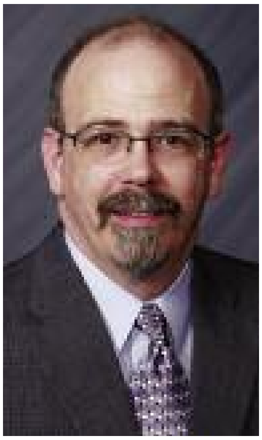


Peter Ulintz is Advanced Product Engineering Manager for Anchor Manufacturing Group, Inc., Cleveland, OH. Having worked in the metalforming industry since 1978, his background includes tool and die making, tool engineering, engineering management, advanced process planning and product development. Ulintz has been speaking at PMA seminars, symposiums and roundtables since 1996, focusing on tool and die technology, deep-draw stamping, metalforming simulation and metalforming problem solving. His published technical works include a computer-assisted deep-drawing method and metalforming-simulation case studies.

Peter Ulintz

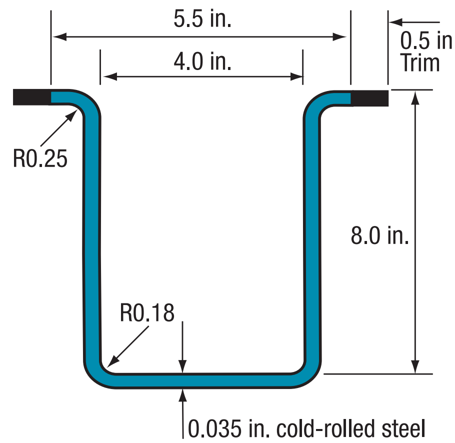
pete.ulintz@toolingbydesign.com

www.toolingbydesign.com

TOOLING BY DESIGN | PETER ULINTZ

Drawing Cups with Flanges

Last month we began to process the deep-drawn cup shown in the figure. First, it was necessary to calculate the blank diameter and then find the maximum percent-reduction. For this particular part, the blank diameter was found to be 13.0 in. and the first draw reduction was 42 percent. Applying the percent reduction formula we found the first reduction (cup) diameter should be 7.54 in.



Flange or No Flange

The next step is to determine if the cup should be drawn with or without a flange. Let's assume a small 0.25-in.-wide flange was to be left on the cup after the first draw. This would make the flange diameter 8.04 in. and the flange would remain this size through the redraw operations. The amount of material to be removed at the trim station is calculated as follows:

Cup flange diameter at last redraw:	8.04 in.
Flange diameter after trimming:	5.50 in.
	2.54 in.
Trim allowance = 2.54 divided by 2:	1.27 in.

Usually, only 0.5 in. of material or less is desired for trimming in order to provide optimum material utilization. If a progressive die were chosen for this part, a flange would be needed in the draw operation to attach the carrier ribbons. But a transfer die would allow the cup to be completely drawn without a flange, saving a significant amount of material that would otherwise go into the scrap container. This savings potential is sometimes overlooked during process planning and estimating.

Cup Height

The expected cup height at the first draw can be determined by using the surface-area approach found in most die-design handbooks for calculating blank diameters. The formula for a flangeless cup is:

$$D = \sqrt{d^2 + 4dh}$$
$$13.0 = \sqrt{(7.54)^2 + (4)(7.54)h}$$
$$169 = 56.85 + 30.16h$$

Solving for h, cup height = 3.72 in.

Punch and Die Radii

Punch and die radii can be specified at this point. It is not necessary to use the part-print radii in the draw operation since the neither the shell diameter nor the shell height is near the final part-print size. In fact, there is an advantage gained by using a larger punch radius in the draw operation. The redraw blankholder fits inside the drawn cup at this radius. This provides for a larger redraw radius on the blank-holder, thus reducing the bending and straightening loads for that operation.

First Redraw

The redraw reduction percentage can never be as high as the first draw because the redraw has more bending and straightening forces, the cup wall in tension is smaller, and the material has been previously work-hardened. Reductions for the first redraw are usually 55 to 60 percent of the initial draw ratio. Thus, the first redraw reduction would be:

42 percent blank reduction x 0.55 = 23 percent

The original draw diameter (7.54 in.) is reduced by 23 percent, giving a redraw diameter of 5.81 in. It now is clear that the first redraw cup must have a flange since the redraw-cup diameter is smaller than the flange diameter before trimming—6.50 in.

Second Redraw

The second redraw-reduction percentage must be less than the first redraw due to more severe work-hardening plus an even smaller cup wall in tension. As a general rule, the second redraw reduction will be approximately 10 percent less than the first redraw. For our particular case study:

First redraw reduction = 23 percent
23 percent x 0.10 = 2.3 percent
Second redraw reduction = 21 percent

Reducing the first redraw diameter (5.81 in.) by 21 percent gives a second redraw diameter of 4.59 in., but the flange diameter does not change and remains 6.50 in.

Subsequent Redraws

A third redraw operation is required to obtain the final cup diameter of 4 in. and a depth of 8 in. To find the percent reduction for the subsequent redraws, continue to reduce the percent reduction by an additional 10 percent for each redraw. For example, the third redraw reduction percentage would be 10 percent less than the second redraw, giving a 19-percent reduction. The fourth redraw would be 10 percent less than the third, yielding a 17-percent reduction.

But suppose the third redraw reduction was only 6 percent. It may not be cost effective to build a third redraw tool for such a small reduction. In many instances, it would be better to slightly increase the draw and other redraw percentages in order to eliminate the third redraw. If the process is already critical, the initial draw and redraw percentages should be reduced so that the third redraw reduction percentage is higher and worthwhile.

I have found that different die-design handbooks will have slightly different reduction percentages among them. But for the most part, they tend to follow the approximations given here. **MF**