3.3.10 Maximum Possible Reduction

When the process of wire drawing is considered, the drawing stress cannot exceed the flow strength of the material (σ_o). Thus, a limit is set on the relative drawing stress of Eq. (1) as follows

$$\frac{\sigma_{xf}}{\sigma_0} \le 1 \qquad \text{Eq. (j)}$$

Thus, when the limit of Eq. (j) is set on the left-hand side of Eq. (1) and the equation is rearranged to solve for the reduction ratio, the following expression for the maximum possible reduction for wire drawing is obtained:

$$\frac{R_0}{R_f}\Big|_{\max} = \exp\left(\frac{1 - \dfrac{\sigma_{xb}}{\sigma_0} - \dfrac{2}{\sqrt{3}}\left[\dfrac{\alpha}{\sin^2\alpha} - \cot\alpha + \dfrac{mL}{R_f}\right] - \dfrac{1}{2}\dfrac{\rho_0}{g\sigma_0}v_f^2}{2\left[f(\alpha) + \dfrac{m}{\sqrt{3}}\cot\alpha\right]} \right) \qquad \text{Eq. (3a)}$$

When open-die extrusion is considered, the extrusion pressure of Eq. (2) cannot exceed the flow strength of the workpiece. The maximum possible reduction can be found by substituting $\sigma_{xb} = \sigma_o$ into Eq. (2) and solving for R_o/R_f by successive approximations. However, when the inertia term is neglected, the maximum possible reduction for open-die extrusion is

$$\frac{R_0}{R_f}\Big|_{\max} = \exp\left(\frac{1 + \dfrac{\sigma_{xb}}{\sigma_0} - \dfrac{2}{\sqrt{3}}\left[\dfrac{\alpha}{\sin^2\alpha} - \cot\alpha + \dfrac{mL}{R_f}\right]}{2\left[f(\alpha) + \dfrac{m}{\sqrt{3}}\cot\alpha\right]} \right) \qquad \text{Eq. (3b)}$$

The characteristics of Eq. (3a) when inertia forces are neglected are presented above, where the abscissa is the semi-cone angle of the die (α) and the ordinate is the reduction ratio (R_o/R_f). Note that when the semi-cone angle of the die is either zero or about 63°, no reduction is possible for any friction value. The typical curve in Fig. <18> starts with zero reduction ($R_o/R_f = 1$) when $\alpha = 0$, increasing when the die angle commences to increase. The maximum possible reduction reaches a peak for some angle α and drops with further increase in α, reaching zero at $\alpha \approx 63°$. The uppermost curve corresponds to no friction (m=0) and lower curves correspond to higher friction values. When friction is zero, the peak occurs at $\alpha = 0$ and the value of the maximum possible reduction is:

$$\frac{R_0}{R_f}\Big|_{\max} = \frac{R_0}{R_f}\Big|_{ideal} = e^{1/2} \approx 1.65 \qquad \text{Eq. (k)}$$

When no back pressure is applied ($\sigma_{xb} = 0$) and friction is zero, the uppermost value of reduction is $R_o/R_f = 1.65$. For higher friction values, the peak is lower and occurs with larger die angles. Inertia forces cause further reduction in the maximum possible reduction.

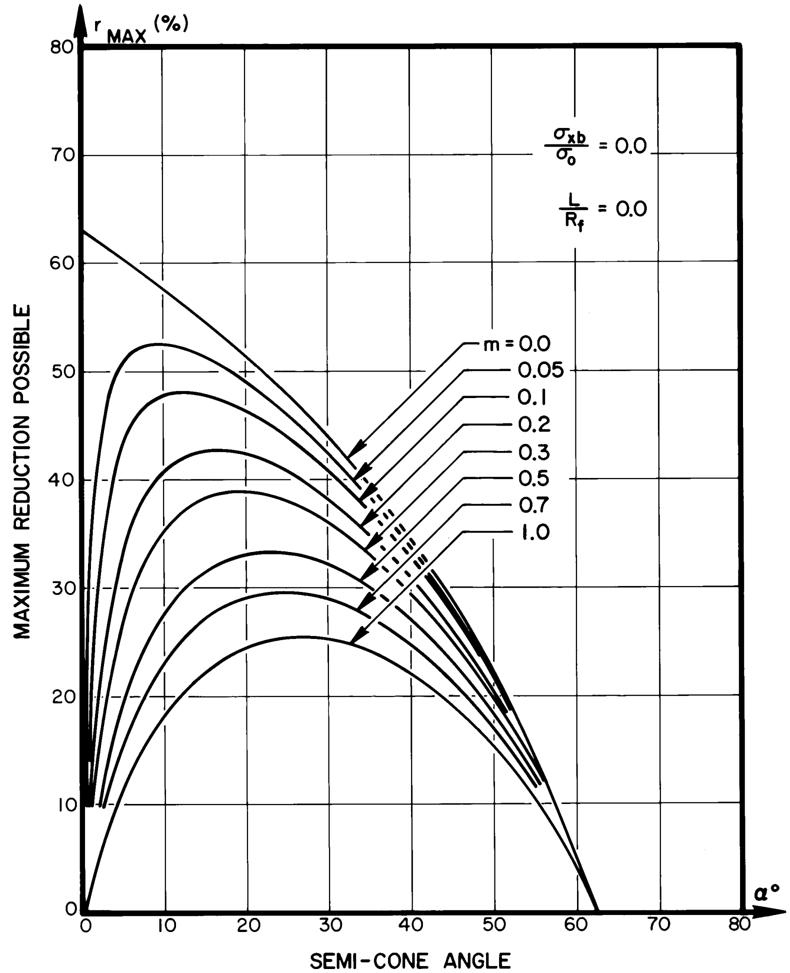

Fig. 18 Maximum possible reduction as a function of α and M.

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