept Los Alamos National Lab $109k (2 Grads)	Transmutation Sciences
6	Neutron Multiplicity Measurements for AAA Target/Blanket Materials	Harry Reid Center Los Alamos National Lab $140k (1 Grad)	Transmutation Sciences
7	Develop Dose Conversion Coefficients for Radionuclides Produced in Spallation Neutron Sources	Health Physics Department Los Alamos National Lab $160k (2 Grads)	System Integration
8	Development of a Systems Engineering Model of the Chemical Separations Process	Mech. Engineering Dept Argonne National Laboratory $150k (2 Grads)	Separations
9	Design and Evaluation of Processes for Fuel Fabrication	Mech. Engineering Dept Argonne National Laboratory $87k (1 Grad)	Fuels
10	Development of a Mechanistic Understanding of High-Temperature Deformation of Alloy EP-823 for Transmutation Applications	Mech. Engineering Dept Los Alamos National Lab $99k (1 Grad)	Transmutation Sciences
11	Nuclear Criticality Analyses of Separations Processes for the Transmutation Fuel Cycle	Physics and Mech Eng Dept Argonne National Laboratory $110k (2 Grads)	Separations
12	Radiation Transport Modeling of Beam-Target Experiments for the AAA Project	Mech. Engineering Dept Argonne National Laboratory $110k (2 Grads)	Transmutation Sciences
13	Developing a Sensing System for the Measurement of Oxygen Concentration in Liquid Pb-Bi Eutectic	Electrical an Mech Eng Dept Los Alamos National Lab $146k (2 Grads)	Transmutation Sciences
14	Use of Positron Annihilation Spectroscopy for Stress-Strain Measurements	Mech. Engineering Dept Argonne National Laboratory $120k (2 Grads)	Transmutation Sciences

REFERENCES

1. Hechanova, A.E., "Proposal to Establish an Advanced Accelerator Applications University Participation Program at the University of Nevada, Las Vegas," Rev. 3, March 6, 2001.
2. Hechanova, A.E., "UNLV AAA University Participation Program Statement of Work for the First Quarter (Revision 2)," March 26, 2002.
3. Hechanova, A.E., "UNLV AAA University Participation Program: Program Administration," AAA FY02 Work Package Form, July 25, 2002.

Task 1: Third Quarter Report

Phase I: Design and Analysis for Melt Casting Metallic Fuel Pins Incorporating Volatile Actinides

Quarterly Progress Report
11/16/01- 2/15/02

UNLV-AAA University Participation Program

Principle Investigator: Yitung Chen
Co-Principal Investigators: Randy Clarksean and Darrell Pepper

Purpose and Problem Statement

An important aspect of the Advanced Accelerator Applications (AAA) program is the development of a casting process by which volatile actinide element (i.e., americium) can be incorporated into metallic alloy fuel pins. The traditional metal fuel casting process uses an inductively heated crucible. The process involves evacuation of the furnace. The evacuation of the furnace also evacuates quartz rods used as fuel pin molds. Once evacuated the open ends of the molds are lowered into the melt; the casting furnace is then rapidly pressurized, forcing the molten metal up into the evacuated molds where solidification occurs.

This process works well for the fabrication of metal fuel pins traditionally composed of alloys of uranium and plutonium, but does not work well when highly volatile actinides are included in the melt. The problem occurs both during the extended time period required to superheat the alloy melt as well as when the chamber must be evacuated. The low vapor-pressure actinides, particularly americium, are susceptible to rapid vaporization and transport throughout the casting furnace, resulting in only a fraction of the charge being incorporated into the fuel pins as desired. This is undesirable both from a materials accountability standpoint as well as from the failure to achieve the objective of including these actinides in the fuel for transmutation.

Candidate design concepts are being evaluated for their potential to successfully cast alloys containing volatile actinides. The selection of design concepts has been conducted in close cooperation with ANL staff. The research centers on the development of advanced numerical models to assess conditions that significantly impact the transport of volatile actinides during the melt casting process. The work will include the collection and documentation of volatile actinide properties, development of several conceptual designs for melt casting furnaces, modeling and analysis of these concepts, development of sophisticated numerical models to assess furnace operations, and analysis of these operations to determine which furnace concept has the greatest potential of success. Research efforts will focus on the development of complex heat transfer, mass transfer, and inductive heating models.

Personnel

Principal Investigator:
Dr. Yitung Chen (Mechanical Engineering)

Co-Principle Investigators:
Dr. Randy Clarksean (Mechanical Engineering)
Dr. Darrell Pepper (Mechanical Engineering)

Student:

- Mr. Xiaolong (Frank) Wu, M.S. Graduate Student, (Mechanical Engineering)

National Laboratory Collaborators:

- Dr. Mitch Meyer, Leader of Fabrication Development Group, ANL-West
- Dr. Steve Hayes, Manager of Fuels & Reactor Materials Section, Nuclear Technology Division, ANL-West

Management Progress

Budget Issues:

- The budget information is not shown correctly from the school accounting system in time because the employee documents and contracts have not correctly been done. The problem has been corrected in January, 2002.

Management Problems

We would like to make a request to carry over the first year budget to the second year. One undergraduate student will be recruited to work with us on this project in summer.

Technical Progress

The developmental work for the calculation of induction heating is nearing completion. The modeling efforts have centered around the development of the governing equations, developing a method to incorporate then into FIDAP, setting up a test problem, and making preliminary calculations for the geometry of interest. Complete details of the derivation and model development will be presented in the final report.

The resulting governing equations are shown below.

$$\left.\begin{aligned}\nabla\cdot\left(\tfrac{1}{r}\nabla C\right) &= -\mu J_o \\ \nabla\cdot\left(\tfrac{1}{r}\nabla S\right) &= 0\end{aligned}\right\} Coil \qquad (1)$$

$$\left.\begin{aligned}\nabla\cdot\left(\tfrac{1}{r}\nabla C\right) &= \frac{\mu\sigma\omega}{r} S \\ \nabla\cdot\left(\tfrac{1}{r}\nabla S\right) &= -\frac{\mu\sigma\omega}{r} C\end{aligned}\right\} Conductor \qquad (2)$$

$$\left.\begin{aligned}\nabla\cdot\left(\tfrac{1}{r}\nabla C\right) &= 0 \\ \nabla\cdot\left(\tfrac{1}{r}\nabla S\right) &= 0\end{aligned}\right\} Elsewhere \qquad (3)$$

where

C, S	=	real and complex components of function substituted into governing equations to simplify solution process
r	=	radial coordinate
J_o	=	current density
μ	=	permeability
ω	=	frequency
σ	=	electrical conductivity

Using the appropriate relationships and integrating gives the heat deposition as a function of position.

$$Q(r,z) = \frac{\sigma\omega^2}{2r^2}\left[S^2 + C^2\right] \qquad (4)$$

Surface plots of each of the functions, *C* and *S*, are shown in Figure 1 for a test problem. The test problem was taken from work previously reported in the literature. The domain consists of a crucible, a coil region, and a surrounding vessel. The regions of compressed mesh represent the crucible or coil regions. The left hand side image is the *C* variable and its greatest value occurs in the coil region. The right hand side image is the *S* variable and should be largest in the crucible region. Physically, each of these plots shows the proper trends and relationships for each of the variables in each of the regions of the mesh. Further work will be conducted to verify the solution and to calculate the power densities.

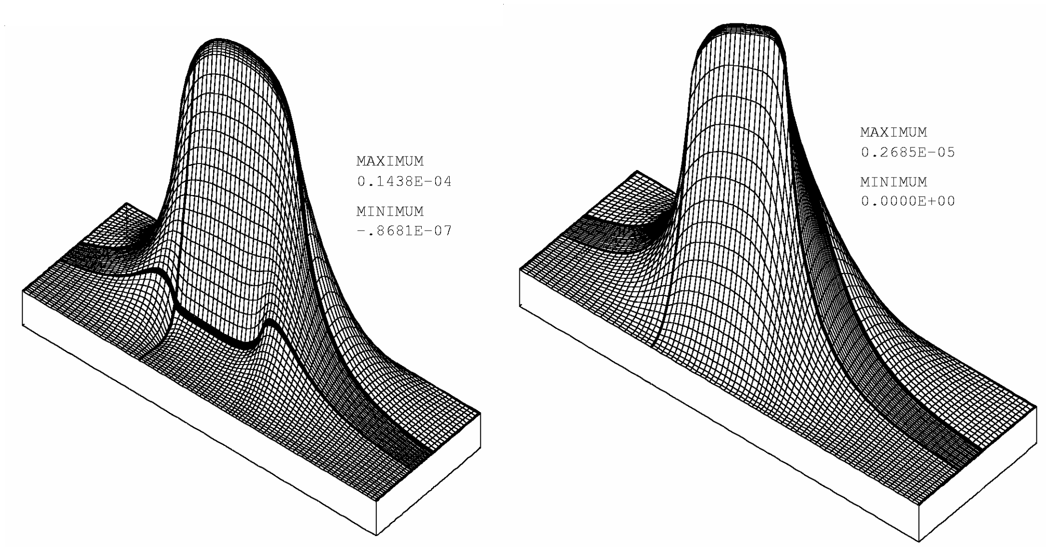

Figure 1 – Surface plots of the solution variables C and S for the analysis of the induction heating within an inductively heated furnace.

Modeling results for the injection into the mold have been completed and a parametric study is currently being undertaken. The general model geometry is shown below in Figure 2. The problem considers the flow of the melt into the mold and the heat transfer from the melt into the mold.

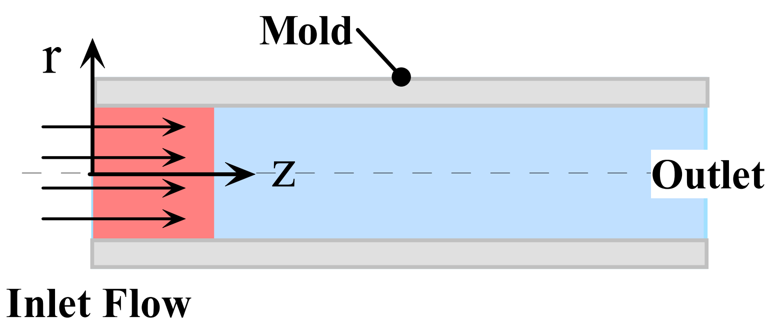

Figure 2 - Schematic of fuel rod casting model.

Figure 3 shows radial temperature profiles of the melt just behind the melt front as it advances into the mold. This region would be the melt region that would solidify most rapidly. The axial location for each of the temperature profiles is approximately located at the product of the velocity (1.6 m/sec) and the time.

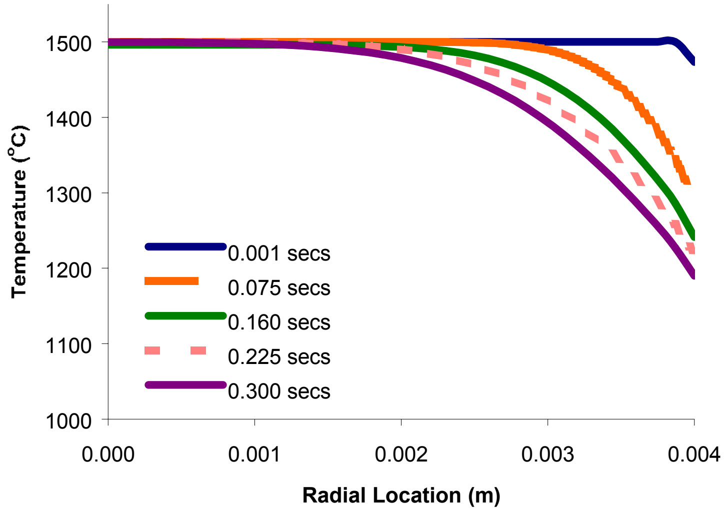

Figure 3 – Temperature profiles from the centerline projected radially outward for an initial mold temperature of 1000 °C. The axial location of each profile is slightly behind the front of the melt (location is the product of velocity times the time). Last profile is near the end of the mold.

Task 2: Third Quarter Report

Modeling, Fabrication, and Optimization of Niobium Cavities – Phase I

Quarterly Progress Report
11/20/01 - 2/20/01

UNLV-AAA University Participation
Program

Principal Investigators: Robert A. Schill, Jr. and Mohamed B. Trabia

Purpose and Problem Statement

Multipacting is one of the major loss mechanisms in RF superconductivity cavities for accelerators. This loss mechanism limits the maximum amount of energy/power supported by the cavities. Optimal designs have been identified in others' studies. In practice, these designs are not easily manufactured. Chemical etching processes used to polish the cavity walls result in a nonuniform surface etch. A nonuniform surface etch will leave some unclean areas with contaminants and micron size particles. These significantly affect multipacting. Further, a nonuniform etch will leave areas with damaged grain structure, which is not good for superconducting properties. Typically, the depth of chemical polishing etch ranges between 10 to 150 microns.

It is the purpose of this study to examine the chemical etching process in the design of niobium cavities so to maximize the surface quality of the cavity walls while minimizing the multipacting losses. Single and multiple cavity cell geometries are to be investigated. Optimization techniques will be applied in search of the chemical etching processes, which will lead to cavity walls with near ideal properties. Figure 1 depicts a block diagram of the optimization procedure, which is intended to be fully automated among a variety of existing codes.

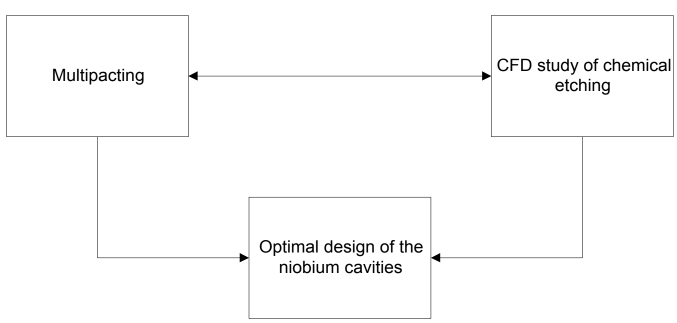

Fig. 1 Block Diagram of Optimization Procedure

Personnel

Principal Investigators:

- Dr. Robert A. Schill, Jr. (Electrical Engineering)
- Dr. Mohamed B. Trabia (Mechanical Engineering)
- Research Investigator:
- Dr. Yi-Tung Chen (Mechanical Engineering)

Students:

- Ms. Myong Holl, Undergraduate Student, (Mechanical Engineering)
- Mr. Satishkumar Subramanian, M.S. Graduate Student, (Mechanical Engineering).
- Ms. Qin Xue, M.S. Graduate Student, (Mechanical Engineering).

National Laboratory Contact:

- Dr. Dominic Chan, Project Leader for Superconducting RF Engineering Development and Demonstration AAA Technology Project Office at Los Alamos National Laboratory
- Dr. Tsuyoshi Tajima, Team Leader, Accelerator Physics & Engineering, LANSCE-1, Los Alamos National Laboratory

Management Progress

Budget Issues: N/A.

Notes:

1. Most of the major equipment budget has been spent.
2. Salary expenditures are on target.

Management Problems: N/A

Technical Progress

Dr. R. Schill and Dr. M. Trabia had a visit to LANL on January 17, 2002. During this visit Dr. Chan introduced us to Dr. Tsuyoshi Tajima. We are glad to report that we established a good working relation with Dr. Tajima. We update LANL personnel of our progress. The visit helped us better understand the concerns and interests of LANL relative to this research.

Multipacting Study

A multipacting study is essential in the design of super conducting, high power, niobium cavities for high-energy proton acceleration in linacs. Multipacting limits the quality factor of the cavity due to losses associated with secondary emission resulting from impacting resonance which is spatially localized.

Commercial codes from Field Precision Inc. (Xlate, Mesh, and Wavesim), a research code (Trak_rf) developed by Stan Humphries, and various MATLAB programs developed at UNLV are used to investigate particle tracking and multipacting. The Trak_rf code is a finite element code that tracks charged particles in RF fields based on supplied initial conditions. Particles are launched when the E-field reaches a threshold value as determined by programmer to simulate field emission. This study focuses on the significant localized increases in impacting on the cavity surface and the secondary electron emission coefficients generated by each particle launched at each point of impact. Trak_rf only tracks the primary particle launched and not the secondary particles. If the primary particle exhibits some type of spatial impacting resonance and the secondary electron coefficient is greater than one at each impact, one usually interprets the impacting as multipacting. Although this is valid and satisfies the multipacting criteria, it is believed to be a special case of multipacting. If the primary particle does not exhibit a spatial resonance, then based on the multipacting criteria, we only have impacting. Although this may be true, it is possible that one of the secondary electrons emitted will result in multipacting. Because the codes do not track the emitted particles, a scheme to be able to identify potential multipacting locations based on both the spatial resonance of the primary electron and the potential spatial resonance of the secondary electron was developed.

As a first study to obtain a suitable level of confidence in the correctness of the codes, RF field resonance and particle tracking in the pillbox geometry was examined. The MATLAB generated cavity shown in Fig. 2 below has a calculated and a numerical resonant frequency of about 570 MHz for the dominant supported TM_{010} mode. Ten electrons were launched at the same initial position with the same initial particle trajectories. A subroutine (MATLAB) to plot single particle trajectories was developed to help visualize impacting and multipacting conditions for the primary particle. It is observed in Fig. 2 that the ten particles exhibit vary different particle orbits. Figure 3 shows the two dimensional front and side view of the particle orbits. This is a result of the non-deterministic or random nature of the emission calculation based on supplied secondary electron emission coefficient data. It was anticipated that two-point multipacting would exist in the region near the center of the pillbox end caps.

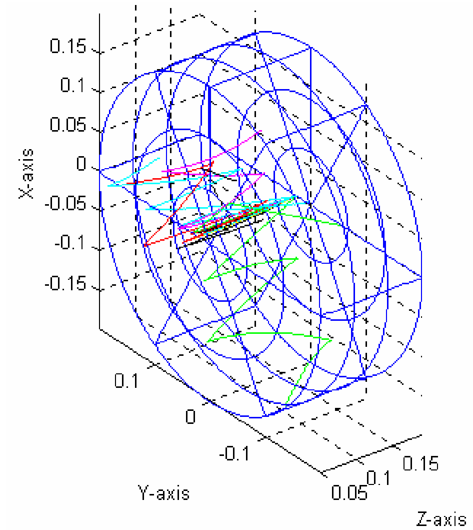

Fig. 2 Tracking of Ten Electrons with Identical Initial Conditions in a Pillbox Geometry.

