PYQ

4.(b) A nuclear reactor power plant operates continually for one year producing 500 MW. The power plant efficiency is 33%. The reactor contains 75 metric tons of 3% enriched uranium dioxide fuel. Calculates-

(i) the mass of U_{235} consumed in kilograms;

(ii) the fuel burnt up in MWd/T.

Solⁿ:-

(i)

$$E_{consumption} = P \times 1\,year \times \left(\frac{No.\ of\ days}{1\,year}\right) \times \left(\frac{No.\ of\ seconds}{1\,day}\right)$$

$$= 500 \times 10^6 \times 1\,year \times \left(\frac{365.25\,day}{1\,year}\right) \times \left(\frac{86400}{1\,day}\right)$$

$$= 1.58 \times 10^{16}\ J$$

Now,

$$Efficiency = \frac{E_{consumption}}{E_{generation}}$$

$$\Rightarrow E_{generation} = \frac{E_{consumption}}{Efficiency}$$

$$= \frac{1.58 \times 10^{16}}{0.33}$$

$$= 4.79 \times 10^{16}\ J$$

By Albert einstein theory,

$$E = mc^2$$

$$\Rightarrow E_{generated} = mc^2$$

$$m = \frac{E_{generated}}{c^2}$$ $(1J = 1kg\text{-}m^2/s^2)$

$$= \frac{4.79 \times 10^6}{(3 \times 10^8)^2}$$

$$= \frac{4.79 \times 10^6}{9 \times 10^{16}} = 0.532\ kg\ U235/day$$

(ii)

$$P_{generation} = \frac{P_{consumption}}{Efficiency}$$

$$= \frac{500 \times 10^6}{0.33}$$

$$= 1515.15 \times 10^6\ W$$

Now,

Fuel Burnt up in MWd/T

$$= \frac{P_{generated} \times \text{no of days in a year}}{\text{mass of uranium dioxide present}}$$

$$= \frac{1515.15 \times 10^6 \times 365.25}{75}$$

$$= 7378.79 \times 10^6\ Wd/T$$

$$= 7378.79\ MWd/T$$ (mega-watt-day/Tonn)

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