

TEMPERATURES IN PLATES SUBJECTED TO A SUDDEN INCREASE IN RECOVERY TEMPERATURE

1. NOTATION

SI units only are quoted but any coherent system of units may be used.

B	Biot number, hd/k	
d	plate thickness	m
h	heat transfer coefficient of plate material	W/(m ² K)
k	thermal conductivity of plate material	W/(m K)
T_a	initial temperature of plate and initial value of recovery temperature	K
T_d	temperature of insulated surface at time t	K
T_o	temperature of heated surface at time t	K
T_r	recovery temperature after sudden increase	K
T_x	temperature at point x inside the plate at time t	K
t	time	s
x	normal distance from the heated surface	m
κ	thermal diffusivity	m ² /s

2. NOTES

Figures 1 and 2 show, for various values of the Biot number, the variation with time of the temperature change at the insulated and heated surfaces of a plate. The heated surface is subjected to a sudden increase in recovery temperature (see Data Item No. 89022^{*}).

It is assumed that the initial temperature of the plate is uniform and equal to the initial value of the recovery temperature and that all the physical and mechanical properties are constant throughout the plate thickness over the time interval considered.

For values of $\kappa t/d^2 > 0.3$, an approximate value of the temperature at any point inside the plate may be obtained from Figure 3.

^{*} Data Item No. 89022 "Heat transfer definitions and equations".

3. DERIVATION

This section lists selected sources that have been used in the compilation of this Data Item.

1. PRZEMIENIECKI, J.S. Bristol Aircraft Ltd, Internal Report TOR 125, December 1959.
2. SHARP. Unpublished work at Advanced Projects Group, Hawker Siddeley Aviation Ltd, December 1962.

4. EXAMPLE

For the example on the outer windscreen described in Data Item No. 89023, it is required to determine the temperatures at the two surfaces and the mid-point of the windscreen 8½ minutes after a change in the recovery temperature. The aircraft is initially cruising at a height and speed such that the recovery temperature, T_a , is 115°C. The recovery temperature suddenly decreases to $T_r = 50^\circ\text{C}$.

$$\text{Then} \quad B = \frac{136 \times 0.0127}{1.06} = 1.63$$

$$\text{and} \quad \frac{\kappa t}{d^2} = \frac{0.465 \times 10^{-6} \times 510}{0.0127^2} = 1.47.$$

Therefore, from Figure 1,

$$\frac{T_d - T_a}{T_r - T_a} = 0.68,$$

$$\text{hence} \quad T_d = (50 - 115) \times 0.68 + 115 = 71^\circ\text{C}.$$

From Figure 2,

$$\frac{T_o - T_a}{T_r - T_a} = 0.84,$$

$$\text{hence} \quad T_o = (50 - 115) \times 0.84 + 115 = 60^\circ\text{C}.$$

From Figure 3, for $x/d = 0.5$,

$$\frac{T_r - T_x}{T_r - T_d} = 0.87,$$

$$\text{hence} \quad T_x = 50 - 0.87(50 - 71) = 68^\circ\text{C}.$$