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Contents

Session 1

1-A Fusion Technology/Plasma Physics

Location: 24–115
Time: Friday, 11:00–12:30

Utilization of a Laser-Induced Plasma as a Conductive Pathway

Karl Robert Umstadter
Rensselaer Polytechnic Institute

Plasmas are being used in many industrial and experimental applications. Some applications that utilize plasmas include power generation, metal cutting and welding, and testing. We have developed a laser-induced plasma-based noncontact test method. This method utilizes a small volume of highly-ionized air, commonly referred to as a plasma, as a conductive pathway. The pathway is capable of conducting both AC and DC signals with negligible distortion. The current method of testing the printed wiring boards (PWBs) in electronic equipment requires physical contact with the desired lead. The ongoing decrease in the feature size of new PWBs and the potentially damaging contact made with one or more metal pins has made it more difficult to test these boards with conventional methods.

An NCT plasma is generated in air when the constituent atoms or molecules are broken down into charged particles. A laser is first used to ionize the gas, the resulting plasma can then absorb energy from the beam. The mechanism by which breakdown occurs requires a two step process. A "multiphoton process" that involves the simultaneous absorption of a number of photons, provides sufficient energy to free electrons from an outer shell, thereby producing the seed electrons for a cascade ionization of the gas. The free electrons can then gain sufficient energy from the laser to ionize an atom by absorbing photons and colliding with neutral atoms. The number of ions increases over time and a cascade process causes an exponential growth of ionization. It is at this point that the plasma becomes capable of serving as a non-loading conductive pathway.

The basic elements of the NCT system include a pulsed laser, a focussing system and an electrode (which is connected to a test system and serves as the probe). The laser produces a plasma in the region located between the electrode and the PWB, thus creating a pathway for current to flow. The resulting electrical pathway exists for approximately 20 μsec in ambient air. The irradiance required to create a plasma in air was found experimentally to be on the order of 10^9 W/mm^2. A variety of experiments were performed to investigate how the plasma forms and the NCT system elements effect the conductive properties of the non-contact pathway. We have also investigated the effects that different gas environments have upon the creation of a plasma. Finally, various optical systems, electrode materials and methods of extending the plasma lifetime have also been explored.

Current Distribution and Stability in Cable-In-Conduit Superconductors

Matthew A. Ferri
Massachussetts Institute of Technology

Next generation tokamak devices such as ITER and TPX are relying on cable-in-conduit superconducting magnets for both their toroidal and poloidal field coils. The cable-in-conduit conductor (CICC) is composed of multiply twisted superconducting strands contained in a metallic sheath which provides structural support as well as a passage for liquid helium coolant. The U.S. Demonstration Poloidal Coil (US-DPC) was built and tested in 1990–91 to demonstrate the feasibility of this technology for fusion devices. Although the magnet performed as expected in DC operation, an unexpected limitation was discovered when the coil current and the resulting magnetic field were ramped at a linear rate.

This "Ramp Rate Limitation" has been duplicated in small-scale testing using a 27-strand cable, but has not yet been explained. This paper investigates one possible explanation for the insability; uneven distribution of current amongst the superconducting strands in the cable. Although a current imbalance could be caused by many factors, the paper focuses on the effects of strand-to-strand crossover currents induced by the ramping external field. The 27-strand small-scale sample is used as the basis of the analysis since there is a large experimental data base with which to compare results. Since it would be extremely difficult to solve for the induced currents analytically, a discrete model is developed and solved using appropriate simplifying assumptions.

The results of the model rely on accurate measurements of the transverse resistance between each strand in the cable. Using resistance measurements made on a sample very similar to the 27-strand cable being modeled, the induced currents were on the order of 10 mA for a typical ramping scenario. This result should be compared to the applied current per strand, 160 A, and the "allowable" current per strand, 180 A. Obviously, the 10 mA result seems too low to be significant. However, using resistance measurements by other researchers on strands similar to the ones being studied would give induced currents on the order of 10 A, definitely large enough to affect the stability of the cable. At this point, the disparity in the resistance measurements makes definitive conclusions difficult.

Deuterium Retention by Molybdenum Walls of the Alcator C-Mod Tokamak*

A. Niemczewski
G. McCracken
Massachussetts Institute of Technology

One of the still unsolved problems of a commercial tokamak reactor is the retention of hydrogen isotopes by its first wall material. Large numbers of experiments performed to date in graphite and beryllium wall tokamaks indicate that the first wall hydrogen reservoir exceeds particle plasma content by many orders of magnitude. In the case of tritium that constitutes a large radioactive material inventory.

Alcator C-Mod, the only high performance high-Z metal (molybdenum) wall tokamak, allows investigation of the retention and release of hydrogen isotopes in a metal wall under reactor-relevant conditions. During the 1993 experimental campaign (achieved plasma parameters: $I_p = 1$ MA, $t = 1$ s, $\langle n \rangle = 10^{21}$ m^{-3}, $B = 5$ T) extensive measurements of deuterium wall inventory have been made.

The wall retention measurements are based on a total particle balance inside the Alcator C-Mod vacuum vessel. Fast time-scale measurements of gas puffing rate, electron plasma count and vessel neutral pressure allow one to infer wall loading or wall pumping rate during the shot. It has been found that the wall pumping rate is fairly independent of plasma current, or electron temperature. It depends strongly on the gas puffing rate. The wall reservoir starts to saturate at a rate of 10^{21} deuterons per second after about 0.1 seconds. The total deuterium wall reservoir in Alcator C-Mod is about 1 to 10 times the plasma particle content, which is a few orders of magnitude smaller than the wall reservoir in graphite tokamaks.

Long time scale (100-1000 second) measurements of the outgasing rate after the shot provide information about the release of deuterons. Even though the release rate is 2-3 orders of magnitude slower than the pumping rate, in molybdenum (unlike in graphite), almost all the particles pumped during a 1 second shot are released within 100 second after the shot.

From the perspective of hydrogen isotope retention in a tokamak first wall, molybdenum seems to be a more viable reactor material candidate than graphite, since there will be no large inventory of tritium stored in the wall.

*Supported by U.S. DOE Contract No. DE-AC02-78ET51013.

Fusion Via Sound-Wave Induced Bubble Compression

Christopher Funk
Hideo Esaka
Rensselaer Polytechnic Institute

In the light of decreasing fossil fuel resources and increasing pollution problems, it is of utmost importance to develop safe and effective alternative energy sources. Among the most promising of these alternatives is the nuclear fusion reactor. This presentation will summarize the work done at Rensselaer Polytechnic Institute regarding a reactor design which utilizes ultrasound energy to initiate the fusion reaction.

Sonochemistry will be discussed first. It is hypothesized that the process of sonochemistry can be used to raise a deuterium bubble's temperature to a point where a fusion reaction becomes feasible. When sound waves at a resonant frequency are transmitted through a liquid medium, the bubbles within the medium undergo a large compression. This dramatic decrease in the bubble's volume results in an increase in the bubble's energy. Current uses for sonochemistry as well as its practical applications to the fusion reactor will be summarized.

A reactor which can harness this sound wave-induced fusion would offer several advantages. First, existing technology can be used. Existing pressurized water reactor (PWR) loops can be used; only the reactor core need be replaced. Further, the reactor offers outstanding cleanliness. The reactor will use deuterium fuel, which requires little processing and is non-radioactive. To further minimize environmental and handling hazards, light water will be used as a coolant and fuel bubble medium. Finally, the reactor is inherently safe. This is due to the reactor's dependence on the input of sonic energy. The reactor can be shut down at any time by cutting the ultrasound emitter's power supply. Further, decay heat will not need to be considered after a shut down. This is because there is neither the possibility of continued reaction of fuel, nor is there any high-energy emitting nuclides in the reactor core. The aforementioned advantages will be discussed in greater detail.

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1-B Radiation Detection/Nuclear Chemistry

Location: 24–121
Time: Friday, 11:00–12:30

The Retention of Iodine by Stainless Steel Tubing

Christopher Deir
Greg J. Evans
University of Toronto

Gas sampling lines at many nuclear power stations employ stainless steel tubing to transport the air to the monitoring sections. Iodine may be lost to these lines, therefore invalidating the readings. This work determines the expected losses along these lines and the impact on iodine monitoring stations. It is found that the flow rate, temperature and relative humidity all have a profound effect on the levels of iodine deposited on the steel. Desorption rates from the steel is seen to be decreased at higher temperatures. Iodine remains in the molecular form throughout the its residence upon the steel.

