Calculating Bend Deductions using Test Bend Pieces

Overview:

Autodesk® Inventor™ provides two methods of unfolding a folded model to a flat pattern. The first method involves applying a uniform (linear) *K Factor* to all bends (any angle or bend radius). This method can be extremely accurate for simple models. The second method involves searching through a bend table which has specific values for bend deductions that are specific to: material, material thickness, bend radius and bend angle. This method can ensure accuracy that is specific to certain pieces of shop floor equipment all will be extremely accurate for any bends produced on that equipment for measured angles and bend radii. To maximize the benefits of the bend table unfold method a table must be created which contains specific bend deductions using values calculated from measuring test bend pieces using the specific material, material thickness, bend radius and bend angle.

> Note – The procedures described below rely upon the creation and measurement of physical test pieces and are therefore subject to manufacturing tolerances and measurement accuracy. Ideally all dimensions (and measurements) would be exact to as many decimal places as practical. This includes both linear and angular values. Repeatability in manufacture and accuracy of measurement will ensure maximum benefits.

Process:

1. Choose a material thickness and prepare a sufficient number of blanks. In the example described a 6.000” x 6.000” blank of 13 ga. (0.090” nominal) aluminum is used. Attention should be paid to the preparation of the blanks as size and squareness will factor into subsequent measurements.
2. Choose tooling to create a bend of known angle and radius. In the example described a bend angle of 90° is used with a bend radius of 0.250”
3. Create a set of test bends using the selected tooling, bend angle and radius. Ensure that the bends created are parallel to the edge of the blank with a high degree of accuracy.

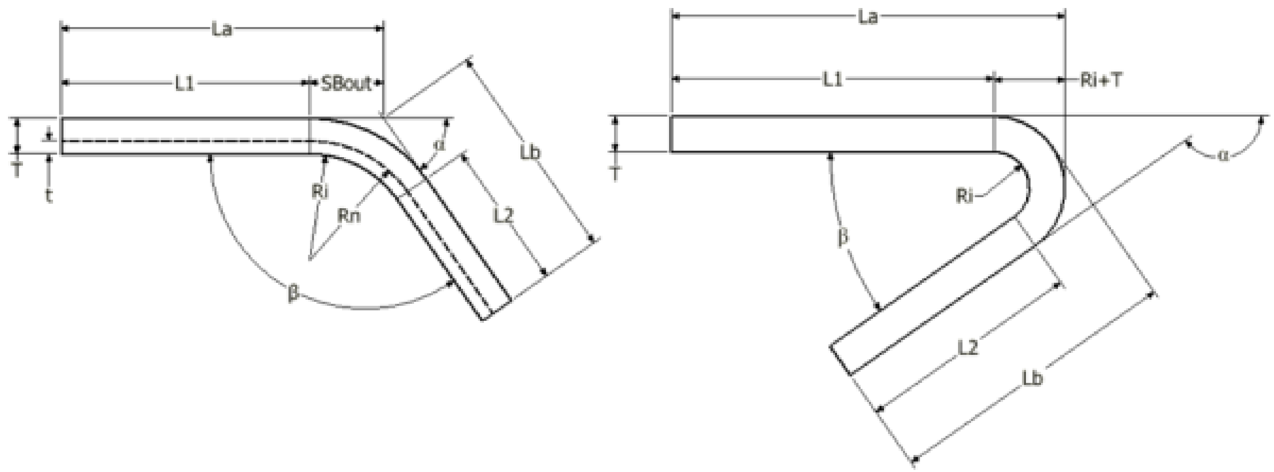

Figure 1

$$\boldsymbol{L = L_a + L_b - L_{BD}}$$

$$L_a = L_1 + L_S$$

$$L_b = L_2 + L_S$$

$$L_S = \begin{cases} \tan\left(\frac{\alpha}{2}\right) \cdot (R_i + T), & 0^\circ \leq \alpha \leq 90^\circ \\ (R_i + T), & 90^\circ < \alpha \leq 180^\circ \end{cases}$$

