Forming Technology

Deep Drawing

In this cold metal forming process, the part is made by a punch that forces a sheet metal blank into a closely matched die to produce sheet geometries. Very deep parts can be formed using progressive dies.

Costs	Typical Applications	Suitability
• High to very high tooling cost • Moderate unit cost	• Automotive and aerospace • Food and beverage packaging • Furniture and lighting	• Medium to high volume production
Quality	**Related Processes**	**Speed**
• Good surface finish	• Metal spinning • Metal stamping • Superforming	• Rapid cycle time (a few seconds to several minutes), depending on the number of operations

INTRODUCTION

Cold metal pressing is known as 'deep drawing' when the depth of the draw is greater then the diameter (sometimes when the depth is only 0.5 times greater than the diameter). This process can be used to produce seamless sheet geometries without the need for any further forming or joining operations.

There is a limit to how much sheet metal can be deformed in 1 operation, and the type of material and sheet thickness determine the level of deformation. A variety of techniques are therefore used to produce different geometries. Simple cup-like geometries can be produced in a single operation, while very deep parts and complex geometries are made using progressive dies or the reverse drawing technique. Reverse drawing presses the sheet material twice in a single operation, inverting the shape after the first draw. Operating in this way accelerates cycle time and reduces the number of progressive tools required.

TYPICAL APPLICATIONS

The most common products manufactured by deep drawing include beverage cans and kitchen sinks. However, these techniques are also used to produce a variety of items in the automotive, aerospace, packaging, furniture and lighting industries.

RELATED PROCESSES

Shallow profiles are formed by metal stamping (page 82). Metal spinning (page 78), sheet ring rolling (see tube and section bending, page 98) and superforming (page 92) can be used to make similar geometries in sheet metal. Deep drawing and metal spinning produce seamless parts that typically do need to be welded post-forming.

QUALITY

Surface finish is generally very good, but depends on the quality of the punch and die. Wrinkling and surface issues usually occur around the edge, which is trimmed post-forming.

DESIGN OPPORTUNITIES

Various sheet geometries can be produced with the deep drawing, including cylindrical, box-shaped and irregular profiles, which can be formed with straight, tapered or curved sides.

Undercuts can be achieved with progressive dies or perpendicular action in the drawing press. However, this will greatly increase the tooling costs.

DESIGN CONSIDERATIONS

Depending on the type of material and thickness, parts ranging from less than 5 mm to 500 mm (0.2–19.69 in.) in diameter can be formed by deep drawing. The length of draw can be up to 5 times the diameter of the part. Longer profiles require thicker materials because material thickness is reduced in long draws.

The limits of deep drawing are often determined by the capabilities of the machine such as bed size (controls the size of blank), stroke (determines the length of draw achievable) and speed (which is restricted by stroke height and complexity of part).

COMPATIBLE MATERIALS

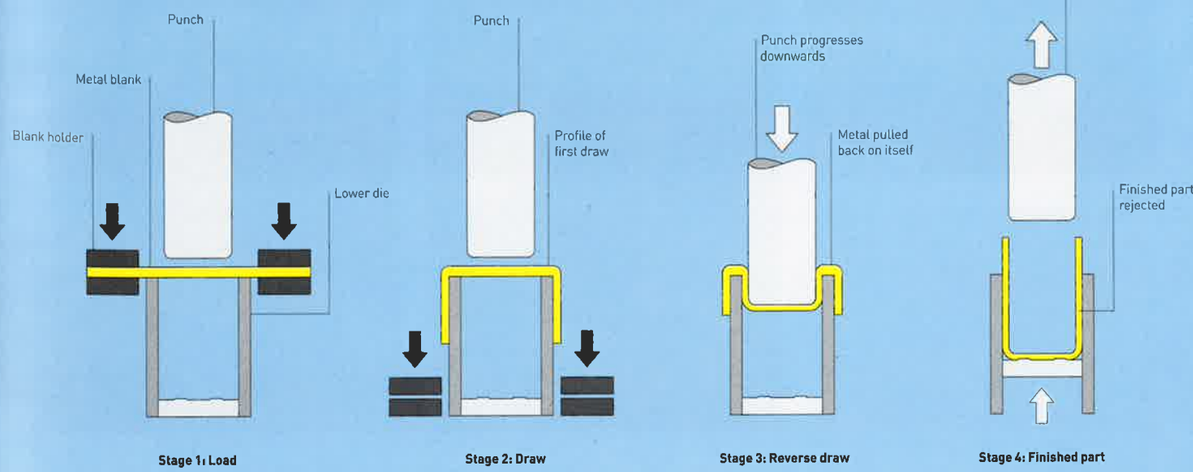
Deep drawing relies on a combination of a metal's malleability and resistance to thinning. The most suitable materials are steels, zinc, copper and aluminium alloys.

