SHEET-METAL BEND ALLOWANCE

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TABLES, rules of thumb, and cut-and-try methods are usually used to estimate the length of straight stock needed when sheet metal is bent. Unfortunately, these methods are often unsatisfactory because the required stock length depends not only on bend radius, material thickness, and angle of bend, but also on the specific material being used.

A better method is a series of equations, valid for all materials, that has been developed to calculate bend allowance and bend length. If the strength and ductility of the material are already well known, the equations can be used directly. If not, the equations can be used with data from a simple test bend to determine material properties, then applied to the specified bend. To reduce workloads even further, the equations can be programmed into hand-held calculators such as the TI 59.

Finding bend length: If the material bends with the neutral plane in the exact center of the sheet, bend length can be calculated from

$$B_l = \frac{\theta\pi}{180}\left(R + \frac{T}{2}\right)$$

The bend allowance for outside measurements A and B is related to bend length by

$$B_a = \frac{\theta}{90}[2(R + T) - B_l]$$

However, when materials undergo plastic deformation, as they do in bending operations, the neutral plane does not remain at the center of the sheet. Under these conditions, bend length can be found from

$$B_l = \frac{\theta\pi}{180}\left(R + C\frac{T}{2}\right) \qquad (1)$$

where C is related to the ductility of the material.

An indication of ductility is the ratio of yield strength to tensile strength K. Materials of low ductility have K ratios approaching 1.0, whereas materials of high ductility have K ratios much less than 1.0. Values of K have been determined for several common sheet metals, and through linear regression with the bend-length equation, an equation for C has been determined:

$$C = 0.668 + 0.326K^2$$

Because sheet metals vary from batch to batch, K and C are best determined from test-bending a material sample and computing new values, rather than relying on previously established values or published data. Both K and C are properties of the material, rather than geometry, so the test bend can be made on any convenient thickness and at any convenient radius. Using the above equations and data from a test bend, K^2 can be found from

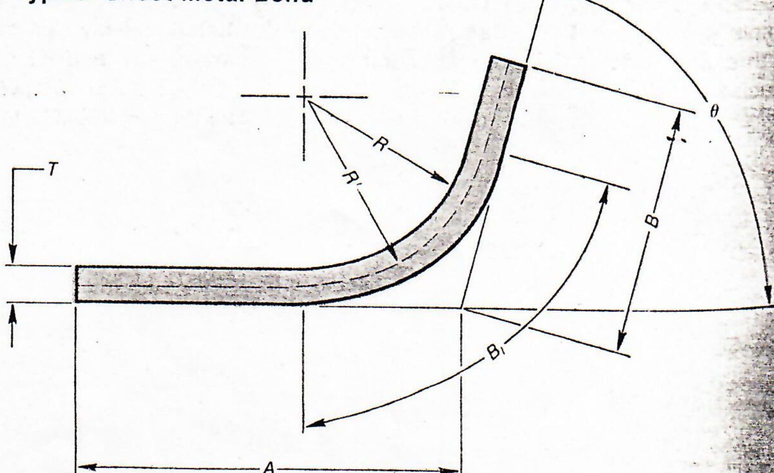
$$K^2 = \left[\left\{\left[2(R + T)\tan\frac{\theta}{2} - B_a\right]\frac{180}{\theta\pi} - R\right\}\frac{1}{T} - 0.334\right]\frac{1}{0.163} \qquad (2)$$

Using the equations: In practice, Equation 2 is usually used to determine K from a test bend, then solved for B_a and used to find the bend allowance for production bends. If needed, bend length can then be calculated from Equation 1.

As an example, consider a 20-gage (0.036-in.) low-carbon steel sheet that must be bent 75° with an inside radius of 0.093 in. Bend allowance is needed to determine raw-material requirements.

The material is not at hand, but a sample of the same steel in 16 gage (0.060 in.) is available. The sample length is

Typical Sheet-Metal Bend



3.230 in., and the sample is bent 90° with a radius of 0.125 in. After the bend, dimensions A and B are found to be 1.506 and 1.857 in. Bend allowance for the test bend is

$$B_a = A + B - L$$
$$= 1.506 + 1.857 - 3.230$$
$$= 0.133 \text{ in.}$$

From Equation 2, the value of K^2 for this material is

$$K^2 = \left[\left\{\left[2(0.125 + 0.060)\tan\frac{90}{2} - 0.133\right]\frac{180}{90\pi} - 0.125\right\}\frac{1}{0.060} - 0.334\right]\frac{1}{0.163}$$
$$= 0.597$$

Now by solving Equation 2 for B_a, using the value of K^2 just found, and inserting the thickness and radius of the production bend, the bend allowance of the production bend can be found:

$$B_a = 2(R + T)\tan\frac{\theta}{2} - \frac{\theta\pi}{180}[R + (0.334 + 0.163K^2)T]$$
$$= 2(0.093 + 0.036)\tan\frac{75}{2} - \frac{75\pi}{180}\{0.093 + [0.334 + 0.163(0.597)]\,0.036\}$$
$$= 0.056 \text{ in.}$$

If raw-material calculations make it more useful to have bend length than bend allowance, B_l can be found from Equation 1:

$$B_l = \frac{\theta\pi}{180}\left[R + (0.668 + 0.326K^2)\frac{T}{2}\right]$$
$$= \frac{75\pi}{180}\left\{0.093 + [0.668 + 0.326(0.597)]\frac{0.036}{2}\right\}$$
$$= 0.142 \text{ in.}$$

Nomenclature

A = Straight-line dimension on one side of bend (see illustration), in.
B = Straight-line dimension on other side of bend, in.
B_a = Bend allowance, in.
B_l = Bend length, in.
C = Ductility constant
K = Ratio of yield strength to tensile strength
L = Straight-line length of piece before bending, in.
R = Bend radius measured on inner surface, in.
T = Material thickness, in.
θ = Bend angle, °

PLATING WITH A BRUSH

SELECTIVE brush plating has long been considered a quick, inexpensive method of touching up defective electroplated parts. As such, it has never had the reputation for producing high-quality finishes. Often, plating equipment was crude and produced only a thin deposit with fair adhesion, and corrosion developed rapidly on the repaired area.

However, International Nickel Co. Inc. reports that a number of improvements have been made in the process so that selective brush plating can be performed at fairly high rates to produce controlled, metallurgically sound deposits with good adhesion and mechanical properties. For example, special electrolytes have been developed with metal contents appreciably higher than those in standard plating solutions. Also, better working tools (styli) have been developed along with improved power sources that allow precise current control to regulate coating thickness.

As a result, the technique is becoming widely accepted for applications where conventional electroplating is difficult or impossible. Such applications include components too large to be dip plated and delicate assemblies, such as printed-circuit boards, that cannot be immersed without contamination.

Although no longer restricted to repair applications, brush plating can still be used to touch up defective parts. When used for repair, the technique eliminates the need to completely strip the deposit and replate the part. Brush plating can also be used with regular plating processes for plating into difficult recesses and blind holes where inside anodes would normally be required. MD

—DTC