TUBE Bending Formulas

B = degree of bend
E = feathered edge thickness
F_b = bend difficulty factor
F_d = "D" of bend
F_w = wall factor
K_r = constant for rigidity
K_s = constant for minimum clamp length
K_z = constant for feathered edge
L_c = clamp length
L_p = pressure die length
M_b = mandrel ball diameter
M_d = mandrel nose diameter
M_m = mandrel body diameter
M_r = mandrel nose radius
P_e = percentage of elongation at arc
P_t = percentage of wall-thinning
P_w = wall thickness after thinning
R = centerline radius
R_i = inside radius
R_o = outside radius
S = maximum set-up depth
T = tube outside diameter
T_i = tube inside diameter
W = wall thickness
W_i = thickness of inside lamination
W_o = thickness of outside lamination

Tube inside diameter:

$$T_i = T - (W \times 2)$$

Inside radius:

$$R_i = R - (T / 2)$$

Outside radius:

$$R_o = R + (T / 2)$$

Wall factor:

$$F_w = T / W$$

"D" of bend:

$$F_d = R / T$$

Bend difficulty rating (the higher the value, the more difficult the bend is to make; rule of thumb only):

Where "K_r" = a constant for material rigidity (assign the same value to "K_r" as you would to calculate pressure die length; a value of 2 is suitable for most applications; click here for more information) and "n_1" through "n_4" are values to adjust the weight of each factor in the equation (see below for our recommended weighting):

General formula: $\mathbf{F_b = [(n_1 \times K_r) + (n_2 \times F_w) + ((n_3 \times B) / 180))] / [n_4 \times F_d]}$

Formula with recommended weighting: $\mathbf{F_b = [2K_r + .2F_w + (B / 180)] / [F_d]}$

Note: A bend difficulty rating (calculated with our recommended weighting) of 7 or less indicates a bend that is relatively simple to produce with the rotary-draw method. Factors in excess of 7 typically require either additional precision in set-up or close attention during production in order to hold the set-up parameters.

Wall-thinning of extrados at outside radius after bending (rule of thumb only):

Where "P_t" = percentage of wall-thinning and "P_w" = targeted thickness of wall after thinning out from bending:

$\mathbf{P_t = (R_o - R) / R_o}$

$\mathbf{P_w = W \times (1 - P_t)}$

Percentage of elongation at arc of the bend (rule of thumb only):

$\mathbf{P_e = (R_o / R) - 1}$

Mandrel nose diameter for single-wall tubing:

$\mathbf{M_d = T - (W \times 2.21)}$

Mandrel nose diameter for double-wall tubing:

Where "W_o" = wall thickness of outside lamination and "W_i" = wall thickness of inside lamination:

$\mathbf{M_d = (T - (W_o \times 2)) - (W_i \times 2.21)}$

Mandrel nose radius:

if $F_w < 50$ then $M_r = M_d \times .1$ else $M_r = M_d \times .02$

Mandrel body diameter:

$$M_m = M_d \times .995$$

Mandrel ball diameter:

$$M_b = M_d \times .998$$

Maximum set-up depth of mandrel nose relative to the line of tangency, as measured from nose end (including nose radius):

$$S = [\ (\ R + (\ T\ /\ 2) - W\ )^2 - (\ R + (\ M_d\ /\ 2\ )\ )^2\ ]^{1/2} + M_r$$

Wiper feathered edge thickness (simple-sweep geometry only):

Where "K_z" = a constant approaching zero depending upon limitations of material and method of manufacturing (with current technology, a value of .0025 is reasonable for "K_z"):

if $T \times K_z > .006$* then $E = T \times K_z$ else $E = .006$*

* Inches. For metric applications, substitute .15 millimeters.

Clamp length:

Where "K_r" = a constant for material rigidity (assign a value of 2 to "K_r" for most applications; click here for more information) and "K_s" = a constant limiting the minimum clamp length depending upon the surface of the cavity (assign to "K_s" the value of 2 for smooth cavities and 1 for serrated cavities; click here for more information):

if $(\ T \times (\ K_r \times 2.5)\ ) - R < T \times K_s$ then $L_c = T \times K_s$ else $L_c = (\ T \times (\ K_r \times 2.5)\ ) - R$

Pressure die length:

Where "K_r" = a constant for material rigidity (assign a value of 2 to "K_r" for most applications; click here for more information):

$$L_p = (\ R \times 3.14 \times (\ B\ /\ 180\ )\ ) + (\ T \times K_r\ )$$

Contact Tube Form Solutions for more information or to answer any tube fabrication questions.

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