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A Review of Experimental study of Springback Determination of Ferrous Sheet Metals in an Air Bending

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Abstract

The air bending process can be erroneously considered as an easy understanding process without complication, but this is a false judge. Several parameters have to be considered in order to avoid precision problems: material and process parameters. Among them, springback phenomenon has a significant role. Traditionally, springback has attempted to be expressed in handbook tables or in springback graphics. But both ways of giving expression to springback amount show shortcomings. This paper presents new springback graphics for air vee bent sheet metal parts. The developed experimental procedure has two main stages.

Keyword: sheet metal , Bending, Air bending.

Introductions

The dimensional change generated in the shape part after punch removal due to material elastic recovery is an easy approximation to springback definition. Springback occurs not only in flat sheets or plate, but also in rod, wire, and bar with any crosssection. This recovery or springback causes deviations in the desired final shape; therefore, the part after the springback may not be within tolerance limits, stopping of being suitable for the application for which it was designed.

Sheet metal bending

Bending of sheet metal is a common and vital process in manufacturing industry. Sheet metal bending is the plastic deformation of the work over an axis, creating a change in the part's geometry. Similar to other metal forming processes, bending changes the shape of the work piece, while the volume of material will remain the same. In some cases bending may produce a small change in sheet thickness. For most operations, however, bending will produce essentially no change in the thickness of the sheet metal. In addition to creating a desired geometric form, bending is also used to impart strength and stiffness to sheet metal, to change a part's moment of inertia, for cosmetic appearance and to eliminate sharp edges.

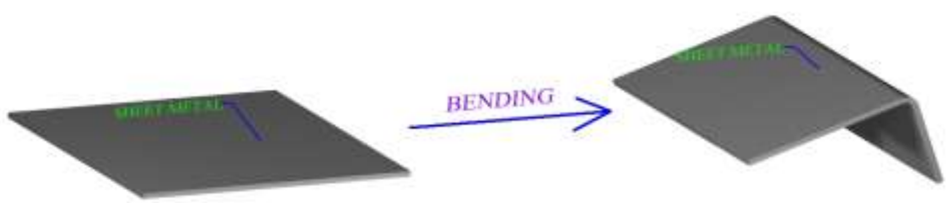

Figure.1. Bending operation

Metal bending enacts both tension and compression within the material. Mechanical principles of metals, particularly with regard to elastic and plastic deformation, are important to understanding sheet metal bending and are discussed in the fundamentals of metal forming section. The effect that material properties will have in response to the conditions of manufacture will be a factor in sheet metal process design. Usually sheet metal bending is performed cold but sometimes the work may be heated, to either warm or hot working temperature.

Most sheet metal bending operations involve a punch die type setup, although not always. There are many different punch die geometries, setups and fixtures. Tooling can be specific to a bending process and a desired angle of bend. Bending die materials are typically gray iron, or carbon steel, but depending on the work piece, the range of punch-die materials

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varies from hardwood to carbides. Force for the punch and die action will usually be provided by a press. A work piece may undergo several metal bending processes. Sometimes it will take a series of different punch and die operations to create a single bend. Or many progressive bending operations to form a certain geometry.

Sheet metal is referenced with regard to the work piece when bending processes are discussed in this section. However, many of the processes covered can also be applied to plate metal as well. References to sheet metal work pieces may often include plate. Some bending operations are specifically designed for the bending of differently shaped metal pieces, such as for cabinet handles. Tube and rod bending is also widely performed in modern manufacturing.

Sheet metal roll forming

Roll forming of sheet metal is a continuous manufacturing process, that uses rolls to bend a sheet metal cross section of a certain geometry. Often several rolls may be employed, in series, to continuously bend stock. Similar to shape rolling, but roll forming does not involve material redistribution of the work, only bending. Like shape rolling, roll forming usually involves bending of the work in sequential steps. Each roll will form the sheet metal to a certain degree, in preparation for the next roll. The final roll completes the geometry.

Channels of different types, gutters, siding and panels for structural purposes are common items manufactured in mass production by roll forming. Rolls are usually fed from a sheet metal coil. The entry roll is supplied as the coil unwinds during the process. Once formed, continuous products can be cut to desired lengths to create discrete parts. Closed sections such as squares and rectangles can be continuously bent from sheet metal coil. Frames for doors and windows are manufactured by this method. Sheet metal coil is often roll bent into thin walled pipe that is welded together, at its seam.

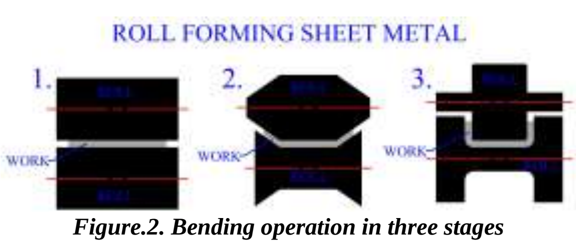

Figure.2. Bending operation in three stages

This channel could be produced with a punch and die. However, in that case, the length of the channel would be limited by the length of the punch and die. Roll forming allows for a continuous part, (limited practically to the length of the sheet metal coil), that can be cut to whatever size needed. Productivity is also increased, with the elimination of loading and unloading of work. Rolls for sheet metal roll forming are typically made of grey cast iron or carbon steel. Lubrication is important and affects forces and surface finish. Sometimes rolls will be chromium plated to improve surface quality.