Radioanalytical Investigations of Iodine Transport in the Terrestrial Environment

K. A. Hammad G. J. Evans
Department of Chemical Engineering and Applied Chemistry
University of Toronto
Toronto, Canada

The study of radioiodine fate and behaviour in the terrestrial environment is of interest to insure a permanently safe disposal of highly radioactive wastes in deep geological depositories. The modelling of potential movements of radioiodine in the biosphere is dependant on the understanding of the factors that affect its behaviour and transport in the system.

Radiochemical techniques were used to evaluate the concentration and distribution of iodine among soil, water, sediments, and plant media samples collected from the same site. Preconcentration neutron activation analysis (PNAA) was used to measure iodine content in these samples. Iodine partitioning between various soils, sediments and water was evaluated using ^{131}I tracer, and the effect of chemical speciation on the distribution of iodine was also examined. Experiments involving gamma irradiation suggested that much of the sorption of iodide, and reduction of iodate was related to microbial processes.

Trace Elements in Motor and Fuel Oils

Xudong Huang Esteban Mondoza Ilhan Olmez
Department of Nuclear Engineering
Massachusetts Institute of Technology

The instrumental neutron activation analysis (INAA) technique is an accurate elemental analytical method for obtaining the trace-element composition of motor and fuel oils. The oils were analyzed directly, without any physical or chemical treatments such as dissolving or ashing which were used in past analyses. Among the 11 toxic metals regulated by the Clean Air Act Amendments (CAAAs), Cr, Mn, Co, As, Sb, and Hg elements were found in both motor and fuel oils. this information is important for urban scale source identification and apportionment studies, and has previously been unavailable. The trace-element emission rates due to motor oils are estimated for the U.S. vehicle fleet. Our results indicate that zero emission from gasoline-powered, internal combustion based vehicles is not practical with respect to element emissions.

The Trace Element Characterization of *Cannabis Sativa* Samples To Support Criminal Proceedings

David P. Henderson Jr.
University of Florida

The University of Florida Training Reactor (UFTR) Facilities including the analytical laboratory are utilized for a wide range of educational, research and community usages. The UFTR is a 100 kW light-water-cooled, graphite-and-water-moderated modified Argonaut-type reactor. The UFTR utilizes high enriched plate-type fuel in a two-slab arrangement and operates at a 100 kW power level. Since first licensed to operate at 10 kW in 1959, this non-power reactor facility has had an active but evolving record of continuous service to a wide range of academic, utility, and community users. The services of the UFTR have also been utilized by various state authorities in criminal investigations. In a specific legal investigation conducted in Florida by the Office of the State Attorney, various samples of the controlled substance *cannabis sativa* (marijuana) are being used as evidence. Some of the samples are presumed to be from the same plant tissue but have been obtained from different locations. The UFTR analytical laboratory facilities were used to quantify trace element concentrations of identical plant tissue samples from different locations. Additional *cannabis sativa* samples from unrelated locations as well as control standards were used to support analytical results.

Plant tissue samples were analyzed over a period of four weeks using the k_0 standardization method of Instrumental Neutron Activation Analysis (INAA) to provide multielement plant tissue characterization. This characterization assumed that matrices from a common source would have a similar trace element composition and that matrices from different sources would exhibit dissimilar compositions. The k_0 standardization method is the best suited method for bulk, multielement analyses in a single determination. Using the k_0 method, trace element concentrations were quantified and compared among various vegetation samples.

Results for 36 elements in each *cannabis* sample were examined using the k_0 standardization method. Only activated nuclides with relatively long half-lives ($t_{1/2} > 10h$) were investigated. The criterion used to establish positive identification between trace element concentrations was conservatively determined to be less than a 100% difference. Ratios of the number of similar elemental concentrations to the total number of identified elemental concentrations for each sample were calculated. Control samples were compared to the results and percentages of similar trace element constituents were determined. Three sample pairs contained 41.7%, 47.2% and 86.1% similar trace elements as compared to control samples. The results indicate that trace elements were very similar for samples taken from different locations but assumed to be of the same plant tissue (stolen). Based on the results of this investigation, it is concluded that *cannabis sativa* samples from different locations have a common source and are identified as samples removed surreptitiously from law enforcement custody.

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Session 2

2-A Advanced Reactor Technology

Location: 24–115
Time: Friday, 2:30–4:00

Conceptual Design of a Large, Passive, Pressure-Tube LWR

Pavel Hejzlar
Department of Nuclear Engineering
Massachusetts Institute of Technology

A new concept for an advanced passive light water reactor is described. The proposed concept is a pressure tube reactor of similar design to CANDU reactors, but differs in three key aspects. First, a solid fuel matrix is used in place of pin-rod bundles to enhance the dissipation of decay heat from the fuel in the absence of primary coolant. Second, the heavy water coolant in the pressure tubes is replaced by light water, which serves also as a moderator. Finally, the heavy water moderator is replaced by low pressure gas and the normally voided calandria is connected to a light water heat sink. The purpose of the gas is to keep the light water out of the calandria during normal operation, while during loss of coolant or loss of heat sink accidents it allows passive calandria flooding.

The proposed pressure tube reactor can survive LOCA without scram and without replenishing primary coolant inventory, while the safe temperature limits on the fuel and pressure tube are not exceeded. The heterogeneous arrangement of the fuel and moderator ensures a negative void coefficient under all circumstances. Although light water is used as both coolant and moderator, the reactor exhibits high neutron thermalization and large prompt neutron lifetime, similar to D_2O moderated cores. Moreover, the neutron migration length is substantially increased, which results in a strongly coupled core with almost flat power density profile, and absolute stability against spatial xenon oscillations.

The entire primary system is enclosed in a robust, free standing cylindrical steel containment with concrete shield building. Large heat capacity of the water pool outside the calandria, available for flooding, absorbs significant amount of decay energy and reduces peak pressure during the long term containment pressurization. CONTAIN analysis shows that the primary steel shell of the proposed containment can be cooled indefinitely by buoyancy-induced air flow while the maximum pressure peak remains below 0.36 MPa.

Accelerator Driven System for Nuclear Waste Transmutation

Jon Bergman Johannes Strydom Mark Winslow
Alan Paulus
Rensselaer Polytechnic Institute

As the political structure of our world changes, our national defense concerns have had to adapt to many new circumstances. One of the problems arising is the nuclear arsenal developed during the cold war by the United States and the former Soviet Union. The United States seeks to maintain tight control over the world's plutonium inventory as outlined in the Nuclear Non Proliferation Treaty. One of the possible ways currently in negotiation is to purchase the stockpiles of nuclear warheads amassed in the republic of Ukraine. This leads to the obvious question of what to do once we have accquired this plutonium, for it has almost no other practical uses besides building nuclear bombs and warheads. Our project hopes to offer an alternative solution to the burial of this extremely lethal metal.

The gereral idea is to design a reactor capable of burning, thus converting, the plutonium and produce electricity. There are many differences between a uranium and a plutonium fueled reactor. The major distinction lies in the operation of the plutonium burning reactor, as the chain reaction would be driven by an accelerator and maintained in a subcritical arrangement. This factor is thought to greatly increase the safety of the plant.

The presentation will discuss several issues, namely the use of the accelerator to maintain a chain reaction, the heat removal requirements for the molten salt carrier loop and a brief mention of economic and radiological concerns.

Holographically Enhanced Thermophotovoltaic Energy Conversion

Thomas M. Regan
University of Massachusetts Lowell

This paper presents an innovative concept in thermophotovoltaic (TPV) energy conversion. The concept is directed to a non-terrestrial power supply using a nuclear reactor. It uses three advanced technologies: rare earth selective emitters, holographic concentrators, and high temperature gas cooled space reactors. The use of selective emitters matched to photovoltaic cells with bandgaps that correspond to the bandwidth of the emitter can have conversion efficiencies as high as 45 percent. The use of holographic concentrators will provide a low mass mechanism for concentration and offband filtering, which will reduce the area, mass and heating of the photovoltaic cell. Coupling a helium cooled reactor to a selective emitter utilizes radiant heat transfer, a more efficient mechanism for energy transport than conduction or convection. The reactor based TPV system can have high conversion efficiencies; this increases the energy-to-mass ratio and this also reduces the radiator area necessary for heat rejection. Ongoing research aims to demonstrates the viability of the reactor based TPV by developing a small scale reactor simulator, operating within the temperature range of "super alloys" approximately 1300 Kelvin.

The performance enhancements gains by use of selective emitters in conjunction with holographic concentrators will allow for a relatively small surface of photovoltaic cells to efficiently produce large amounts of electric power. The system also has a reduced number of moving parts, reducing the potential for mechanical failure.

