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SPACE ENGINEERING RESEARCH CENTER

DIRECTOR'S COLUMN

In this issue of the SERC newsletter, we present six research reports from University of Arizona students associated with the Center. The papers presented were selected to give an overview of some of the projects underway at SERC and to suggest the level of student involvement.

Fundamental and encouraging changes have occurred in education at the University of Arizona since the founding of the Space Engineering Research Center. From the outset, SERC has considered graduate and undergraduate education to be an integral part of its mandate. Twenty professors on campus (and three elsewhere) are currently supporting twenty-seven students in SERC research activities. Of these, the majority (21) are graduate students, the remainder undergraduates. Additionally, nine undergraduates are voluntarily working on SERC projects with no financial support whatsoever. Many students have stated an interest in pursuing space as a career, and nine graduate students have begun MS/PhD programs in Space Engineering.

Also, the number of courses in technical space subjects has increased dramatically. One new course, "An Introduction to Space Technologies", taught by Professors Ramohalli and Sridhar, has proved to be exceptionally popular. Introduced only a year and a half ago, this course has had the largest enrollment of any elective course in the Aerospace and Mechanical Engineering Department, reaching a peak of fifty-three students.

Another special course, developed by Dr. Andrew Cutler, entitled, "Space Manufacturing" is scheduled to begin in Spring Semester 1991. This course is open to both graduates and undergraduates--not only to students in the College of Engineering, but also to others adequately prepared in the physical sciences. Its goal is to provide a context within which space manufacturing schemes can be evaluated, as well as to perform some preliminary technical and economic studies.

Existing courses have changed, too. Such traditional engineering courses as Propulsion and Combustion have evolved to include more space disciplines. Engineering students have begun to take courses in departments other than those in the College of Engineering because of the strong cross-disciplinary approach featured at SERC. It is no longer unusual to find a Chemical Engineering student enrolled in a course in the Planetary Sciences Department, or a Materials Science and Engineering student participating in an Aerospace class. Currently three engineering graduate students are pursuing minors in Planetary Science, due entirely to their involvement with SERC.

SERC SEMINARS, FALL 1990

The weekly SERC seminars have become an important focus of research education. Seminars are scheduled in pairs: Faculty Investigators report on their research one week; the following week, one or more of their students make a presentation on the portion of the work assigned to them. Visiting speakers are also included as available.

The following are typical presentations and seminars held during the Fall Semester, 1990:

STUDENT PRESENTATIONS

- August 22--Paul Schallhorn, In-Situ Oxygen Production
- September 5--Bruce Preiss, Figure of Merit Approach to Extraterrestrial Resource Utilization
- September 19--Cameron Williams, Carbonyl Processing of Ferrous Metals
- October 17--Yi Zhao & Charles Massion, Kinetics of Lunar Ilmenite Reduction
- November 14--Tom McCanless, Ilmenite Separation Procedures
- November 28--Jeff Johnson, Titanium Mapping of the Moon
- December 12--Kunal Bose, Release of Volatiles during Heating of Minerals from Carbonaceous Chondrites

SERC FACULTY SEMINARS

- August 29--Kumar Ramohalli, Overview of the SERC Engineering Research Program

Student exposure to the cross-disciplinary approach begins with weekly student/ Principal Investigator seminars. Alternating with speakers from industry, education, or government, students learn of recent results from each other, or from the professors leading the projects. The seminar setting provides a responsive and timely forum for SERC research progress, and at the same time gives students a taste of "science and engineering in action". (See Sidebar.)

The emphasis on research projects is perhaps the most important aspect of SERC education. Students are strongly encouraged to learn by doing, and this kind of stimulus seems to both interest and inspire them in a way seldom seen in conventional lecture/laboratory classes. Several have actually co-authored research papers presented at the SERC Annual Symposium and other professional conferences.