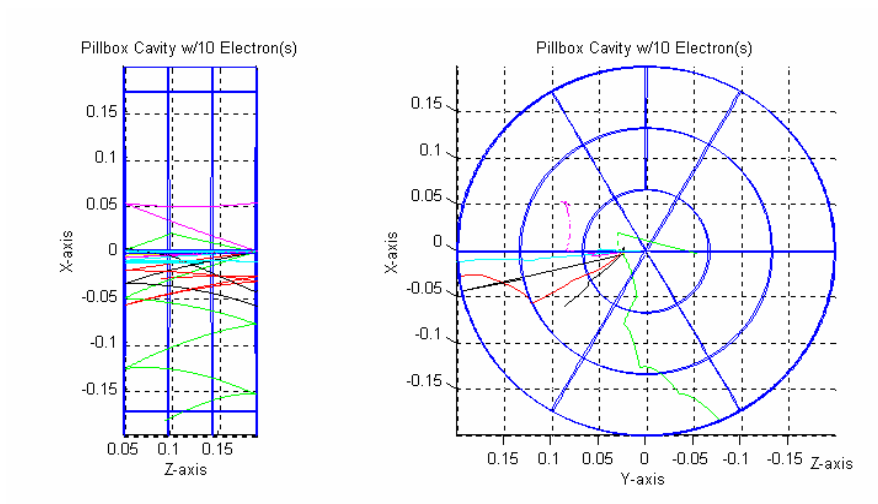

Fig. 3 Side and Front View of Figure 2.

Track_rf was modified to examine localized secondary electron emission and impacting over the cavity surface. Figures 4a and 4b illustrate the field emission statistics [maximum, minimum, average and standard deviation] for the cylindrical cavity when many electrons (50 electrons) with the same initial conditions are launched at the same time from the center of the end cap of the cylinder. Based on the statistics, a multipacting condition has not been identified for particle trajectories shown in Fig. 2.

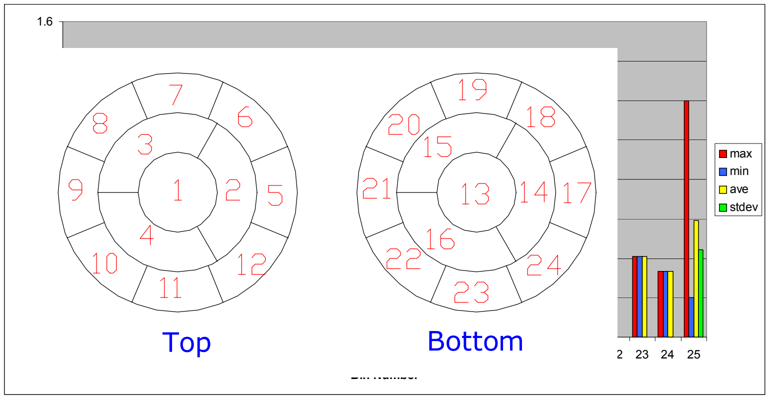

Fig. 4 a) Binning of the surface of a cylindrical cavity, and b) Bin statistics of secondary electron emission.

A MATLAB program was developed to draw a single cell elliptic cavity given some of the cavity's geometrical parameters. At present, a similar program is being developed for the five-cavity geometry. Wavesim has correctly determined the cavities dominant resonant frequency as compared to estimated calculations based on a cylindrical geometry. Tracking in these cavities is underway.

Discussions are underway to compare this code with baseline studies and known multipacting conditions at Los Alamos.

The secondary electron emission predicted due to impacting is only as good as the data supplied to the code. It has been shown in literature that generic secondary electron emission curves may not be the standard at all angles of incidence. Furthermore, the way the cavity surface is prepared significantly affects the secondary electron emission coefficient. Such studies have not been performed for Los Alamos cavities. Consequently, for the code to accurately predict multipacting conditions, we have submitted a proposal to experimentally study the secondary emission properties of a Los Alamos surface treated niobium target. Experimental findings are to be incorporated in the existing Trak_rf code in the future.

<u>CFD Study of Chemical Etching</u>

Niobium cavities are important component of the integrated NC/SC high-power linacs. Over the years researchers in several countries have tested various cavity shapes. They concluded that elliptically shaped cells and buffered chemical polishing produce good performance. The objective of this research is to study the effect of chemical etching, on the surface quality, and to optimize this process. Chemical etching of the inner surface of the cavity is achieved by circulating acid through it. As the acid interacts with the surface, it eliminates imperfections and improves surface quality. During etching, a pipe with baffles is inserted within the cavity to direct the flow along the surfaces. A finite element computational fluid dynamics model is developed for the etching process. The problem is modeled as a two-dimensional, axisymmetric, steady state fluid flow problem. This model is used to evaluate the current etching process. An alternative design with an expanding baffle is proposed. The new design is optimized to improve the chemical etching process.

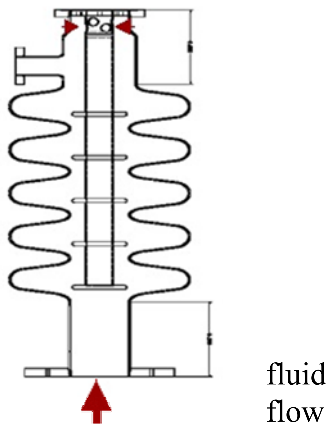

Fig. 5 Current Etching Configuration of Niobium Cavities

The following steps were taken toward understanding and modeling of this problem:

1. Continuous discussions with Dr. D. Chan, LANL, and his colleagues to understand the problem.
2. Developing a finite element model for five-cell niobium cavity with a baffle using FEMLAB software (chemical engineering module).

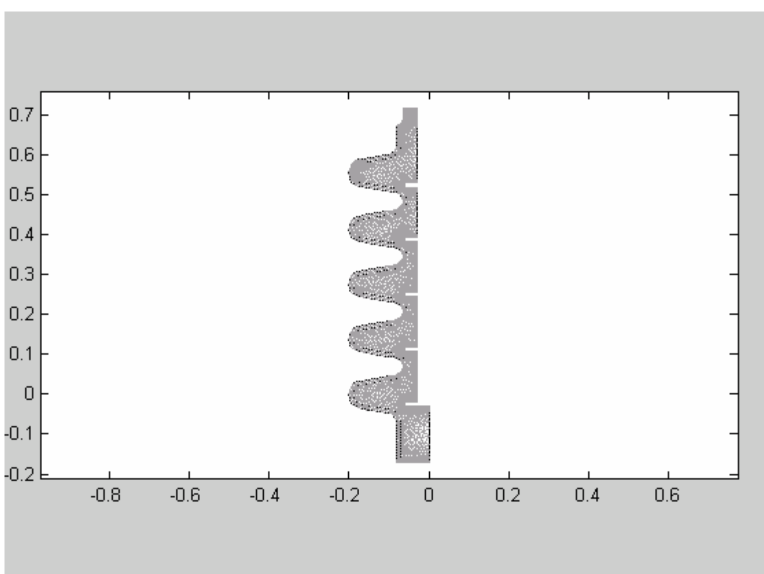

Fig. 6 Finite Element Model of the Baffle

Internal boundaries are created close to the inner walls of the cavity, Figure 7. Each cavity is divided into six sections as can be seen in the zoomed-in view in the same figure:

- Bottom iris
- Bottom straight
- Bottom equator
- Top equator
- Top straight
- Top iris

Inlet and outlet sections are represented using one boundary each. The velocity is integrated along each section. A performance index is defined using two quantities as follows:

$$PI = F\left(\frac{v_{av}}{\frac{\sum_{i=1}^{n}\frac{\int vds}{\int ds}}{n}}\right) + \frac{\sum_{i=1}^{n}\left[\frac{\int vds}{\int ds} - V\right]^2}{nV} \tag{1}$$

where, F is a factor to allow combining the two quantities in the same performance index.

v_{av} is the average inlet velocity.

v is the velocity at any point along the internal boundaries.

n is the number of sections (total of thirty-two).

V is the average velocity along the walls of the cavity, which can be expressed as,

$$V = \frac{\sum_{i=1}^{n}\frac{\int vds}{\int ds}}{n}$$

The first quantity describes the average velocity along the internal boundaries of the baffle while the second one defines its standard deviation. The objective of the optimization is to maximize the first and minimize the second variable.

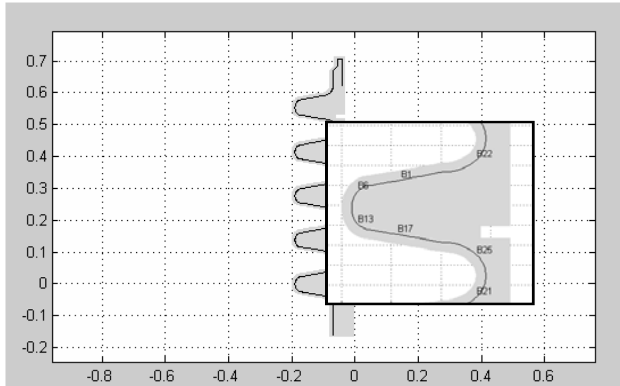

Fig. 7 Internal Boundaries of the Cavity (inset: zoomed–in view of a cavity)

4. A parametric study of the problem was conducted by varying the variables that describe the geometry and location of the baffle subject to the constraint that the baffle fits within the cavity. No case provided appreciable improvement in the performance index over the current design.
5. To verify the accuracy of FEMLAB software as modeling tool, we created a model for the problem of a flow above a square cavity that was presented by [1]. Results for both low and high Reynolds Number show close correspondence. This study also helped in better tuning of the software variables to produce better results.

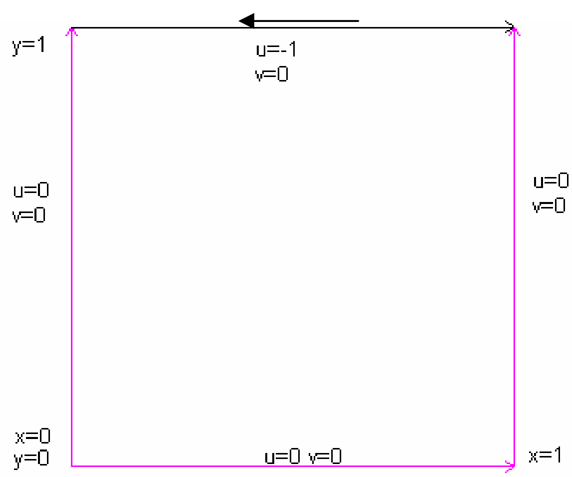

Fig. 8 Geometry and Boundary conditions for cavity flow

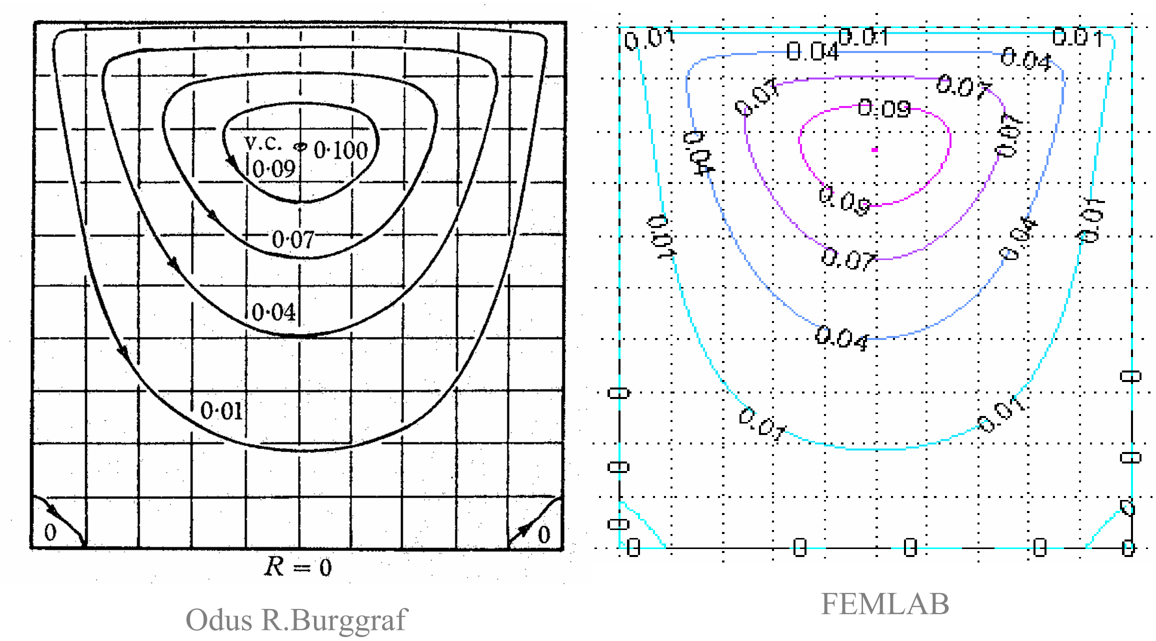

Fig. 9 Comparison of Stream Function Contours for Re=1

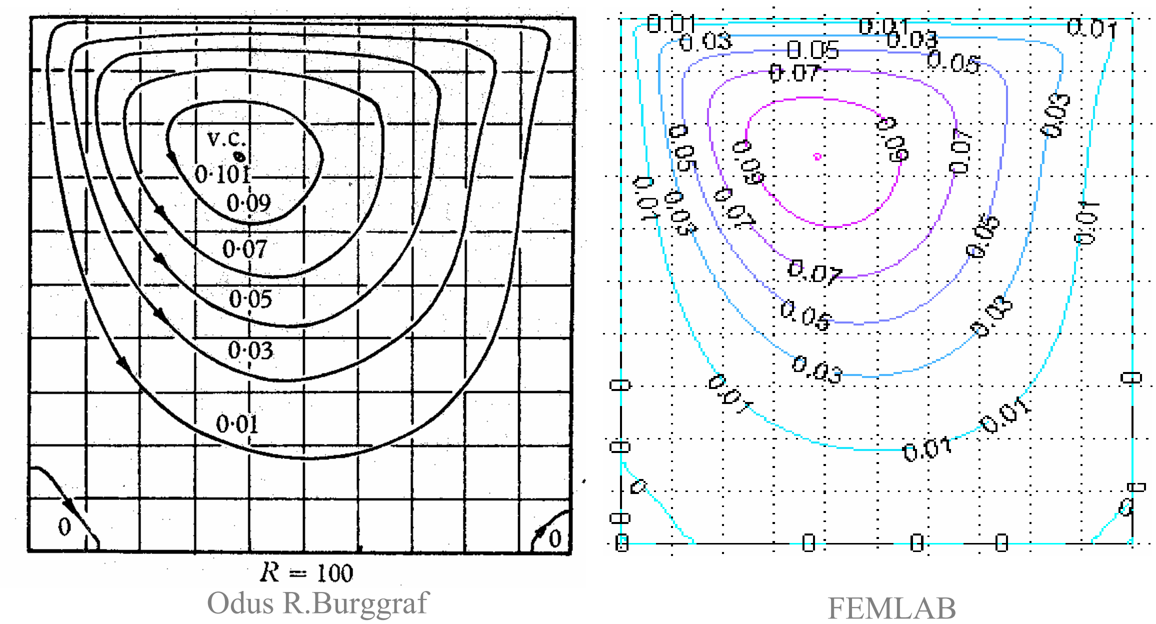

Fig. 10 Comparison of Stream Function Contours for Re=100

Optimization Study

1. While the idea of having a baffle inside the cavity partially succeeded in directing the flow inside the cavity, a different design configuration may be necessary to get the flow closer to the equator regions. The modified baffle design has the following features:
   - The baffle is angled near the inlet of each cavity.
   - The baffle is modified so it can be extended inside the cavities. This design has the baffle made of four sections. Each section can be expanded or retracted by rotating a cam that moves a spring-loaded follower, which is attached to the baffle section.
   - Flow exit is now parallel to flow inlet.
   - Each baffle is centered along the equator of a particular cavity.

   Six design variables are identified. Table I presents description of these variables.

