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A Review of Experimental Study of Spring Back Effect of Aluminum Sheet Metal

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Abstract

To predict the exact shape, the geometry based punch contact program must be used. The shape changes once the punch is withdrawn, because of the materials elasticity. Prediction of such a spring back effect is a major challenging problem in industry involving sheet metal forming operations. It also needs applying appropriate back tension during the forming complex shapes. Slight deformation of the metal leads to non-axisymmetric loading. One can predict the residual stress by determining plastic and elastic deformation. Thus appropriate spring back effect can be investigated.

Keyword: sheet metal , applied force, lever.

Introduction

In typical sheet metal forming process, the shape of the blank obtained at the end of the forming step closely conforms to the tools geometry. However, as soon as the loads are removed, elastically- driven change in the blank shape takes place. This process is termed spring back .

The most important task in sheet metal forming design is to define such a tool geometry that geometry of the actual product coming out from the manufacturing process is as close as possible to the one prescribed by the design . In sheet metal forming, there are two regimes; elastic and plastic deformation. Forming a sheet to some shape obviously involves permanent 'plastic' flow and the strains in the sheet could be quite large. To minimize the spring back effect several methods are applied . The comprehensive compensation (CC) method considers the fact that large rotation and displacement would occur during spring back, which is more common for automotive panel stamping . The displacement adjustment (DA) method in which compensation magnitude and compensation direction are the two important aspects, has been proved in practice to be successful . However, no theory behind the DA method is present, tests of industrial case also shows that the effectiveness of the method depends on various parameters including the part geometry, material and process settings .

Sheet Metal

Sheet metal is metal formed by an industrial process into thin, flat pieces. It is one of the fundamental forms used in metalworking and it can be cut and bent into a variety of shapes. Countless everyday objects are constructed with sheet metal. Thicknesses can vary significantly; extremely thin thicknesses are considered foil or leaf, and pieces thicker than 6 mm (0.25 in) are considered plate.

Sheet metal is available in flat pieces or coiled strips. The coils are formed by running a continuous sheet of metal through a roll slitter.

The thickness of sheet metal is commonly specified by a traditional, non-linear measure known as its gauge. The larger the gauge number, the thinner the metal. Commonly used steel sheet metal ranges from 30 gauge to about 8 gauge. Gauge differs between ferrous (iron based) metals and nonferrous metals such as aluminum or copper; copper thickness, for example is measured in ounces (and represents the thickness of 1 ounce of copper rolled out to an area of 1 square foot).

There are many different metals that can be made into sheet metal, such as aluminum, brass, copper, steel, tin, nickel and titanium. For decorative uses, important sheet metals include silver, gold, and platinum (platinum sheet metal is also utilized as a catalyst.)

Sheet metal is used for car bodies, airplane wings, medical tables, roofs for buildings (architecture) and many other applications. Sheet

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metal of iron and other materials with high magnetic permeability, also known as laminated steel cores, has applications in transformers and electric machines. Historically, an important use of sheet metal was in plate armor worn by cavalry, and sheet metal continues to have many decorative uses, including in horse tack. Sheet metal workers are also known as "tin bashers" (or "tin knockers"), a name derived from the hammering of panel seams when installing tin roofs.

Tolerances

During the rolling process the rollers bow slightly, which results in the sheets being thinner on the edges. The tolerances in the table and attachments reflect current manufacturing practices and commercial standards and are not representative of the Manufacturer's Standard Gauge, which has no inherent tolerances.

Steel sheet metal tolerances[3][14]

Gauge	Nominal [in (mm)]	Max [in (mm)]	Min [in (mm)]
10	0.1345 (3.42)	0.1405 (3.57)	0.1285 (3.26)
11	0.1196 (3.04)	0.1256 (3.19)	0.1136 (2.89)
12	0.1046 (2.66)	0.1106 (2.81)	0.0986 (2.50)
14	0.0747 (1.90)	0.0797 (2.02)	0.0697 (1.77)
16	0.0598 (1.52)	0.0648 (1.65)	0.0548 (1.39)
18	0.0478 (1.21)	0.0518 (1.32)	0.0438 (1.11)
20	0.0359 (0.91)	0.0389 (0.99)	0.0329 (0.84)
22	0.0299 (0.76)	0.0329 (0.84)	0.0269 (0.68)
24	0.0239 (0.61)	0.0269 (0.68)	0.0209 (0.53)
26	0.0179 (0.45)	0.0199 (0.51)	0.0159 (0.40)
28	0.0149 (0.38)	0.0169 (0.43)	0.0129 (0.33)

Forming Processes

Bending

The equation for estimating the maximum bending force is,

$$F_{max} = k\frac{TLt^2}{W},$$

where k is a factor taking into account several parameters including friction. T is the ultimate tensile strength of the metal. L and t are the length and thickness of the sheet metal, respectively. The variable W is the open width of a V-die or wiping die.