Mechanics of sheet metal bending

To understand the mechanics of sheet metal bending, an understanding of the material properties, characteristics and behaviors of metal, is necessary. Particularly important is the topic of elastic and plastic deformation of metal. Information on the properties of metals, with relation to manufacturing, can be found in an earlier section, (metal forming). It should be understood also that sheet metal bending produces localized plastic deformation and essentially no change in sheet thickness, for most operations. It does not create metal flow that affects regions away from the bend.

The force required to perform a bend is largely dependent upon the bend and the specific metal bending process, because the mechanics of each process can vary considerably. Proper lubrication is essential to controlling forces and has an effect on the process. In punch and die operations, the size of the die opening is a major factor in the force necessary to perform the bending. Increasing the size of the die opening will decrease the necessary bending force. As the sheet metal is bent, the force needed will change. Usually it is important to determine the maximum necessary bending force, to access machine capacity requirements.

The important factors influencing the mechanics of bending are material, sheet thickness, width over which bend occurs, radius of bend, bend angle, machinery, tooling and specific metal bending process. Bending a sheet will create forces that act in the bend region and through the thickness of the sheet. The material towards the outside of the bend is in tension and the material towards the inside is in compression. Tension and compression are opposite, therefore when moving from one to the other a zero region must exist. At this zero region no forces are exerted on the material. When sheet metal bending, this zero region occurs along a continuous plane within the part's thickness, called the neutral axis. The location of this axis will depend on the different bending and sheet metal factors. However, a generic approximation for the location of the axis could be 40 percent of sheet thickness, measured from the inside of the bend. Another characteristic of the neutral axis is that because of the lack of forces, the length of the neutral axis remains the same. Fundamentally, to one side of the neutral axis the material is in tension, to

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the other side the material is in compression. The magnitude of the tension or compression increases with increasing distance from the axis.

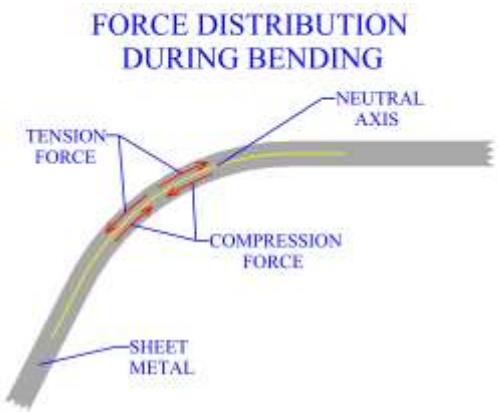

Figure.3. Bending operation by force

If a relatively small amount of force is exerted on a metal part, it will deform elastically and recover its shape, when the force is removed. In order for plastic deformation of metal to occur, a minimum threshold of force must be reached. The force acting on the neutral axis is zero and increases with distance from this region. The minimum threshold of force required for plastic deformation is not reached until a certain distance from the neutral axis in either direction. The material between these regions is only plastically deformed, due to the low magnitude of forces. These regions run parallel to, and form an elastic core around, the neutral axis.

Literature

The developed experimental plan consists of obtaining bend parts within an interval of 22° and 90°as bending angle. The experimental procedure has two stages. In the first one, the experimental study consists of the material identification by means of tensile test. The adoption of a material model is important, because the material properties have influence over the bending process.

Two different common sheet metals, with different thickness, are formed: aluminum (very low work hardening) and stainless (high work hardening). In the second stage, bending tests for several specimens have been performed on a laboratory testing machine, anMTStensile testing machine. The dimensions of the bending specimens are 130mm×50 mm. Their thicknesses are 1 and 1.35mm for aluminum samples, and 1, 1.5, 2 and 3mm for stainless sheet metals. To be able to do bending tests, a bending sub-frame has been built, and as a unit, placed in the laboratory machine. This test machine allows a very accurate force–displacement registration. In the sub-frame, high quality nindustrial bending tools are used (MECOS tools). A punch of 0.8mm radius and a 'V' type-bending die with four different widths (16, 22, 35 and 50 mm) were used as bending tools. Nowadays, bending tool combinations with a reduced die width are increasingly being used . As well as bending sub-frame, a loaded bending angle measurement fixture nwas developed, because its determination is essential for the computation of the springback amount. The transducer leans on the internal surface of one of the bent sheet straights legs. The vertical displacement readings are directly recorded by the same MTS machine computer. Therefore, a geometrical expression can be defined for loaded angle determination (βc), nknowing: position of the transducer at the end of the bending process (T), location of transducer axis respect to the axis of the bending sub-frame (XT) and punch penetration (Z).

The main performer parameter of the air bending process is the punch penetration (Z), each Z value corresponds with a different attempting bending angle. These both parameters are linked by the well-known geometrical formulation of the rigid–plastic model, which assumes an ideal geometry for a bent part (two straight legs joint by a circular bent) and a rigid plastic material behavior. Because of that, to carry out the tests, several values of Z are set, and by means of geometrical formulation the bending angle

In a first step, a micro-structured surface is formed in a planarsemi-finished sheet metal part by micro-impact extrusion. Piezoceramic fibers are then assembled intothis micro-structured surface with a small assembly clearance. The fibers and the structured surface ofthe sheet metal are joined by a forming process. In the next step, the sheet metal with piezoceramicfibres within a locally micro-formed substructure is shaped by deep drawing into a 3D-geometry. In thispaper, results of the micro-impact extrusion and the joining by forming experiments are presented. Fur-thermore, the design constraints for assembly and joining due to the dimensional and form deviations ofthe piezoceramic fibers are discussed.

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