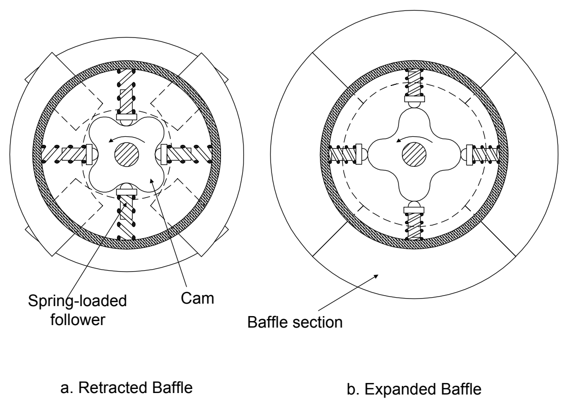

Fig. 11 Possible Design for an Expanding Baffle

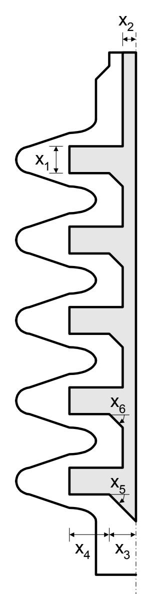

Fig. 12 Design Variables of the Expanding Baffle

Table I. Variables of the Modified Baffle Design

Variable	Description
x_1	Thickness of the baffle
x_2	Radius of the baffle pipe
x_3	Radius of the fixed portion of the baffle
x_4	Length of the extended portion of the baffle
x_5	Baffle angle at the first cavity
x_6	Baffle angle at the second through fifth cavities

2. We investigated the possibilities of improving this modified baffle design. Inequality constraints are used to ensure realistic solution. The problem is subject to several constraints including:

$$0.005 \leq x_1 \leq 0.044 \quad \text{m} \tag{2}$$

$$0.01 < x_2 < 0.04 \quad \text{m} \tag{3}$$

$$0.01 < x_3 < 0.06 \quad \text{m} \tag{4}$$

$$0 \leq x_4 \leq 0.8\,x_3 \quad \text{m} \tag{5}$$

$$0 \leq x_5 \leq \frac{\pi}{3} \quad \text{rad.} \tag{6}$$

$$0 \leq x_6 \leq \frac{\pi}{3} \quad \text{rad.} \tag{7}$$

The upper bound in the fourth set of constraints indicates a physical limit on the length of the extended portion of the baffle. Additional constraints ensure that baffle does not intersect the internal boundaries of Figure 3. These constraints are created by representing each segment of the internal boundaries of the cavity and the baffle using the parametric form of a curve:

$$\begin{Bmatrix} x \\ y \end{Bmatrix} = \begin{Bmatrix} x_s \\ y_s \end{Bmatrix} + u \begin{Bmatrix} f(x_s, x_f) \\ f(y_s, y_f) \end{Bmatrix} \qquad 0 \leq u \leq 1 \tag{8}$$

where, (x_s,y_s) and (x_f,y_f) are the starting and final point of segment respectively. Possibility for intersection between two segments, *a* and *b*, is checked by solving their parametric equations simultaneously. If both u_a and u_b are between *zero* and *one*, intersection occurs. All constraints are included in the objective function using penalty terms. Since the quality of the mesh changes for each set of variables, an additional constraint is needed to ensure that the results of the finite-element model are reasonable. The following constraint compares the flow rate in the inlet and the exit of the cavity as follows,

$$|Q_i - Q_e| \leq 0.02\,Q_i \tag{9}$$

where, Q_i and Q_e are the flow rates at inlet and exit of the cavity respectively. Flow rate at exit, Q_e, is calculated by integrating velocity over exit area. Constraints are incorporated in the objective function using the bracket function. The modified objective function is,

$$\text{minimize,} \qquad FC = PI + \sum_{i=1}^{m} \Omega_i$$

$$if \;\; g_i(x) \le 0 \quad \Omega_i = R * g_i(x)^2 \qquad (10)$$

$$if \;\; g_i(x) > 0 \quad \Omega_i = 0$$

3. The algorithm reached the following solution after *738* function evaluations:

$$\{\mathrm{x}\}^T = \{0.044, 0.013, 0.060, 0.048, 0.005, 0.004\}^T$$

Average velocity in this case is equal to 0.0553 m/s while the standard deviation is 0.1854.

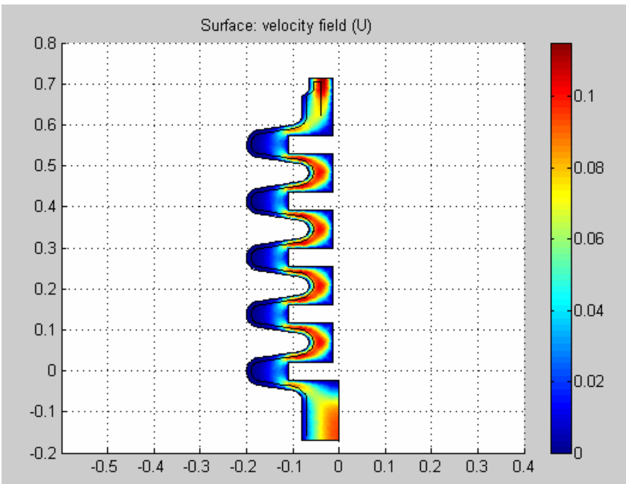

Fig. 13 Velocity Field for the Optimized Modified Baffle Design

Research Outcome:

We have a paper under review for publication in the International Congress on Advanced Nuclear Power Plants (ICAPP). The paper title is, "Modeling and Optimization of the Chemical Etching Process in Niobium Cavities." The abstract is already accepted and we were invited to submit a full paper.

References:

[1] Odus R. Burggraf, Analytical and numerical studies of the structure of steady separated flows, J. Fluid Mech. (1966), vol.24, part1, pp113-151.

Task 3: Third Quarter Report

Task 3. Third Quarter Report, Covering January through March 2002

Principal Investigators: Farley and Perry

Progress from June 2001-November 2001 was presented at the winter meeting of the American Nuclear Society in Reno (November 12-15, 2001), and incorporated into a refereed conference proceeding. A copy of the refereed conference proceeding has been provided to Tony Hechanova. In brief, the paper described the new program to examine the corrosive effects of lead-bismuth eutectic (LBE) on steels. We employed various types of surface studies (Scanning Electron Microscope [SEM], and X-ray Photoelectron Spectrometry [XPS]) to examine steel samples that had been exposed to LBE for various lengths of time at various temperatures. The goal is to understand the chemical reaction products and chemical reactions involved in the corrosion. More than 40 samples were examined. Preliminary results of our measurements were presented.
We were able to find the atomic composition as a function of position on the sample. We examined both exposed and unexposed samples, and found significant differences.

On the unexposed steel, we found the expected surface dominance of Cr over Fe and Ni, as one expects for a passivated surface. No Pb or Bi is seen. However, we were surprised by the levels of Zn. On the exposed sample, we see the suppression of Cr with respect to Fe as seen in other corroding stainless steel systems. We also see some residual Pb and Bi.

Progress since November 2001

Sputter depth profiling was performed on samples of steel that were exposed to LBE by the IPPE laboratory in Moscow. In sputter depth profiling, the surface is sputtered away by ion milling. This allows analysis of the material farther down in the sample. This is the first time that sputter depth profiling has been carried out at UNLV.

After sputter depth profiling, survey XPS scans were taken. Preliminary analysis has been done of the survey scans. This yields a plot of the elemental abundance as function of depth, at one location on the steel-LBE sample.

In addition, XPS data has been taken at high resolution. This can reveal the oxidation state of the element. This data has not been analyzed yet.

We are currently engaged in a critical analysis of the literature: of studies of LBE from issues of JNM, and more generally in the literature of corrosion of steel, both by LBE and in conventional "rusting." The vast experience and expertise of Dale Perry has been of immense value in this regard. Perry and a student at Univ. California Berkeley have conducted a literature search, and Perry has the encyclopedia knowledge of the field to assess critically the various reports in the literature.

Our preliminary findings are as follows:

(1) In the corroded region, we find experimentally that the nickel is totally gone. This is consistent with the literature, which says that nickel dissolves first, then iron, and finally chromium.
(2) In our measurements, we find no chromium in the outer region of the oxidation layer. The literature says there should be some chromium deeper in, but we have not yet probed deeply enough into sample to find it. We will do that.

(3) We observe high abundances of iron at and near the surface of the oxidation layer. It increases once you get through the thin outer layer of surface contamination.

Dan Koury has started to write his Masters' thesis, and expected to receive his degree in August 2002.

Brian Hosterman joined the research group in fall 2001 as a new graduate student. Hosterman is participating in all of the activities of the group, including data-taking and data analysis with Dan Koury, and the writing of the manuscript for Journal of Nuclear Materials.

In addition to working with Koury, Hosterman is initiating another research thrust in the LBE program. He is planning to examine the LBE samples using the laser Raman system at UNLV. Laser Raman measures vibrational frequencies, and thus is very sensitive to chemical species, not just the element. Hosterman is working with UNLV postdoc Wayne Stanbery in becoming familiar with the laser Raman system. Hosterman made a first measurement of a glass cuvette to see if the cuvette had an appreciable Raman signal. Fortunately it did not, because this would have been a background signal.

Dale Perry has supplied some lead oxide standards, which will be examined by various techniques, including laser Raman. In recognition of the many contribution that Dale Perry has played in the LBE project, the Physics Department voted on April 2 to appoint him as an Adjunct Professor of Physics.

Task 4: Third Quarter Report

Subject: AAA Task-4 Quarterly (12/1, 2001 – 02/28, 2002) Report

Introduction

The primary objective of this task is to evaluate the effect of hydrogen on environment-assisted cracking of candidate materials for applications in spallation-neutron-target (SNT) systems such as accelerator production of tritium (APT) and accelerator transmutation of waste (ATW). The materials selected for evaluation and characterization are martensitic stainless steels including HT-9, EP 823 and 422. The susceptibility to stress corrosion cracking (SCC) and hydrogen embrittlement (HE) of these alloys will be evaluated in environments of interest using tensile specimens under constant load and slow-strain-rate (SSR) conditions. The extent and morphology of cracking of these alloys will further be evaluated by optical microscopy and scanning electron microscopy (SEM). The concentration of hydrogen resulting from cathodic charging will be analyzed by secondary ion mass spectrometry (SIMS).

Personnel

The current project participants are listed below.

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Investigators (UNLV): Dr. Zhiyong (John) Wang, Department of Mechanical Engineering
Dr. David W. Hatchet, Department of Chemistry
Mr. Konstantin G. Zabotkin, Department of Mechanical Engineering
Mr. Mohammad K. Hossain, Department of Mechanical Engineering
Mr. Mark Jones, Department of Mechanical Engineering
Mr. Aaron Tippetts, Department of Mechanical Engineering
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Collaborator (DOE): Dr. Ning Li, Los Alamos National Laboratory, New Mexico
Phone: (505) 665-6677 email: ningli@lanl.gov

Highlights of Accomplishment

Design of the "Materials Performance Laboratory (MPL)" has been finalized to accommodate numerous materials and corrosion testing related to both the Yucca Mountain (YM) and UNLV AAA projects. A formal request (inter-departmental-requisition) has been submitted to the UNLV Planning and Construction Department for necessary modifications of the existing facilities/utilities in room #B129 so that all desired experimental activities can be performed in MPL in the most efficient and timely manner. It is anticipated that the construction of MPL would be completed by the middle of April 2002. Meanwhile, tests are currently being performed in room #B113.

- Equipment ordered as part of infrastructure development have started arriving at UNLV. It is anticipated that a major portion of these equipment will be installed in MPL by the end of April 2002.

- Nine experimental heats of desired target materials (three each of Alloys HT-9, EP-823 and 422) have been melted and processed at the Timken Research Laboratory, Canton, Ohio. One heat of each material has been heat treated to produce quenched and tempered metallurgical microstructures typical of martensitic stainless steels. Rockwell hardness measurements of some of the heat-treated materials have been done. Efforts are well underway to send these heat-treated materials to an off-site facility to machine tensile specimens for evaluating their ambient temperature mechanical properties, and their susceptibility to SCC/HE in aqueous environments of interest.

- Evaluation of the SCC behavior using proof rings (at constant load) and cladding materials (YM Project) has now been well established. A similar approach will be used to evaluate the cracking susceptibility of target materials upon availability of the machined tensile specimens.

- Meanwhile, trial tests involving slow-strain-rate (SSR) units and electrochemical equipment (potentiostat) are being performed to establish the testing techniques and related parameters. It is anticipated that all testing techniques will be standardized prior to their implementation in MPL.

- Mr. Konstantin Zabotkin has recently joined this task as a research associate to expedite the construction of MPL and experimental activities.

- Mr. Mohammad Kamal Hossain will soon be joining this task as a research assistant in the Mechanical Engineering Department to fill the empty position vacated by Mr. Raymond Kozak.

- Finally, Mr. Aaron Tippetts, an undergraduate student in mechanical engineering, has joined this task in January 2002 to assist in experimental work.

Problems

Assuming that the modification of the room #B129 and the installation of the major equipment in this location are completed by the desired timeframe (April 2002), no problems are envisioned.

Status of Funds

Expenditures incurred during this quarter are within the target amount allocated.

Plans for Next Quarter

- Consolidate all testing activities in room #B129 (MPL). Install equipment according to the final design.
- Perform SCC tests using constant load and SSR techniques without applied electrochemical potentials (E_{cont}).
- Perform electrochemical polarization tests using calibrated potentiostats.
- Initiate metallurgical characterization of tested specimens using optical microscopy and SEM.

Task 5: Second Quarter Report

Modeling Corrosion in Oxygen Controlled LBE Systems with Coupling of Chemical Kinetics and Hydrodynamics

Quarterly Progress Report
11/16/01- 2/15/02

UNLV-AAA University Participation Program

Principal Investigator: Samir Moujaes
Co-Principal Investigator: Yitung Chen

Purpose and Problem Statement

The Lead-Bismuth eutectic (LBE) has been determined from previous experimental studies by the Russians and the European scientific community to be a potential material that can be used as a spallation target and coolant for the AAA proposed application.

Properly controlling the oxygen content in LBE can drastically reduce the LBE corrosion to structural steels. However, existing knowledge of material corrosion performance was obtained from point-wise testing with very limited density. The transport of oxygen and corrosion products, their interaction and variation of corrosion/precipitation along the flow are not well understood.

An experimental study monitored corrosion history of specimens in one test loop over several thousand hours and showed that corrosion would occur at higher temperatures i.e. 550 ^{0}C but precipitation occurs around 460 ^{0}C, which is at the intermediate temperature. This confirms that the temperature distribution in an LBE system is important for understanding the system corrosion performance.

The first subtask of this project involves using a CFD code (2-D simulation) such as STAR-CD to obtain averaged values of streamwise velocity, temperature, oxygen and corrosion product concentrations at a location deemed close to the walls of the LBE loop at more than one axial location along it. The oxygen and corrosion product inside the test loop will be simulated to participate in chemical reactions with the eutectic fluid as it diffuses through towards the walls. Details of the geometry of these loops will be obtained from scientists at LANL. These values will act as a set of starting boundary conditions to the second task.

The second subtask and the more important objective of this project is to use the information supplied by the first task as boundary conditions for the kinetic modeling of the corrosion process at the internal walls of the test loop. The outcome of the modeling will be fed back to the first subtask, and the steady state corrosion/precipitation in an oxygen controlled LBE system will be investigated through iterations. The information is hoped to shed some light on the likely locations for corrosion and precipitation along the axial length of parts of the test loop.

Personnel

Principal Investigator:

- Dr. Samir Moujaes (Mechanical Engineering)

Co-Principal Investigator:

- Dr. Yitung Chen (Mechanical Engineering)

Students:

- Mr. Chao Wu, M.S. Graduate Student, (Mechanical Engineering)
- Mr. Kanthi Kiran, M.S. M.S. Graduate Student, (Mechanical Engineering)

National Laboratory Collaborator:

- Dr. Ning Li, Project Leader, Lead-Bismuth Material Test Loop, LANL

Management Progress

Budget Issues:

- Salary expenditures has been adjusted in January according to the proper account number.

Management Problems

We have encountered so many problems in using STAR-CD + CHEMKIN software since CHEMKIN is a beta version from Adapco company. We have been working with their technical groups to help them to debug those library links errors in order to make the program running in the SGI Origin 2000 at NSCEE.

Technical Progress

As specified earlier, STAR-CD+CHEMKIN has been chosen as the CFD tool for analyzing the fluid flow and chemical reactions. The method of solvability used in STAR-CD is a Control Volume Method or finite-volume method. The governing equations followed by STAR-CD for fluid analysis and mass transfer are shown below.

Continuity:

$$\nabla \bullet \rho V = 0 \qquad (1)$$

Momentum:

$$\rho \frac{DV}{Dt} = \rho g - \nabla p + \mu \nabla^2 V \qquad (2)$$

Energy:

$$\rho C_p \frac{DT}{Dt} = k\nabla^2 T + \mu \Phi_V \qquad (3)$$

Species transport:

$$\frac{DC}{Dt} = D_{coeff}\nabla^2 C + R \qquad (4)$$

For testing the chemistry and fluid analysis solvability strengths of the STAR-CD, a simple model involving the surface chemistry has been chosen and the results analyzed. A flow over a flat plate has been considered as the test model. A section of the plate has been chosen with dimensions of 2mm x 100mm for the analysis. Air along with propane is allowed to flow over a Vanadium plate. The fluids at a temperature of 600K are allowed to flow over the plate with temperature at 1290K. The mesh has been refined at the wall surface for clear depiction of the surface reactions. The propane gas disassociates by reacting with air at high temperatures and also reacts with the vanadium surface resulting in the formation of various chemical species which are described in more detail using the figures. The fluids are allowed to flow at a velocity of 5m/s in the turbulent regime. The initial concentrations of the species of the gases are given below.

C_3H_8 ---------- 0.01746
O_2 ---------- 0.23922
N_2 ---------- 0.74332

The above values are specified in terms of weight percent.

The results are depicted in the form of figures and followed by an explanation. Figure 1 shows the geometry of the model that has been considered. Figure 3 describes the velocity variation of the fluids along the surface of the flat plate. The values vary from 5m/s at the inlet to 13m/s at the outlet. The velocity of the fluid in more detail at a particular section of the considered geometry is shown in Figure 4. The profile and the formation of the boundary layer can be seen more clearly in this figure. The variations of the temperature along the lateral direction of the plate is shown in Figures 5. The variations of concentration of oxygen due to the reaction with propane are shown in Figure 6 The final concentration of the oxygen comes down to 0.2240 weight percent, the initial concentration being 0.2392. Figure 6 shows a closer view of the variation of oxygen concentration.

