

**Material Model 101: GE Thermoplastics**

The constitutive model for this approach is:

$$\dot{\epsilon}_p = \dot{\epsilon}_0 \exp(A\{\sigma - S(\epsilon_p)\}) \times \exp(-p\alpha A)$$

where  $\dot{\epsilon}_0$  and  $A$  are rate dependent yield stress parameters,  $S(\epsilon_p)$  internal resistance (strain hardening) and  $\alpha$  is a pressure dependence parameter.

In this material the yield stress may vary throughout the finite element model as a function of strain rate and hydrostatic stress. Post yield stress behavior is captured in material softening and hardening values. Finally, ductile or brittle failure measured by plastic strain or maximum principal stress respectively is accounted for by automatic element deletion.

Although this may be applied to a variety of engineering thermoplastics, GE Plastics have constants available for use in a wide range of commercially available grades of their engineering thermoplastics.

**Material Model 102: Hyperbolic Sine**

Resistance to deformation is both temperature and strain rate dependent. The flow stress equation is:

$$\sigma = \frac{1}{\alpha} \sinh^{-1} \left( \left[ \frac{Z}{A} \right]^{\frac{1}{N}} \right) \quad (19.102.1)$$

where  $Z$ , the Zener-Holloman temperature compensated strain rate, is:

$$Z = \dot{\epsilon} \exp \left( \frac{Q}{GT} \right) \quad (19.102.2)$$

The units of the material constitutive constants are as follows:  $A$  (1/sec),  $N$  (dimensionless),  $\alpha$  (1/MPa), the activation energy for flow,  $Q$  (J/mol), and the universal gas constant,  $G$  [J/(mol · K)]. The value of  $G$  will only vary with the unit system chosen. Typically it will be either 8.3145 J/(mol · K), or 40.8825 lb · in/mol · R .

The final equation necessary to complete the description of high strain rate deformation herein is one that allows computation of the temperature change during the deformation. In the absence of a coupled thermo-mechanical finite element code we assume adiabatic temperature change and follow the empirical assumption that 90-95% of the plastic work is dissipated as heat. Thus the heat generation coefficient is

$$HC \approx \frac{0.9}{\rho C_v}$$

where  $\rho$  is the material density and  $C_v$  is the specific heat.