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| Benha University | Heat Transfer |
| Faculty of Engineering (Shoubra) | 2nd Year (Power) |
| Mechanical Engineering Department  | Sheet No. 3 |

1. Define heat generation in a solid. Give examples.
2. Consider a large 3-cm-thick stainless steel plate$ \left(k=15.1 W/m°C\right)$ in which heat is generated uniformly at a rate of$ 5x10^{5} W/m^{3}$. Both sides of the plate are exposed to an environment at $30℃$ with a heat transfer coefficient of$ 60{W}/{m^{2}}.℃$. Obtain a relation for the variation of temperature in the wall by solving the differential equation, and determine the location and value of maximum temperature.
3. Consider a large 5-cm-thick brass plate $\left(k=111 W/m°C\right)$ in which heat is generated uniformly at a rate of$ 2x10^{5} W/m^{3}$. One side of the plate is insulated while the other side is exposed to an environment at 25°C with a heat transfer coefficient of$ 44 W/m^{2}℃$. Obtain a relation for the variation of temperature in the wall by solving the differential equation, and determine the location and value of maximum temperature.
4. In a nuclear reactor, 1-cm-diameter cylindrical uranium rods cooled by water from outside serve as the fuel. Heat is generated uniformly in the rods $\left(k=29.5 W/m℃\right)$ at a rate of$ 7x10^{7} W/m^{3}$. If the outer surface temperature of rods is 175°C, determine the temperature at their center.
5. A copper cable $\left(k=400 W/m℃\right)$ of $30 mm$ diameter has an electrical resistance of $ 5x10^{-3}{Ω}/{m}$ and is used to carry an electrical current of$ 250 A$. The cable is exposed to ambient air at$ 20℃$, and the associated convection coefficient is$ 25 W/m^{2}℃$. What is the centerline and surface temperature of the wire?
6. Consider a long resistance wire of radius $r\_{i}=0.3 cm$ and thermal conductivity $k\_{wire}=18{W}/{m}.℃$ in which heat is generated uniformly at a constant rate of $\dot{g}=1.5 W/cm^{3}$ as a result of resistance heating. The wire is embedded in a 0.4-cm thick layer of plastic whose thermal conductivity is$ k\_{plastic}=1.8 W/m℃$. The outer surface of the plastic cover loses heat by convection to the ambient air at $T\_{\infty }=25℃$ with an average combined heat transfer coefficient of$ h=14 W/m^{2}℃$. Assuming one-dimensional heat transfer, determine the temperatures at the center of the resistance wire and the wire-plastic layer interface under steady conditions.
7. Consider a homogeneous spherical piece of radioactive material of radius $r\_{o}=0.04 m$ that is generating heat at a constant rate of$ \dot{g}=4x10^{7} W/m^{3}$. The heat generated is dissipated to the environment steadily. The outer surface of the sphere is maintained at a uniform temperature of 80°C and the thermal conductivity of the sphere is $k=15{W}/{m}.℃$. Assuming steady one-dimensional heat transfer; (a) obtain a relation for the variation of temperature in the sphere by solving the differential equation, and (b) determine the temperature at the center of the sphere.
8. Consider one-dimensional conduction in a plane composite wall. The outer surface of wall A is insulated while the outer surface of wall C is exposed to a fluid at 25 and a convection heat transfer coefficient of 1000$ W/m^{2}.℃$. The middle wall B experiences uniform heat generation$ \dot{g}\_{B}=10^{6} W/m^{3}$, while there is no heat generation in walls A and C. The thickness of each wall is$ L\_{A}=30 mm, L\_{B}=60 mm, L\_{C}=20 mm$, and walls A and B and C have thermal conductivity of$ k\_{A}=25{W}/{m}°C $and $k\_{B}=30{W}/{m}°C $and $k\_{C}=50 W/m°C$. Determine the temperatures at the interfaces and plot the temperature distribution throughout the system.

