Teaching Notes

Operational Reactor Safety Course

Lecture: 3 – Reactor Kinetics and Control

Objective:

To introduce the concept of prompt and delayed neutrons and point kinetics equations, reactivity, and the Inhour equation. Feedback effects are discussed including Doppler, moderator, void, fuel, etc. This is followed by a brief discussion of reactor control and power.

Key Points to Bring Out:

Slide number	Points
3	Here we want to introduce the key concepts of the time dependent diffusion equation and the definition of reactivity. Mean generation time is an important concept since it identifies the speed with which things occur without delayed neutrons. Discuss the concept of a reactor period being the change in reactivity divided by the mean generation time.
4	The importance of delayed neutrons should be emphasized as being a significant aspect of reactor control.
5	Identifies the typical six precursors of delayed neutrons as precursor groups with a total delayed neutron fraction of .0065. which allows thermal reactors to be controlled.
6	Identifies the various neutrons coming from time dependent neutron balance equations.
7	Presents the point kinetics and Inhour equations to the students as shown in the attached class notes. Write them on the board from Kneif.
8	The key point is to identify the importance of delayed neutrons. Noting the difference in delayed neutron fraction of Pu vs U235 and the energy at which delayed neutrons are born.

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9	Key points here are to point out how reactors behave in response to a change in reactivity, either positive or negative. The impact of the prompt neutron population followed by an asymptotic effect of delayed neutrons. Key factor for thermal reactors is that the period of the core is roughly 80 seconds to allow for measured start up.
10	These slides show the students the effect of prompt jump and prompt drops in terms of reactivity insertions.
11	Explain the various feedbacks that occur and how they affect reactivity and why.
12	Coefficients are defined and described. (Use Kneif definitions.)
13	Discusses the Doppler broadening phenomenon. The key point is it's an important control mechanism for reactors. Doppler provides a net increase in cross section for reactor control for fast neutron transients.
14	This slide puts the entire reactivity feedback loop into perspective. Once there is a reactivity change whether it be the movement of a control rod, the kinetic response is quite fast depending upon neutron lifetime, which creates a local increase in power, which can then be compensated for by fuel temperature, moderator and density differences which may provide negative feedbacks each with its own time constant based on how quickly the phenomenon occur. The feedback loop determines whether reactor power goes up or down.
15	What happens in the helium reactor for a drop in coolant temperature. It ends up being a positive reactivity effect. The key point here is that the decrease in temperature can increase power but ultimately be stabilized by other feedback effects.
16	The key point here is to make note of the fact that the soluble boron may add positive reactivity as the temperature increases. The moderator temperature coefficient is a function of the boron concentration which changes as a function of cycle life.

Also to be noted are attached highlights of the Kneif text to allow one to develop the appropriate equations in the class lecture. Equations should be written in class to show the effect of prompt and delayed neutrons, the time dependant equations for the delayed groups, time dependant neutron balance equations for six delayed neutron groups as well as the development of the point kinetic equations. The highlighted sections are those that should be brought out in class as part of the lecture.

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