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Experimental Method on Spring Back Prediction for Sheet Metal V-Bending

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Abstract— Spring back is a common phenomenon in sheet metal forming caused by elastic redisitribution of the internal stresses during unloading. It has been reconized that spring back is essential for the design of tools used in sheet metal forming operations.An experimental method has been to analyze the sheet metals axisymmetric v bending process.The principal objective of this analyze consist of predicting the spring back for flanging and compares these results with some experimental data.knowing that spring back amount of bending materials in bending dies is as important as the die itself,because the material leaving the die should be within the allowed tolerance limits.therefore,in his study the subject of bending dies and spring back in bending process has been researched.in order to find spring back in bending,a v shape die designed and it has been aimed to find out how much can steel sheet metal materials reside in various angles and to bring forward spring back graphics to add literature regarding this issue.in order to reach a conclusion,different dies have been prepared more than 70 samples each of which have been bent and the obtained angles have been measured with profile meter.the acquired results have been satisfically evaluated in a computer media and converted to graphics.

Keywords—sheet-metal,sheet-thickness,v-bending .

I. INTRODUCTION

Sheet metal is a critical material for vehicle design due to design veracity andManufacturability. Low carbon steel sheet has long been the workhorse materialin auto and consumer industries it can be stamped into inexpensive, complexcomponents at very high production rates.

Sheet Metal Forming Operations

In sheet metal forming a shape in produced from a flat blank by stretching andshrinking the dimensions of all its volume elements in three mutuallyperpendicular principal directions. A large variety of shapes such as singly curvedparts, contoured flanged parts, curved sections, deep recessed drawing parts,etc.

Bending Of Sheet Metal

Bending is one of the most important sheet metal forming operations by which astraight length is transformed into a curved one with the help of suitably designeddie and punch. It is very common process of changing sheet and plate intochannel, drums, tanks, car bodies, aircraft fuselages etc. In addition is a part ofdeformation in many other forming process

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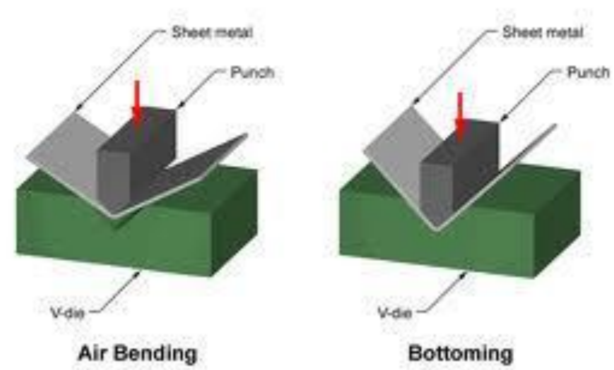
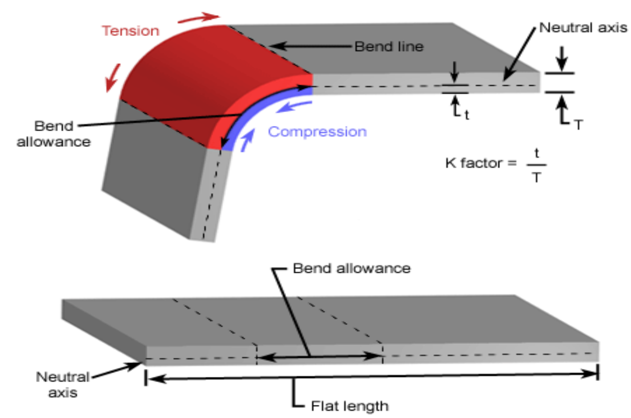




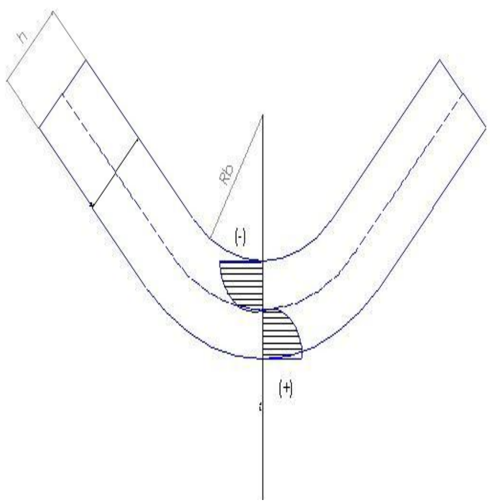
Bend Allowance is the length of Neutral Axis in the Bend Area and is used todetermine the blank length for a bent part. However the radial position of the neutral axis depends on the bend radius and bend angle, an approximate formula for thebend allowance is α(R+kt).Where,α is the bend angle(in radians),R is the bend radius, k is constant, and t is thesheet thickness. For an ideal case the neutral axis remains at the center and hencek=0.5, value of k varies from 0.33 to 0.5.Minimum bend radius: The outer fibers of the part being in tension, and the innerfibers are in compression. Theoretically the strains at the outer and inner fibers are equal in magnitude and are given by

eo=ei (1.1)

