

3 Exercices

3.1 Exercice 1 : Heat Pulse on opaque medium

In a flash method experiment used to determine the thermal diffusivity of a material, the measured quantity is the temperature evolution of the rear face, located at $z = e$, of a cylindrical specimen with plane and parallel faces, as illustrated in Figure 3.1.

This sample is subjected to a heat pulse of total energy Q (in J m^{-2}) on its front face $z = 0$. The convective losses (and linearized radiative losses, see Section 2.3.2) with the surrounding environment at temperature T_∞ are modelled by two heat transfer coefficients h_0 and h_e . The lateral losses are neglected ($h_r = 0$). We further assume an initial thermal equilibrium. The ultimate goal is to find the rear face Laplace temperature of the sample.

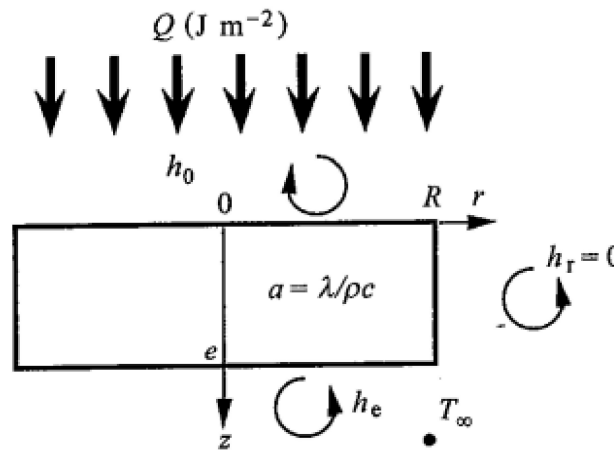


FIGURE 7 – Heat pulse experiment to measure the diffusivity

1. Establish the heat transfers equation and the associated boundary conditions
2. Write the heat transfer equation in Laplace domain.
3. Write the equivalent circuit of the heat transfer using the impedance formalism.
4. Compute the time constant of the wall
5. Write the quadripole matrix
6. Find the equation of the rear face temperature in Laplace domain
7. (with a computer) Solve and plot the temporal evolution of the temperature for different value of convective coefficient.

3.2 Exercice 2 : Composite Walls subject to Solar radiation

A two-layer wall is composed of two media (1 and 2) with an imperfect contact at their interface (thermal contact resistance R_c). The wall separates the outside

environment at temperature $T_{\text{out}}(t)$ from the inside environment that is assumed to have a uniform temperature $T_{\text{in}}(t)$ with a thermal capacity C_t (in the case of the wall of a building, for example, this capacity is

$$C_t = (\rho c)_{\text{air}} V \quad (54)$$

where V is the volume of a room). Medium 1 exchanges heat by convection with the outside environment (heat transfer coefficient h_{out}). In a similar way medium 2 exchanges heat with the inside environment (heat transfer coefficient h_{in}). A direct solar flux $\Phi_s(t)$ is absorbed by the outside surface of medium 1. At time

$$t = 0 \quad (55)$$

we assume that the whole system is in thermal equilibrium, i.e.

$$T(t = 0) = 0 \quad (56)$$

A sketch of the wall is shown in Figure 3.2. We are looking for the temperature variation $T_{\text{in}}(t)$ of the internal air.

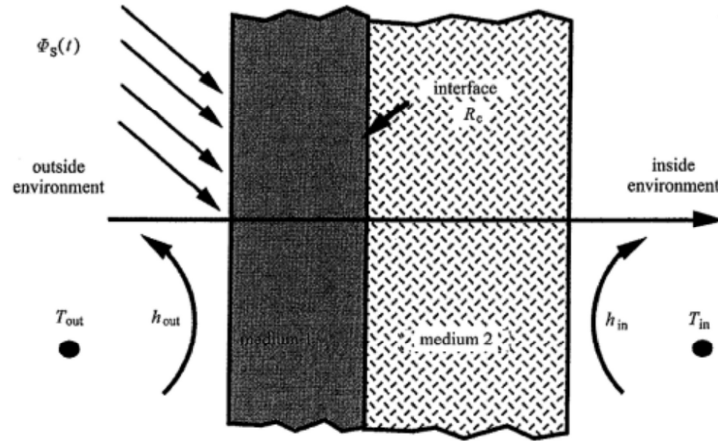


FIGURE 8 – Composite wall subjected to solar radiation.

1. Establish the solution in Laplace domain using the quadrupole matrix.
2. Use the lumped body to model the heat transfers at the internal surface.
3. Represent the wall using thermal impedance
4. Compute the internal temperature