Heat flow and temperature distribution in plate fuel elements

K.S. Rajan
Professor, School of Chemical & Biotechnology
SASTRA University

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1 Quiz

1.1 *Questions*

1. A slab of 80 mm thick made up of a material of thermal conductivity 100 W/mK generates heat at a rate of 2 MW/m^3. Determine the temperature at the centre of the slab, if the outer surface of the slab is maintained at 200 °C.

2. A slab of 120 mm thick made up of a material of thermal conductivity 150 W/mK generates heat at a rate of $2.5\cos(\pi x/a)$ MW/m^3, where 'x' is the distance from the centre of the slab and 'a' is thickness of the slab. Determine the temperature (i) at the centre of the slab (ii) at midway between centre of the slab and outer surface, if the outer surface of the slab is maintained at 180 °C.

3. A slab of thickness 100 mm generates heat at the rate of 300 kW/m^3. If the slab is cooled by water at a temperature of 25 °C, determine the temperature on the outer surface of the slab. The heat transfer coefficient may be taken as 500 W/m^2K.

4. What is the ratio of average flux to maximum flux in an infinite slab reactor?

(a) single-phase heat transfer (b) subcooled nucleate boiling
(c) saturated nucleate boiling (d) dryout

1.2 *Answers*

1. Data: k = 100 W/mK; T_S = 200 °C; $P_{avg}''=2\times 10^6$ W/m^3; a = 0.08 m
Substituting above and x= 0 in Eq. (16), we get T = 216 °C

2. Data: k = 150 W/mK; T_S = 180 °C; $P''=2.5\times 10^6 \cos(\pi x/a)$; $K'= 2.5 \times 10^6$ W/m^3; a = 0.12 m

Equation (14) is to be used for this purpose:

$$T = T_S + \frac{K' a^2}{k\pi^2}\left(\cos\frac{\pi x}{a}\right)$$

Solving the above equation for x = 0 gives T= 204.3°C at the centre of the slab.

Note: Please use π as 180 not as 3.14

At mid-way between centre of the slab and outer surface, x = 30 mm = 0.03 m, the temperature is 197.2 °C

3. Data: T_c = 25 °C, h = 500 W/m^{2}K; P_{avg}''=3x10^5 W/m^3; a = 0.1 m

Substituting the above in Eq. (22),

$$T_S = T_c + \frac{P''_{avg} a}{h}$$

T_S = 85 °C.

4. Answer: 0.64