However due to shifting of neutral axis towards the inner surface.The length of thebend is smaller in the outer region than in the inner region. Consequently the outerand inner strains are different and the difference increases with decreasing R/t ratio.The radius R at which a crack appears on the outer surface of the bend is calledminimum bend radius

Stresses In Bending

During bending, the entire stress-strain curve in traversed.. As shown in figure 1.2 , fibers below the neutral line aresubjected to tensile (+) stress and fibers above the natural line are subjected tocompressive (-) stress. Stresses are greatest on the outside and zero at neutralline. For a given sheet thickness T, tensile and compressive strains increase withdecrease with decreasing forming radius Rb (i.e. with decreasing Rb/T



Bending Forces can be estimated by assuming that the process is that of the simplebending of rectangular beam. Thus, the bending force is a function of the strength ofmaterial, the length and thickness of part, and the width of the die opening,excluding friction, the general expression for the maximum bending force is

Fmax=k UTS lt2/W (1.2)

Where k ranges from 1.2 to1.33 for a V-die, the k values for wiping and U dies are0.25 and 2 times respectively that for V dies.The effect of various factors such asfriction, on the bending force, is included in factor k.

Spring Back

The stress state is complex in bending. Around the neutral plane, the stress mustbe elastic because complete tensile and compressive stress-strain curves of thematerial are traversed on both bend side. When the forming tool is removed fromthe metal, the elastic components of stress cause spring back which changes both the angle and radius of the bent part as shown in Figure 1.4. The part tendsto recover elastically after bending, and its bend radius becomes larger. This elastically-driven change in shape of a part upon unloading after forming is referred to as spring back.

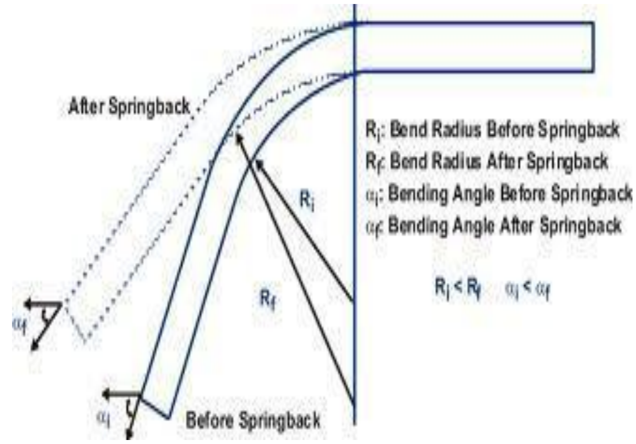


Fig.1.6.Spring-back Phenomenon in bending process.

Spring-back poses a major problem in sheet bending operation as it cause ashape change that makes the assembly of the parts very difficult and itscompensations are to be taken care of while designing the dies and punches.The spring-back is measured in terms of the ration of initial and the final angle ofthe sheet, called as spring-back ratio (Ks).

Ks =αf-αi (1.3)

Spring-back establishes new force equilibrium with a residual stress distributiontypified by a compressive stress on the outer and tensile stress on the innersurface.

Compensation Of Spring Back

Spring-back may be reduced by:

- Over-bending[figure 1.6(a),(b)]
- Plastic deformation at the end of the stroke, and[Figure 1.6(c)]
- Subjecting the bend zone to compression during bending with a

Counterpunching Coining Process.

II. Important Factors In Bending

A) Design Parameters:

The critical design parameters in sheet metal forming operations include the diecorner radius, punch corner/nose radius clearance punch and die etc.

B) Sheet Metal Properties:

Most polycrystalline materials possess a texture (directional properties) are

determined in tension tests. Which are repeated in the different directions relative tothe rolling direction.Plastic strain ratio: this ration is measure of anisotropy and its value indicated theresistance of a materials to thinning (Hansford(1993))

Rp=Ew/Et

Where,

Ew=strain in width direction

Et=strain in thickness direction

The anisotropy is of two types:

1). Normal anisotropy,

R=[R0+R45+R90]/4

2). Planar anisotropy

$\Delta R = [R0 - 2R45 + R90]/2$

The R value with subscript denotes the value for specimen taken at that angle to therolling direction.Tan et al. (1995) studied the effect of anisotropy on pure bending of sheet metals.They proposed two models one neglecting the effect and the other considering the effect. They also found that the effect of anisotropy onmaterial thinning of bend is small but has a relatively large effect on the bendingmoment.