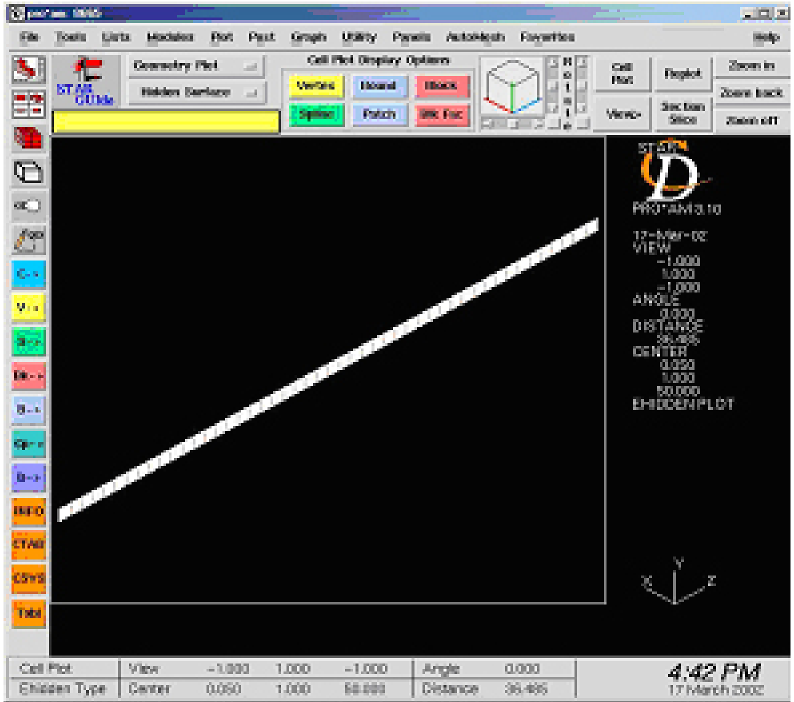


Figure 1: Geometry of the example model

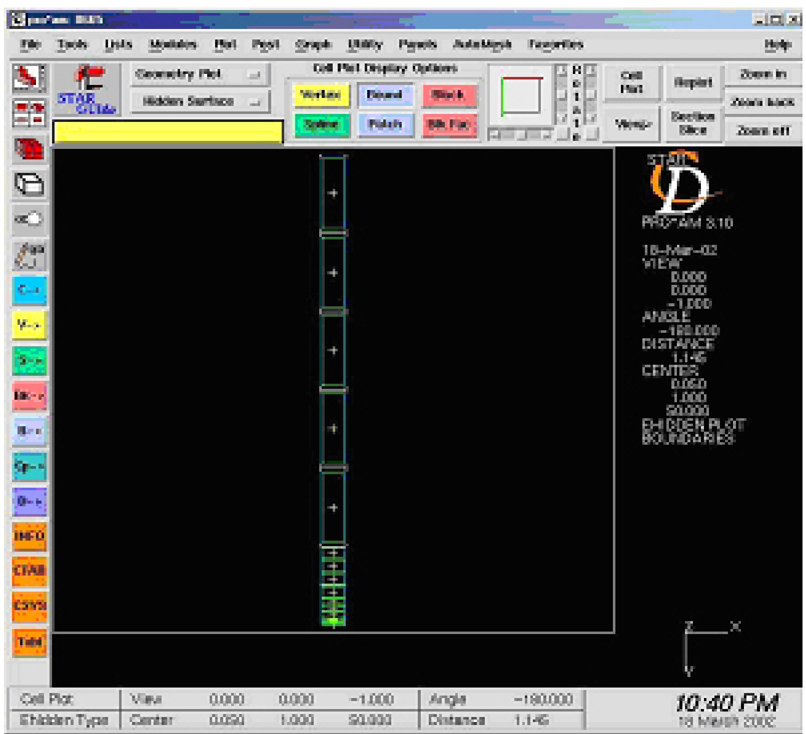


Figure 2: Mesh refinement at the wall surface

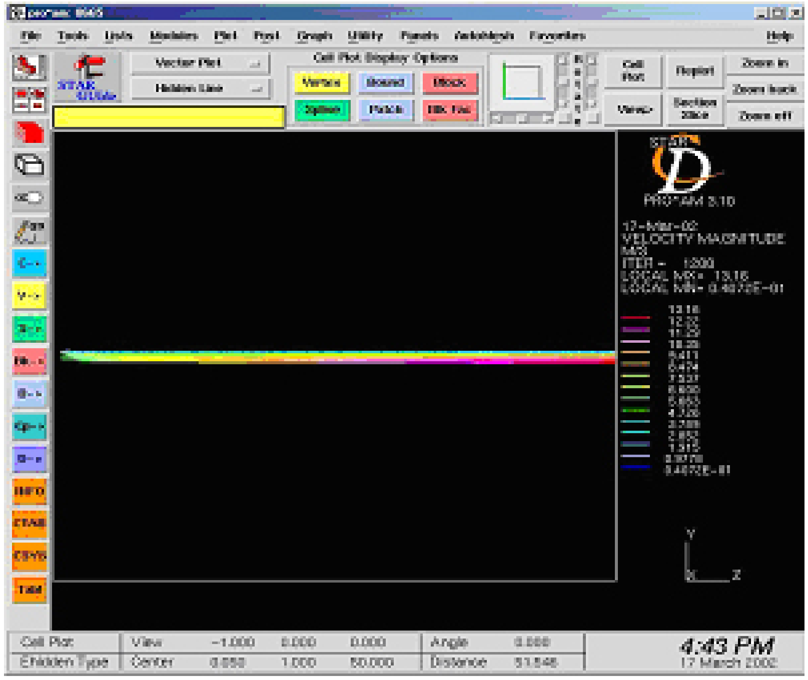


Figure3: Velocity profile along the surface of the plate

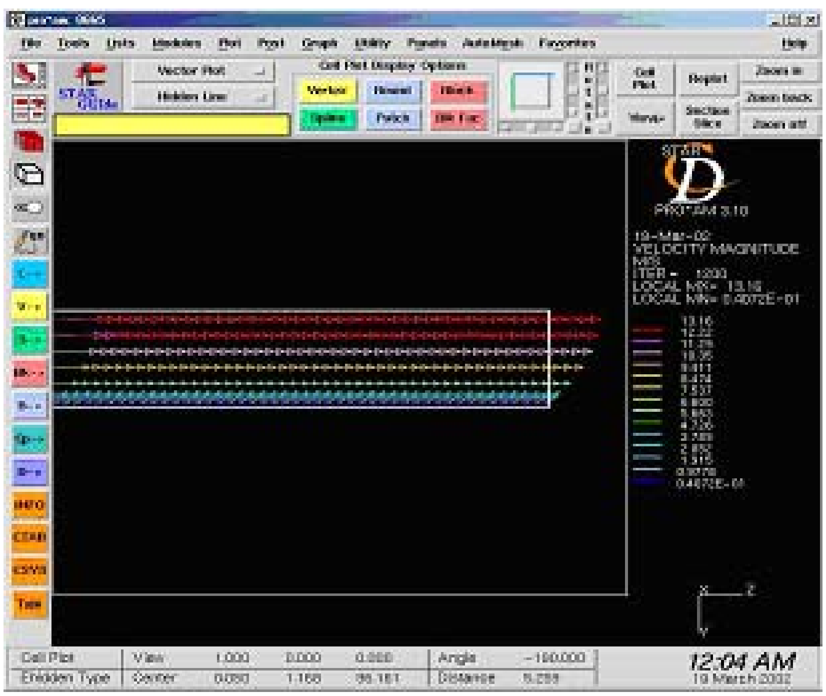


Figure 4: Velocity profile along the longitudinal direction to the surface

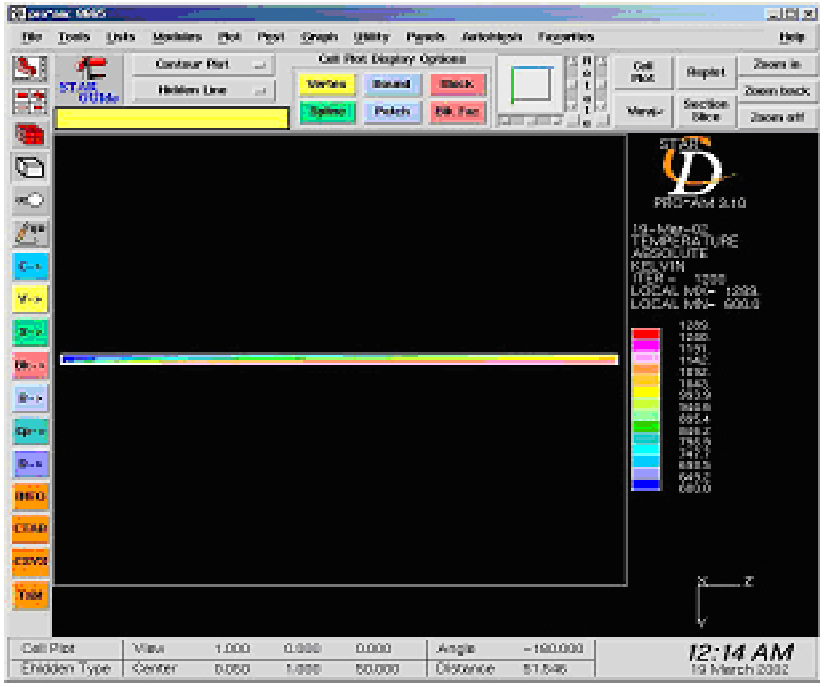


Figure 5: Temperature profile

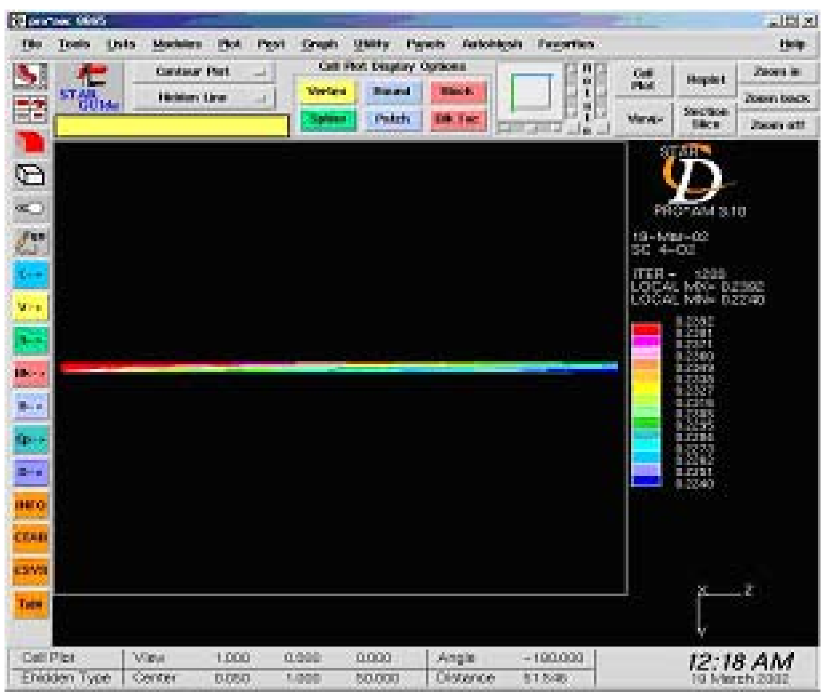


Figure 6: Oxygen concentration diagram

Task 6: Second Quarter Report

SECOND QUARTERLY REPORT
AAA UPP

Neutron Multiplicity Measurements of AAA Target / Blanket Materials

Carter Hull
Nuclear Sciences and Technology Group
Harry Reid Center
University of Nevada, Las Vegas

Background and Overview of Research

We are fabricating two detector systems to measure the neutron multiplicity of large (5 - 40 cm diameter by 30 - 100 cm length) Pb and possibly complex targets (W, Pb, Pb/Bi, *etc*.). One detector system makes use of multiple detector arrays (60 channels *per* array), which correlates the neutron multiplicity to each event. The detector system that has been most often utilized for these measurements is the ^{3}He gas tube counter configured with polyethylene moderator. The ^{3}He system operates with about 1 microsecond timing resolution and a 256-microsecond duration. A ^{3}He detector system of this type is capable of measuring multiplicities up to about 200 neutrons *per* event with limited position sensitivity. A ^{3}He multi-element detector system should have a modular design to accompany a number of complex target designs and configurations. One inherent shortcoming of ^{3}He detectors is that they are count rate limited (10-100 events *per* second or 1000-10,000 neutrons *per* second). However, these systems have been in use for many years and are well characterized. The second detector type is a Lithium Loaded Optical Fiber ("neutron glass fiber") detector that may be capable of 150 ns time resolution and count rates up to 100 kHz. An array of 160 neutron glass fiber detector elements would be capable of 5-degree angular resolution and measurements of more than 500 neutrons *per* event. These new detectors need to be tested under realistic experimental conditions to understand any detector and system limitations.

The aim of this AAA detector development program is two-fold. First, we hope to measure the neutron leakage from 5, 10, 20 and 40-cm diameter Pb targets and to compare empirical measurements with MCNPX results. Additionally, neutron-multiplicity measurements of a variety of targets (Al, Fe, W, Pb, *etc*) over a range of energies (800-3000 MeV) will be performed for validation and benchmarking the MCNPX results. Comparison of results from the two detector systems will decrease uncertainties and allow the derivation of relative measurements in the few percent range at the 95% confidence level (CL). Secondly, precision position sensitive measurements of the source term volume for neutron production will allow systematic determination of major uncertainties in the nuclear transport code, which should allow for uncertainty measurements in the 2-3 percent range at the 95% CL.

Facilities at LANSCE or possibly in Russia at Dubna or at St. Petersburg Nuclear Physics Institute could be used for appropriate proton beams. These results are of major interest to all spallation neutron projects such as AAA and SNS and therefore will add greatly to the nuclear database. These measurements may also be performed on the secondary beam line at the AGS Accelerator at Brookhaven National Lab since beams of pions, kaons and protons of appropriate energies could be used to test the codes.

This specific AAA project represents only the "proof of principal" study for evaluating the response of the prototype neutron glass detector in the accelerator / target environment. Only two detector elements and associated electronics will likely be fabricated for this initial study of the neutron glass fiber detector. Further development of neutron glass detector systems for AAA target monitoring will be predicted on these initial studies. The multi-element ^{3}He detector, which is being designed and constructed at the Khlopin Radium Institute (KRI) in St. Petersburg, Russia, will not be completed and ready for testing until 2002. The ^{3}He detector system will then be shipped to a selected AAA facility for testing.

Progress During the Second Quarter of Research

Two major lines of research were continued during the Second Quarter. The first line of work involves the nuclear transport code development and the second addresses the design and acquisition of the nuclear instrumentation required to perform the neutron multiplicity measurements.

First Major Line of Research Continued in the 2nd Quarter

Nuclear transport code models and calculations of neutron detection efficiency at various points in the target-detector assembly must be completed and interpreted prior to developing preliminary designs of the neutron detection systems needed to perform multiplicity measurements.

Our Russian colleagues completed preliminary nuclear transport codes using customized code that has been developed by researchers at KRI. These modeling efforts were coordinated with U.S. researchers. Initial modeling results indicate neutron production efficiencies of approximately 13% to 19% in a lead target of 40 cm diameter and 1 meter in length that is bombarded with a pulsed 1 GeV proton beam. It is stressed that these preliminary results are extremely simplified and represent only a "first cut" at the transport code models.

- Numerical models to be performed at the Harry Reid Center using MCNPX Code were initiated during the 2nd Quarter. Dr. Anthony Hechanova acquired the funding and arranged for an MCNPX course to be presented by Drs. Laurie Waters and Greg McKinney in January 2002. This training was conducted at UNLV and all AAA researchers and their students involved in this research were invited. Two grad students and two undergrad (and the PI, C. D. Hull) successfully completed the MCNPX training course conducted at UNLV in January 2002.

- Computers and Personnel for Developing MCNPX and MCNP 4B Models

  - Two personal computer systems were purchased, received and configured to run MCNPX software and support graphics packages. Two WINDOWS versions of MCNPX code for PCs (Versions 2.2.4 and 2.4.6) and MCNP 4B and databases have been loaded and configured. However, there are extensive problems with neutron cross sectional data files for MCNPX. A Type I binary file format is required for MCNPX 2.2.4 and 2.2.6 and these datafile conversions are beyond the scope (or budget) of the current project.

  - Dean Curtis, an undergraduate student at UNLV, hired during the first quarter, has been tasked with assisting with MCNPX model development for both the Russian ^{3}He and American neutron glass fiber detector systems. Mr. Curtis is a computer science major and has already been very helpful in the configuration and operation of the personal computer systems that will be used for executing transport codes and archiving modeling results. Dean has been tasked with working with Bill Culbreth and students who have been developing first SCALE and KENO models. Dean is now coordinating with Daniel Lowe who is performing the great majority of MNCPX models for Mechanical Engineering (Culbreth's group).

  - The preliminary geometric model has been completed for the ^{3}He detector configuration that was selected of the 3 models submitted by KRI and approved by C. D. Hull and Tom Ward in February '02. The initial model of the neutron glass fiber detector has also been completed. Models of both detector systems are being finalized utilizing MCNP 4B. The MCNPX models should be able to be developed once the data file structure issues are resolved. Late in the Second Quarter, student work hours for developing transport code models were doubled in order to accelerate progress on models of both detector systems.

Second Line of Research Continued in the 2nd Quarter - Neutron Detector Designs/Fabrication

This line of work involves the design and acquisition of the nuclear instrumentation required to perform the necessary measurements of neutron multiplicity in accelerator targets.

Glass Fiber Detector System

This type of neutron multiplicity detector system utilizes neutron sensitive scintillating glass fibers as detector elements. This newer, solid-state technology is comprised of ^{6}Li glass fibers, which act as both the detector and scintillator waveguide. These ^{6}Li glass fiber detectors can be configured in complex geometries to provide very high-resolution positional data for individual neutron captures. The glass fiber also has very high temporal resolutions (<160 nanoseconds) and may be capable of detecting more than 500 neutrons *per* event. "Neutron glass fiber" detectors are capable of <100 nanosecond (ns) or faster time resolution (including deadtime) and count rates up to 100 kHz. A 64 ns time resolution may be achieved subsequent to the limited electronics re-design proposed in this research. The ultimate goal for developing a neutron glass fiber detector array is to fabricate an array of 160 neutron glass fiber detector elements that are capable of 5-degree angular resolution. This array would provide significantly higher countrates *per* event and very precise position sensitivity.

- The modification of neutron glass detector system to be used in initial neutron multiplicity measurements from AAA targets, now scheduled for July '02. Coincidence and logic circuits now nearing completion as well as the remounting of neutron glass fiber bundles in housings.

- A proposal for the use of instrumentation and beam time and facilities use/ instrumentation was written and submitted to LANCSE for testing of Neutron Glass Fiber detector system in the next round of target testing which is scheduled to commence at LANSCE in July, 2002.

- Two neutron fiber detector elements, packaged in two detector elements, all electronics, and support instrumentation will be donated for use in this graduate student research. The neutron fiber detector panels to be utilized, although less complex (and expensive) than the 5-degree angular resolution detector array described above, will provide valuable program data as these new detectors are tested. Detector evaluation under realistic experimental conditions also is needed to understand any limitations in applying this technology for performing neutron multiplicity measurements. Therefore, two goals for instrumentation testing are achieved at insignificant costs and crucial data are produced for the AAA project. A diagrammatical representation of one of the glass fiber detector panels that may be employed for this proof-of-principal research is shown in **Figure 1** below.