TECHNICAL DESCRIPTION

The deep drawing process is carried out in different ways – the method of process being determined by the complexity of the shape, depth of draw, material and thickness. In stage 1, a sheet metal blank is loaded into the hydraulic press and clamped into the blank holder. In stage 2, as the blank holder progresses downwards the material flows over the sides of the lower die to form a symmetrical cup shape. In stage 3, the punch forces the material through the lower die in the opposite direction. The metal flows over the edge of the lower die to take the shape of the punch. In stage 4, the part is ejected.

The tonnage of the press is determined by the tooling. Anything up to 1,000 tonnes may be applied to shape a long or large profile.

Deep Drawing Process



Stage 1: Load | Stage 2: Draw | Stage 3: Reverse draw | Stage 4: Finished part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Metals with high resistance to thinning are less likely to tear, wrinkle or fracture during processing, so thinner sheet material can be used to start with.

COSTS

Tooling costs are very expensive because the punch and die have to be engineered to precise tolerances. Progressive tooling, required to produce complex or especially deep parts, increases costs considerably for this process.

Cycle time is quite rapid but depends on the number of stages in the pressing cycle, while labour costs are moderate due to the level of automation.

ENVIRONMENTAL IMPACTS

Scrap is produced when the sheet material is cut to size and the finished part trimmed. Fortunately, all scrap material can be recycled into new sheet metals or other metal products.

Case Study

Deep drawing the Cribbio

Blanks are cut to suit each deep drawing application. In this case, the Cribbio is circular, so a circular blank is cut from a sheet of 0.8 mm (0.031 in.) carbon steel (**image 1**). The final part has a reduced wall thickness of 0.7 mm (0.028 in.) as a result of thinning during drawing. A fine layer of oil is then applied to both sides of the blank, for lubrication (**image 2**).

The blank is loaded into the blank holder (**image 3**) on a 500 tonne press, which progresses downwards, forcing the sheet metal to flow over the lower die (**image 4**). The punch simultaneously forces the material inside the lower die (turning it inside out). The first stage of this part's forming is complete and it is removed (**image 5**).

The drawn part is loaded onto the second of the progressive dies (**image 6**). A punch forces the material into the lower die, turning it inside out once again. This process of reverse deep drawing means that fewer tools are required to achieve the same length of draw. The drawn part is then removed (**image 7**). At this point the metal blank has been forced through 2 progressive deep drawing cycles, which both applied reverse draw. Even though the Cribbio is a complex part to deep draw, production remains as high as 50 parts per hour. The top edge is then trimmed to remove any wrinkles and tearing that may have occurred to the perimeter of the metal blank during clamping and drawing (**image 8**) and so produce a clean edge detail. The parts are transferred onto a punch that perforates the surface (**image 9**).

Side actions are extremely expensive to incorporate into the deep drawing cycle, so are often carried out post-forming. After perforation a ring of pressed metal is crimped over the top edge to create a safe and ergonomic trim (**images 10** and **11**). The steel Cribbio is finished with a hardwearing epoxy coating (**image 12**).


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