Reactor Operations Training via Web-Based Access to the UMass-Lowell Research Reactor

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INTRODUCTION

Over the last few years, the UMass-Lowell Research reactor (UMLRR) has developed capability to perform live experiments and deliver archived reactor operations data via a web-based interface to remote users.[1] This capability has matured to the point where significant educational content, including live interactive laboratories, can be delivered simultaneously to as many as 30 remote sites. Access to the UMLRR Online link is available through the www.nuclear101.com website, which has been set up as a general educational resource for students, instructors, and working professionals interested in the nuclear engineering field. The website currently has archived data and descriptions for a dozen different demonstrations and experiments that address a variety of subjects, including energy balance considerations, differential worth measurements, xenon poisoning, temperature coefficient effects, approach to critical experiments using 1/M plots, and a variety of routine operational transients (power maneuvers, flow transients, etc.). Along with a continually growing set of lecture notes and example experiments and demos, the really unique aspect of this website is that it provides a direct link to real-time and archived data from the UMLRR. In fact, almost everything on this site is related, in some fashion, to the UMass-Lowell Research Reactor.

RECENT UPDATES

The user interaction for real-time access to the UMLRR has seen significant upgrades in recent months. In particular, all the trend screens for the various power indicators, the primary and secondary-side temperatures, several pump and fan on-off indicators, etc. have been upgraded to include more interactive controls by the individual users so that they decide what to view, the scale for the plots, whether they view real-time or archived data, etc. In addition, new capability has been added to allow the user to download the current daily history file to his or her local machine for additional offline processing -- and a set of Matlab codes are also available for download to assist in the local post-processing step.

Real-time web conferencing capability via the Centra Live package[2] has also been added to UMass-Lowell's distance education infrastructure, and this tool has greatly improved the communication and interaction among all the sites involved in a particular online lab. For example, a recent "Approach to Critical Experiment" with two separate groups of UMass-Lowell students and a group at the University of Illinois proved to be quite successful.[3]

REACTOR OPERATIONS DEMONSTRATION

One focus of this paper is to highlight the availability and capabilities of the UMLRR as a distance education resource for Nuclear Engineering education and general reactor operations training. In addition, however, an equally important goal is to provide an explicit example of the type of demonstrations and experiments that can be performed. Towards that purpose, the remainder of this paper focuses on a particular Reactor Operations Demonstration that was conducted recently for a group of ROSE students (ROSE stands for Reactor Operations and Systems Experience and it is a summer internship/training program at UMass-Lowell that introduces undergraduate engineering and science students to the nuclear engineering field via a concentrated reactor operations experience within an operating research reactor). The demonstration was given towards the end of the training session after the students were already familiar with a variety of the systems within the UMLRR and some of the terminology associated with reactor operations.

Two groups, each with four students, were in a remote computer lab with PCs equipped with speakers and microphones. The lab facilitator was at another remote site with similar equipment and an inexpensive webcam and, of course, the reactor control room was online with similar, but more robust capability. All the groups were connected via a Centra e-meeting, with the facilitator and the reactor operators acting as presenters and the two groups of students as participants. The reactor went through a power-up sequence and operated at near full power for about an hour before the students came online. The actual student interaction lasted about two hours. This gave the group a chance to discuss some historical data (only an hour or so after actual operation) and to participate in live discussions of real-time operations.

A rough overview of operations during the demo is as follows:

1. After the normal checkout process, the control blades were moved out in a standard controlled pattern until criticality was reached.

2. Once critical, an additional small positive reactivity put the reactor on a positive period to allow the power to increase to the desired level. At about 10 kW, the regulating blade was put into auto mode while the source was removed. The startup counter was then moved to just above the active core level and the reactor was put on a positive period again to go to the desired operating level of about 0.9 MW.

3. At this point the primary pump was on but the secondary system was off with the reactor operating at near full power. Thus, as expected, all the primary side temperatures increased during this interval of steady operation. During this phase of operation, one can also see the combined effects of xenon buildup and a negative temperature coefficient by observing the behavior of the regulating blade during the pool heat-up period.

4. After about an hour of full power steady state operation, a secondary system transient was imposed by turning on the secondary pump and cooling fans for about 20 minutes. This usually introduces significant cooling on the primary side. However, Aug. 2, 2006 was a very hot summer day with outside temperatures of about 90-95 F during the experiment -- thus, there was relatively little impact on the primary side temperatures on this particular day.

5. After about 145 minutes into the demo, the reactor power was reduced to about 80 kW so that the system could be operated in natural convection mode (note that the UMLRR is licensed to operate in natural convection mode for power levels up to 100 kW).