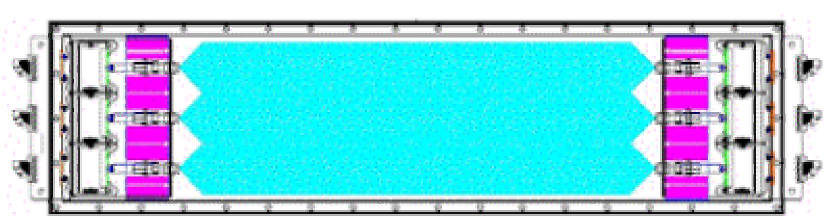


Figure 1. Neutron glass fiber detector panel. The specific panels that will be utilized in the AAA research work each contain three 8 cm wide glass fiber ribbons *per* panel.

- Two panels as shown in Figure 1 above or two glass fiber "boat" elements that are presently used in a Portable Radiation Search Tool (PRSST) will be used in the neutron multiplicity measurements at LANSCE and perhaps at BNL as well. The use of the smaller PRST neutron glass detector elements may be required due to the neutron flux on the detectors at a relatively short range from the target (< 2 meters). The detector electronics may not required as extensive re-design and configuration is the neutron flux *per* detector element is less than 1 MHz.

- Regardless of which types of detector elements are employed, the system will allow for up to six coincident channels, all of which have timing resolutions of less than 160 ns. The "throughput" for this system should be orders of magnitude greater than for a multi-element ^{3}He based neutron detector systems and the neutron glass fiber system should not saturate as ^{3}He detectors often do in a high neutron fluence environment.

- This "loaner" system will not have the spatial resolution that will be required in the actual target / blanket monitoring systems, but this should provide proof-of-principal data that is invaluable. The coincidence electronics have now been designed and are nearing completed. All that remains to be completed prior to testing the neutron glass system is the prompt signal modification (from the proton beam trigger) and the gating circuit for activating the counting registers.

<u>Russian 60-Element ^{3}He Tube Neutron Detector System</u>

- The ^{3}He neutron detection system proposed for use in this research was given highest priority so the system design could be finalized and fabrication begun as soon as possible.

- Our colleagues at the V. G. Khlopin Radium Institute (KRI), St. Petersburg, Russia (Dr. Mikhail N. Chubarov, Mr. Nikolai A. Kudryashev and lead by Dr. Dr. Alexander Rimsky-Korsakov) are highly experienced in ^{3}He detector system design and fabrication Researchers at KRI successfully demonstrated an original system of multi-channel time- and position-sensitive neutron detector, suitable for experiments to measure neutron generation in massive lead targets.

- Three basic detector configurations were considered in the preliminary numerical models of the ^{3}He detector system: 1) A concentric style of detector system in which the long-axes of 3He tube detector elements are located in concentric rings about the long axis of the cylindrical accelerator target; 2) a "box" arrangement where the long axes of the tubes are perpendicular to that of the long axis of the target cylinder. The tube elements are "fixed" in this geometry, in that the tube elements are placed into holes that are machined into the polyethylene moderator blocks; 3) a "framework" geometry in which the tube element long axes are also at right angle to the target cylinder, but the tubes are sited in recesses within the moderator blocks so that this geometry can be modified to accommodate a number of target geometries.

- As briefly mentioned above, the PI and and Tom Ward met with Dr. Alexander Rimsky-Korsakov at HRC for two days in February 2002. Agreement was reached on the basic design of the 60-element KRI ^{3}He detector system and began final design computer models. KRI initiated purchases of components to begin fabrication of the system.

- During the 2nd Quarter KRI continued the design of 60-channel neutron detection system, capable of timing neutron counts for at least 256 microseconds during multiple neutron events, with timing resolutions of ~1 microsecond. Neutrons will be detected with ^{3}He counters (after moderation in polyethylene). The system had to be flexible in that the modular design could accommodate various configurations around neutron-generating target. The target design depends on U. S. Laboratory needs and experimentation protocols.

- Testing a similar target that can be economically manufactured at KRI (but not necessarily shipped to US Laboratory) has also been proposed. The ^{3}He detection system will be designed to be suitable for prolonged unobserved non-stop operation and data to be accessible *via* telecommunication line (*e.g*. computer and modem). This general design was discussed and amended by researchers in the AAA program. This task was performed by the PI and KRI specialists, one of whom will visit U.S. Laboratory / Institute(s) to explain the proposed design and to take into account all details of future on-site operation.

- Work on the KRI ^{3}He system which was also completed during the 2nd Quarter:

  - Completed and disbursed first $35,000 payment of AAA Instrumentation grant of $100,000 (over 2 Yrs) to KRI (St. Petersburg, Russia) to design, fabricate, ship, and install a 64-element ^{3}He neutron detection system for performing target neutron multiplicity measurements at a AAA research institute. First Progress Report, which addressed the various configurations and design specifications for the detector system, received and approved.

  - Approved an amendment of the AAA subcontract to KRI in order to satisfy Russian Customs needs for a mode of transportation of controlled materials (the 3He elements) to a selected AAA facility in the U.S. subsequent to completion of the system.

  - Arranged for travel for the PI and Dr. Ward to attend design meetings at KRI in June 2002.

Instrumentation Options during the Research Project Timeframe

All equipment and facilities that are required to perform the proposed research in the given timeframe are available with the exception of the ^{3}He-based detector system, which is discussed above. The ^{3}He system is extremely important to addressing the on-going research projects that has been planned as Add-ons to this initial project. However, the instrumentation and facilities that are needed for the initial, first year of research are in place or can be modified prior to the academic quarter of this research project (May 2002). Neutron instrumentation that requires modification prior to performing neutron multiplicity measurements will be modified and available in January 2003.

Scheduling and Timelines

The modified schedule and timelines for this AAA Research and Development Project are summarized in **Table 1** below.

TABLE 1
Neutron Multiplicity Measurements of AAA Target / Blanket Materials
YEAR 1 - Major Tasks, Milestones, and Estimated Amounts of Time Required for Developing Model and Performing Multiplicity Measurements

Major Tasks or Milestones	**2001**				**2002**							
	SEP	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**
Quarterly Briefings / Reports				● (red)			● (red)			●		
Develop initial / refine LAHET-MCNPX models			→ (red)			— (red)	→ (red)	→ (red)	→ (red)			→ (red)
Milestones	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**
Modification of glass fiber neutron system (Initial portion COMPLETED)	→ (red)	→ (red)	→ (red)	→ (red)		→ (red)	→ (red)		→	→		
Integrate and test *n fiber* detector and electronics			→ (red)				→ (red)		→	→		
Initial neutron multiplicity measurements (First set CANCELLED)											→	
Compare numerical models and model results with initial measurements											→	→
Review / modify codes (if necessary)							→	→		→		
Conduct 2nd set of *n* multiplicity measurements(?)												→
Modeling & Data review / validation Preparation of Thesis									→	→	→	→
Semi-Annual Report Final Reports, Prepare Graduate Thesis						● (red)						●

Task 7: Second Quarter Report

Development of Dose Conversion Coefficients for Radionuclides Produced in Spallation Neutron Sources

Quarterly Progress Report
11/20/01 – 2/20/01

UNLV/AAA University Participation Program

Phillip Patton and Mark Rudin
Principal Investigators

Project Summary

A research consortium comprised of representatives from several universities and national laboratories has been established as part of this project to generate internal and external dose conversion coefficients for radionuclides produced in spallation neutron sources. Information obtained from this multi-year study will be used to support the siting and licensing of future accelerator-driven nuclear initiatives within the U.S. Department of Energy complex, including the Spallation Neutron Source (SNS) and Accelerator Production of Tritium (APT) Projects. Determination of these coefficients will also fill data gaps for several hundred radionuclides that exist in Federal Guide Report No. 11 and in Publications 68 and 72 of the International Commission on Radiological Protection (ICRP).

Personnel

Principal Investigators:

- Dr. Phillip Patton (Health Physics)
- Dr. Mark Rudin (Health Physics)

Graduate Assistants

- John Shanahan (Health Physics)
- Yayun Song (Health Physics)

National Laboratory Contacts

- Brent Boyack, AAA Project Leader for NEPA/Safety at Los Alamos National Laboratory
- Tony Andrade, Los Alamos National Laboratory

University and National Laboratory Participants

- Idaho State University
- Georgia Institute of Technology
- University of Florida
- University of Tennessee
- Oak Ridge National Laboratory

Management Issues

Personnel Issues:

Dr. Phillip Patton continues to be on active military duty in California. He is not expected to return until March 2002, at the earliest. A more realistic estimation of his return would be May/June of 2002. His work schedule has recently changed to 10 days on/4 days off, which allows him to travel back to Las Vegas periodically. Dr. Mark Rudin, who has been coordinating project activities in his absence, has been working to bring Dr. Patton up to speed on project activities. It is expected that Dr. Patton will play an increasingly larger role in the project as Summer 2002 approaches.

Two graduate assistants, John Shanahan and Yayun Song, have been assigned to the project. Both are currently first semester students in the M.S. in Health Physics Program. Mr. Shanahan has extensive experience as a nuclear medicine technologist and is relatively well versed in computer programming. Ms. Song was a physician in China prior to coming to the United States in early 2001. Both appear to have the necessary skills and desire to make positive contributions to the project.

Budget Issues:

Project funds were used to host a meeting of the Working Group on January 7-8, 2002, in Las Vegas, NV. No additional projects funds were used to purchase equipment or supplies this quarter. All expenditures appear to be on target and consistent with the budget set forth in the project proposal.

Technical Issues

The following technical work was performed this quarter on the project:

Working Group Meeting

The first meeting of the project's Working Group was held on January 7-8, 2002, in Las Vegas, NV. Participants in the meeting included: Dr. Nolan Hertel and Omar Wooten of Georgia Institute of Technology, Drs. Richard Brey and Thomas Gesell of Idaho State University, Samson Pagava of Tbilisi State University of Georgia, Keith Eckerman of Oak Ridge National Laboratory, and Dr. Mark Rudin of UNLV. Dr. Wesley Bolch of the University of Florida is also a member of the Working Group, but was unable to attend the January meeting.

The primary purpose of the meeting was to have participants to work together to formulate an action plan for the rest of the project. The Working Group reached consensus on the following action items and their completion dates:

Initial prioritization of radionuclides based on half-life to be considered in the project (Shanahan and Song of UNLV, and Wooten of Georgia Tech) – March 30, 2002
Distribution of initial list of prioritized radionuclides to members of the Working Group for review – April 1, 2002

Modify EDISTR Code to facilitate its use for calculating dose coefficients (Eckerman) – March 30, 2002

Hold a workshop at UNLV to train graduate students from participating universities on the methodology to generate dose coefficients (Rudin, Patton, Shanahan, and Song of UNLV, and Wooten of Georgia Tech) – May 19-23, 2002

Next Working Group meeting at UNLV – tentatively scheduled for May 23, 2002

Two issues surfaced during the Working Group meeting. First, the currently accepted term to describe a value to convert an intake to an equivalent dose is a "dose coefficient," rather than a dose conversion coefficient. Members of the Working Group strongly recommended that the project be referred to as the UNLV/AAA Dose Coefficient Project. This change will be reflected in publications, presentations, proposals, etc. that are associated with the project in the future. Working Group members also recommended that the DOE Collaborators identified for the project, Brent Boyack and Tony Andrade of Los Alamos, should be invited to the next meeting and should have an increased role in project activities.

Presentation of Project at Meetings

The scope of work of the UNLV/AAA DC project was submitted for consideration at the 2002 Annual Meeting of the Health Physics Society in Tampa, FL:

Shanahan, J., Song, Y., Patton, P., and Rudin, M. Development of Dose Conversion Coefficients for Radionuclides Produced in Spallation Neutron Sources, Annual Meeting of the Health Physics Society, Tampa, FL, June 16-21, 2002.

Task 8: Second Quarter Report

Development of a Systems Engineering Model of the Chemical Separations Process

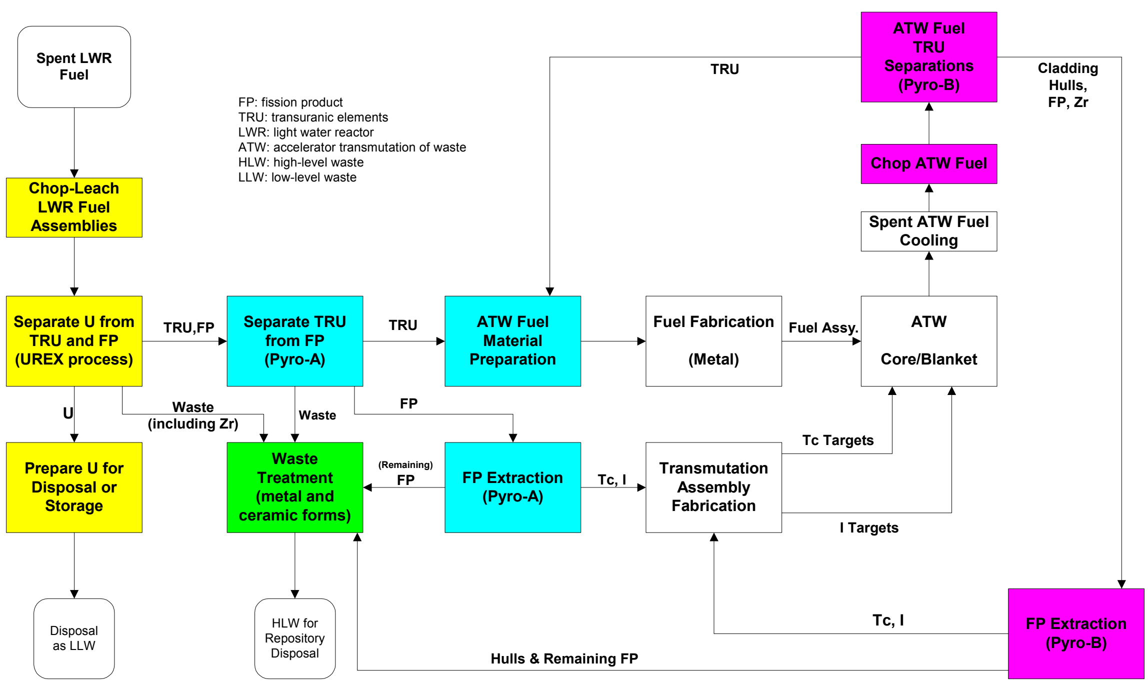
Quarterly Progress Report
11/16/01- 2/15/02

UNLV-AAA University Participation Program

Principle Investigator: Yitung Chen
Co-Principle Investigators: Randy Clarksean and Darrell Pepper

Purpose and Problem Statement

The AAA program is developing technology for the transmutation of nuclear waste to address many of the long-term disposal issues. An integral part of this program is the proposed chemical separations scheme. The following figure shows a block diagram of the current process as envisioned by Argonne National Laboratory (ANL) researchers.



Two activities are proposed in this Phase I task: the development of systems engineering model and the refinement of the Argonne code AMUSE (Argonne Model for Universal Solvent Extraction). The detailed systems engineering model is the start of an integrated approach to the analysis of the materials separations associated with the AAA Program. A second portion of the project is to streamline and improve an integral part of the overall systems model, which is the software package AMUSE. AMUSE analyzes the UREX process and other related solvent extraction processes and defines many of the process streams that are integral to the systems engineering model.

Combining these two tasks is important in ensuring that calculations made in AMUSE are accurately transferred to the overall systems model. Additional modules will be developed to model pyrochemical process operations not treated by AMUSE. These modules will be refined as experiments are conducted and as more knowledge is gained in process steps.

Integrating all aspects of the proposed separations processes will allow for detailed process analyses, trade-off studies or the evaluation of proposed process steps, complete material balances that include all potential waste streams, the impact of changes in feed streams, studies detailing the importance of process control and instrumentation, and the ultimate optimization of the process.

Personnel

Principle Investigator:

- Dr. Yitung Chen (Mechanical Engineering)

Co-Principle Investigators:

- Dr. Randy Clarksean (Mechanical Engineering)
- Dr. Darrell Pepper (Mechanical Engineering)

Students:

- Mr. Lijian (Rex) Sun, M.S. Graduate Student, (Mechanical Engineering)
- Ms. Jianhong Li, M.S. Graduate Student, (Computer Science)

National Laboratory Collaborators:

- Dr. James Laidler, Senior Scientist, Chemical Technology Division, ANL-East
- Dr. George Vandergrift, Senior Scientist, Chemical Technology Division, ANL-East
- Ms. Jacqueline Copple, Information Systems Group, ANL-East

Management Progress

Budget Issues:

- Annual user license of commercial system engineering software iSight^{TM} has been purchased. The academic price was granted.
- Salary expenditures have been adjusted according to the proper account number and student names

Management Problems

The Program Director of AAA-UPP at UNLV, Dr. Anthony Hechanova, has indicated that the funding for this research project was already allocated to our research account. The students' and professional stuffs' contracts will be prepared from 05/01/02 to 06/30/02 and 07/01/02 to 08/31/02.

One high-end personal computer has been received in the middle of December 2001. This serious delay has caused a lot of research schedule timeline problems for us.

We are still looking for one undergraduate student to work with us on this project in summer.

Technical Progress

AMUSE code is currently being studied and analyzed. The input and output parameters are carefully being tracking and marking. The capability of graphs and tables output and displaying is currently under designing. The system engineering model will be coupled with the graphical interface, AMUSE code, MATLAB and iSIGHT. Graphical User Interface of login prompt is shown in Figure 1.

