Innovations in Nuclear Engineering Distance Education at The University of Tennessee

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Abstract

The University of Tennessee Department of Nuclear Engineering (UTNE) offers both graduate and undergraduate internet-based courses that support a Master of Science (MS) degree and several certificate programs. In particular a MS degree can be conveniently obtained through distance classes. In addition certificates in Nuclear Criticality Safety and in Maintenance and Reliability can be obtained by completing a subset of courses offered for the MS degree. Students enrolled in these courses are predominately located in East Tennessee, but many live throughout the United States and in several foreign countries.

An innovation of significant benefit to the UTNE undergraduate program is the implementation of reactor and laboratory experiments that are conducted over the Internet on the PULSTAR reactor at North Carolina State University (NCSU). These experiments are conducted live with video, audio, and data transmission, and to date experiments involving approach to critical, rod calibration using incremental and inverse kinetics methods, thermal calibration of neutron detectors, and reactivity coefficients have been conducted. Neutron scattering experiments are planned for remote control by students.

The use of internet-based education has enhanced the undergraduate program at the UTNE, and it has created opportunities for students with Internet access to obtain a quality education in Nuclear Engineering.

1. INTRODUCTION

The University of Tennessee Department of Nuclear Engineering (UTNE) offers a comprehensive Master of Science (MS) distance education program for professionals who cannot attend classes on a university campus[1,2]. The courses offered in distance format permit students with undergraduate degrees in engineering, physics, chemistry, and mathematics to obtain an MS degree in Nuclear Engineering. More specifically, UTNE has created five distance education programs during the past six years. They are the MS in Nuclear Engineering, which is essentially identical to our local on-campus MS program, a Graduate Certificate in Nuclear Criticality Safety, a Graduate Certificate in Maintenance and Reliability Engineering, a weekly Colloquium Program that is web cast, and a one-week short course on Nuclear Criticality Safety. Distance delivery of the latter program has only recently become available and is therefore untested. However, the first four distance programs have proven to be successful.

All five programs are primarily synchronous and interactive in real time. The two certificate programs are actually subsets of our MS program, which has been responsible for a 30% increase in our graduate enrollment attracting distance students from Seattle, Washington to Paris, France and from Rochester, New York to Sao Paulo, Brazil. The Colloquium Program is the only program of the five that is free and open to everyone, including the entire nuclear community as well as the general public, via the web cast. Further, distance education technology provides the opportunity to create collaborative educational programs (e.g., an MS in Nuclear Engineering) whereby several countries could come together *virtually* with each offering a special aspect of the virtual program. The program's courses would then be delivered to distance students from all of the participating countries; whereas, without virtual collaboration, it could be difficult for each country to produce a quality program alone.

Another innovative activity of the UTNE distance education program is the ability to conduct laboratory courses over the Internet. Many nuclear engineering programs have had the benefit of reactor experiments as an integral part of their nuclear engineering laboratory experience, but this opportunity for students has greatly diminished during the past 20 years. However, these reactor experiments can now be accomplished over the internet at some of the remaining university reactors, and this capability is currently undergoing evaluation between UTNE and the North Carolina State University (NCSU) PULSTAR reactor facility.

Developments in both hardware and software during the past several years have opened new and significant opportunities for remotely managed experiments, and use of this software and hardware, coupled with cameras controlled by a remote experimenter, permit UTNE students to utilize the PULSTAR reactor at NCSU. We also plan to develop and demonstrate these capabilities for a variety of remotely controlled experiments.

2. INTERNET BASED REACTOR EXPERIMENTS

Equipment for performing PULSTAR reactor experiments between UTNE and the NCSU campus has been purchased and tested[3]. UTNE is experienced with video conferencing and this experience facilitates the accomplishment of our Internet based reactor experiment project. Good video conferencing capability is considered important because we believe that students not located at a reactor facility and operators at the reactor facility should have very effective, high quality, video and audio communication.

Cameras at the reactor facility are available for remote control by UTNE students and faculty, and personnel at the reactor facility have the capability to focus cameras on individuals engaged in communication. Persons at UTNE are able to view the reactor facility, personnel, and data on a large LCD screen and on a touch-sensitive SmartBoard (about 16 square feet) screen with the capability imbedded displays. Likewise, operators, faculty and administrators at the reactor facility have similar capability.

In addition to direct video and audio communication, real-time data are collected during experiments. Examples of data collected thus far during experiments include temperature measurements during thermal transients, and simultaneous control rod and reactor power data obtained during rod calibrations.

