# Heat Transfer

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# Practical Lecture 6

40. A solid with volume $V$ and surface area $A$ is at the temperature $T_\infty$ and is immersed in a fluid at the same temperature. At a given instant $t = 0$, heat starts to be released in the solid at the rate per unit mass $\dot{q}_0 \exp(-\beta t)$, where $\dot{q}_0$ and $\beta$ are constants. Assuming constant properties and neglecting the internal temperature gradients, deduce an expression for the temperature in the solid as a function of time for $t > 0$.

43. The diffuser wall in the exhaust of a rocket motor has a thickness $L = 25\,\mathrm{mm}$ and consists of a steel alloy whose properties are $\rho = 8000\,\mathrm{kg\,m^{-3}}$, $c = 500\,\mathrm{J\,kg^{-1}\,K^{-1}}$, and $k = 25\,\mathrm{W\,m^{-1}\,K^{-1}}$. During a fire-resistance test, the wall is at a uniform initial temperature of $T_i = 25°\mathrm{C}$ and is exposed to the hot gases resulting from the combustion, whose temperature is $T_\infty = 1750°\mathrm{C}$. The outer surface of the wall is insulated. The wall should be maintained at a temperature of at least 100°C below the material melting temperature, which is equal to 1600°C. Assume that the diffuser diameter is much larger than the wall thickness and that the convection coefficient on the hot gases side is equal to $500\,\mathrm{W\,m^{-2}\,K^{-1}}$.

    (a) Determine the temperature on the surface of the wall in contact with gases after 30 s.

    (b) Determine the time at which the maximum permissible temperature is reached.

46. (Homework) A steel ball ($k = 36.4\,\mathrm{W\,m^{-1}\,K^{-1}}$, $\rho = 7750\,\mathrm{kg\,m^{-3}}$ and $c = 486\,\mathrm{J\,kg^{-1}\,K^{-1}}$) with diameter of 8 cm is heated in a furnace until it reaches a uniform temperature of 800°C. It is then cooled by immersion in a bath maintained at 300°C until the temperature in the center of the sphere reaches 500°C. Determine the time required for this cooling, assuming a very high convection coefficient.

55. (Homework) A glass of water at 300 K with 8 cm in diameter and 12 cm in height is placed in a refrigerator, which maintains the air temperature at 277 K. The convection coefficient is $5\,\mathrm{W\,m^{-2}\,K^{-1}}$. After 6 hours the glass is removed from the refrigerator. Estimate the average water temperature at this time, assuming that there is only heat conduction in the water.