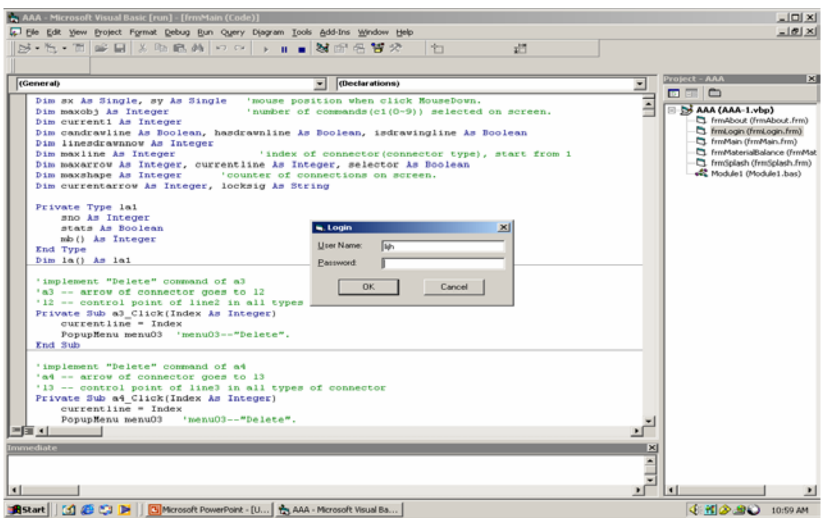


Figure 1. Graphical User Interface (GUI) of login prompt

Figure 2 shows the UREX main page design which contains the different chemical separation modules on the left-hand side of main page. User can drag and drop the various chemical process modules to the main page which is shown in Figure 3. Then user can make the line connection among those chemical process modules and indicate the mass flow directions among them by using arrows that are shown in Figures 4 and 5, respectively. The UREX demonstration flowsheet for glovebox operations and uranium strip section is shown in Figure 6. Window pull down manual is shown in Figure 7.

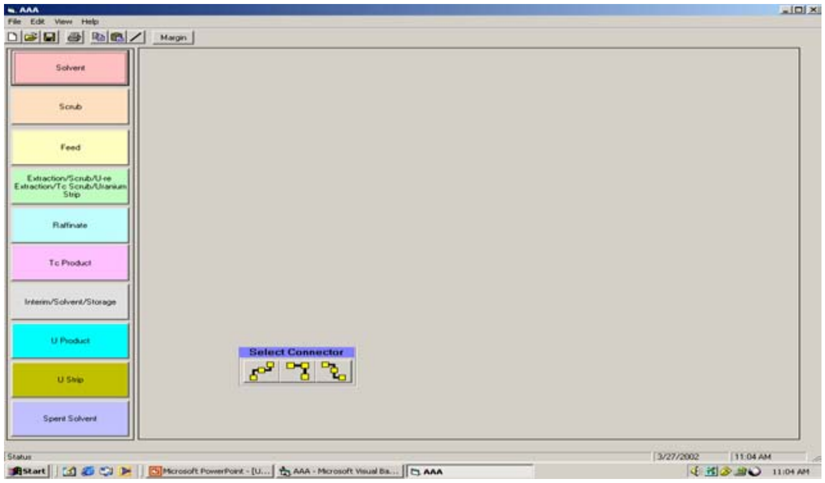


Figure 2. UREX main page

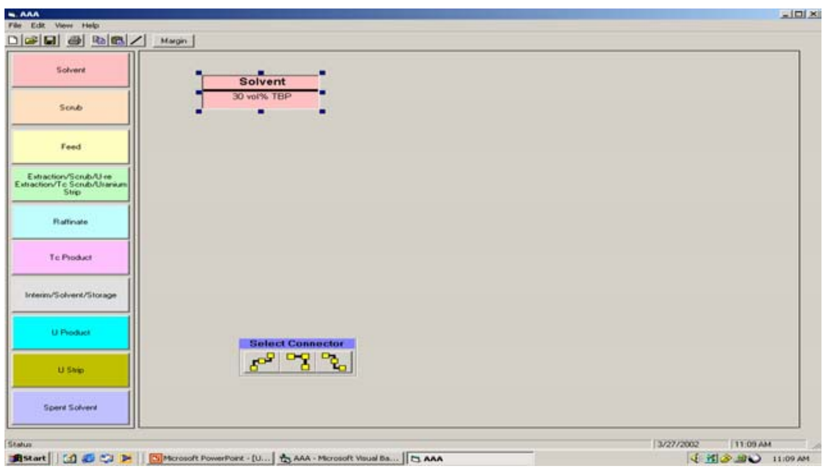


Figure 3. Drag and drop functions for the various chemical process modules

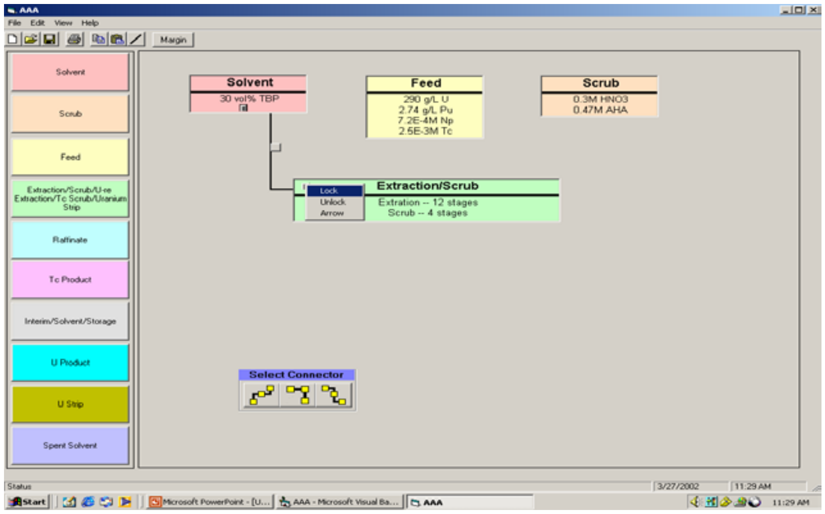


Figure 4. Line connections among various chemical process modules

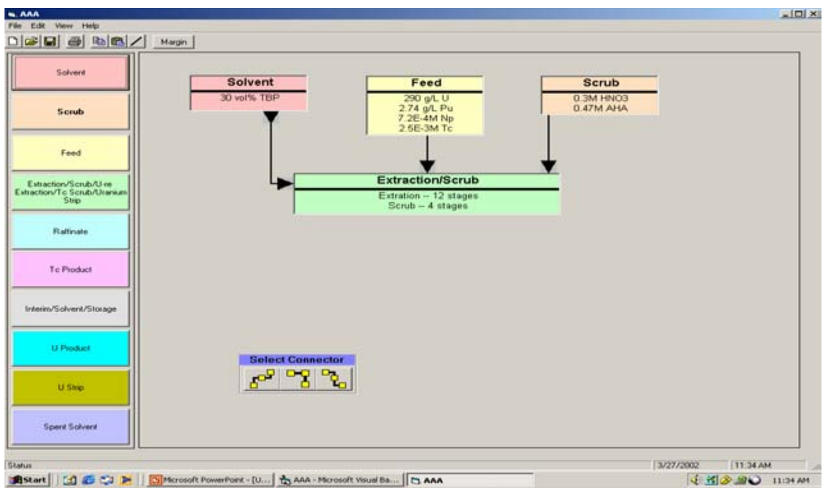


Figure 5. Arrows indicated mass flow directions among chemical processes

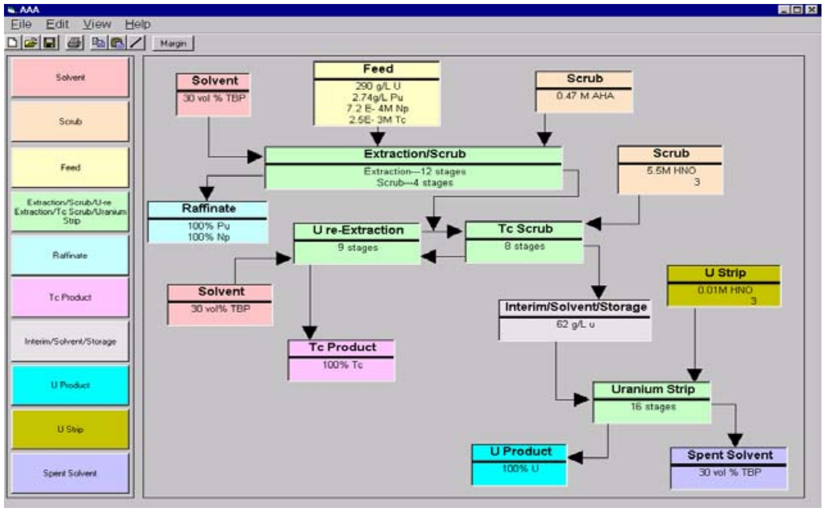


Figure 6. UREX demonstration flowsheet for glovebox operations and uranium strip section

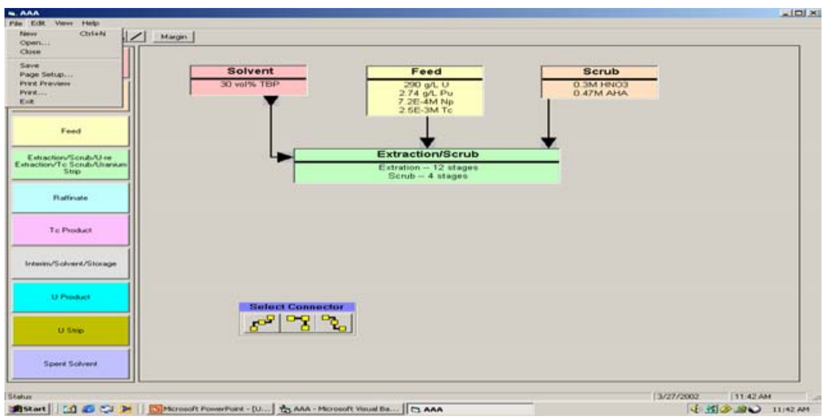


Figure 7. Window pull down manuals

A WebX conference for iSIGHT has be held from 9-11:20 a.m. on December 14. Work continues on two fronts for the systems engineering modeling work. The efforts center around a complete process model in the iSIGHT software and in the development of a general interface for the AMUSE code. Efforts are currently underway to determine if AMUSE is Export Controlled Information (ECI). If it is considered to be export controlled, changes in the way this information is dealt with will have to be made. At present, the students have been made aware of the change in status of the software and we have abided by all of the requirements provided to us by ANL.

The iSIGHT software has been procured, installed, and the students are presently learning how to use the software. While this training effort is ongoing, work is also being started to define the complete process according to published reports. iSIGHT was chosen because of the flexibility it offers in interfacing with numerous types of software packages and languages. The present efforts are preparing students to quickly and efficiently develop a system model later this year. Sample problems and test cases are be setup within the package to verify

iSIGHT is a generic software shell that improves productivity in the design process. In iSIGHT, design problems are specified, and simulation codes from multiple disciplines are coupled, in a description file. After a description file is created, user can then use the iSIGHT interface to set up, monitor, and analyze a design run.

The iSIGHT Graphical User Interface (GUI) is comprised of four main module types that address different aspects of specifying, formulating, monitoring, and analyzing a design problem. Figure 8 illustrates the four main iSIGHT modules.

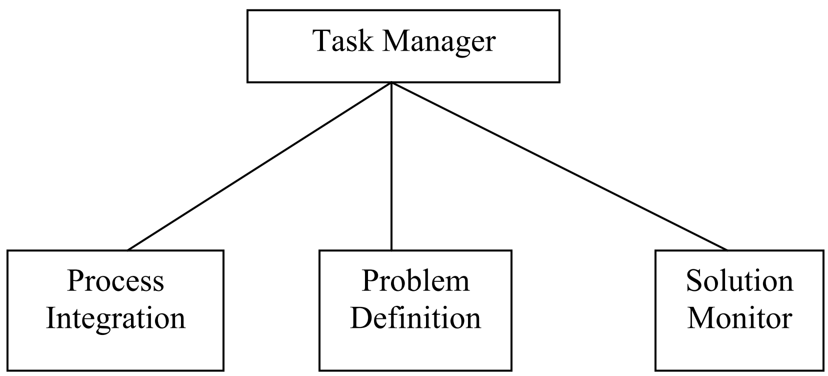


Figure 8. iSIGHT modules

The main iSIGHT interface is the Task Manager. From here a user can launch any of the iSIGHT interfaces. The Task Manager also allows user to ser up and run a design problem.

Process Integration is the iSIGHT module that enables user to couple simulation programs to iSIGHT and specify their execution sequence. Process Integration provides a GUI that acts as a front end for creating an iSIGHT description file written in iSIGHT MDOL language.

Problem Definition provides a convenient means to provide problem formulation information to specific design parameters, allowing user to control information in user's problem. Problem Definition also includes the design exploration techniques used by iSIGHT to reach an optimum during design exploration. The following techniques are available in iSIGHT: (a) optimization, (b) design of experiments, (c) quality engineering methods, (d) multi-criteria tradeoff analysis, (e) approximations, and (f) knowledge rules.

Solution Monitor is the part of iSIGHT that provides a visual means to monitor the optimization process as it moves through the design space. Solution Monitor provides several tables and graphs that can be used to view the runtime changes.

An example of the data flow is shown in Figure 9. The different executable program files can be linked to the main and/or sub-main routines which is shown in Figure 10. The output graphs and tables are generated in the end of simulation of processes. These are shown in Figures 11 and 12.

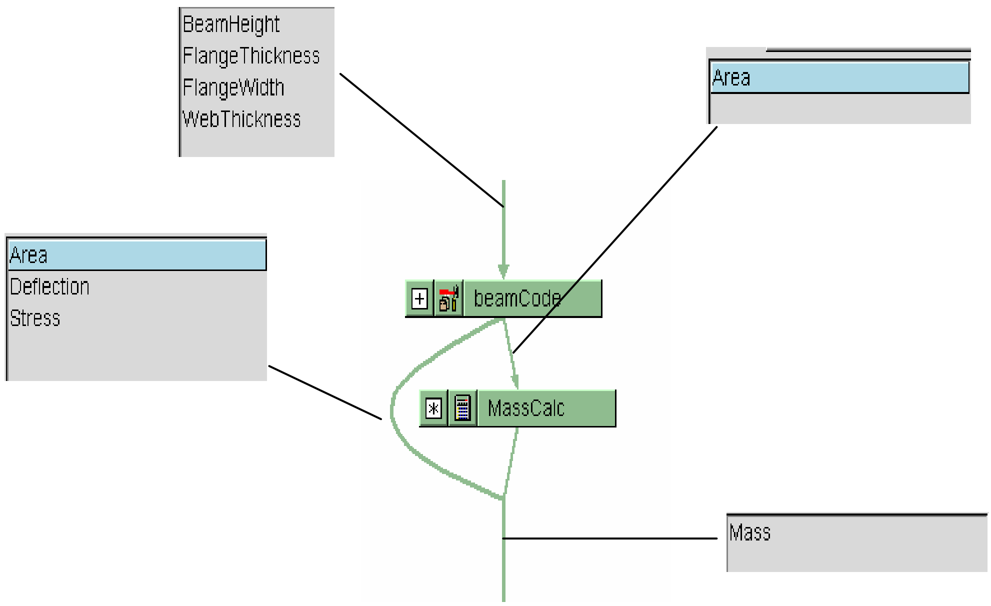


Figure 9. Example of data flow

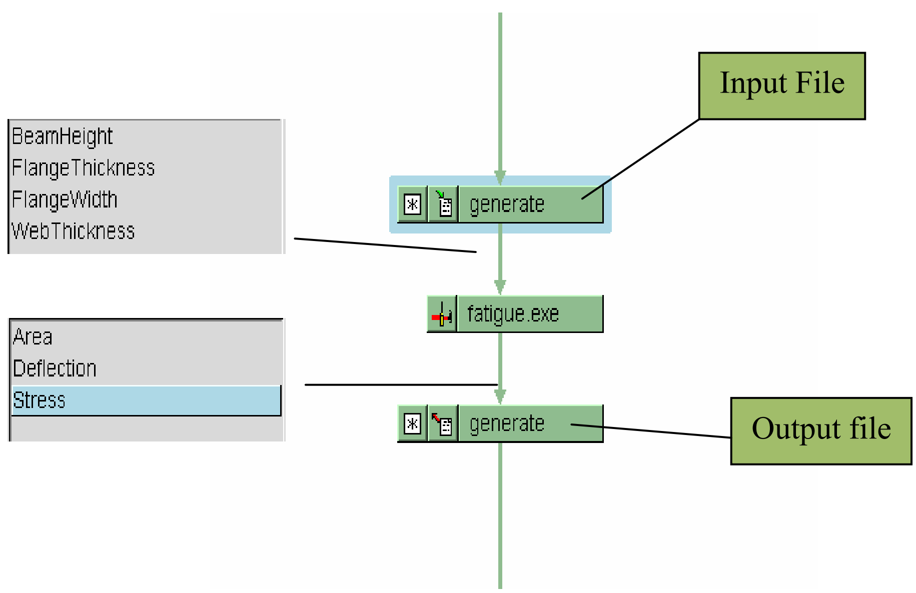


Figure 10. Link to different type of executable program files (.exe)

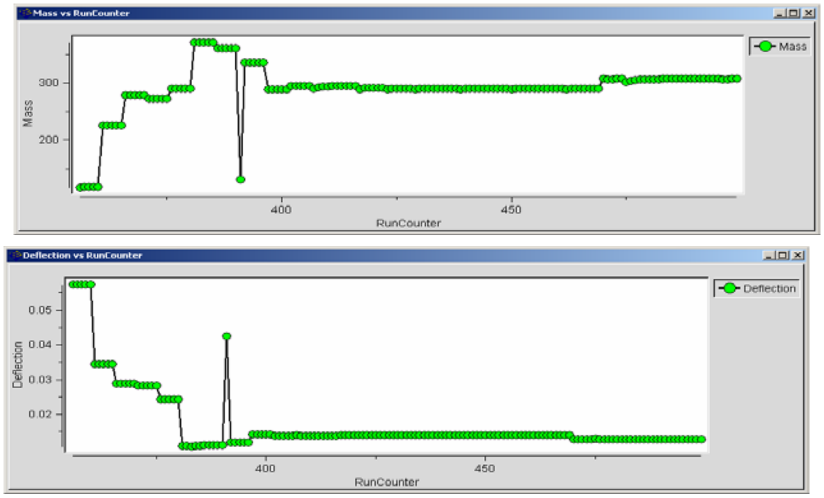
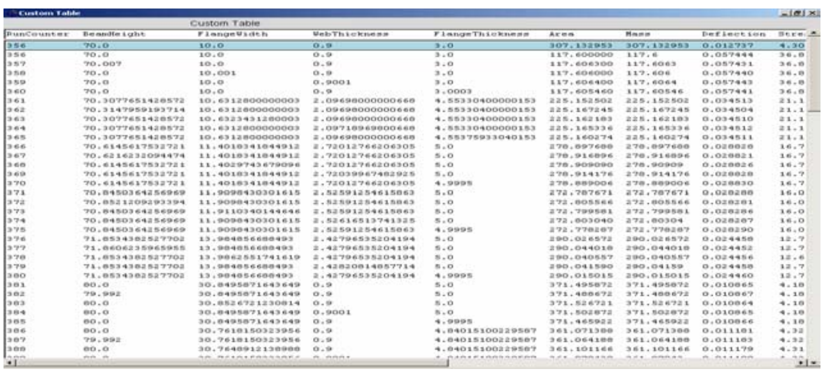


