

HEAT TRANSFER DEFINITIONS AND EQUATIONS

1. NOTATION

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

B	Biot number = hl/k	
c	specific heat capacity	J/(kg K)
d	plate thickness	m
G	irradiation from external source	W/m ²
h	heat transfer coefficient	W/(m ² K)
k	thermal conductivity	W/(m K)
l	characteristic length	m
M_{∞}	free stream Mach number	
q	rate of heat transfer/unit area	W/m ²
r	recovery factor	
T	temperature	K
T_H	stagnation temperature outside boundary layer	K
T_r	recovery temperature	K
T_w	local surface temperature	K
T_1	local static temperature immediately outside boundary layer	K
T_{∞}	free stream static temperature (ambient temperature)	K
t	time	s
α_s	surface absorptivity	
γ	ratio of heat capacity at constant pressure to that at constant volume	
ε	surface emissivity	
κ	thermal diffusivity = $k/\rho c$	m ² /s
ρ	density	kg/m ³
σ	Stefan-Boltzmann radiation constant (= 0.0568×10^{-6} W/(m ² K ⁴))	

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2. INTRODUCTION

High temperature may be induced in parts of an aircraft structure by aerodynamic heating, internal heat sources and irradiation from external sources. This heating produces stresses and affects the mechanical properties. The first step in determining these effects is to determine the temperature distribution.

3. DEFINITION OF TERMS

3.1 Specific Heat Capacity (c)

The specific heat capacity of a substance is the amount of heat required to raise the temperature of unit mass by one degree.

3.2 Thermal Conductivity (k)

The thermal conductivity defines the rate of heat flow by conduction across a unit area due to a unit temperature gradient in a direction normal to the area. The rate of heat transfer per unit area by conduction in the x -direction is given by

$$q = -k \frac{\partial T}{\partial x}. \quad (3.1)$$

The value of k is normally measured under steady conditions but the same value is usually assumed to be true for transient conditions.

3.3 Thermal Diffusivity (κ)

The thermal diffusivity is a measure of the ratio of conducted heat to stored heat in transient heat flow and is given by $\kappa = k/\rho c$.

3.4 Emissivity (ϵ)

The emissivity of a surface is the ratio of the emissive power of the surface to that of a "black body" at the same temperature. The emissive power is the heat flow per unit surface area leaving a body in unit time by thermal radiation and is given by

$$q = \epsilon \sigma T_w^4. \quad (3.2)$$

The values of the emissivities for various flat surfaces at several temperatures are given in Data Item No. 69012 of the Aerodynamics Sub-series.

3.5 Absorptivity (α_s)

The absorptivity of a body is the fraction of irradiation from a particular heat source absorbed by the body. The value of α_s varies with the temperature of the source from which the radiation is received with the wavelength of the radiation. The rate of heat absorbed by the body by irradiation from an external source is given by

$$q = \alpha_s G. \quad (3.3)$$