Deep drawing

Drawing is a forming process in which the metal is stretched over a form. In deep drawing the depth of the part being made is more than half its diameter. Deep drawing is used for making automotive fuel tanks, kitchen sinks, two-piece aluminum cans, etc. Deep drawing is generally done in multiple steps called draw reductions. The greater the depth the more reductions are required. Deep drawing may also be accomplished with fewer reductions by heating the workpiece, for example in sink manufacture.

In many cases, material is rolled at the mill in both directions to aid in deep drawing. This leads to a more uniform grain structure which limits tearing and is referred to as "draw quality" material.

Expanding

Expanding is a process of cutting or stamping slits in alternating pattern much like the stretcher bond in brickwork and then stretching the sheet open in accordion-like fashion. It is used in applications where air and water flow are desired as well as when light weight is desired at cost of a solid flat surface. A similar process is used in other materials such as paper to create a low cost packing paper with better supportive properties than flat paper alone.

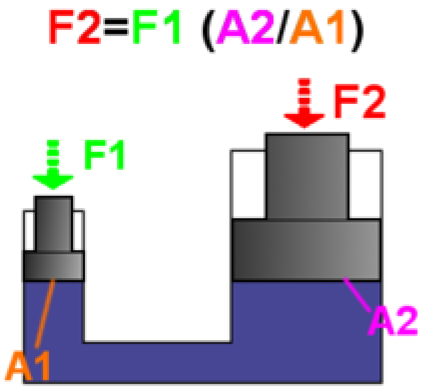
Punching

Punching is performed by placing the sheet of metal stock between a punch and a die mounted in a press. The punch and die are made of hardened steel and are the same shape. The punch just barely fits into the die. The press pushes the punch against and into the die with enough force to cut a hole in the stock. In some cases the punch and die "nest" together to create a depression in the stock. In progressive stamping a coil of stock is fed into a long die/punch set with many stages. Multiple simple shaped holes may be produced in one stage, but complex holes are created in multiple stages. In the final stage, the part is punched free from the "web".

A typical CNC turret punch has a choice of up to 60 tools in a "turret" that can be rotated to bring any tool to the punching position. A simple shape (e.g., a square, circle, or hexagon) is cut directly from the sheet. A complex shape can be cut out by making many square or rounded cuts around the perimeter. A punch is less flexible than a laser for cutting compound shapes, but faster for repetitive shapes (for example, the grille of an air-conditioning unit). A CNC punch can achieve 600 strokes per minute.

A typical component (such as the side of a computer case) can be cut to high precision from a blank sheet in under 15 seconds by either a press or a laser CNC machine.

Hydraulic Press



Principle

The hydraulic press depends on Pascal's principle: the pressure throughout a closed system is constant. One part of the system is a piston acting as a pump, with a modest mechanical force acting on a small cross-sectional area; the other part is a piston with a larger area which generates a correspondingly large mechanical force. Only small-diameter tubing (which more easily resists pressure) is needed if the pump is separated from the press cylinder.

Pascal's law: Pressure on a confined fluid is transmitted undiminished and acts with equal force on equal areas and at 90 degrees to the container wall.

A fluid, such as oil, is displaced when either piston is pushed inward. The small piston, for a given distance of movement, displaces a smaller amount of volume than the large piston, which is proportional to the ratio of areas of the heads of the pistons. Therefore, the small piston must be moved a large distance to get the large piston to move significantly. The distance the large piston will move is the distance that the small piston is moved divided by the ratio of the areas of the heads of the pistons. This is how energy, in the form of work in this case, is conserved and the Law of Conservation of Energy is satisfied. Work is force applied over a distance, and since the force is increased on the larger piston, the distance the force is applied over must be decreased.

Literature

In this, a thin sheet metal blank of thickness to was held between a blank holder and die. When a punch moves down at a velocity U0, the material under the blank holder will bend and deform into L-shape. For L-bending and V-bending, empirical methods and analytical models have been developed and successfully utilized to predict spring back . In this paper, L-bending operations and its thinning and spring back effects were investigated. The L-bending process is limited to certain clearance to thickness ratio before rupture .

Rupture is usually manifested by strain localization followed by disintegration. A closer look at the evolution of the L-bending reveals two major phases: embossing and drawing. Once the embossing phase has been completed the L-bending process begins in which the blank is bent and compressed over the die, then straightened and pulled down to form L-shape.

The region of the sheet wrapped around the punch face and fillet will be subjected to tensile stress under resisting fractural forces. Once the flow stress gets exceeded, the zone I will be stretched and thinning of the wall takes place. In order to avoid eventual plastic instability, one should check the zone I for its non-work hardening. In the plane strain approach, the height at failure is related to the thickness strain of the material when compressibility is assumed. Fig. 3 illustrates the thinning effect in the zone I for a sheet metal of thickness 3.5 mm. The unit in the y-axis is in microns, which is the difference between initial thickness and final thickness after bending. The values L0 = 60 mm, Lc = 30mm and clearance of 3.7 mm were selected for the computation. For the experimental results elasto-plastic modeling is used. An experimental observation of L-bending operation shows the same pattern of thinning. The detailed analysis on thinning for various thicknesses was investigated experimentally.

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