Figure 11. Output graphs



Custom Table

RunCounter	BeamHeight	FlangeWidth	WebThickness	FlangeThickness	Area	Mass	Deflection	Stre
356	70.0	10.0	0.9	3.0	307.132953	307.132953	0.012737	4.30
356	70.0	10.0	0.9	3.0	117.600000	117.6	0.057444	36.8
357	70.007	10.0	0.9	3.0	117.606300	117.6063	0.057431	36.8
358	70.0	10.001	0.9	3.0	117.606000	117.606	0.057440	36.8
359	70.0	10.0	0.9001	3.0	117.606400	117.6064	0.057443	36.8
360	70.0	10.0	0.9	3.0003	117.605460	117.60546	0.057441	36.8
361	70.3077651428572	10.6312800000003	2.0969800000066 8	4.5533040000015 3	225.152502	225.152502	0.034513	21.1
362	70.3147959193714	10.6312800000003	2.0969800000066 8	4.5533040000015 3	225.167245	225.167245	0.034504	21.1
363	70.3077651428572	10.6323431280003	2.0969800000066 8	4.5533040000015 3	225.162183	225.162183	0.034510	21.1
364	70.3077651428572	10.6312800000003	2.0971896980066 8	4.5533040000015 3	225.165336	225.165336	0.034512	21.1
365	70.3077651428572	10.6312800000003	2.0969800000066 8	4.5537593304015 3	225.160274	225.160274	0.034511	21.1
366	70.6145617532721	11.4018341844912	2.72012766206305	5.0	278.897688	278.897688	0.028826	16.7
367	70.6216232094474	11.4018341844912	2.72012766206305	5.0	278.916896	278.916896	0.028821	16.7
368	70.6145617532721	11.4029743679096	2.72012766206305	5.0	278.909090	278.90909	0.028826	16.7
369	70.6145617532721	11.4018341844912	2.72039967482925	5.0	278.914176	278.914176	0.028828	16.7
370	70.6145617532721	11.4018341844912	2.72012766206305	4.9995	278.889006	278.889006	0.028830	16.7
371	70.8450364256969	11.9098430301615	2.52591254615863	5.0	272.787671	272.787671	0.028288	16.0
372	70.8521209293394	11.9098430301615	2.52591254615863	5.0	272.805566	272.805566	0.028281	16.0
373	70.8450364256969	11.9110340144646	2.52591254615863	5.0	272.799581	272.799581	0.028286	16.0
374	70.8450364256969	11.9098430301615	2.52616513741325	5.0	272.803040	272.80304	0.028287	16.0
375	70.8450364256969	11.9098430301615	2.52591254615863	4.9995	272.778287	272.778287	0.028290	16.0
376	71.8534382527702	13.984856688493	2.42796535204194	5.0	290.026572	290.026572	0.024458	12.7
377	71.8606235965955	13.984856688493	2.42796535204194	5.0	290.044018	290.044018	0.024452	12.7
378	71.8534382527702	13.9862551741619	2.42796535204194	5.0	290.040557	290.040557	0.024456	12.6
379	71.8534382527702	13.984856688493	2.42820814857714	5.0	290.041590	290.04159	0.024458	12.7
380	71.8534382527702	13.984856688493	2.42796535204194	4.9995	290.015015	290.015015	0.024460	12.7
381	80.0	30.8495871643649	0.9	5.0	371.495872	371.495872	0.010865	4.18
382	79.992	30.8495871643649	0.9	5.0	371.488672	371.488672	0.010867	4.18
383	80.0	30.8526721230814	0.9	5.0	371.526721	371.526721	0.010864	4.18
384	80.0	30.8495871643649	0.9001	5.0	371.502872	371.502872	0.010865	4.18
385	80.0	30.8495871643649	0.9	4.9995	371.465922	371.465922	0.010866	4.18
386	80.0	30.7618150323956	0.9	4.84015100229587	361.071388	361.071388	0.011181	4.32
387	79.992	30.7618150323956	0.9	4.84015100229587	361.064188	361.064188	0.011183	4.32
388	80.0	30.7648912138988	0.9	4.84015100229587	361.101166	361.101166	0.011179	4.31

Figure 12. Output tables

Task 9: Second Quarter Report

Design and Evaluation of Processes for Fuel Fabrication

QUARTERLY PROGRESS REPORT #2

UNLV AAA University Participation Program

Prepared by: Georg F. Mauer
Department of Mechanical Engineering
UNLV, Las Vegas, NV 89154-4027
Phone: (702) 895-3830
FAX : (702) 895-3936

Reporting Period: December 1, 2001 through February 28, 2002

Design and Evaluation of Processes for Fuel Fabrication

Summary

The second quarter of the project covered the following:

- Project review with Dr. Mitchell Meyer, ANL West: A project review of the transmuter fuels project was conducted during the January 2002 AAA meeting in Las Vegas.
- A second graduate student, Mr. Richard Silva, began working on the project. Rich will develop detailed 3-D process simulation models as his M.Sc. thesis project. Rich is employed with Bechtel at the Yucca Mountain project.
- AAA Seminar Presentation by Mr. Jae-Kyu Lee and G. Mauer. Title: Transmuter Fuel Fabrication Processes.
- More equipment detail and estimates were developed for different manufacturing plant design options.

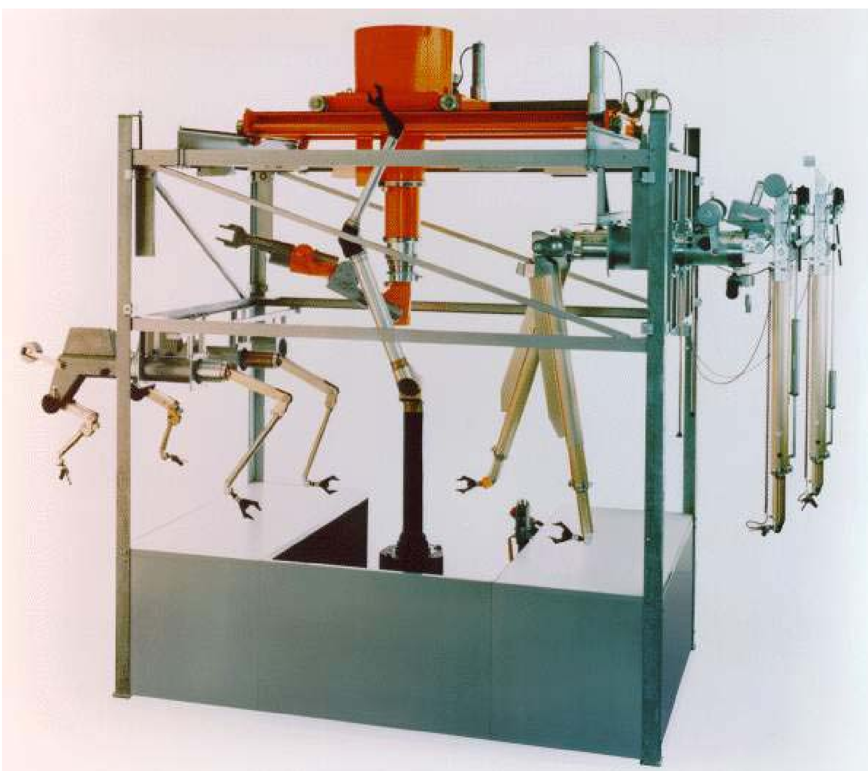


Figure 1 Hot Cell Robots (Wälischmiller GmbH)

1. **Equipment for Fuel Fabrication Processes**

Design Constraints: As described in report #1, criticality concerns mandate fabrication in small batch sizes. Limitations of batch sizes vary with fuel composition.

Generic Equipment Needs: Depending on the process, dedicated equipment such as induction furnaces, V-blenders, Sintering presses, and Arc welders will be required. The transport of the material being processed can be performed using dedicated designs ("hard automation") or robots equipped with suitable end effectors. Hard automation (e.g. conveyors, part feeders) can be advantageous in simple transport applications. However, they cannot normally recover from unusual events such as part misfeeds or blockages. Robots are more complex, but can be programmed and operated flexibly so that normal operation as well as a wide range of possible contingencies can be covered. By changing a robot's end of arm tools, the same robot can be equipped to perform multiple tasks, such as material handling and inspection.

2. **Metallic Fuel Equipment**

Induction furnace. The concept is schematically shown in Fig. 2. ANL West developed a custom furnace for its fuel conditioning facility, at an approximate cost of $2Million. Source: Dale Wahlquist, ANL West.
The ANL casting process employs vacuum casting into an array of quartz tubes. The tubes are broken after casting and must be disposed as waste. A casting process employing reusable molds will be required in order to reduce the quartz waste stream. Evaporation of Am from the liquid phase is a major drawback at present. Dr. Yitung Chen is presently investigating methods to recover the Am-vapor, possibly by deposition on a cold surface, so that the Am can be returned to the fuel stream. Am losses reach up to 40% in the ANL vacuum casting process.

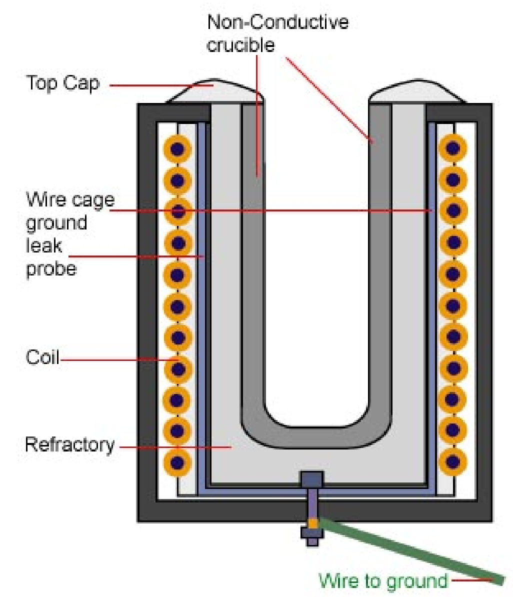


Figure 2 Induction Furnace

The completed fuel pins must be inspected and inserted into a cladding tube. An NA bond phase must be added. An end cap welder seals the tube. The final inspection completes the process.

Cost estimates: The estimates listed below are still very tentative. Although commercial equipment prices are available, the adaptation of such equipment to hot cell requirements can increase the cost 10fold or more. Some equipment is based on custom development, and therefore cost estimates are difficult to obtain or may not exist. The cost estimates presented below are most reliable with regard to metallic fuels due to the ability to contact scientist at ANL West' directly. Estimates for powder processing are indirect at this time and will be concretized as additional information is gained.

Preliminary estimates, **metallic fuel fabrication**.

Equipment	Estim. Cost in US $	Estimated Area requirement ft^2	Comments
Induction furnace	2Million	20	Source: ANL West
Reusable Mold	500K	20	No standard process exists. Conventional methods have not been adapted to hot cell use.
Fuel Pin Assembly Unit (Encapsulation and bonding)	2Million	20	Custom equipment
Automatic Welder	1Million	20	Custom equipment
3 Robots, approx. 1.5 m work envelope at 270 deg. range	1.5 Million		
Inspection station	100k	10	
Supervision (cameras and controllers)	500k	none	
Product storage		10	

A single manufacturing cell would require approx. 100 sq. ft. of hot cell space at a cost of approx. \$30,000/ft^2 or \$3M for the hot cell space. Total installation cost approx. \$11Million.

Preliminary estimates, Powder processing, **ceramic fuel fabrication**.

Equipment	Estim. Cost in US $	Estimated Area requirement ft^2	Comments
V-blender	50k	10	
Pellet press	500K	20	
Sintering oven	1Million	20	Custom equipment
Pellet Inspection Station	1Million	10	Custom equipment
3 Robots, approx. 1.5 m work envelope ea. at 270 deg. range	2 Million		
Fuel Pin Assembly Unit (Pellet insertion, Encapsulation and bonding)	2Million	20	Custom equipment
Automatic Welder	1Million	20	Custom equipment
Supervision (cameras and controllers)	500k		
Product storage		10	
Final Inspection station	100k	10	
	8.15M	120 ft^2	

A single manufacturing cell would require approx. 120 sq. ft. of hot cell space at a cost of approx. \$30,000/ft^2 or \$3.6M for the hot cell space. Total installation cost approx. \$12Million.

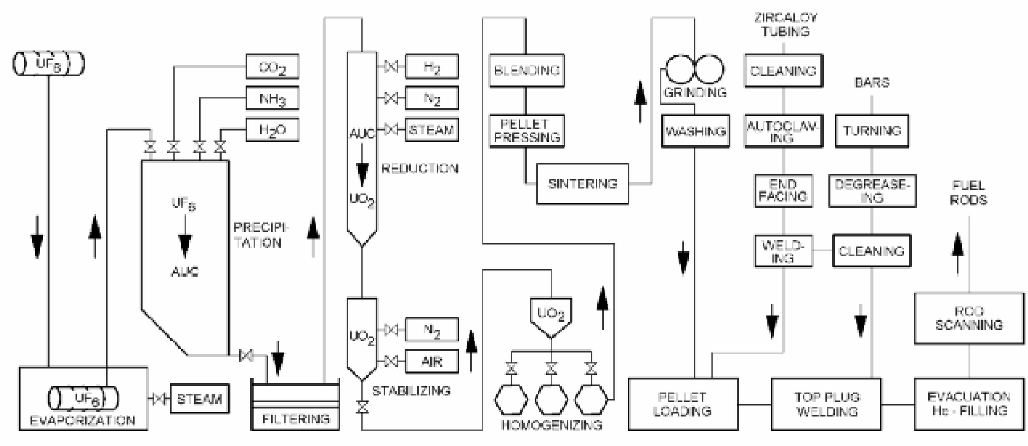


FIG. 21.2. Production of UO_2-fuel rods.

Figure 3 Powder Fabrication Process (Chalmers University)

Preliminary estimates, Powder processing, **Dispersion fuel fabrication**.

Equipment	Estim. Cost in US $	Estimated Area requirement ft^2	Comments
Particle manufacture	n.a.	n.a.	No source
Particle coating	n.a.	n.a.	No source
V-Blender	50k	10	
Cold Press	1Million	10	Custom equipment
3 Robots, approx. 1.5 m work envelope ea. at 270 deg. range	2 Million		
Fuel Billet Assembly Unit	2Million	40	Custom equipment
Hot Extrusion Machine	2Million	20	Custom equipment
Rod trimming Machine	1Million	20	Custom equipment
Supervision (cameras and controllers)	500k		
Product storage		10	
Final Inspection station	500k	20	
	9M excl. front end powder processing	130 ft^2 excl. front end powder processing	

Without consideration of the front end powder processing, a single manufacturing cell would require approx. 130 sq. ft. of hot cell space at a cost of approx. $30,000/ft^2$ or $3.9M for the hot cell space. Total installation cost approx. $13Million + Powder processing costs.

Conclusion

During the second quarter, project needs and issues were detailed. A project review was conducted in Las Vegas during the January AAA review with Dr. Mitchell K. Meyer, Group Leader for Fabrication Development at Argonne National Lab West. It was agreed to complete the preliminary plant cost study, and then to proceed to more detailed 3-D simulations of the plant layout and operation. The present effort is focusing more on collecting more detailed information on the cost and space requirements for powder processing equipment. The floor space requirements will be detailed further through the 3-D manufacturing simulation.

Management Issues: Expenditures were generally as planned in the proposal. Ph. D. student Jae-Kyu Lee was funded throughout the reporting period. In relation to the number of ongoing projects, the number of undergraduate seniors in mechanical engineering is limited. Undergraduate student employment could not be carried out as planned.

Task 10: Second Quarter Report

Subject: AAA Task-10 Quarterly (12/1, 2001 –02/28, 2002) Report

Introduction

The objective of this task is to evaluate the elevated temperature tensile properties of Alloy EP-823, a leading target material for accelerator-driven waste transmutation applications. The test material will be thermally treated prior to evaluation of its tensile properties at temperatures relevant to the transmutation applications. The deformation characteristics of tensile specimens, upon completion of testing, will be evaluated by surface analytical techniques including scanning electron microscopy (SEM) and transmission electron microscopy (TEM). The overall results are expected to provide a mechanistic understanding of high-temperature deformation behavior of Alloy EP-823 as a function of heat treatment.

Personnel

The current project participants are listed below.

Principal Investigators:	Dr. Ajit K. Roy Dr. Brendan J. O'Toole Department of Mechanical Engineering, UNLV Roy: Phone: (702) 895-1463 email: aroy@unlv.edu O'Toole: Phone: (702) 895-3885 email: bj@me.unlv.edu
Investigators (UNLV):	Mr. Martin Lewis (M.S. Student) Mr. John Motaka (Undergraduate Student) Mr. Konstantin Zabotkin (Research Associate) Department of Mechanical Engineering, UNLV Lewis: Phone: (702) 339-3990 email: Martin_Lewis@ymp.gov Motaka: Phone: (702) 205-4203 email: primo_w@yahoo.com Zabotkin: Phone: (702) 581-6659 email: Zabotkin@hotmail.com
Collaborator (DOE):	Dr. Stuart A. Maloy, Los Alamos National Laboratory, New Mexico Phone: (505) 667-9784 email: Maloy@lanl.gov

Highlights of Accomplishment

- Three experimental heats of EP-823 martensitic stainless steel have been melted, and processed into round bars at the Timken Company, Canton, Ohio. One heat of this material has been heat treated (quenched and tempered) to produce fully tempered martensitic microstructure, typical of a martensitic stainless steel. Hardness measurements have also been performed ($\approx$30 R_c). Efforts are well underway to machine tensile specimens from these heat-treated bars.

