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Troubleshooting Guidelines for Deep Drawing

Troubleshooting deep-drawing problems often can be a frustrating experience. For any given problem or failure there can be multiple causes and solutions. Many sophisticated troubleshooting tools are available, including: circle grid analysis (CGA), forming limit diagrams (FLD), computerized forming simulation, ultrasonic thickness gauges, high-speed videotaping and design of experiments, to name a few. But many die-related problems can be solved methodically by addressing the sources of common failures.

The following is a list of common problems that can be encountered when deep drawing round cups, their potential causes and possible remedies:

Many die-related problems can be solved methodically by addressing the sources of common failures.

Shallow cup or no cup formed; material fractures early in the drawing process

1) Drawing ratio too large—Rule of thumb: a safe ratio of blank diameter to cup diameter (D/d) is 1.8 for aluminum; 1.9 for steel; 2.0 for stainless steel.

2) Die radius too small—Rule of thumb: four to six times material thickness for steel; five to 10 times for stainless steel and aluminum.

3) Punch radius too small—Rule of thumb: at least four to eight times material thickness for steel, eight to 10 times for aluminum. It is suggested that the punch radius not be smaller than the die radius for aluminum.

4) Blank not centered over die cavity—Adjust locating pins or gauges.

5) Punch not centered with die cavity—Adjust tooling or mount in a guided die set.

6) Insufficient die clearance—Rule of thumb: approximately 1.10 times material thickness.

7) Punch velocity to high—rule of thumb: 80 ft./min. for deep drawing steel; 30 to 40 ft./min. for stainless steel and strong aluminum alloys.

8) Blankholder pressure too high—Rule of thumb: 600 lb. per linear inch for steel; 1800 lb. for stainless and HSLA steels; 400 lb. for aluminum.

9) Material stretches across punch face—Friction between the cup and punch aids in drawability; roughen punch face to retard material flow. If excessive stretching continues, try roughening the punch radius as well.

Complete or nearly complete cup formed; material fractures late in the drawing process

10) Die radius too large—Reduce die radii (see item 2).

11) Blankholder restraint too high near end of punch stroke—Add gap blocks (stand offs) to accommodate material thickening.

12) Insufficient die clearance—Increase die clearance (see item 6).

13) Blankholder pressure too low, wrinkles form and restrict material flow—See item 8.

Complete cup forms but trim edge is uneven or material wrinkles or bulges in wall

14) Excessive die clearance—Reduce die clearance (see item 6).

15) Die radius too large—Reduce die radii (see item 2).

16) Blankholder pressure too low—See item 8.

Square and rectangular boxes commonly fail (fracture) in the draw corners. Because each corner of the box is a quadrant of a drawn cup, the causes and remedies for corner failures can be similar to cups, but the following also must be considered.

Box fractures in the corners

1) Drawing ratio too large—Crop corners of blank to reduce drawing stresses.

2) Ratio of draw depth to box corner radius too large—Rule of thumb: a) depth of draw five to eight times the corner radius, b) the corner radii should be at least five to six times sheet thickness.

3) Die radius too small—Three to eight times sheet thickness for steel, five to 10 times for aluminum.

4) Insufficient die clearance in draw corners—Rule of thumb: 1.10 times material thickness in the corners, sheet thickness clearance in the straight sides.

5) Blankholder machined flat—The surface of a flat blankholder for box shells must be "spotted-in" to accommodate material thickening in the draw corners.

6) Excessive lubricant—Minimize or eliminate lubricant on the punch side of the blank, maintain lubricant on the die side.

Wrinkles in flange or side walls

7) Blankholder pressure is too low—Rule of thumb: 600 lb. per lineal inch for steel; 1800 lb. for stainless and HSLA; 400 lb. for aluminum. If wrinkles, buckles or waves persist in the straight walls, add draw beads.

8) Gap blocks set with too much clearance—Reduce clearance.

Rules of thumb provided are just that: general rules that do not apply to all alloys, product shapes or failure modes. But they can provide a valuable starting point when no other information is available. Unless otherwise indicated, the rules of thumb provided here were based on draw-quality, low-carbon steel, 1.0 to 3.0 mm thick. Since stainless steel and aluminum sheet are available in a variety of alloys and mechanical properties, guidelines are provided for the more commonly used sheet materials. **MF**

Website update: I've updated my website (www.toolingbydesign.com). The site now contains a Tool Tech page with useful formulas, die engineering tips and some technical papers. The FEA/Simulation page provides useful information and technical information relating to metalforming simulation. The Metal Links page provides quality links to various metal associations.