Teaching Notes

Operational Reactor Safety Course

Lecture: 7 – Design Issues and Power Cycles for Nuclear Plants - Rankine Cycle

Objective:

The objectives of this lecture is to introduce students to fundamental design issues for nuclear plants - namely how does one go about designing a reactor starting from basic power needs and reactor physics and heat transfer including material limitations and accident considerations. Key reactor systems are identified and discussed in terms of function to assure heat removal and safety. Knief chapters 8, 9 and 10 are used as references for this part of the lecture.

The second part of the lecture (which could be broken up into a separate lecture is to introduce the Rankine power conversion system. Since Knief does not cover power conversion cycles, El-Wakil and other text excerpts are used to augment the discussion.

Key Points to Bring Out:

Slide number	Points
3	Establish the key integrating factors in reactor design - nuclear, thermal hydraulics and materials and how each box affects the others in terms of an overall design. This is a very important concept for this engineering systems course - it brings all of the previous fundamental lectures together into a plant.
4-7	These slides cover the steps in nuclear plant design - each should be reviewed linking one step to the other building on the analyses already presented in previous lectures. Although economics was not emphasized in previous lectures it could be reviewed at this time.
8- 11	The key points here are the importance of linear heat rate on fuel performance as a function of local power density as shown in the axial profile. Slide 9 is interesting from the point of view of local power density of PWRs and BWRs and linear heat rate comparisons.

12	The key points to make about this slide are the very important mechanisms listed that affect whether or not the clad (the first fission product boundary) remains intact. All these factors must be considered in the choice of the fuel design and power operating conditions.
13	Key point is that the reactor protective system is designed to prevent clad failure and possible release of fission products. How this is done is described in the trip system logic to prevent overheating of the fuel pins.
14-16	The major points for these slides is to show the complexity of the plant and what is needed to maintain a safely operating power producing plant. The schematics are aimed to impress how the systems are integrated to provide operational and safety functions. Go over key systems as identified in slide 16.

If time remains - begin an introduction to power conversion systems - These lectures should be continued for a number of classes to cover the material.

17-22	Introduce power conversion systems - concept of energy, heat and work. Carnot efficiencies and concept of irreversibility with temperature vs entropy diagrams.
23	Review Rankine steam cycle using TS diagram
24	Review different types of steam generators discussing pinch point concept.
24	Review what nuclear power plant cycles typically have - namely feedwater heaters for improved thermal efficiency

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