6. After about 10 minutes of steady operation at 80 kW with forced convection, the primary pump was shut off, thus inducing a transition to natural convection cooling. With the regulating blade in auto mode, this transient causes the coolant temperatures within the core to increase and, because of the negative temperature coefficient, the regulating blade is also withdrawn.

7. After reaching steady operation at 80 kW in natural convection mode, a large negative reactivity insertion was made to essentially shutdown the system -- thus ending this demo.

The primary purpose of the demo outlined above was to observe and interpret the resulting behavior of the reactor during a variety of normal operational transients. A set of summary plots showing most of the important operational data are shown in Fig. 1. These show several power indicators, the startup counter information, several primary and secondary-side temperatures, the control blade positions, and the pump/fan on-off status during the demonstration. These particular plots were processed offline after completion of the experiment using the Matlab processing tools mentioned above. For comparison, Fig. 2 shows the interactive view for the power trend that was observed by the students during the actual lab (where the buttons along the bottom of the window allow the individual user to view the current status window or a variety of different trend screens). Several trend screens similar to that in Fig. 2 were used during the lab to discuss the reactor behavior in real time.

Both the online and offline capability are extremely important. The online views and user controls allow for real-time discussion of reactor operations, and the offline processing capability is well suited for more detailed qualitative and quantitative analyses of the data. Separate effects can be more easily isolated offline and more detailed comparison to mathematical models or other sources of similar behavior can also be made. Combined, the online and offline data processing and visualizations can give the student a significant educational and training experience in the field of reactor physics and operations.

ACKNOWLEDGEMENTS

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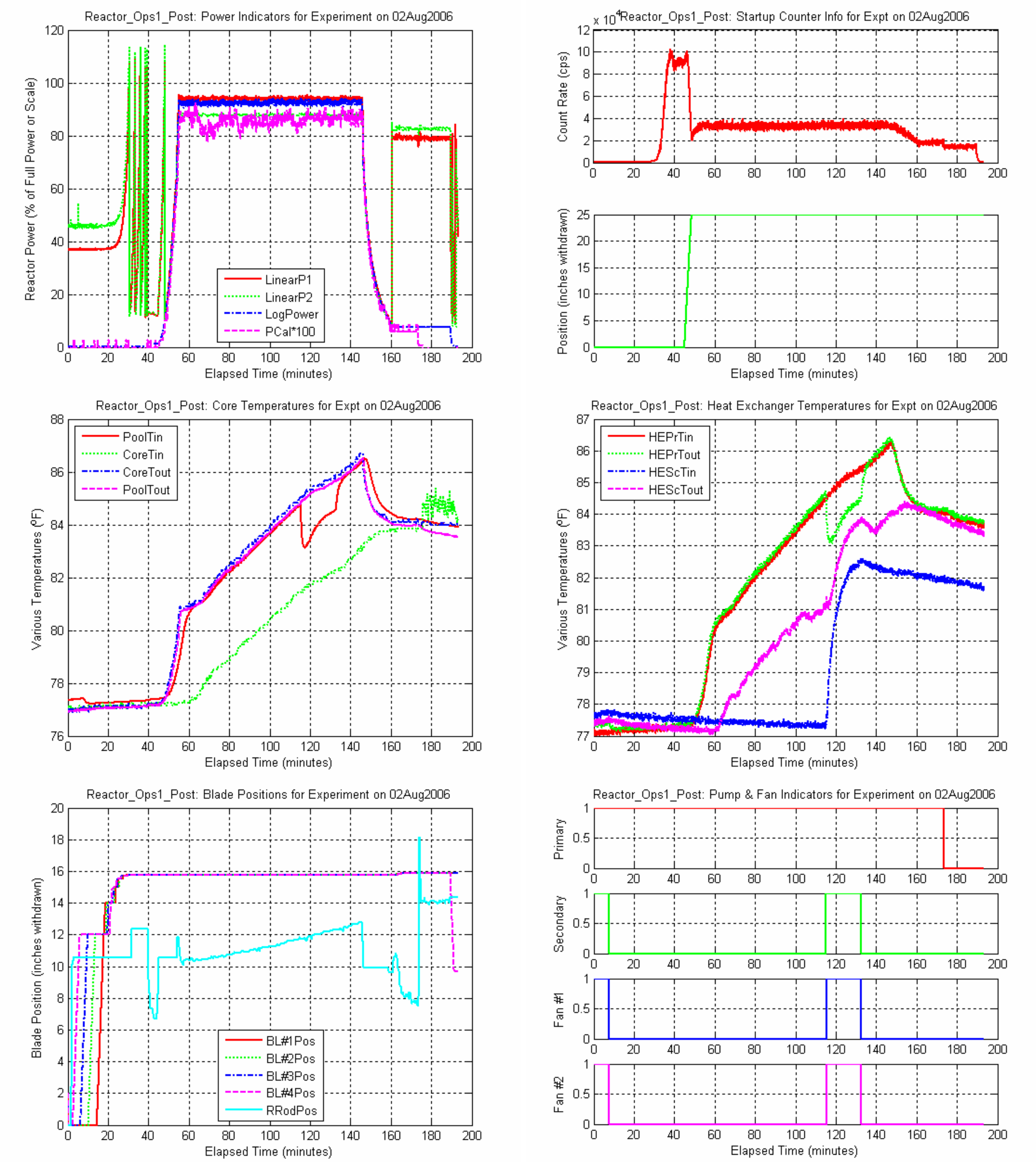

