Velocity and Temperature Relaxation

While the homogeneous model with effective gas properties may constitute a sufficiently accurate representation in some contexts, there are other technological problems in which the velocity and temperature differences between the phases are important either intrinsically or because of their consequences. The rest of the chapter is devoted to these effects. But, in order to proceed toward this end, it is necessary to stipulate particular forms for the mass, momentum and energy exchange processes represented by $\mathcal{I}_N$, $\mathcal{F}_{Nk}$ and $\mathcal{QI}_N$ in equations (Nnb1), (Nnb2) and (Nnb3). For simplicity, the remarks in these sections are confined to flows in which there is no external heat added or work done so that $\mathcal{Q}_N = 0$ and $\mathcal{W}_N = 0$. Moreover, we shall assume that there is negligible mass exchange so that $\mathcal{I}_N = 0$. It remains, therefore, to stipulate the force interaction, $\mathcal{F}_{Nk}$ and the heat transfer between the components, $\mathcal{QI}_N$. In the present context it is assumed that the relative motion is at low Reynolds numbers so that the simple model of relative motion defined by a relaxation time (see section (Nei)) may be used. Then:

$$\mathcal{F}_{Ck} = -\mathcal{F}_{Dk} = \frac{\rho_D \alpha_D}{t_u}(u_{Dk} - u_{Ck}) \tag{Nnd1}$$

where t_u is the velocity relaxation time given by equation (Nei2) (neglecting the added mass of the gas):

$$t_u = m_p / 12\pi R \mu_C \tag{Nnd2}$$

It follows that the equation of motion for the disperse phase, equation **??**, becomes

$$\frac{Du_{Dk}}{Dt} = \frac{u_{Ck} - u_{Dk}}{t_u} \tag{Nnd3}$$

It is further assumed that the temperature relaxation may be modeled as described in section (Nbi) so that

$$\mathcal{QI}_C = -\mathcal{QI}_D = \frac{\rho_D \alpha_D c_{sD} Nu}{t_T}(T_D - T_C) \tag{Nnd4}$$

where t_T is the temperature relaxation time given by equation (Nbi4):

$$t_T = \rho_D c_{sD} R^2 / 3k_C \tag{Nnd5}$$

It follows that the energy equation for the disperse phase is equation **??** or

$$\frac{DT_D}{Dt} = \frac{Nu}{2}\frac{(T_C - T_D)}{t_T} \tag{Nnd6}$$

In the context of droplet or particle laden gas flows these are commonly assumed forms for the velocity and temperature relaxation processes (Marble 1970). In his review Rudinger (1969) includes some evaluation of the sensitivity of the calculated results to the specifics of these assumptions.