2-B Radiation Detection/Nuclear Chemistry

Location: 24–121
Time: Friday, 2:30–4:00

Trace Element Determination in an Antarctic Ice Core

S. Sinan Keskin
Ilhan Olmez
Nuclear Reactor Laboratory
Environmental Research and Radiochemistry Division
Massachusetts Institute of Technology

Antarctic and Arctic ice sheets preserve very valuable information about the past atmospheric conditions. They preserve atmospherically produced or transported substances within the stratigraphic layers as a result of wet and dry deposition mechanisms. These substances include aerosol particles, volcanic dust, and natural and industrial gaseous compounds. Until today some very important findings about the past climatic conditions have come from various ice core studies. The ice cores used in these studies were obtained from shallow, intermediate, or deep drillings made in Antarctica and Greenland after the 1960s.

Our goal is to develop a semi-empirical model to reconstruct the past atmospheric elemental concentration trends by means of snow elemental concentration determination. For this purpose, approximately 200 samples from the 164 meter NBY-89 ice core are being analyzed currently by instrumental neutron activatio analysis (INAA) and inductively coupled plasma-atomic emission spectrometry (ICP-AES). In addition, morphological characteristics of aerosols will be determined by scanning electron microscopy. Some elemental concentration results will be presented in addition to the discussion of sampling and analysis.

Radiolytic Destruction of Organochlorine

F. Taghipour G. J. Evans
Department of Chemical Engineering & Applied Chemistry
University of Toronto

Chlorinated organic compounds, which are formed during the bleaching of kraft pulp, are a major environmental concern. Existing pulp mill effluent treatment methods may not be able to meet future regulations. The effect of free radicals, produced by gamma radiation, on organochlorine existing in pulp mill effluent was investigated as a potential new treatment method.

Certain organochlorine compounds such as chlorophenol, chlorocatechol, chloroacetic acid and chloroform were irradiated at various doses in a ^{60}Co Gammacell. Treated and untreated effluent, as well as E-stage and C-stage samples, from a pulp mill were also investigated. For treated, untreated, E-stage, and C-stage effluent more than 95%, 90%, 70%, and 60% AOX removal was obtained by 60 kGy dosages, respectively. Greater removal is possible at higher dosages. The influence of parameters which may improve free-radical treatment, such as pH and dissolved oxygen, was also studied. Preliminary results suggested that removing the dissolved oxygen and increasing solution pH can improve the radiolytic destruction of organochlorine.

The high degree of organochlorine degradation demonstrated that free-radical treatment may offer an attractive means to enhance the removal of individual chlorinated organic compounds and organochlorine in pulp mill effluent.

The Effect of Organic Peroxides on Iodine Volatility

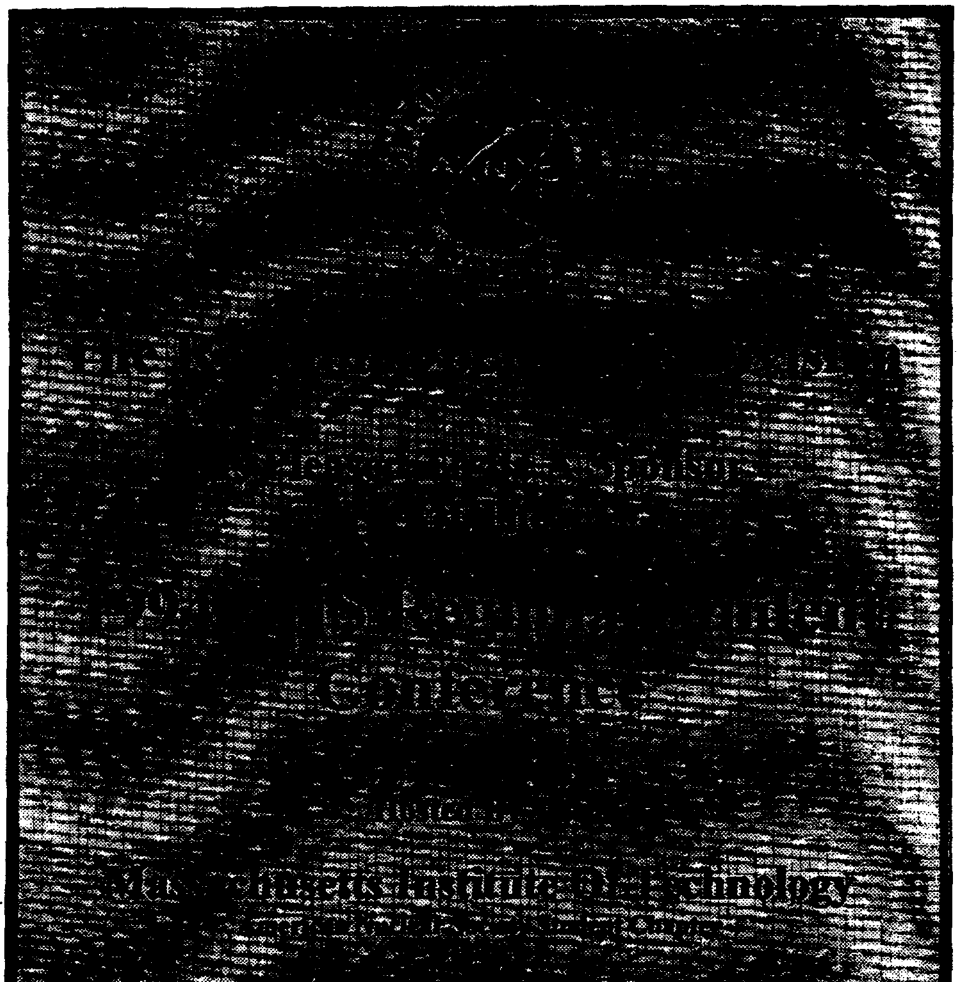
Ka Hing Lin G. J. Evans
Department of Chemical Engineering and Applied Chemistry
University of Toronto

It has been shown that certain organic chemicals, when irradiated, will produce relatively stable products that will affect the volatility of iodine differently than that of the parent organic. it is hypothesized that one of the radiolysis products would be organic peroxide (RO) which could produce volatile iodine species via oxidation of I—and formation of organic iodides (RI). Given the seriousness of iodine release in the event of a major nuclear accident, investigation into this phenomena was started. Using methyl ethyl ketone (MEK) as an initial subject, the effect of irradiated MEK on iodine volatility was compared to non-irradiated MEK. Further investigation into the possible kinetics for the above reactions were initiated.

Atmospheric Mercury Measurements By Instrumental Neutron Activation Analysis

Michael Ames
Ilhan Olmez
Department of Nuclear Engineering
Massachusetts Institute of Technology

An extensive program of atmospheric sampling is being carried out at five sites in upstate New York to better understand the impact of regional air pollution sources on this area. By using Instrumental Neutron Activation Analysis (INAA) to measure mercury concentrations in the vapor, particulate and aqueous phase the sources and fate of this hazardous air pollutant may be assessed. Unique properties of the MITR-II, and new methodologies which have been developed for vapor and particulate analysis allow simpler, more sensitive and more reliable determinations than were previously possible with INAA. A technique for measuring mercury in wet deposition samples by INAA is currently being investigated.



Session 3

3-A Thermal Hydraulics

Location: 2–103
Time: Saturday, 9:30–11:00

Identifying Typicalities of Scaled Thermal Hydraulic Facilities

Sivakumar Gopalnarayanan
Department of Mechanical Engineering
University of Maryland

The natural circulation heating of the primary system components of a B & W Pressurized Water Reactor during the late stages of a severe accident scenario is studied. The purpose of the experiments is to determine the time to failure of the primary system pressure boundary at the pressurizer surge line nozzle location. The temperature response of the model is translated to prototype conditions using the scaling relationships. Sulfur hexaflouride is used in the model to simulate the high pressure steam in the full scale reactor. The energy distribution is anticipated to be symmetric between the two hot legs. However, it is found that as much as fifty percent more energy is transported to one leg, chosen at random, than to the other. Since the surge line nozzle is located in only one of the two hot legs in the prototype, the time to failure depends significantly upon which of the two hot legs becomes favored. The objective here is to ascertain that the observed phenomena is real and is not a typicality of the model. Diagnostic tests indicate a thermosyphon flow that sets in following an unstable situation when the gas in the line connecting the top of the two hot legs is cooler than the gas in the plenum. This thermosyphon flow is superimposed on a dominant recirculating flow resulting in an asymmetric energy transport in the model. The methodology used in identifying this mechanism and minimizing its influence on the time to failure in the prototype is presented.