Implementation of the capability for remote access of university reactors for experiments involves the following general tasks:

1) assessment of data acquisition capabilities at the university reactor
2) installation of hardware and software at the reactor facility for real time data acquisition,
3) selection and installation of software to post data obtained in real time to the internet,
4) selection and purchase of hardware and software for video and audio communication and for control of experimental facilities,
5) selection of experiments for remote participation,
6) development of experimental protocols, and
7) resolution of licensing, safety, and economic issues.

Good video conferencing capability is considered important, because students not at a reactor facility and operators at the reactor facility should have very effective, and high quality, video and audio communication. Some cameras at the reactor facility should be available for remote control by students and faculty not at the facility, and personnel at the reactor facility should have the capability to focus cameras on individuals engaged in communication. Persons at the remote facility should be able to view the facility, personnel, and data on a large screen with multiple displays. Likewise, operators, faculty and administrators at the reactor facility should have equivalent capability.

The video equipment purchased for this activity includes a Polycom unit with a retail price of about $15,000, cameras valued at about $2,000 and an LCD monitor valued at about $5,000. The data display equipment used for these experiments consists of a laptop computer and a Smartboard and is valued at about $15,000. The video equipment is shown in Figure 1 and the Smartboard is shown in Figure 2.

The capability for transfer of data directly over the Internet and to display it on a Smartboard is in progress. Software to be used for this application is identified, but is not acquired. Hardware for implementation of this capability is purchased. Decisions will need to be made regarding the level of detail desired for data acquisition, analysis, and experiment preparation. The manner of display is also significant. For example, some parameters should be displayed in real time at remote locations. This will require quality data acquisition and handling at both sites. Remote control of equipment will in some cases be straightforward and in other cases more challenging.

There are about ten experiments that have been considered for conducting over the Internet. Those performed two or three times since the fall of 2004 include the following experiemts:

1) reactor startup
2) approach to critical,
3) rod calibration with the incremental method,
4) rod calibration using the inverse kinetics approach,
5) reactivity coefficient of moderator temperature, and
6) thermal energy balance for calibration of reactor power instrumentation.

These internet-based reactor experiments offer students an opportunity to gain insight into reactor operation and physics that have not been available to date. The use of remote reactor experimentation improves educational opportunities for nuclear engineering students throughout the United States, and it will enrich academic programs where reactors are not available. It will also most likely improve programs at universities with reactors. In addition, the unique facilities available at university research reactors will be made available to a much wider user group.

Figure 1. Video communication unit, cameras, and LCD monitor on a cart.

Figure 2. Smartboard used for display of data.

The RTP[4] program (used for real-time data transfer over the internet) used in this project is a graphical programming environment, which can be used for testing, measuring, data acquisition, instrument control, data logging, and measurement analysis. It uses icons instead of lines of text to create applications. In contrast to text based programming languages, where instructions determine program execution, RTP uses dataflow programming, where the flow of data determines execution. In particular, it is used as a *virtual instrument*, or VI, similar to LabView. And like LabView, its appearance and operation imitates physical instruments, such as oscilloscopes and multimeters. RTP contains a comprehensive set of tools for acquiring, analyzing, displaying, and storing data. In RTP, one builds a user interface, or front panel, with a set of tools and objects, controls and indicators. Controls are knobs, push buttons, dials, and other input devices. Indicators are graphs, LEDs and other displays. After one builds the user interface, one adds codes using Vis, graphical representations, and structures to control the front panel objects. The block diagram contains this code, which resembles a flowchart. There are currently three display panels developed for this project, which are illustrated in the Figures 3-5.

Figure 3. RTP view panel for reactor power.