Figure 2

4. Using the figures above, measure the lengths: **La** and **Lb**

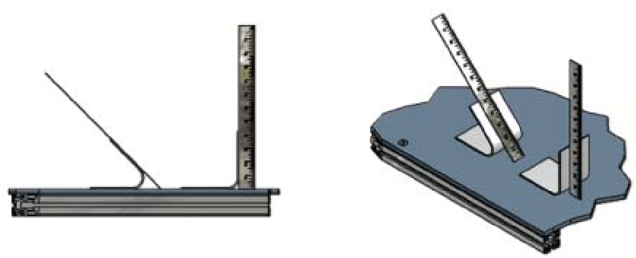

Figure 3

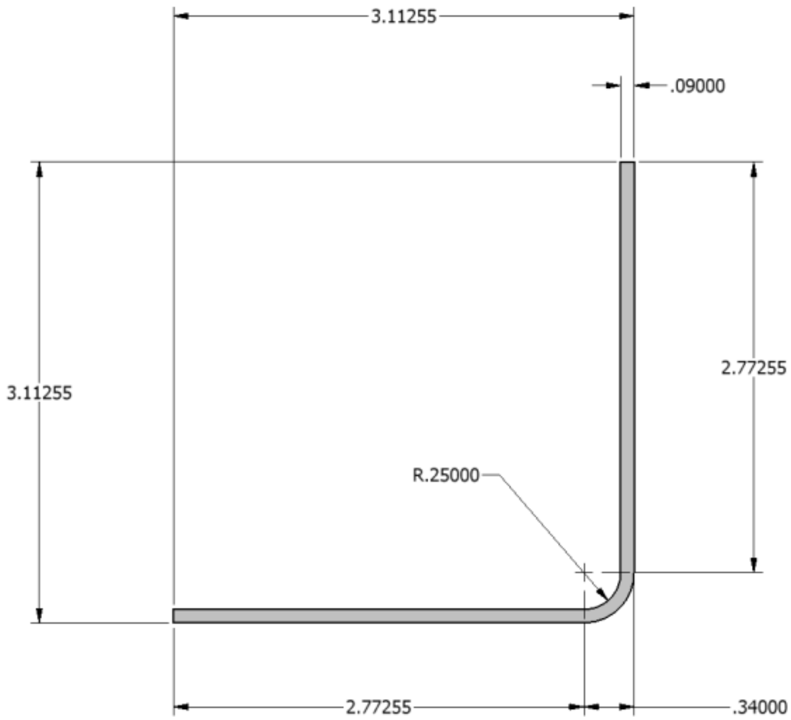

Figure 4

In the example the measurement of **La** and **Lb** is easy and the value for both is 3.11255" as shown in the above figure. For bend angles greater or less than 90° the inspection/measurement process will be more involved.

5. Calculate the bend deduction. Since you know the size of your blank before bending and you have accurately measured the lengths **La** and Lb the bend deduction is equal to:

(**La** + **Lb**) – **L**

in our example:

(3.11255 + 3.11255) – 6

or:

6.2251 – 6

or:

0.2251

6. Repeat the measurement/calculation process for the remainder of the test pieces that were created using the same set-up and average your results.

Based on the measured results, the bend deduction for the given example is: 0.2251

This value would then be included in a bend table for 0.090" thick aluminum in the row for 90° bends under the column heading for the bend radius of 0.250"

Sensitivity Considerations:

In the example discussed, the bend deduction was directly measured to be 0.2251 based on theoretically perfect: blank size, bend angle, bend radius, material thickness and theoretically perfect test pieces (ie: the bend was perfectly parallel to the edge of the piece with absolutely no deviation and the sheared face of the material was perfectly perpendicular to the 6 x 6 face). Additionally, measurements were assumed to be absolute.

Making these sorts of assumptions is unrealistic.

For the example cited (using 0.090” thick material) deviations in the bend deduction will produce measurable deviations in the length measured (assuming a perfectly sized blank) as follows:

Bend Deduction	Measured Length
0.2200	3.11000
0.2240	3.11200
0.2251	3.11255
0.2260	3.11300
0.2300	3.11500

Table 1

In the event that the example blank was 0.005” smaller than the theoretical 6.000” the bend deduction measured would have been 0.2201.

As you can see from the above, all of the measurements will impact the accuracy of the calculated bend deduction and although small in the above example, the impact on the accuracy and subsequent usefulness of a resulting bend table can be significant.