Velocity Measurements in the Horizontal Section of the Hot Leg of a B & W Scaled Model Reactor

Timothy C. McNair
University of Maryland

One intriguing question of the severe accident scenario, in which the inventory of a pressurized water reactor is boiled into steam and the water remaining in the bottom of the steam generators acts as a seal, is "What are the characteristics of the fluid flow in the horizontal portion of the hot leg?" Since buoyant forces act only in the vertical, some other force or combination of forces must be suspect in propelling the fluid. It was surmised that a counter current flow was necessary, with the hotter fluid at the top of the pipe, and the cooler fluid at the bottom.

A series of experiments was devised to examine that flow. The horizontal section of the hot legs of a Babcock and Wilcox Pressurized Water Reactor model was instrumented with two rakes of 5 thermocouples, one closer and the other further from the vessel, in the vertical centerline. Assuming a laminar flow, the thermo-couples were placed in equal cross sectional areas.

The Adiabatic Mass/Energy Balance suggested that the velocity of the outgoing stream (away from the vessel) was on the order of tens of centimeters per second and, because the hot leg is a closed pipe, the incoming stream velocity would be of the same order if the fluid was indeed counter currently flowing. A visual inspection of the temperature profiles indicated that the flow was counter current, as the temperature difference between thermocouples less than four inches distant was roughly 50 C. Adiabatic Mass/Energy Balance also suggested that the interface between the hot and cold streams was closer to the top of the pipe than near the axis, as one would expect. We understood that an "interface" was an artifice, since the reality would be a thick mixing layer, but it helped us to understand the results of the statistical methods employed.

Assuming the Taylor Theorem to be correct; i.e., that a lump of fluid moves relatively unchanged over small distances in short periods, and knowing that the data sets were too small (1050 points) for traditional cross correlation methods, K. K. Almenas proposed a temporal shift cross correlation whereby the temperature profiles (from the outer and inner rakes) are normalized to zero, then shifted in time, towards and away from one another until a maximum cross correlation coefficient is found. At the point of the maximum coefficient, knowing the distance between the rakes, the velocity is determined.

The results were as follows:

- The hot stream velocities were found to be 12 to 25 cm/s.
- The cold stream velocities were found to be 5 to 12 cm/s.
- The "interface" could span three thermocouples.

High Heat Flux Thermal Hydraulic Facility

Anthony Hechanova
Massachusetts Institute of Technology

A high heat flux thermal-hydraulic facility was designed and built to investigate limits of water cooling technology relevant to fusion divertor requirements. The International Thermonuclear Experimental Reactor (ITER) operating conditions are assumed to be representative of near-term divertor parameters. The facility can attain major parameters of channel size, flowrate, pressure and coolant subcooling in the range specified in the ITER conceptual design. An innovative heater design is used to emulate the thermal boundary conditions at the divertor strikepoint. A 45 kW power supply delivers up to 2200 amps across a resistive heater producing a single-sided spike to the coolant channel. Currently, heat fluxes as high as 6 MW/m^2 have been measured using first generation heaters. Future work relies on the development of heaters capable of delivering 20-40 MW/m^2. This appears feasible as fabrication techniques are refined.

3-B Corrosion Science/Waste Issues

Location: 2–105
Time: Saturday, 9:30–11:00

Mass Transport Phenomena in Single-Crystal Stainless Steel Welds

Douglas Corrigan
Rensselaer Polytechnic Institute

By studying microscopic dendritic solidification patterns in single crystals of austentitic stainless steel as a function of melt pool shape, in conjunction with the effects of convection patterns within the the weld pool before solidification, theoretical models can be formulated that relate the crystalline-solidification characteristics to the macroscopic-physical properties of the welds. Hot-cracking effects and the structural integrity of welds are directly related to the microstructural-solidification formation. In this study, various elements were introduced into the weld pool for the purpose of developing a technique for tracing the convection- flow patterns inherent in welds. The ideal additive element in this study is one that accurately reveals the convective patterns without interfering with dendritic growth patterns. Six elements were chosen for evaluation: palladium, carbon, platinum, gold, tungsten, and tantalum. Through conventional back-scattered-electron microscopy, the location of the trace element was mapped in each case to reveal the convection currents due to the melt-pool dynamics.

Characterization of Glass Containing Mixed Waste from Rocky Flats Plant Sludge

Anthony Brinkley
Massachussets Institute of Technology

Glass containing mixed wastes from Rocky Flats plant sludge was tested using the MCC-1P static leach test in order to determine the corrosion mechanism of the glass. Glass compositions for Rocky Flats used thorium in acid solution as a surrogate waste for uranium. This low level waste glass contained approximately 16 ppm of thorium at 100% waste loading. Glass was composed of a Si-Na-Al-[B]-Ca-Fe-Mg-K-S-P-Th structure. Waste loadings from 50% to 100% were used with melting temperatures ranging from 1250 C to 1350 C. The MCC-1 test used a monolithic glass sample approximately 1 cubic cm in volume with a glass surface area to leachate volume of 0.01/mm. The test matrix consisted of 3, 7, 14, 28, 90, and 180 day tests at room temperature, 40 C, and 90 C. Results showed diffusion controlled leaching at room temperature for low waste loading samples and solubility limit controlled dissolving at 90 C and 180 days for most glass compositions. Typically, the higher the waste loading, the higher the temperature, and the higher the silica content, the more durable the glass. Leaching was done in Teflon containers using DIW. As a result of these tests, a long term prediction could be made as to the suitability of this waste buried in an underground repository. Results show that the high waste loading glass melted at high temperatures had a leach rate for Silicon and Sodium of approximately 0.06 g/m/m/day and 0.001 g/cm/cm. Sodium leached from the glass at the highest rate and K, Th, S, P, Mg, and Al were all at the ICP-AES detection limits.

Application of a Passive Electrochemical Noise Technique to Localized Corrosion of Candidate Container Materials

M. A. Korzan
Department of Nuclear Engineering
Massachussets Institute of Technology

One of the key engineered barriers in the design of the proposed Yucca Mountain repository is the waste canister that encapsulates the spent fuel elements. The current candidate metals for the canisters to be emplaced at Yucca Mountain include cast iron, carbon steel, Inconel 825 and titanium code-12. This project was designed to evaluate passive electrochemical noise techniques for measuring pitting and corrosion characteristics of candidate materials under prototypical repository conditions. Experimental techniques were also developed and optimized for measurements in a radiation environment. These techniques provide a new method for understanding material response to environmental effects (i.e., gamma radiation, temperature, solution chemistry) through the measurement of electrochemical noise generated during the corrosion of the metal surface. In addition, because of the passive nature of the measurement, the technique could offer a means of in-situ monitoring of barrier performance. Testing was completed to compare the effects of temperature, radiation and simulated radiation using hydrogen peroxide. For tests using Inconel counter electrodes and carbon steel working electrodes at 25, 50 and 90 C, the increased temperature produced a higher mean voltage as expected. The 90 C run also had a large increase in standard deviation compared to the lower temperature runs. For data analysis, the power spectral density (psd) of the entire current trace for each run was calculated in decibels within the frequency range of interest—from the minimum frequency of the inverse product of the number of samples and the time increment to the maximum frequency of the inverse of twice the time increment. Analysis of the psd was interpreted to indicate localized corrosion in the low frequency range and general corrosion in the higher frequency range. For the temperature comparison runs, an increased temperature produced higher corrosion activity along the entire frequency range. To compare the effects of radiation, tests were done with titanium counter and working electrodes at 90 C using the MITRII spent fuel pool for the radiation source. The radiation environment caused the mean current value to be much lower, and the psd curve also showed less activity for the run exposed to radiation. To simulate radiation, 1 ppm hydrogen peroxide was added to some tests with carbon steel as the working and counter electrodes. This had no significant effect on either the current trace or the psd. One ppm hydrogen peroxide was determined to be insufficient to replicate the chemical changes produced by irradiation of the magnitude expected at the proposed Yucca Mountain repository.

Modeling a Hypothetical Criticality Accident in a Waste Super-Compactor

M. J. Plaster B. Basoglu C. L. Bentley M. E. Dunn
A. E. Ruggles A. D. Wilkinson T. Yamamoto
H. L. Dodds
University of Tennessee

Nuclear waste disposal is a concern in both the commercial and defense nuclear industries. Currently, the waste material may only be stored. Nuclear facilities have limited space for the storage of waste material and the optimum utilization of this space is of paramount importance. Compaction of containers which hold the waste material in order to reduce its volume increases the amount of waste that can be stored in an available area. It is possible, although highly unlikely, for a sufficient amount of fissile material to be placed in a container to be compacted which could result in a nuclear criticality accident during the compaction process. This work is a study of a hypothetical nuclear criticality accident in a waste super-compactor. Specifically, we have developed a mathematical model to predict the consequences of such an accident. The consequences of hypothetical accidents are a prerequisite for determining adequate emergency procedures which may be needed to mitigate the effects of such accidents.