Fig. 1. Summary of operational data from Reactor Operations Demonstration #1.

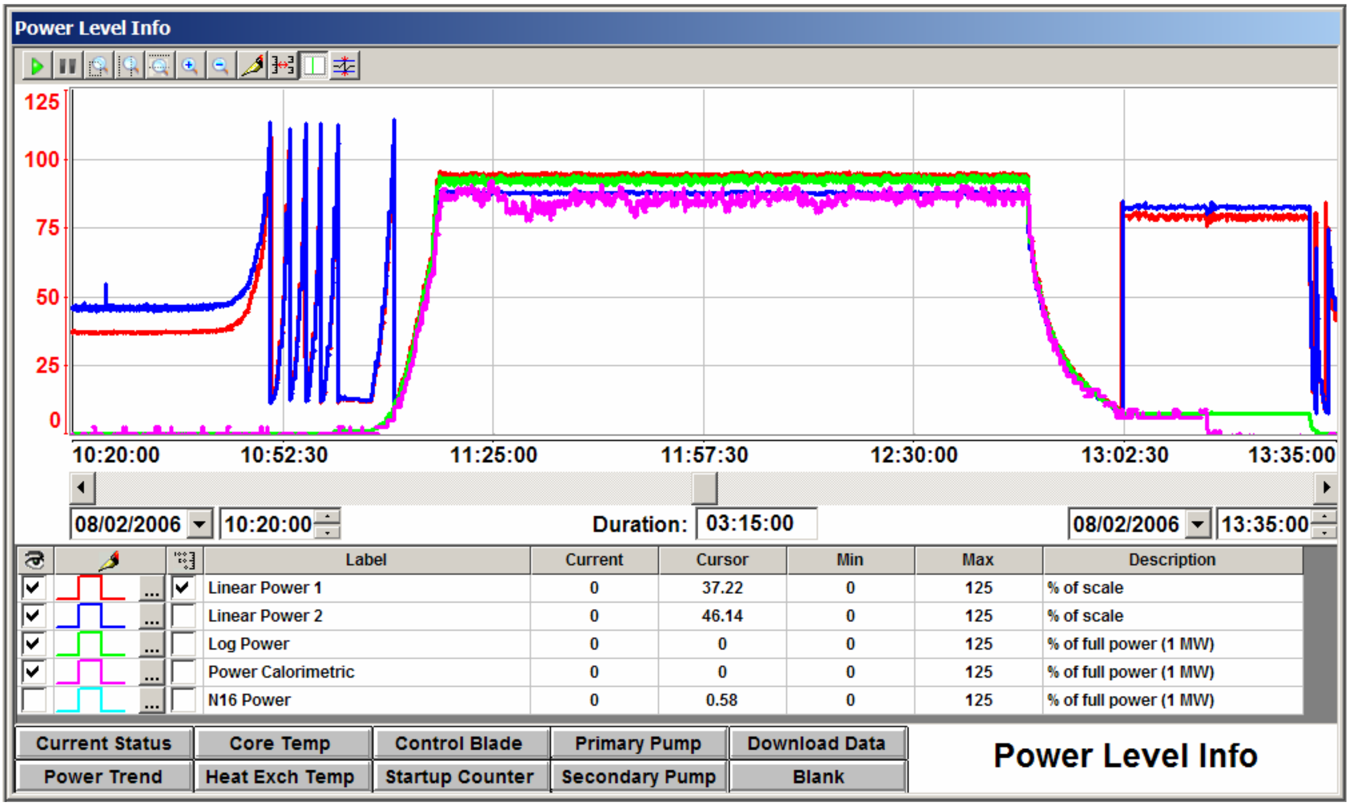

Fig. 2. View of power history trend during the actual online lab session.