Ref. No.: PG/NuE/T/129F/28/2019

Master of Nuclear Engineering 1st year 2nd Semester Examination, 2019

Subject: Reactor Thermal Hydraulics

Time: Three hours

Full marks: 100

Answer any four

1. (a) Why the released energy due to β decay of fission products are non-recoverable? 3

(b) Consider a PWR reactor have the following specifications-

Core power (MWth)	% of power deposited in fuel rods	Fuel assemblies/core	Assembly lateral spacing (mm)	Fuel rods/assembly	Fuel rod length (mm)	Fuel rod diameter (mm)
3800	96	241	207 (sq. pitch)	236	3810	9.7

Determine-

(i) Equivalent core diameter and core length. 6

(ii) Average core power density. 2

(iii) Core-wide average linear heat generation rate of a fuel rod. 2

(iv) Core-wide average heat flux at the interface between the rod and the coolant. 2

(c) Show that, at a position $(\overrightarrow{r})$, the volumetric heat generation rate in a nuclear fuel can be expressed as follows- 10

$q'''(\overrightarrow{r}) = \sum_j \int_0^\infty \chi_f^j \Sigma_f^j(\vec{r},E)\phi(\vec{r},E)dE$, Where, χ_f^j, $\Sigma_f^j(\vec{r},E)$ and $\phi(\vec{r},E)$ are percentage fraction of the recoverable fission energy deposited in the fuel, macroscopic fission cross section of the jth isotope and neutron flux having energy E.

2. (a) What do you mean by microscopic and macroscopic fission cross section? 2

(b) What is the role of pressuriser in a PWR primary coolant circuit? 3

(c) A large PWR designed to produce heat at a rate of 3083 MW has 193 fuel assemblies each loaded with 517.4 kg of UO_2. If the average isotopic content of the fuel is 2.78 weight percent of U^{235}, what is the average thermal neutron flux in the reactor? 20

Assume: 95% of the energy/fission is generated in the fuel. σ_f= 350 barns. Molecular masses (in g/mole) for U^{235}=235.0439, U^{238}=238.0508, O^{16}=15.9994

3. (a) Briefly discuss about the different phases of Fuel Coolant Interaction during severe accident scenario in a nuclear reactor. 5

(b) Derive an analytical expression for the expansion work done during a FCI scenario by assuming coolant and fuel expanded as one system in thermal equilibrium adiabatically and isentropically 20

4. (a) Derive the energy conservation equation across the surface of discontinuity within a control volume. Assume the jump in the kinetic energy and stress work are negligible. 15

(b) During a shutdown condition in a PWR, the flow is driven through the loop by natural circulation at a rate corresponding to about 1% of the flow rate provided by the pumps. Assume: Total flow rate is 4686 kg/s in the full flow condition, Number of tubes = 3800, Tube diameter = 0.022 m, Tube length = 16.5 m, ρ = 1000 kg/m^3 and μ = 0.001 kg/m.s

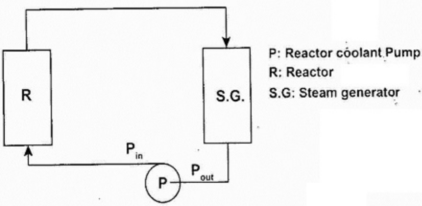
Determine:

(i) Whether the flow is turbulent or laminar? 3

(ii) The value of the friction factor 1

(iii) The friction pressure loss between the inlet and outlet of one tube 6

5. Consider a reactor flow loop, shown in the following figure-



Determine the steady-state value of the flow rate. How long does it take the system to reach 90% of this value? Assume: Pump provides a pressure head equivalent to 85.3 m of water. ρ = 1000 kg/m^3. 25

The dimension of each of the component and piping are given below.

Component Name	Length (m)	Area (m^2)
Pump outlet piping	8.0	0.4
Reactor	14.5	20.9
Reactor outlet piping	17.0	0.4
Steam generator	16.5	1.5
Pump inlet piping	10.0	0.35