The material being compressed in the compactor is assumed to be a homogenous mixture of Be and ^{249}Pu contained in a thirty-five gallon, twelve gauge, carbon steel drum. The reactor point kinetics equations with simple thermal-hydraulic feedback are used to model the transient behavior of the system. A lumped parameter energy balance is performed to determine the bulk temperature of the system. A computer code, SKINATH-SC, has been developed to solve the model equations. SKINATH-SC calculates the fission power history, fission yield, the bulk temperature history of the system, and several other thermal-hydraulic parameters of interest.

In order to validate SKINATH-SC as much as possible, the code was modified to be case specific for the calculation of several experiments. The results of these calculations are in good agreement with the experimental results. One example of this agreement is a calculation of the DOSAR reactor for a positive 4.3 cent step change in reactivity. The modified version of SKINATH-SC calculates the maximum power pulse as 1.6×10^{13} fissions per second which agrees quite well with the DOSAR experimental result of 1.8×10^{13} fissions per second.

Calculations using SKINATH-SC have been performed for the waste super-compactor for various hypothetical accident scenarios represented by final external reactivity insertions of 20, 10, 5, 1, and 0.5 dollars. The consequences of these accidents vary significantly. Specifically, the maximum power pulses for the various scenarios range from 1.04×10^{17} to 4.85×10^{20} fissions per second. The fission yields vary from 8.21×10^{17} to 7.73×10^{18} fissions. The maximum bulk temperature of the system varies from 412 to greater than 912 K (melting point of ^{249}Pu). As stated previously, results such as these are needed in order to develop adequate emergency plans for such accidents.

Session 4

4-A Reactor Physics

Location: 2–103
Time: Saturday, 1:00–2:30

Neutron Energy Spectra Determination for the University of Massachusetts Lowell Research Reactor using Foil Activation

Robert Marseglia
University of Massachusetts Lowell

Characterization of neutron energy spectra for the University of Massachusetts Lowell Research Reactor is useful for several reasons. The characterization will allow the University to market the reactor for use by vendors and will enable more thorough and diverse research. Also, this characterization will be performed again when the HEU (high enriched uranium) fuel is replaced with LEU (low enriched uranium) fuel as early as the summer of 1994. Having performed neutron energy spectra determinations for the HEU fuel will allow more efficient spectra determinations for the LEU fuel.

In order to determine a neutron energy spectrum, several concurrent activities were performed. Foil activation was done in core location D-1, a radiation basket located at the periphery of the core. Activation was done at approximately 100 kW, providing activities which gave good counting results while minimizing radiation exposure. Counting was performed using a GeLi (germanium-lithium) detector. The count rate obtained from the GeLi detector was converted to a saturated activity which was used in the computer code SAND-II.

SAND-II is an unfolding code which uses several saturated foil activities (measured activity) to calculate a differential flux spectrum. The chosen foils are sensitive to different neutron energies, resulting in saturated activities from fast, epithermal and thermal neutrons. Unfolding of a neuron energy spectrum is done to obtain a measured neutron energy spectrum from a calculated (reference) spectrum library. The code will chose the best reference spectrum based on the standard deviation of the measured to calculated activities. SAND-II will extrapolate or interpolate sections of the energy spectrum which are not covered by foil activities. A differential and an integral flux spectrum are obtained from SAND-II, showing the neutron energies and magnitudes over an energy range of 0.001 eV to 18 MeV.

Results from SAND-II show that the code calculates a differential flux spectrum with a similar shape to that of the reference spectrum. The code will run until the maximum specified number of iterations has been reached or until the spectrum has converged to a selected standard deviation. Future work is needed to complete the core characterization. First, a 2-D transport model specific to the University of Massachusetts Lowell Research Reactor will be used to determine a more accurate neutron energy spectrum. Using the 2-D trial spectrum will show if the code determines a neutron energy spectrum which is a strong or weak function of the initial reference spectrum. Second, other locations, including the Rabbit Tubes, other Radiation Baskets and the Beamports, will be used for spectra determinations.

Doppler Weighting and Radial Peak Reduction Factor Development for Maine Yankee CEA Ejection Analysis using STAR

Stephen Peterson
University of Massachusetts Lowell

A Control Element Assembly (CEA) Ejection analysis is performed each cycle for the Maine Yankee Atomic Power Station. The current method uses Doppler weighting and radial peak reduction factors to conservatively incorporate complex three dimensional (3-D) effects into a point kinetics analysis approach. The Doppler weighting factor is used to account for Doppler feedback effects which are specific to a more complex 3-D analysis. This factor is applied to modify the corewide Doppler feedback reactivity from the point kinetics approach to provide a conservative, but more realistic, corewide reactivity feedback based on 3-D analysis results. The radial peak reduction factor is used to account for a lower radial peak in the vicinity of the ejected CEA as calculated by the transient 3-D analysis as compared to the radial peak calculated from a static 3-D analysis. This factor is used to reduce the magnitude of the radial peaking increase used in the point kinetic analysis. Currently, Maine Yankee uses generic conservative factors derived by Combustion Engineering (CE). However, Maine Yankee has recently had approved a method to develop Maine Yankee specific factors which need not be so conservative. This study describes the implementation of the new method and the development of new Doppler weighting and radial peak reduction factors. The resulting factors will provide more accurate and less limiting CEA Ejection results.

Validation of KENO V.a with ENDF/B-V Cross Sections for ^{233}U Systems

M. E. Dunn B. Basoglu C. L. Bentley C. Haught M. J. Plaster
A. D. Wilkinson T. Yamamoto H. L. Dodds
Nuclear Engineering Department
University of Tennessee

^{233}U is a fissile isotope which is generated by nuclear reactors operating on the thorium fuel cycle. Criticality safety is an important concern that must be addressed in the storage of this fissile material. In order to establish subcritical storage limits on the basis of calculations, the calculational method (e.g., Monte Carlo) and neutron cross section data must be validated against experimental criticality data. Once validated for particular systems, the calculational method and cross section data can then be used for studies of similar systems which contain ^{233}U. The purpose of the current work is to validate the 44 and 238 energy group ENDF/B-V cross section libraries for ^{233}U systems using KENO V.a, a multigroup Monte Carlo code.

A series of 51 ^{233}U critical experiments (for which experimental values of $k_{eff} = 1.0$) with ^{233}U ratios ranging from 0 to 1986 were selected to validate the ENDF/B-V libraries. All experiments were modeled using the 44 and 238 group ENDF/B-V, the 27 and 218 group ENDF/B-IV, and the 16 group Hansen-Roach libraries. The mean calculated k_{eff} for all experiments using the 44 and 238 group libraries is 1.00896 ± 0.00211 and 1.00636 ± 0.00200, respectively (one standard deviation). In comparison, the mean calculated k_{eff} using the 27, 218 and 16 group libraries is 1.01419 ± 0.00379, 1.01252 ± 0.00379, and 0.99905 ± 0.00193, respectively.

In a general comparison, the mean k_{eff} values for the ENDF/B-V libraries are 0.5-0.6% lower than the ENDF/B-IV results while the ENDF/B-V values are 0.7-0.98% higher than the Hansen-Roach results. In summary, the use of KENO V.a with either the 44 or 238 group ENDF/B-V libraries is considered to be validated for ^{233}U systems of the type considered in this work.

Effect of External Surfaces on Leakage in SHEBA-II

John Miller
University of New Mexico

SHEBA-II is a low-enriched (5%) uranyl fluoride Solution High-Energy Burst Assembly located at Los Alamos National Laboratory. SHEBA-II generates relatively slow neutrons such as those emitted by critical solutions and was designed especially for proof testing critically accident detection systems. It is fueled with an aqueous solution of $U(4.95)O_2F_2$. The cylindrical stainless steel container has an inside radius of 23.9 cm and a height of 73.7 cm. There is a central thimble which handles a safety rod as required. The thimble has an outside radius of 3.0 cm and is normally empty. The entire assmbly can be operated above ground or while placed inside a pit. The pit walls and floor are lined with 0.64 cm thick stainless steel. Outside the stainless steel is concrete.

As SHEBA-II is designed with about 25% leakage, the effects of the pit on the critical solution height have been examined through the use of computer models. Solutions systems are difficult to characterize and may not be adequately analyzed with every available cross section set. For this work, three computer codes and associated cross section libraries were used. A deterministic S_n code, TWODANT, was used with a 16 group Hansen-Roach cross section library. Two Monte Carlo codes were used—MCNP with a continuous cross section library, and MONK with an 8220 pointwise library. The critical height was calculated with each of the three codes for each of three different situations:

1. SHEBA-II above ground with no external surfaces affecting leakage,
2. SHEBA-II inside the pit with no top surface, and
3. SHEBA-II inside the pit with a top surface of 10 cm of polyethylene.