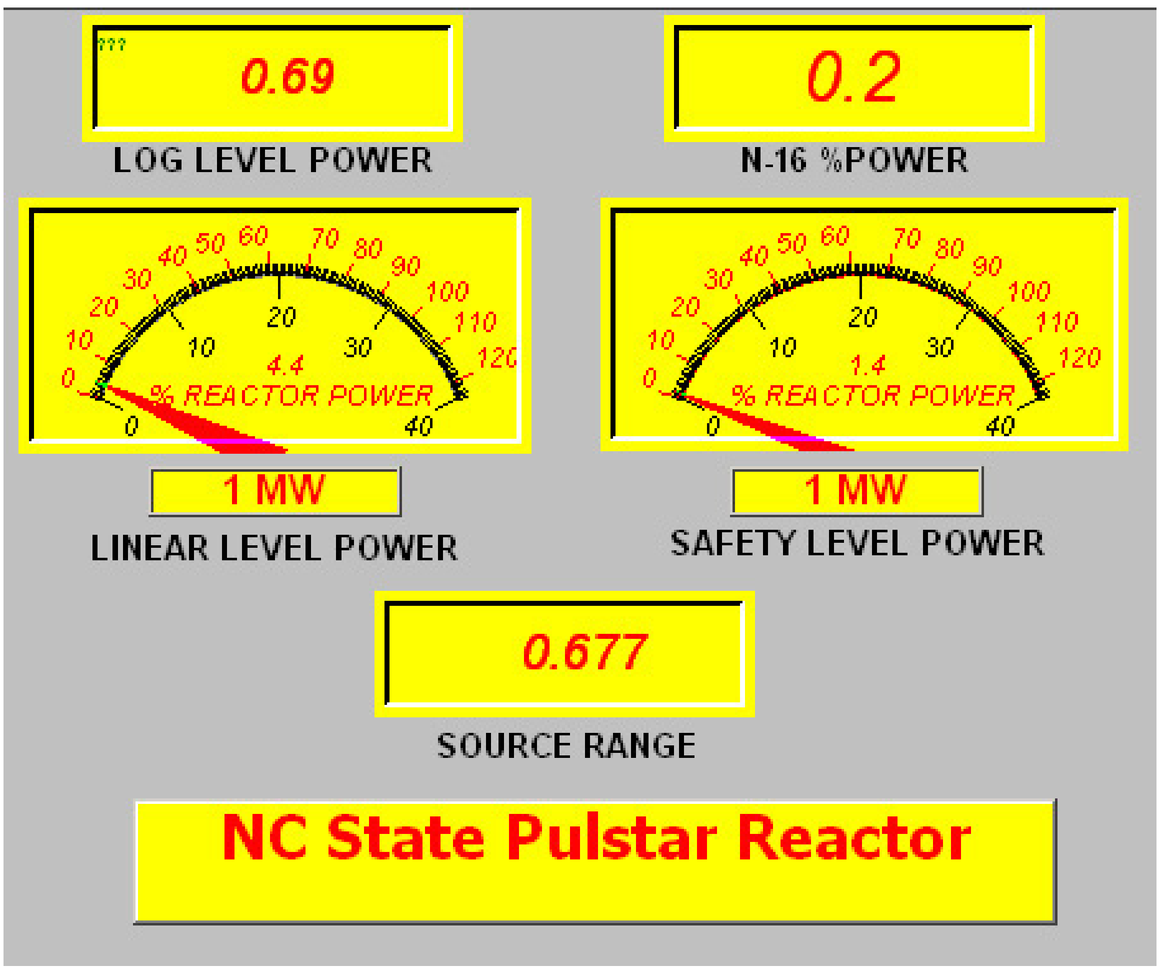

Figure 4. RTP view panel for the reactor system

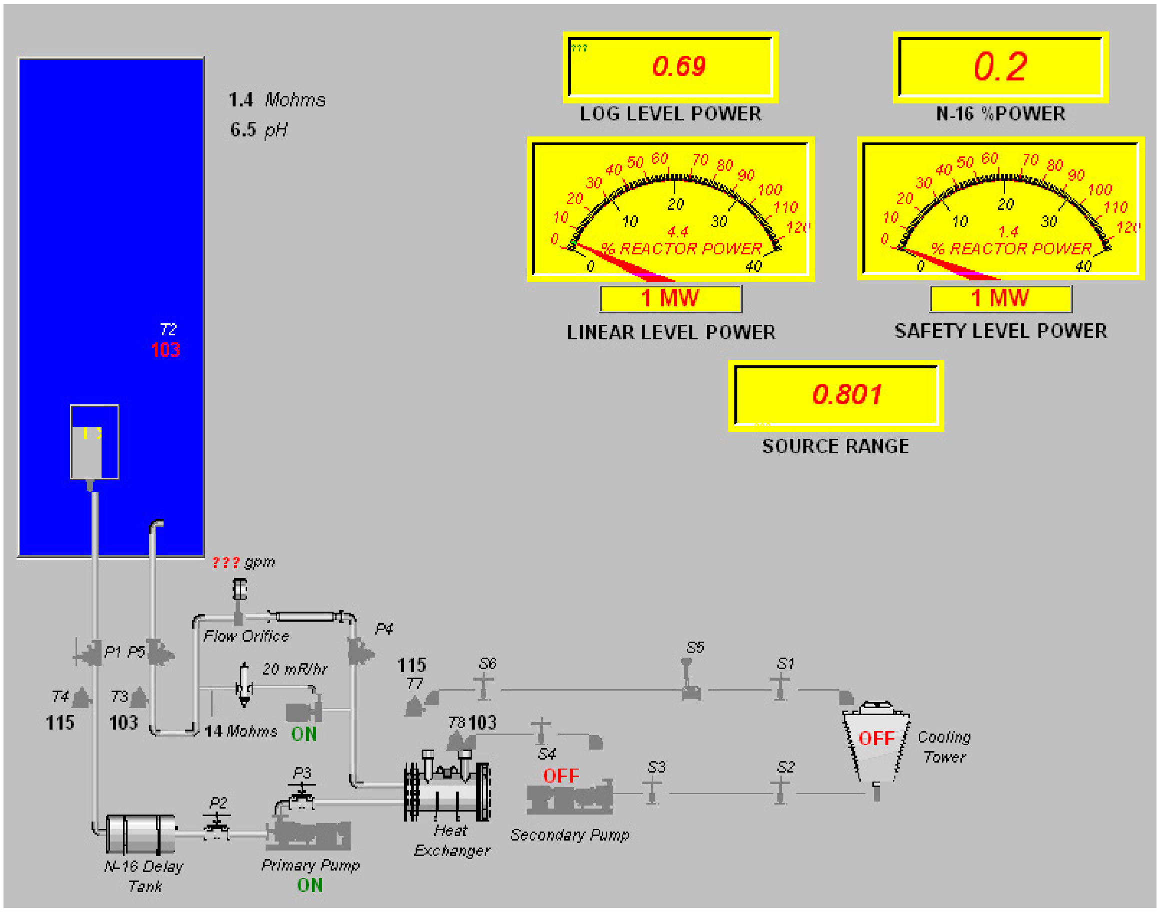

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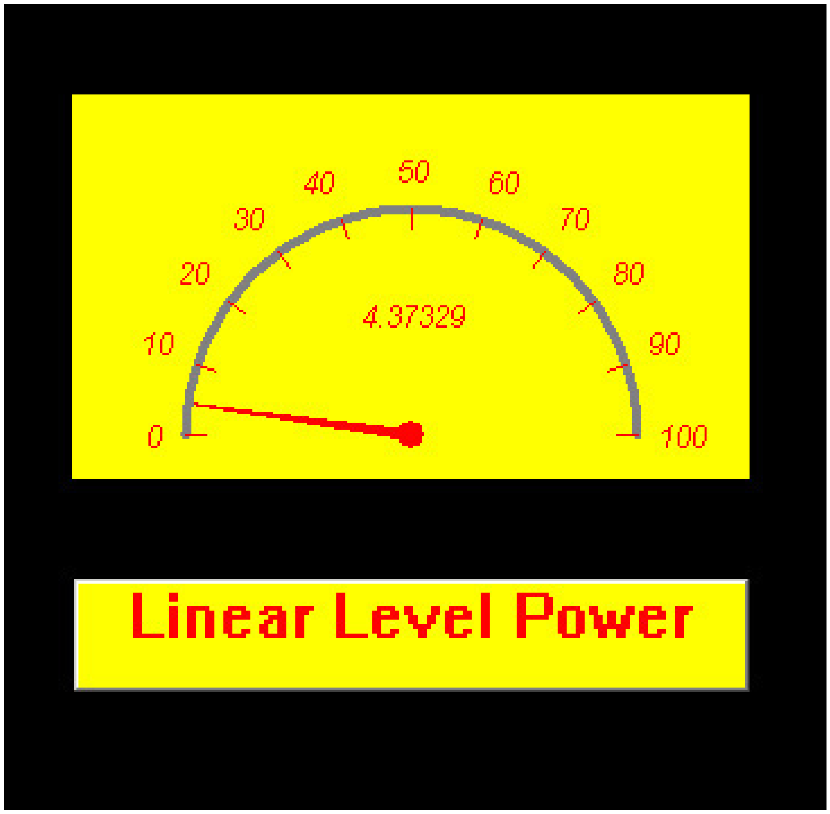
Figure 5. RTP view panel for linear power.



3. CONCLUSIONS

In summary, distance education utilizing remote reactor experimentation will improve educational opportunities for nuclear engineering students located at UTNE and elsewhere. This capability will enrich academic programs where reactors are not available, and it will most likely improve programs at universities with reactors. In addition, the unique facilities available at university research reactors will be made available to a much wider user group.

REFERENCES

1. H.L. Dodds, "Distance Education in Nuclear Engineering at The University of Tennessee," H. L. Dodds, An Invited Article for ***Nuclear News*** magazine, pp. 37-39 (June, 2002).
2. H.L. Dodds, "Nuclear Engineering Distance Education Initiatives at The University of Tennessee," H. L. Dodds, an invited paper for the ***2004 Pacific Basin Nuclear Conference***, Honolulu, Hawaii, March 20-25, 2004.
3. L.F. Miller, A.I. Hawari, and A. Cook, "Internet University Reactor Experiments for Education in Nuclear Engineering," Transactions of the American Nuclear Society, (November 2004)
4. RTP Corporation Software Manual (www.rtpcorp.com)

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