A rigorous solution for the elastic – plastic bending of wide sheets exhibiting normalanisotropy has been presented by chakra arty el al. (2001) assuming a state of planestrain for deformation mode . Such a solution is necessary for a critical evaluation ofelementary theories of sheet bending in the partially plastic stare. The resultsindicated that the elementary bending theory significantly overestimates themagnitude of the bending couple to produce a given elastic – plastic curvature of thebent sheet.

Factors Influencing Spring Back

1. Young's modulus:

Spring reduces with increase in elastic modulus, because the resistance to elasticbending increases with increase in elastic modulus (Wang et al (1993)).

2. Yield stress:

Spring-back increases with increase in yield stress, because higher the strength themore will be the resistance to plastic yielding.

3. Plastic anisotropic ratio(r) and hardening coefficient (n):

The higher the normal anisotropic values the more the spring-back was observed. De (1997) developed an analytic model to predict the effect of normal anisotropyand hardening coefficient and arrived at the concluded that spring-back is almostproportional to the normal anisotropic parameter and decreases sharply with smallerstrain hardening exponent n. And at higher values of n and thickness ratio, thechange in spring-back values is very smaller. But this model ignored the variation of in the plane strain of the sheet.

III. Methodology

In present study the spring-back of tailor welded strips has been analyzed in Vbendingoperation. The methodology includes experimental methods

*3.1. Materials***:**

Different bending samples of Steel(En 42).

Table no.1.Chemical composition of en 42 material**.**

Material	C	Mn	Si	S	P
EN 42	0.70-0.85	0.55-0.75	0.10-0.40	0.040	0.040

Dimension of the material: 25*100mm

Various thickness of the sheet: 0.55mm,0.7mm,1 mm

3.2. Equipment's:

Hydraulic Pressing machine, Bending dies, and vernier, caliper,micrometer and measuring tools are required.

3.3. Procedures:

1) Set the bending die on the pressing machine.

2) Set up the pressing machine for the test.

3) Select a sample test, and then measure its thickness (t).

4) Measure the die angle (αi) and die radius (RI).

5) Perform the bending process by putting the flat sheet on the lower half of thebending die and then press the sheet to the required bending shape by the upper

Half of the bending die.

6) Measure the final sheet angle (αf) and radius (Rf). After bending.

7) Record all the measurements and observations.

8) Repeat the test for different sheet thicknesses and materials.

3.4. Requirements:

1) Draw all the test bends before and after the bending test and indicate on eachdrawing all the dimensions of the bends.

2) Sketch the complete set of die and punch

3) Calculate the spring back factor for each used bend.

4) Find the spring back for used specimen.

3.5. Control Spring back

The automotive and other manufacturers of sheet metalparts rely on several methodologies to control spring back, namely, mechanics-based reduction and geometry-based compensation. The mechanics-based reductionmethodology is based on physics of the spring backphenomenon. The amount of spring back is reduced bychanging or constantly varying the process parameters.The mechanics-based reduction methodology relies on themechanics of sheet metal forming, which becomes thebasis for identifying and modifying the critical processparameters at the critical time intervals to control theamount of spring back.

There are three commonly usedmethods: Blankholder force control, through thicknessdeformation and Forming in multiple steps. Thegeometry-based compensation methodology can guarantee the shape accuracy of the formed product by performingthe appropriate modifications of the tools. The bases ofmodification of the tool geometry are the results ofsimulations or the measurements of the part after realforming.Spring back compensation often relies on trial-and-errorat a great cost and time-consuming or on empirical ruleson

Simple analysis, which is only available to simpleshapes based on well-known materials.

3.6.Hydraulic Machine Details:

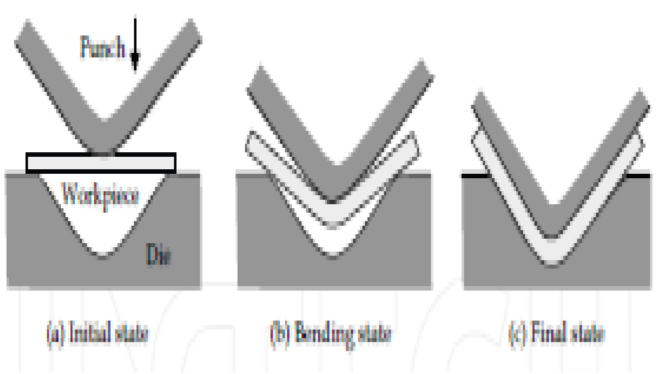
Fig.3.1 hydraulic sheet bending machine

Principle of V-die Bending Process

The V-die bending process is the bending of a V-shaped part in a single die. The principle ofthe V-die bending process is shown in. The work piece is bent between a V-shapedpunch and die. The force acting on the punch causes punch displacement and then thework piece is bent. The work piece is initially bent as an elastic deformation. With continueddownward motion by the punch, plastic deformation sets in when the stresses exceed theelastic limit. This plastic deformation starts on the outer and inner surfaces directlyunderneath the punch. The greatest tensile stress is generated on the outer surface.