The results indicate less than 0.3 cm difference in estimated critical heights for the three different situations. In fact, there was more variation among the codes than for the different scenarios using any one code.

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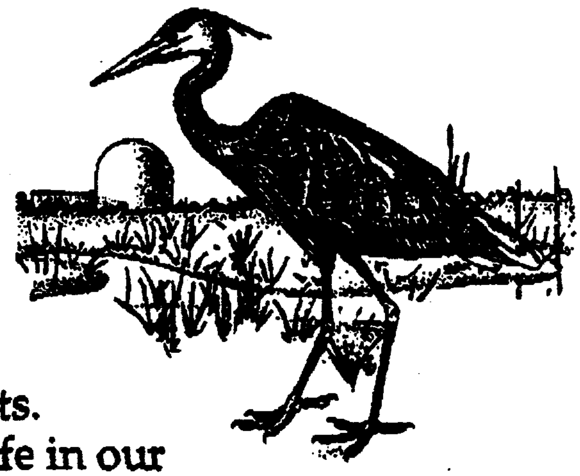

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4-B Corrosion Science/Waste Issues

Location: 2–105
Time: Saturday, 1:00–2:30

Buffered Tungsten Reference Electrode for Hydrogen Water Chemistry Applications

B. A. Hilton
I. S. Hwang
Massachusetts Institute of Technology

In order to mititgate irradiation assisted stress corrosion cracking of austenitic stainless steels in boiling water reactor (BWR) systems, efforts to lower elecrochemical corrosion potential (ECP) are being made. This has generally been done by injecting hydrogen into the reactor coolant. A tungsten reference electrode that can be used to measure ECP over a wide range of BWR water chemistry has been developed. The principal advantage of the electrode over currently used internal Ag/AgCl electrodes is its long-term stability in both normal water chemistry (NWR) and hydrogen water chemistry (HWC) even at high hydrogen concentrations. Disadvantages of a bare tungsten electrode, associated with its sensitivity of pH and redox agents, have been overcome by using a saturated $Ca(OH)_2$ solution as a buffer. It is assumed that the buffered tungsten electrode (BTE) potential is determined by $W/CaWO_4/WO_4^-$ equilibrium. Long-term tests have been made in simulated BWR operating conditions using an in-pile coolant chemistry research loop at the MIT Nuclear Reactor Laboratory. The BTE was exposed to a wide range of pH and redox potentials, including NWC and HWC with up to 2 ppm hydrogen. Its potential was stable during two campaigns; each involved over 20 heatup/cooldown transients, between 25 C and 300 C, over a period of eight weeks. An internal Ag/AgCl electrode had degraded during the second campaign in HWC. Since the BTE's potential is about 350 mV lower than the H/H^+ equilibrium at 288 C, we believe that the BTE is thermodynamically stable in HWC as well as NWC.

Design, Construction, and Commissioning of an In–Core ECP Testing

Theodore J. Weber
Department of Nuclear Engineering
Massachusetts Institute of Technology

Irradiation assisted stress corrosion cracking (IASCC) has caused the failure of several austenitic stainless steel parts in boiling water reactor (BWR) cores. In order to study the characteristics of failure due to IASCC a facility has been designed and built at the MIT Nuclear Reactor Laboratory. Integral to this study is the effect of various water chemistries and other factors relevant to the corrosion potential in the reactor core.

A facility to study electrochemical corrosion potential (ECP) in typical BWR water and radiation environments has been designed, built, and has recently begun in-core operation. This facility positions 6 ECP electrodes in the core of the MIT research reactor and circulates water with controlled temperature and chemistry past the electrodes. the electrodes are incorporated to measure the ECP to varying water chemistry, flow rate, in-core position, and reactor power level. A chemistry control system was designed and built to measure and control the water chemistry. The facility and operating procedures were designed to minimize radiation exposure of personnel during facility operation and transfer to a hot cell for storage and maintenance. the facility's design also ensures that testing mishaps pose minimal risk to safe reactor operation.

Out-of-core tests have been successfully completed. In-core testing began this month. A program of tests is planned to investigate the effects of neutron fluence on ECP.

Criticality Analysis of Spent Fuel Storage Options Using KENO V and MCNP

Grace M. Lam
University of Massachusetts Lowell

Spent fuel storage design has taken a new wave of interest in the nuclear industry. With the lack of long-term storage facilities, optimization of the existing storage pools and examination of feasible spent fuel storage alternatives, such as dry storage, are essential. The major emphasis of this work is to establish in-house criticality capability with a series of base designs to demonstrate the use of KENO V and MCNP for general spent fuel storage criticality analyses. The primary effort will be on the implementation and verification of local capability with KENO V and MCNP.

A series of critical experiments were performed during the late 1970's by The Babcock & Wilcox Company (B & W). There were 20 critical assemblies constructed to simulate a variety of close-packed LWR fuel storage configurations. The verification phase of this study will utilize these critical experiments for comparison with real measured data.

This series of experiment provide a solid basis of benchmark criticality data. A subset of these experiments will be examined using KENO V along with available cross section libraries as part of a larger data and code validation effort.

Preliminary Evaluation of Radioactive Effluents for an Upgraded MITR-III Research Reator

Joseph J. Bambenek
Massachusetts Institute of Technology

As the MITR-II approaches the expiration of its licence in 1996, decisons must be made regarding the future of the reactor including whether its power should stay at 5 MW or be raised to 10 MW. Complicating the situation is a tightening of the NRC Regulations of radiation releases, which are promulgated in 10CFR20 (also known as Part 20).

Based upon calculations in this report, it appears that there is apporximately a linear relationship between the effluents produced by a 5 and 10 MW reactor. This relationship would approximately hold with all conditions being equal. However, there is a chance for deviation in either direction from this linear relationship due to the nature of the production of the effluents at the MIT Reactor. Based upon the findings of this report, the current MITR-II reactor should be able to meet any forseeable standards that might be promulgated by the NRC. The compliance of a 10 MW MITR-III reactor is in much greater doubt, however.

One alternative for handling this situation, albeit undesirable, is to hope that a 10 MW MITR-III would initially meet the 1994 10CFR20 regulations as well as all subsequent revisions to Part 20 during MITR-III's lifetime. Fortunately, there are two much safer alternatives. The first would be to attempt to prove that the current dilution factor of 3000 is one order of magnitude too conservative; and to rigorously demonstrate and calculate a new dilution factor, using advanced diffusion models and validation studies. While this likely could be done from a technical standpoint, there would be a cost associated with this and the possibility that the NRC would not allow the change on political grounds. The other option would be to install an off-gas treatment or some other post-source term system to reduce the amount of effluent released. A problem associated with this option is cost. While such a system is probably not needed to meet the intent of the NRC regulations, this may be the financially and politically most effective method of dealing with the problem. Further study should be made on the economic costs and benefits of these two options. Regardless of the option chosen, the reactor redesign efforts should include considerations for further reductions in the source terms.

Session 5

5-A Radiation Science Applications

Location: 2–103
Time: Saturday, 3:00–4:30

Non-Traditional Application of a Cyclotron as an Electron Buncher

Devin P. Barry Taven Hendrick Dean Richardson
Rensselaer Polytechnic Institute

With the increasing use of linear accelerators in industry and research, more emphasis must be placed on finding suitable ways to make such devices more cost effective, reliable, and efficient. Linear accelerators drive electrons to the necessary energies needed for specific applications. It is necessary for these electrons to enter the accelerating system in a manner tht will result in a high beam current. This may be achieved in several ways.

One such way is by using a cyclotron as a buncher. Its unique ability to bunch particles in a very precise and defined manner lends it to applications as a stable electron source. It has always been able to accelerate particles well, but with its specificatopns based on mass, and the electron's tendency to emit morst of the energy absorbed when accelerated, the cyclotron has been overlooked as an electron accelerator. Low non-relativistic energies are not often considered; but for certain applications, a cyclotron's beam dynamics and phase characteristics can be very effectively utilized.

A particular application to be discussed is the use of a cyclotron as a buncher in a microwave electron accelerator. The electrons in a microwave accelerator system are accelereated by their transport on the crest of the microwaves in the accelrator wave guide. In order to maximize imparted energy from the microwaves to the electrons, it is necessary to spatially distribute the electrons in well defined packets as they leave the electron source. This is known as electron bunching.

