

BACHELOR OF POWER ENGINEERING FINAL EXAMINATION, 2009

(4th Year-2nd Semester)

NUCLEAR POWER GENERATION

Time : Three hours

Full Marks : 100

Answer any five

1. Derive a relationship between the power P produced by a fission reactor and neutron flux ϕ .

5

A reactor is fuelled with 10% enriched Uranium fuel. Assume that the microscopic absorption cross section of U_{235} is 694b while that of U_{238} is 2.71b. Assume further that the microscopic fission cross section of U_{235} is 582b, its atom density is 4.83×10^{21} atoms/cm³, while the atom density of U_{238} is 4.35×10^{22} atoms/cm³. Calculate the neutron flux required to produce 1MW/cm³ for this reactor. Assume each fission produces 231 MeV.

15

2. Define multiplication factor and hence define sub-critical, critical and super-critical States.

5

State and explain the different terms in the 4-factor formula for neutron Multiplication

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Calculate the value of thermal utilization factor with the data for problem 1 above.

What is Doppler broadening?

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3. A 250 Mwe Pressurized Water reactor uses slightly enriched Uranium as fuel with a burnup of 30000 MWtd/Tonne. Calculate the fuel consumption of the reactor in Tonnes/yr assuming a conversion efficiency of 30%.

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Can the flux in a nuclear reactor be arbitrarily increased? What is the limitation?

1+4

How is the average number of neutrons per fission of a Uranium atom a fraction and not an integer?

5

Calculate the energy of a thermal neutron.

5

4. Define Moderating ratio and Moderator Slowing Down Power
- What type of moderation is recommended for Light Water Reactors from reactor control point of view and why?

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Explain what would happen if a heavy water reactor is filled with Light Water at full power.

5

Why are some reactors kept over moderated?

5

5. Define reactivity. What is the value of multiplication factor for a reactivity of 1 pcm?

5

What is reactivity defect and how does it change with increasing power in an over-moderated reactor?

8

The moderator temperature coefficient of a reactor is -3.6 pcm/ $^{\circ}$ C. Calculate the reactivity defect for a temperature change of 10° C. What happens if the nett reactivity defect is positive?

3+4

[Turn over

6. What are the requirements for control rods in a reactor? 5
What is a *black rod* and a *gray rod*? Why is a gray rod preferred? 3
Define the terms integral worth and differential worth of a control rod and explain where the control rod should be placed in a reactor if it has a single control rod? 5
Starting from the expression for reactor period derive an expression for doubling time and explain why a reactor power cannot be increased at any arbitrary rate. 7
7. A reactor is operating at a steady power P_1 . Calculate the equilibrium concentration of Iodine and Xenon and hence derive an expression of Xenon concentration with time if the reactor is shutdown at this power level 10
Explain how spatial Xenon oscillation occurs in a reactor. 10
8. Does a turbine trip always require a reactor trip in a CANDU reactor? Explain your answer. 5
CANDUs can be fuelled with natural Uranium while PWRs require enriched Uranium. Why? 5
What are the built in safety features associated with a CANDU reactor? 5
What is a reactor set-back? Can a CANDU be started anytime after shutdown? Explain your answer. 5
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