24.536 Reactor Experiments and 407.403 Advanced Nuclear Lab

HW #11: "Measuring and Interpreting Reactivity Effects" Post-lab Exercises

Introduction/General Tasks

The purpose of Reactor Experiment #4 is to fully understand the inherent feedback effects that occur within the UMass-Lowell Research Reactor (UMLRR). In all our previous lab exercises the reactor was operated at low power levels with the intent of minimizing the effects of the inherent temperature and xenon feedback effects on our reactivity measurements and our overall observations of feedback-free reactor dynamics. In contrast, in this lab, the feedback effects are the primary focus area! Since we can only measure the total reactivity level of the system, we will use a relatively simple 11-equation dynamics model to help isolate and quantify the different feedback mechanisms (fuel temperature, coolant temperature, and xenon reactivity) that are inherent to all thermal reactor systems. The goal of this post-lab assignment is to give you a good understanding of how to model and interpret the various inherent feedback mechanisms and how they affect real reactor operations.

The specific tasks and deliverables for this post-lab assignment are described below:

Summarize the Goals, Experimental Sequence, and the Primary Results/Conclusions from Reactor Experiment #4: Measuring and Interpreting Reactivity Effects

The explicit post-lab analyses that are expected are given below. Please include your responses, analyses, and discussions, as needed, for each of these tasks as part of your complete package for HW#11.

1. Summarize the goals of the experiment and the overall steps/procedures that were performed. This should be a general overview of the goals and reactor sequence that was performed, not a list or copy of the formal procedure given to you. Write this as though you were describing the lab to a colleague.

2. **Phase I -- Natural Convection Mode**

   a. Compare the P(t) profile obtained from the Phase I operational data while in **natural convection mode** with a best-estimate simulation that includes the actual blade movements and the $T_{in}(t)$ recorded during the reactor run. Compare the actual measured reactor P(t) data and the simulation results on the same plot and comment on the goodness of the simulations.

   b. Compute and plot the "measured" $\rho_{tot}(t)$ profile obtained from processing the measured P(t) data through the inverse kinetics algorithm. In addition, you should also compute and plot the individual contributions to the simulated $\rho_{tot}(t)$ profile using our 11-equation dynamics model. Again, plot the measured $\rho(t)$ data and the simulated $\rho(t)$ profiles on the same plot and comment on your comparisons here. Also, comment on the relative contribution of the various feedback mechanisms for this portion of the lab.

   c. Based on your results/comparisons for Parts a and b, what can you say about the utility of our 11-equation dynamics model for quantitatively and/or qualitatively representing real reactor behavior within the UMLRR? For example, comment on whether or not the model is sufficient for use as a simulation tool for training reactor operators, for illustration of feedback effects within an undergraduate Reactor Theory course, etc.. Also, if the measured and simulations results do not match in one or more areas, please try to address why, and suggest improvements to the model that might help remedy the situation...

3. **Transition from Phase I to Phase II -- The Pump-On Transient**

   Using the ***umlrr_data GUI*** to help visualize operations, describe in as much detail as possible what happens in the reactor during the transition from natural to forced convection flow mode, with specific focus on the "pump-on" transient that was observed.

4. **Phase II -- Forced Convection Mode**

   Perform the same tasks as listed under Item #2 for the Phase II **forced flow** portion of the experiment. As before, comment on the utility of our 11-equation dynamics model for forced flow simulations of the UMLRR.

5. Highlight any key differences that were observed between the forced and natural convection reactor runs and simulations.

6. Finally, as closure for this lab exercise, also briefly discuss your overall experience from this reactor experiment -- that is, did you gain a better understanding of inherent reactivity feedbacks in nuclear systems? Also please comment on any changes that could be made in future experiments of this type to improve the overall learning experience for the class -- your feedback here could improve the learning experience for future students…

Documentation and Submission of HWs

In general, I expect a professional, well-written, semi-formal report for each HW assignment in this course. Please refer to HW#1 regarding the format for each HW assignment in this course -- **they should all be done and submitted in a similar fashion!!!**

For this HW, you need to post-process the measured data associated with Phases I and II, compare these data to simulations using the 11-equation model developed in class, discuss your overall results, and draw some conclusions about the usefulness of the simple 11-equation mathematical model in understanding basic reactor operations.

As done previously, please put everything together, including all your Matlab m-files used to post-process the experimental data, in a single zip file -- **only one zip file per HW please** -- and **email this to me before 4 pm (UML time) on the Sunday** before our next class.

Good luck…