Additional topics of interest will include phase stability and particle bunching in microwave driven accelerator systems. By aligning the phase of the cyclotron and the accelerator, the particles are injected into the wave guide with a maximum efficiency. This allows the electrons to receive the full energy of the microwaves, without losses associated with accelerator bunching. Large improvements in efficiency can be made with this type of electron injector.

Advanced Design of Efficient Linear Induction Accelerator

Devin P. Barry Taven Hendrick Dean Richardson
Rensselaer Polytechnic Institute

With the increasing use of linear accelerators in industry and research, more emphasis must be placed on finding suitable ways to make such devices more cost effective, reliable, and efficient. Linear accelerators drive electrons to the necessary energies needed for specific applications. Advances have been made in materials, power supplies, switches, cryogenics, and microelectronic controls. With the advent of better accelerator systems, commercial radiation processing can benefit with increases in efficiencies, reduced maintenance, increased availability, automation, and more versatility. This leads to improved economic feasibility.

The linear accelerator is the primary component to benefit from the revolutions in technology. The advent of cost effective superconductors is an enabling technology which allows efficient inductive energy coupling. Linear induction accelerators have a number of important advantages over direct-action acclerators. One in particular that will be adressed is the possibility of accelerating charged particles to high energies with an acceleration rate of a few MeV per meter of apparatus length. This can be accomplished at a relatively low voltage on the accelerator elements with a high efficiency conversion of electrical eneergy to charged-particle kinetic energy.

The main topic to be presented will be inductive coupling. Magnet currents, geometries, power supplies, superconductor design, and material selection are the central components here. Collectively the accelerating field, which is actually a sharply defined changing magnetic field in a particular region, is produced by these components. Creation of close proximity circumferencial currents and their associated magnetic fields couples with the centrally defined electrons and has an accelerating effect. With enough systems in series, a very high exit potential can be realized.

Microelectronic integration with control systems and high frequency oscillators control how the beam will also be defined. Beam timing, magnetic currents, beam properties, exit potential and phase stability can all be determined and defined with simple off the shelf computers. This control system, when properly implemented, has the capacity to automate all beam controls. Radiation monitoring, cryogenic temperatures, and other afety concerns can also be monitored with a central unit.

Experimental Beta Dosimetry in Radiation Synovectomy

L. S. Johnson J. C. Yanch
Department of Nuclear Engineering &
Whitaker College of Health Sciences and Technology
Massachusetts Institute of Technology

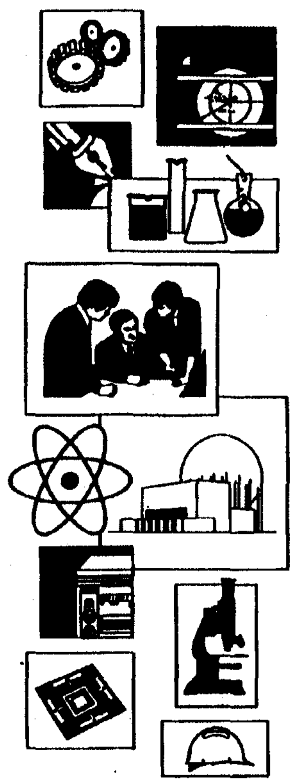
Beta dosimetry was experimentally determined for a radionuclide of interest in radiation synovectomy, an intra-articular radiation therapy to treat rheumatoid arthritis. The treatment consists of the injection of a short-lived, low-energy beta-emitting radionuclide directly into the joint in order to eliminate swollen, inflamed tissue (synovium) through irradiation. The radionuclide investigated was ^{165}Dy. Ultrathin radiachromic dosimeters were used to measure absorbed dose distributions in joint phantoms and the knees of fresh, human cadavers. In the phantoms, thin slabs of aluminum and solid water (a specially formulated, commercially available plastic) served as bone-, articular-cartilage-, and tissue-equivalent materials; planar beta sources were prepared by drying ^{164}Dy onto filter papers and irradiating the papers at the MIT nuclear reactor. Dosimeters sandwiched between the aluminum and solid water slabs measured absorbed dose at depth in the phantom. In the cadavers, knees were injected with a therapeutic dose of radioactivity which was allowed time to decay; dosimeters stitched to various locations in the joint measureded absorbed dose at several points on the synovial surface. Results of the experiments can be used to estimate dose distributions in treated joints. In particular, the results provide previously unavailable information regarding the treatment's potential for producing radiation damage in other, non-target tissues, such as bone and articular cartilage. Dose to bone is particularly important since it is a dose-limiting structure to be protected in procedures involving bone irradiation.

Spectroscopic Measurement of Impurity Transport Coefficients and Penetration Efficiencies in Alcator C-Mod Plasmas*

M. A. Graf J. L. Terry J. E. Rice E. S. Marmar J. A. Goetz
G. M. McCracken F. Bombarda
M. J. May
Plasma Fusion Center
Massachussetts Institute of Technology

Impurity transport coefficients and the penetration efficiencies of intrinsic and injected impurities through the separatrix of diverted Alcator C-Mod discharges have been measured using a number of x-ray, VUV, and visible spectroscopic diagnostics. The dominant low Z intrinsic impurity in C-Mod is carbon and is found to be present in concentrations of approximately 0.5%. Molybdenum, from the plasma facing components, is the dominant high Z impurity and is typically found in concentrations of about 0.03%. Trace amounts of medium and high Z non-recycling impurities can be injected at the midplane using the laser blow-off technique and calibrated amounts of recycling gaseous impurities can be introduced through fast valves either at the midplane or at various locations in the divertor chamber. A five chord crystal x-ray spectrometer array with high spectral resolution is used to provide spatial profiles of high charge state impurities. A three channel multi-layer mirror based XUV monochromator observes high, medium, and low charge state bands of line emission from molybdenum. An absolutely calibrated grazing incidence VUV spectrograph with high time resolution and a broad spectral range allows for the simultaneous measurement of many impurity lines. Various filtered visible and soft x-ray diode arrays allow for spatial reconstructions of plasma emissivity. The observed brightnesses and emissivities from a number of impurities are used together with the MIST transport code and a collisional-radiative atomic physics model to determine charge state density profiles and impurity transport coefficients. Comparisons of the deduced impurity content with the measured Z_{eff} and total radiated power of the plasma are made. Using the calibrated gas injection system it is observed that only about 1% of the injected high recycling argon penetrates into the core plasma, whereas the penetration of the laser injected impurities is approximately 30%. Little difference is observed between gas injections at the midplane and at the divertor plate. Strong changes in penetration efficiency without corresponding changes in core transport are seen following plasma detachment from the divertor plate, perhaps owing to changes in edge density and temperature at that time.

*Supported by USDoE Contract No. DE-AC02-78ET51013.



5-B Computational Methods/Reactor Operations

Location: 2–105
Time: Saturday, 3:00–4:30

Computerized Data Acquisition for the MUTR

Wayne McCullough
University of Maryland

Using a MS-DOS 486/50 and a Strawberry Tree card, the computer program allows operators at the Maryland University Training Reactor to monitor various systems of the reactor. Currently all three control rods, reactor period, log percent power, one linear power channel, fuel temperature and bulk water temperature are monitored. All of these channels are connected to the computer through an isolation amplifier to minimize the risk of computer trouble affecting nuclear instrumentation.

The program was written using Borland Pascal v.7.0, taking advantage of its object oriented programming. Borland Pascal was chosen for several reasons: familiarity of the language, strong typing, and availability of drivers for the Strawberry Tree card. The majority of the setup of the program is maintained in a configuration file. It is unnecessary to recompile the program for most reconfiguration. The program also dynamically queries the system clock, and attaches a real time to each data point, simplifying analysis.

By writing the program in house reactor specific features are more easily handled. It allows the program to display an interpret period information, and estimate and display current rod worth based on the current rod worth calibration curves.

Using the program, the operator can alter the sampling rate while running. This program can sample from rates faster than 50 hz for special configurations to arbitrarily slow rates. The program will graphically display the channel on a signal-time graph. This graph can operate at full speeds (i.e. one graph point per sample) or at a slower speed to see long-term trends.

The program allows the operator to save the data real time to the computer hard drive. The operator can fully control the rate of data saving to the hard drive. The operator can specify to save a full speed, or to save at a time interval.

The program allows for alarm signals for each channel. The alarm settings are adjustable in the configuration file. For each channel there is a warning and an alarm setpoint. When a channel goes above a warning or alarm the program will display the information textually on the screen, save the information to a log file, change the color of the corresponding bar graph, and change the color of the part over the setpoint on the line graph.

