Design constraints – Maximum allowable coolant velocity

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1 Quiz

1.1 Questions

1. What is the predominant mode of heat transfer from clad to coolant?

2. With increase in velocity of coolant, heat transfer coefficient increases. Say true or false.

3. Which one of the following is the main impediment in increasing the velocity of sodium in a fast reactor?
(a) embrittlement of material (b) high pressure drop
(c) corrosion (d) low Prandtl number

4. Define corrosion constant.

5. Which of the following gases is maintained above the surface of sodium in the pool of sodium cooled fast reactor?
(a) nitrogen (b) helium (c) argon (d) oxygen

6. Liquid sodium is characterized by
(a) low Prandtl number (b) high Prandtl number
(c) high Reynolds number (d) low Reynolds number

7. The sodium-side heat transfer coefficient in a heat exchanger operating a flow rate is 25000 W/m^2K. If the flow rate of sodium is reduced to 50 % of designated flow rate due to partial malfunctioning of the pump, determine the heat transfer coefficient at this operating condition. Assume that all other conditions remain same.

8. Comparing the cores of sodium cooled fast reactor and thermal reactors, the higher fuel density per unit core cross sectional area of fast reactor is attributed to
(a) higher velocity of sodium required (b) lower sodium velocity
(c) lower pin pitch (d) higher pin pitch

9. Which one of the following is not likely to influence the corrosion of iron by sodium?
(a) sodium velocity (b) oxygen content
(c) solubility of iron in sodium (d) density of iron

10. The saturation concentration of chromium in sodium is 2.2×10^{-7} mole % and 5.6×10^{-4} mole % at 500 °C and 700 °C respectively. Determine the ratio of dissolution rates of chromium in sodium at 500 °C and 700 °C.

1.2 Answers

1. Convection

2. True

3. (c) Corrosion

4. It is defined as the ratio of dissolution rate to the saturation concentration of iron in sodium

5. (c) Argon

6. (a) low Prandtl number

7. From Eqn. (1) & (2) of the lecture,

$$h \; \alpha \; u^{0.8}$$

Therefore, $\frac{h_1}{h_2} = \left(\frac{u_1}{u_2}\right)^{0.8}$

When the flow rate is reduced by 50 %, sodium velocity corresponding to this flow rate (u_2) is reduced by 50 % of the sodium velocity at the original flow rate (u_1).

Hence, $u_2=0.5u_1$

Therefore, the heat transfer coefficient corresponding to the reduced flow rate is 14359 W/m^{2}K.

8. (c) lower pin pitch

9. (d) density of iron

10. Please recall Eq. (3),

Dissolution rate α T

Therefore, $\frac{Dissolution\ rate_{973\ K}}{Dissolution\ rate_{773\ K}} = \frac{C^*_{973\ K}}{C^*_{773\ K}} = \frac{5.6x10^{-4}}{2.2x10^{-7}} = 2545$

The ratio of rate of dissolutions at these temperatures is 2545. Hence the rate of dissolution of chromium at 700 °C is three-orders of magnitude greater than that at 500 °C.