Whereasthe greatest compressive stress is generated on the inner surface; these stresses decreasinglypropagate inward toward the Therefore, crack formation usually occurs on theouter surface and a wrinkle usually occurs on the inner surface.

The initial bending stagethe so-called “Air bending” starts the moment the punch establishes contact with the and is completed either when the legs of the become tangential to the faces of the die or when the smallest internal radius of thebecomes smaller thanthe radius of the punch. As the process continues, after completion of air bending, thebending is focused on the three points of the punch and the two faces of the die. The contact points between theand die are shifted toward the centerline of the die, and the legs of the try to close around the punch. As the punch proceeds further, the legs of the establish contact with the punch, and it is pressed to open up again untilthe bend angle approaches the die angle (Schuler, 1998), (Lange, 1985). The clearancebetween the punch and the die in V-die bending is commonly dependent of the thickness. The usual thickness of the in the V-die bending process ranges from



Approximately 0.5 to 2.5 mm

Fig 3.4. Principle of the V-die Bending Process**Methods Of Analyzing The Spring Back angles:**

1.Varying The Sheet Metal Thickness.

2.Varying The Punch Velocity.

3.Varying The Waiting Seconds.

4.Varying The No of Strokes.

3.12.1. Varying The Sheet Metal Thickness:

If varying the sheet metal thickness the spring back angle of a specimen will be changed. The sheet metal thickness increases means spring back angle increased. We are choose various thickness of sheet metals(0.5mm,0.7mm,1.0mm).

Varyingthepunchvelocity:

If increasing the punch velocity means the spring back angles will be varied.The punch velocity ranges 10cm/sec,15cm/sec,20cm/sec

Varying The Waitingseconds:

If the weighting seconds has been increased the spring back angle will be reduced. We are choosing no waiting seconds,2 seconds and 4 seconds.

Varying TheNo of Strokes:

If no of strokes increases means the spring back angles should be increased. We are choosing the no of strokes 1,2,3 strokes.

IV. Result And Discusion

MATERIAL THICKNESS=0.7MM				
Parameters				
TRIAL NO	Punch velocity cm/sec	Cutting stroke	Waiting sec	Spring back
1	10	1	0	-3
2	10	2	1	-4
3	10	3	2	-5
4	10	1	0	-5
5	10	2	1	-4
6	10	3	2	-1.7
7	10	1	0	-2
8	10	2	1	-2
9	10	3	2	-2
10	15	1	0	-1.9
11	15	2	1	-2.2
12	15	3	2	-3
13	15	1	0	-1.5
14	15	2	1	-3
15	15	3	2	-2.6
16	15	1	0	-3.2
17	15	2	1	-3.5
18	15	3	2	-3.6
19	20	1	0	-4.8
20	20	2	1	-5
21	20	3	2	-3
22	20	1	0	-3
23	20	2	1	-4.5
24	20	3	2	-3.1
25	20	1	0	-1
26	20	2	1	-2.7

TRIAL NO	Punch velocity cm/sec	Cutting stroke	Waiting sec	Spring back
1	10	1	0	-6
2	10	2	1	-5
3	10	3	2	-6.5
4	10	1	0	-6
5	10	2	1	-5
6	10	3	2	-6.5
7	10	1	0	-6.6
8	10	2	1	-6
9	10	3	2	-6.5
10	15	1	0	-5.5
11	15	2	1	-7
12	15	3	2	-5
13	15	1	0	-5.8
14	15	2	1	-5.8
15	15	3	2	-5
16	15	1	0	-6.6
17	15	2	1	-6
18	15	3	2	-4.8
19	20	1	0	-7
20	20	2	1	-7.4
21	20	3	2	-8
22	20	1	0	-6.6
23	20	2	1	-6.6
24	20	3	2	-6
25	20	1	0	-8.5
26	20	2	1	53.2
27	20	3	2	52.5

V. CONCLUSION

The major conclusions drawn from the study for V-die bending test are:

1. This experiment confirmed that the forming of low carbon steels is associated mainly with spring back problems.

2.It is seen from the above experimental results the sheet metal spring back angle dependent upon the stroke, weighting seconds, punch velocity and material thickness parameters.

3. As the thickness of the sheet metal increases there will be a decrease in the spring back effect.

4. As the material strength increases the spring back effect decreases.

5. When the no weighting seconds, maximum velocity, minimum strokes and minimum thickness of the sheet metal give the minimum spring back angle.

6.For each material and thickness, equations and graphics were obtained. Obviously this paper gave us a complete solution.

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