- The high-temperature and inert gas chamber with extension rod assembly and system software, that were ordered during this past quarter to perform high-temperature mechanical testing of Alloy EP-823 using an existing MTS machine, is expected to arrive at UNLV during April/May 2002 timeframe. Meanwhile, ambient-temperature tensile data will be generated as the machined test specimens of Alloy EP-823 become available.

- Round wedges for specimen grips in the MTS equipment have been ordered to facilitate the tensile testing using the inert gas chamber.

Problems

Since the MTS equipment will stay in its current location (#B150), no delays or problems are anticipated.

Status of Funds

Expenditures incurred during this quarter are within the target amount allocated.

Plans for Next Quarter

- Machine tensile test specimens from the heat-treated bars.
- Prepare test matrices.
- Perform additional thermal treatments.
- Initiate ambient-temperature tensile testing.
- Install the new inert gas chamber/other accessories to conduct elevated-temperature testing.

Task 11: Second Quarter Report

Nuclear Criticality Analyses of Separations Processes for the Transmutation Fuel Cycle

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1. Project Description

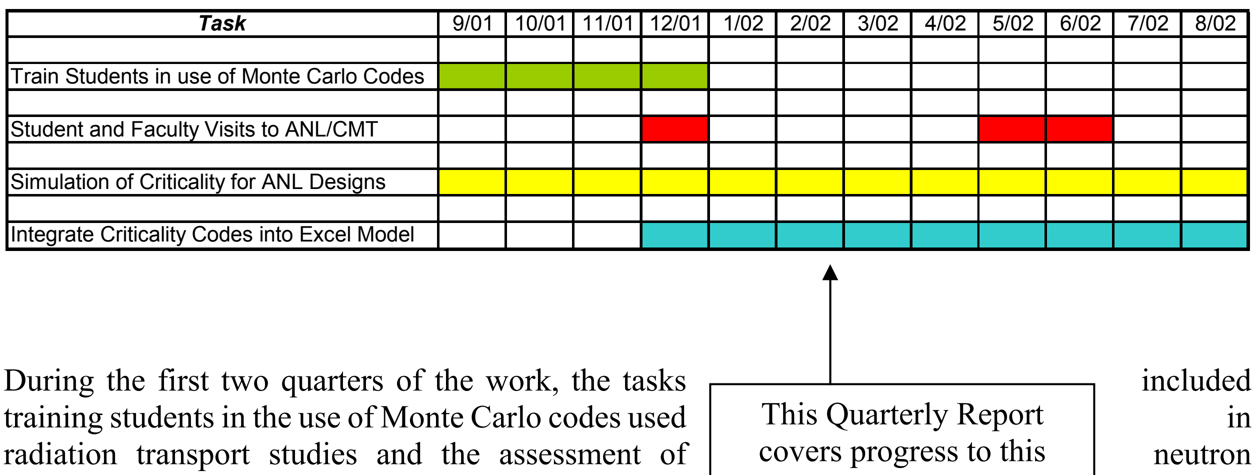
The success of the ATW program will rely upon the ability of radiochemists to separate spent nuclear fuel into uranium, fission products, and transuranic wastes. The Chemical Technology Division at the Argonne National Laboratory is actively involved in the development of pyrochemical separation technology that minimizes the usage of strong acids with the subsequent problems involved in disposing of the acidic residue.

Small-scale experiments are being validated at ANL to separate spent fuel, but they must be scaled up to accommodate the large amount of commercial spent fuel that must be treated. As the volume of waste to be treated is increased, there is a higher probability that fissionable isotopes of plutonium, americium, and curium can accumulate and form a critical mass. Criticality events can be avoided by ensuring that the effective neutron multiplication factor, k_{eff}, remains below a safe level. NRC regulations normally allow an upper value of 0.95 for k_{eff}. This parameter can be computed for any combination of fuel and geometry using Monte Carlo neutron transport codes. SCALE 4.4a from the Oak Ridge National Laboratory and MCNP4C2 from the Los Alamos National Laboratory are two codes that are regularly used to assess criticality.

In this project, students at the University of Nevada were trained in the use of KENO and SCALE 4.4a to assist Dr. Laidler and his team at ANL in criticality safety assessments.

2. Review of Tasks

The proposed tasks for this project are listed in the timetable shown below:



During the first two quarters of the work, the tasks included training students in the use of Monte Carlo codes used in radiation transport studies and the assessment of neutron multiplication factors for specific problems outlined by ANL-East through Drs. Laidler and Vandegrift.

The proposal also included objectives for the first year of work on this project, as listed below. The work conducted in the second quarter of the project was in partial completion of these objectives.

- Train UNLV students in the use of SCALE and/or MCNP for the assessment of nuclear criticality.

- Assess neutron multiplication factor, k_{eff}, for geometries and material concentrations as defined by the collaborating team from ANL-CMT for the ATW project.

- Provide software, extrapolation tables, or other methods to incorporate criticality estimates into the existing ANL Excel model of the pyrochemical treatment process to be used for ATW.

3. Progress in the Second Quarter

Student Training

The following students are continuing their work from the first quarter.

- Jason Viggato – doctoral student in mechanical engineering.
- Elizabeth Bakker – senior in mechanical engineering.
- Daniel Lowe – sophomore in mechanical engineering

Mr. Lowe and Mr. Viggato are also involved with another AAA project involving radiation transport calculations for neutron spallation target studies at LANSCE. During the first quarter of both projects, students were taught to use KENO and SCALE 4.4a in preparation for their work in radiation transport and criticality.

In January 2002, all three students also completed the introductory course in MCNPX offered by Dr. Laurie Waters from LANL. The course was taught at UNLV and was supported by Tony Hechanova and the UNLV/AAA University Participation Program. In addition to radiation transport modeling, the students also did a criticality problem in class. The nuclear criticality program, MCNP4C, is included in the current distribution of MCNPX.

In April, 2002, Mr. Viggato accepted a job with Bechtel, SAIC working on the Yucca Mountain Project. His job involves the analysis of thermal and criticality problems for the proposed national nuclear waste repository. He is continuing his work to finish his doctoral project.

Computational Resources

The students working on the project have been trained in the use of SCALE 4.4a, a Monte Carlo simulation code that simulates the scattering and absorption of neutrons in nuclear fuel. Students began their training with simple problems using KENO IV and are now involved in preparing CSPAN input files. Danny Lowe and Elizabeth Bakker are also involved in writing BASIC programs that automate the process of preparing CSAS and KENO-VI input.

Through the project, each student was equipped with a 1.8 GHz Gateway computer with 512 MB of memory. The students have desks and workspace allocated in TBE B-113 of the Engineering Complex at UNLV.

Simulation of Criticality for ANL Designs

Dr. Laidler requested information about the potential for samples of curium to become critical. The curium will be separated from spent nuclear fuel and will contain fissionable isotopes. The problem was analyzed using SCALE 4.4a by Ms. Bakker and an extensive report titled: "Fission and Thermal Effects in Curium Separated from Spent Nuclear Fuel" was prepared and submitted to ANL.

Curium separated from spent fuel also contains isotopes that generate a great deal of decay heat. This heat generation also creates safety problems in the handling and storage of curium. The decay heat can cause samples to melt very quickly if excessive quantities of curium are created. The report also outlines the thermal problem and the maximum mass of curium that can be safely stored is documented.

Integrate Criticality Codes into Excel Model

An Excel model was created in the first quarter for the analysis of mixtures of fission products, process salts, and TRU. In the second quarter, MathCad models were used to analyze thermal problems in curium.

4. Work Scheduled for Third Quarter

With completion of the second quarter work on curium, we are seeking additional criticality problems to analyze. Dr. Laidler previously expressed an interest in us looking at criticality safety in pyrochemical cells and we will pursue this analysis.

Distributed Report to ANL:

Culbreth, B., E. Bakker, and J. Vigatto, "Fission and Thermal Effects in Curium Separated from Spent Nuclear Fuel," April 19, 2002, complete document located on UNLV website at http://aaa.nevada.edu/task11.html or from UNLV AAA program office.

Appendices: *(Located on UNLV website at http://aaa.nevada.edu/task11.html)*

Appendix A – Sample SCALE 4.4a Input and Output Files
Appendix B – Decay Heat Generation by Isotopes of Curium
Appendix C – Heat Transfer Analysis for a Curium Sphere with a Generation Rate of 10 W/g
Appendix D – MathCad Program "Transient Temperature of a Curium Sphere using a Lumped Capacity Analysis"

Task 12: Second Quarter Report

Radiation Transport Modeling of Beam-Target Experiments for the AAA Project

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Date:	April 15, 2002

1. Project Description

The national development of technology to transmute nuclear waste depends upon the generation of high energy neutrons produced by proton spallation. Proton accelerators, such as LANSCE at the Los Alamos National Laboratory, are capable of producing 800 MeV protons. By bombarding a lead/bismuth target, each proton may generate 500 or more neutrons that can activate fission products or induce the fission of transuranic isotopes.

The Monte Carlo radiation transport code MCNPX developed at LANL is an important tool in the design of transmuter technology. It must be validated, however, for the neutron energy that will be employed. Experiments are being conducted at LANSCE to test the ability of MCNPX to accurately predict neutron production and leakage rates from lead/bismuth targets. Students at UNLV are being educated in the use of MCNPX to analyze the results of these tests and to use the software to in the development of future experimental studies.

2. Review of Tasks

The development of new systems for the transmutation of nuclear waste will depend upon computational tools that can provide an accurate assessment of the system performance. MCNPX, a Monte Carlo neutron transport code, will be used by UNLV students to support AAA experimental work at LANSCE. The tasks listed in the proposal are outline in the table below. The work conducted in the first quarter is highlighted in this report.

	Year 1											
Task	9/01	10/01	11/01	12/01	1/02	2/02	3/02	4/02	\5/02	6/02	7/02	8/02
Neutron Leakage Experiments												
MCNPX Training												
LANL/LANSCE Visits and Work												
Postanalysis of neutron data												
Sodium Activation Experiments												
MCNPX Training												
MCNPX (and other codes) modeling												
LANL/LANSCE Visit												
Analysis of Data												
Actinide Fission Measurements												
Neutron Multiplicity Measurements												
MCNPX Simulations												
LANSCE Site Visit												

The second quarter report covers work completed to this point.

Tasks

- Acquire MCNPX for use on student workstations and provide for the adequate training of the student researchers.

- Work with Drs. Beller, Klann, Pitcher, and Wender along with other researchers at LANL and ANL to model the integral experiment at LANSCE.

- Conduct MCNPX simulations of the preliminary design of an integral experiment to estimate the neutron leakage from lead/bismuth targets of varying radii. Provide similar computational support for proton activation experiments in sodium coolant.

3. Progress in the Second Quarter

- Student Training

The students working on the project are indicated below. Mr. Viggato recently started working at Bechtel, SAIC in Las Vegas and is not continuing the AAA work. We recently hired Ashraf Kaboud, an MS student in mechanical engineering. Mr. Kaboud is a U.S. citizen and will begin work in May.

- * Jason Viggato - doctoral student in mechanical engineering.
- * Daniel Lowe – sophomore in mechanical engineering.
- * Suresh Sadenini – masters student in mechanical engineering. Mr. Sadenini is on a teaching assistantship this semester and is not receiving financial support from this project. He is working on his M.S. project in neutron spallation.

MCNPX

J. Viggato, D. Lowe, S. Sadenini, and W. Culbreth completed an introductory MCNPX course taught by Dr. Laurie Waters and her staff from LANL. The course was conducted at UNLV in January 2002.

The students each have a 1.8 GHz computer with 512 MB of RAM for their MCNPX work. We also acquired Techplot 9.0, an interactive graphics program compatible with MCNPX. We also obtained ProEngineer, a computer-aided design program, for creating accurate images of the Blue Room at LANSCE and the experimental setup.

Visits

- UNLV

Dr. Klann visited with the project members at UNLV in February and in April to discuss the research project. Mr. Lowe is being scheduled to work at LANL on additional Pb/Bi target experiments during this summer.

- IAC

Mr. Sadenini is schedule to work at IAC during the summer to help with an experiment to generate neutrons in a lead target with an electron accelerator. He will also provide MCNPX simulations, and to analyze data. Mr. Sadenini will be supported by the IAC during the summer. This work at IAC nicely complements the work that we are doing on the LANSCE experiments.

- Postanalysis of Neutron Data

Experiments were conducted by Dr. Klann and his team at LANL/LANSCE in December to study the leakage of neutrons from a lead/bismuth target exposed to an 800 MeV neutron beam. The experiments were conducted on a 20 cm diameter, 50 cm long solid target. Neutron fluence was measured from time-of-flight detectors located in the room and from activation foils. Dr. Klann asked us to prepare a number of MCNPX simulations to compare with the results of the experiment. A second experiment is scheduled in July, 2002 on a larger target.

Mr. Lowe has prepared ProEngineer files to document the geometry of the experiment. An example drawing is shown in figure 1.

The students have been working on a number of MCNPX simulations of the neutron leakage. An example of the number of neutrons per square centimeter passing through the surface of the target is shown in figure 2. The top of the target is located at zero degrees and a steel table underneath the target causes a high neutron flux through the lower surface of the target.

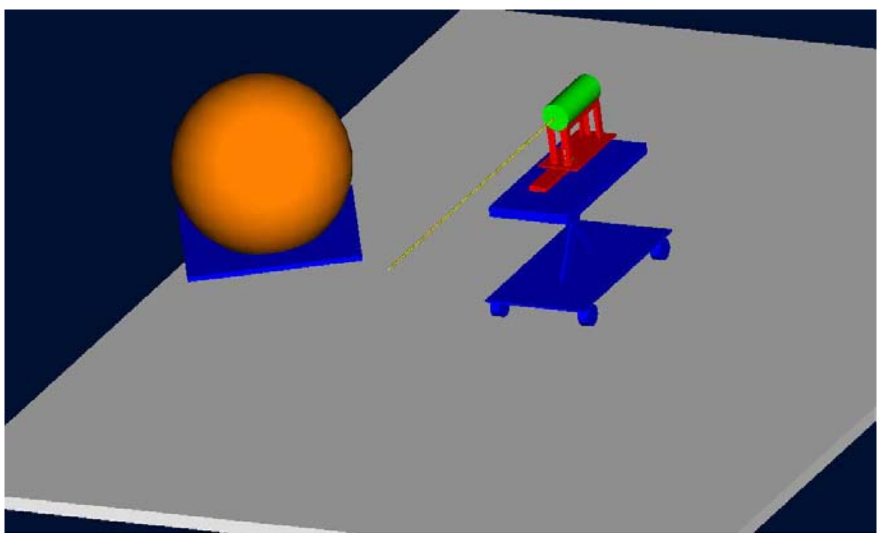

Figure 1 Schematic of the Blue Room Experiment at LANSCE, December 2002

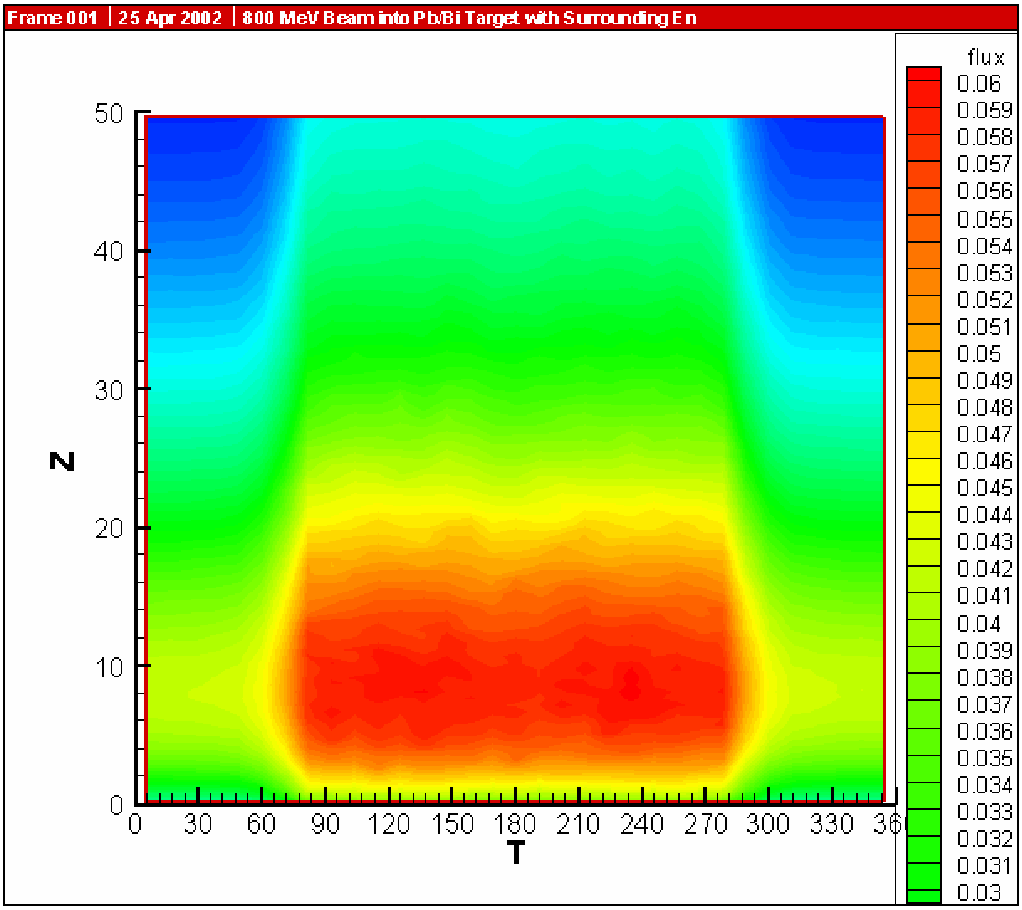

Figure 2 Neutrons per Square Centimeter per Incident 800 MeV Proton in on Lead/Bismuth Target

4. Work Scheduled for Third Quarter

During the third quarter, the students will continue to work on MCNPX simulations of the Blue Room experiments from December. We will also integrate Mr. Kaboud into the work. We still have some unresolved problems with MCNPX 4.2.j that we will seek resolution to in the third quarter.

Mr. Lowe is working with Dr. Klann for his summer work at LANL. We have also been asked to study the possibility of conducting tests in a manner similar to the international nuclear criticality benchmark project with well documented experiments and simulations.