At a time when science and engineering education appear to be on the wane in the United States, SERC is proving to provide the kind of arena for technical education that may be capable of creating the enthusiasm and interest needed to reverse the trend. Nationwide we must somehow interest today's undergraduates in considering technical careers. The lure of space, presented in a relevant, hands-on format and integrated with a wide variety of related disciplines, may well be the key to providing the expertise we need for the next century.

--T. Triffet

- September 12--John Lewis, Overview of the SERC Science Research Program
- October 3--Andrew Cutler, Transportation Economics of Lunar Resource Utilization
- October 10--Farhang Shadman, Hydrogen, Carbon Monoxide, and Carbothermal Reduction of Ilmenite
- November 7--Joaquin Ruiz, Ilmenite Beneficiation on the Moon

VISITING SPEAKERS

- September 26--Sanders Rosenberg, Concepts in Lunar Resource Utilization: Fuel Manufacture
- October 31--William Agosto, Lunar Mineral Beneficiation
- November 21--Steven Howe, The Space Exploration Initiative and Advanced Propulsion
- December 19--Joseph Angelo, Role of Space Nuclear Power in the Lunar-Mars Initiative.

SIMULATION OF AN OXYGEN PRODUCTION SYSTEM

by Glenn Robert Farrenkopf, Graduate Student, Electrical and Computer Engineering Department, University of Arizona. Advisor: Dr. François Cellier, Associate Professor of Electrical and Computer Engineering, and SERC Investigator.

Oxygen is utilized in burning rocket fuel, and comprises a significant portion of the overall weight of a vehicle launched from Earth into space. Since the cost of carrying weight out of the Earth's gravitational field is high, the ability to extract and store oxygen from local planetary resources becomes lucrative. A test bed system for extracting oxygen from carbon dioxide (which comprises 95% of Mars' atmosphere) has been designed and is being constructed at SERC. The development of simulation models of this test bed system is the subject of my research.

There are numerous reasons why modeling and simulation are important in the development of new systems. Often it is not economically feasible or safe to experiment with the actual system. Sometimes the actual system is not available or does not yet even exist. By constructing a simulation model, the feasibility and efficiency of the system can be evaluated for different configurations before system components are actually bought, assembled and connected.

Three simulation models of the oxygen production system are of particular interest. The first involves the static mass flow of CO_2, CO, and O_2 within the system, and is based on thermodynamic and conservation-of-mass principles. From this simulation we can estimate what the production rate of oxygen will be in steady state, and what various system pressures and temperatures can be expected.

The second simulation concerns the static energy flow within the system, and is based on thermodynamic and conservation of energy principles. This simulation allows conditions that were assumed in the first model to be verified, and enables an estimation to be made of the power requirements of the different system components.

The third simulation model will describe the dynamics of the system, and will be based on a modeling and design methodology involving the use of bond graphs. Bond graphs were originally introduced to model mechanical systems, and have since been adapted by Dr. François Cellier to model chemical reaction systems. Chemical reaction bond graphs model dynamic chemical reactions through the use of six variables: chemical potential, molar flow, hydraulic/pneumatic pressure, volume flow, temperature, and entropy flow. This model will enable temperature and energy to be balanced for each separate subsystem of the entire system. These modular subsystems can then be connected together to form the model for the entire oxygen production plant, and valuable information can be learned about system start up and shut down. In addition, control strategies can be studied both for normal operation and for handling emergency situations.

The subsystem that performs the actual separation of the carbon dioxide into oxygen and carbon monoxide is a zirconia cell. A dynamic model for this cell will be developed based on the chemical reaction and power balance that takes place within the cell. Separate program modules will be developed for each of the system processes, and then the simulation software DYMOLA will be used with DESIRE or ACSL to simulate a hierarchical coupling of these processes.

The static simulation models are written in Ada and are currently running on a MicroVax workstation at the University of Arizona. A remote controlling computer (another MicroVax) sends input data to the local simulation computer over an Ethernet connection. The simulation executes on the local computer and then sends its results back to be displayed.

As the simulations and actual construction of the oxygen production plant enter their mature stages, model validation can be made and the simulation predictions used to give insight into which system configuration will result in the optimum input/output behavior.