Flow Regime Identification with Neural Networks

William Granger Jason Gruzleski Gamaliel Rivera
Vaughan Scott
Rensselaer Polytechnic Institute

In numerous industrial settings today, there is a need for the ability to quickly and accurately identify specific flow regimes in two-phase flow in a horizontal pipe. These flow regimes are affected by several factors, including relative amounts of gas and liguid, relative velocity of gas and liquid, and viscosity, and they include wavy flow, plug flow, slug flow, and annular flow. Applications exist in which certain of these flow regimes can be non-productive, or worse yet, dangerous to the operation. These dangers arise mostly from inadequate heat transfer allowed by a certain regime. Therefore, there is a need to be able to quickly and accurately identify which flow regime is present, so that corrections can be implemented. This kind of determination is made difficult be the fact that most such pipes are opaque, barring direct observation, and also that conventional pressure-signature data is so unpatterned as to be unreadable by humans, and readable by conventional software given sufficient length of data (approximately 50 seconds worth). This amount of time is too great; damage could be irreversible by the time the improper regime was discovered.

The presentation will discuss how quickly (taking less than one second of pressure data) identification will be achieved through the use of neural network software, a type of artificial intelligence. The first topic covered will be the collection of test data from an experimental two-phase flow laboratory. Several data sets were taken for each flow-regime mentioned above; in this case the regimes were visible, since the horizontal pipe was made of clear material. These initial data sets will be used to "teach" the neural net program to identify the patterns for each regime. The next subject in the presentation will be a program to identify the patterns for each regime. The next subject in the presentation will be a program which performs the fast-fourier transform on the collected test data. The transformation is necessary in order to get the data inta a more "normalized" form which is readable by the neural net program. Finally, the training and testing of the program will be discussed. Once the fourier transofrm is completed, the transformed data can be input into the program. Then, the neutral net is run in training mode, in which it develops weights based on the test data in order to be able to correctly identify between flow regimes. After it has learned, it will be given different test data and allowed to try to identify which flow regimes produced it, based on its weights from the original test data. This determines if the neural net program can successfully accomplish the flow-regime identification.

Attendees

Georgia Tech

Capell, Brent
Klima, Shane
Quan, Diep
Rafferty, Paul

Massachusetts Institute of Technology

Ames, Michael
Bambenek, Joseph
Brinkley, Anthony
Ferri, Matthew A.
Graf, M. A.
Gormely, Bob
Habboush, Isam
Hejzlar, Pavel
Hechanova, Anthony
Hilton, Bruce A.
Hu, Lin-Wen
Huang, Xudong
Johnson, L.
Kazimi, Mujid
Keskin, S.
Korzan, M. A.
Lanning, David
Lucas, Don
Mattingly, Brett
Niemczewski, A.
O'Donnell, Jeff
Rasmussen, Norman
Rogus, Ron
Turek, Mike
Weber, Theodore

Nuclear Regulatory Commission

L'Rourke, Chris
Polich, Tim

Radiation & Health Physics

Frank Masse

Attendees
(continued)

Rensselaer Polytechnic Institute

Allen, Scott	Barry, Devin
Bergman, Jon	Charpentier, Pierre
Corrigan, Douglas	Esaka, Hideo
Funk, Christopher	Granger, William
Gruzleski, Jason	Hendrick, Taven
Leone, Mark	Paulus, Alan
Possert, Joseph	Richardson, Dean
Rivera, Gamaliel	Strydom, Johannes
Umstander, Karl	Winslow, Mark
Wu, Meng-Hsu	

Studsvik of America, Inc.

DiGiovine, Arthur	Knott, David

University of California, Santa Barbara

Bauman, Christopher

University of Florida

Austin, Aaron	Bisson, David
Henderson, David	Ratner, Richard
Wright, Kenneth	

University of Maryland

Basi, Archana	DeLuca, Patricia
Ennaciri, Nadia	Filippone, Claudio
Flippo, Kirk	Floyd, Jason
Gopalnarayanan, Sivakumar	Green, Joseph
Kniffin, Scott	Martz, Troy
McCullough, Wayne	McNair, Tim
Osborne Jr., Timothy	Paradiso, John
Salay, Michael	Tafreshi, Ali

Attendees
(continued)

University of Massachusetts Lowell

Brown, Gilbert	Fyfe, Andrew
Hawkesworth, Eric	Honnellio, Anthony
Huben, Daniel	Lam, Grace M.
Marseglia, Robert	Martin, Jose
O'Neill, Patrick	Pennacchia, Toni
Peterson, Stephen	Phelps, James
Regan, Thomas	Repetto, Robert
Sheff, James	Silvestri, Vincient
White, John	

University of New Mexico

Harmon II, Charles	Jones, Tom
Miller, John	

University of Tennessee

Dunn, Michael	Mattingly, John
Plaster, Michael	

University of Toronto

Deir, Christopher	Taghipour, F.
Hammad K. A.	Lin, Ka Hing

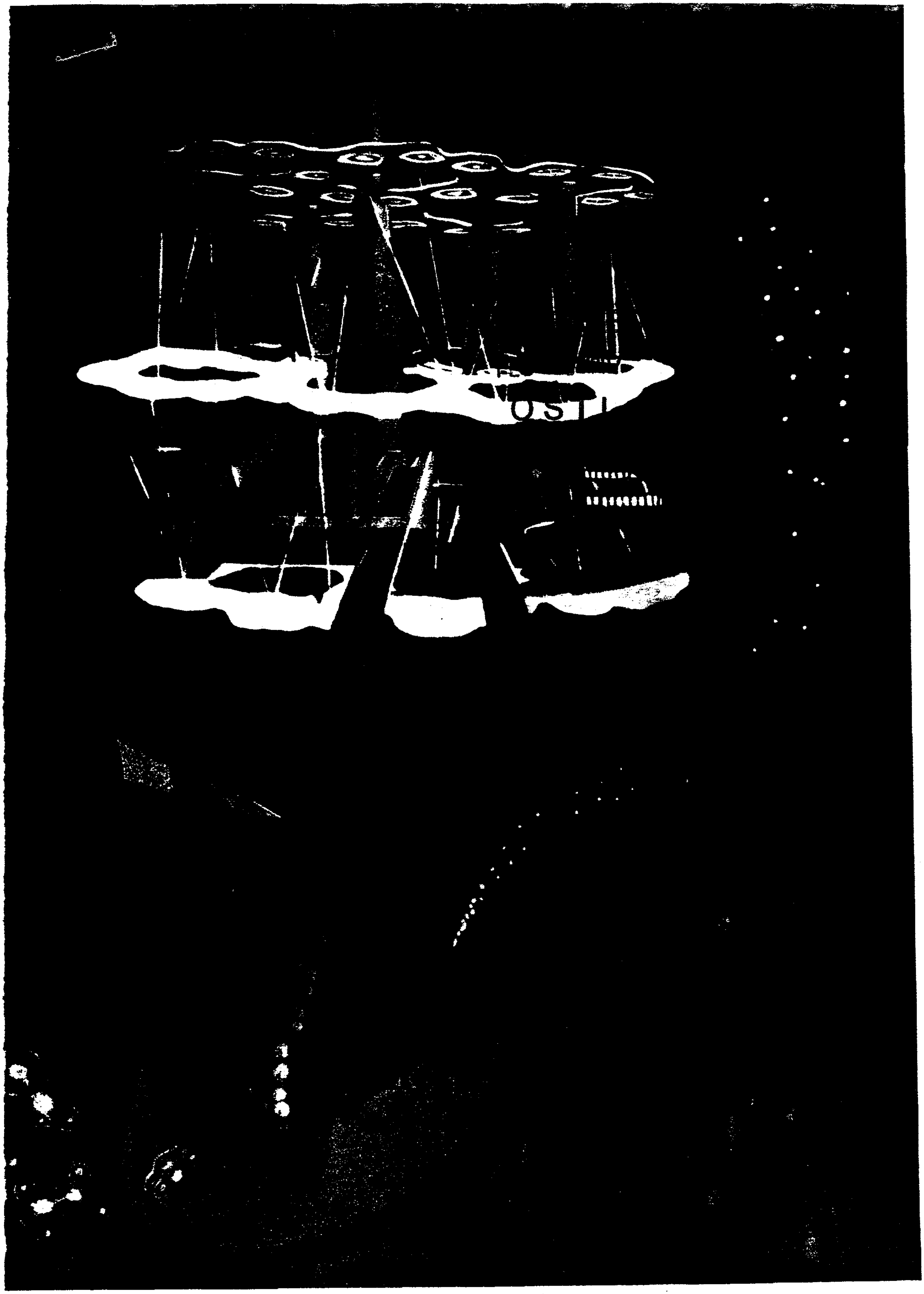
Worcester Polytechnic Institute

Sweeter, John

Yankee Atomic Electric Company

Schultz, Stephen

Author Index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