THE COMPARATIVE STUDY OF DIE CUSHIONING FORCE IN U-BENDING PROCESS USING FEA

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Abstract

This paper presents a study of the effect of the Die cushioning in the U-bending process. Different Die cushioning values are used to study their effect on distributions of stresses and strains in work piece. Two examples were analyzed one without Die cushion and another with Die cushion with Four values (10%, 20%,30% and 40% of bending load) were applied by Die cushioning on bottom of the workpiece.3D model of U-bending was used and analyzed by COSMOS.

Low carbon steel (IS 2062 GrB) was chosen to carry out the simulation. The results show that the Die cushion force has an effect on the center displacement and distribution of strains and stresses in final product.

Keywords: *U-bending, Die cushioning, FEA, Low carbon steel.*

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1. INTRODUCTION

Bending of sheet metal is one of the widely used in industrial process, especially in automobile and aircraft industries, sheet metal bending is one of the most widely applied sheet metal forming operation.

Bending is such a shaping process used commonly in various sheet metal industrial products. The sheet parts in these products and in the others are shaped using bending dies. According to the shape of the product, the bending is divided into the following.

1- Air bending.
2- U-bending
3- V-bending.
4- Roll bending.
5- Edge bending.

The accuracy and success of the bending process depends upon the operating parameters as well as, material properties, clearance, radius of the die and punch, friction condition etc.

2. THE NATURE OF THE BENDING PROCESS

Fig.1 Shows schematic representation of a simple sheet metal U-bending process. In general, the U-bending process passes into two steps, loading and unloading. In the loading step, a sheet metal is begins to bend into the die until the punch moves down completely. So that its shape is formed closely to the die shape. During this step, the work piece undergoes elastic-plastic deformation. Next, the unloading step is happened when the punch is removed. In this step dimension of the final product, particularly the bend radius angle becomes different from that of the product before unloading. This dimensional difference is called the elastic recovery phenomenon, and causes the springback.

In U-bending the work piece is also given its final shape by bottoming the punch. In this case, to prevent the bottom from bulging out during bending, (Fig2) a Die cushion is often used. During the bending process it already starts pressing against the bottom of the work piece.

When a Die cushion is applied in the bending process, flat bottom of the blank is subjected to an opposite force which tends to push the blank to up.

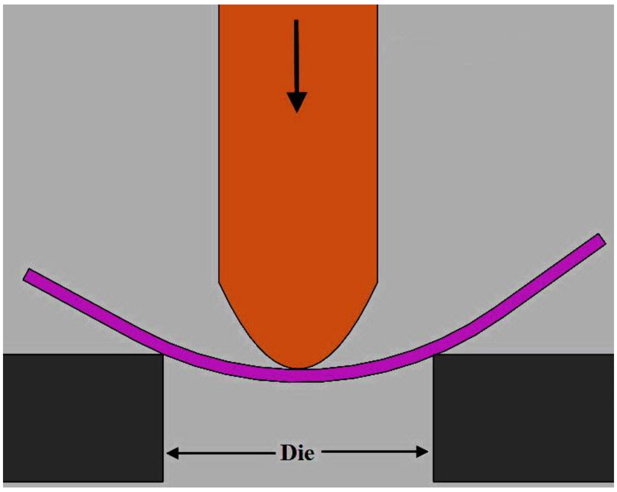

Fig 1 Simple sheet metal U-bending process

3. DIE CUSHIONING

The Die Cushioning is provided with either Die ejector system using springs or Multi point cushion system (MPC). Multi-point cushion (MPC) systems mostly consist of several individually programmable hydraulic cylinders, which apply the force directly to the blank holder. MPC systems are either integrated in the press (see Figure 3) or in the tooling. Thus they allow varying the BHF in location and during the stroke. This enables the manufacturer to better control the material flow into the die cavity. This prevents wrinkling, tearing and reduces thinning throughout the part.

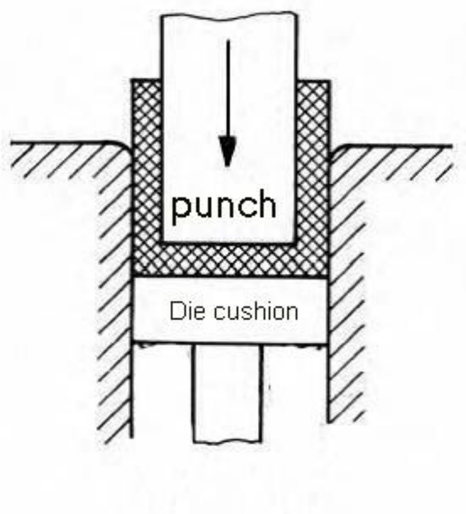

Fig 2 U-bending with Die cushion

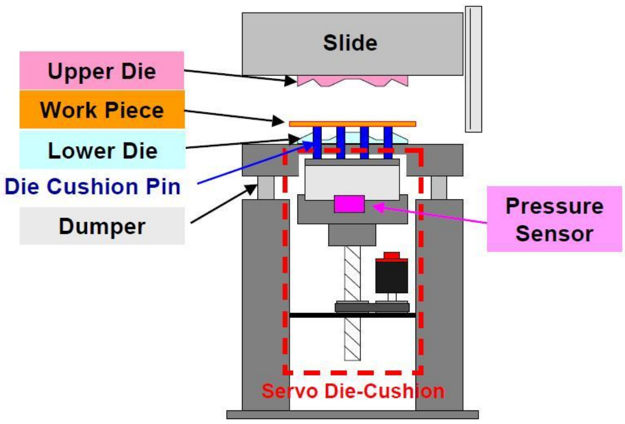

Fig 3 Die cushioning system integrated with Press.

4. MATERIAL DETAILS

4.1 Work Piece (Blank)

The material used in all simulation is low carbon steel (IS 2062 Gr B), where this type is used for stamping applications, such as, automobile bodies, engineering application and other applications. The material properties are taken as per the supplier standard. Table 1 shows the mechanical properties for Is 2062 Gr B.

4.2 Die

D2 material is used for die. AISI D2 tool steel is one of the carbon steels alloyed with Mo, Cr, and V, is widely used for various dies and cutters for its high strength and wear resistance due to formation of chrome carbide in heat treatment.

4.3 Bottom Plate

Mild Steel is used for Bottom plate. Mild steel is the most versatile, least expensive and widely used engineering material which has found extensive application in various industries.

4.4 Die Ejector

D2 material is used for die ejector. AISI D2 tool steel is one of the carbon steels alloyed with Mo, Cr, and V, is widely used for various dies and cutters for its high strength and wear resistance due to formation of chrome carbide in heat treatment.

Table 1 Is 2062 Gr B material details

Parameters	*Units*	*Value*
Young’s modulus (E)	GPa	200
Tangent modulus (Et)	GPa	0.5
Yield strength (σy)	MPa	580
Poisson’s ratio (ν)	__	0.3
Thickness (t)	mm	8

5. CALCULATION

Bending Force,

$F = [(0.67LST^2) / W]$
$= [(0.67 \times 173 \times 410 \times 64) / 23]$
$= 132.23$ KN

Where,
L =Length of bent part in mm.
S = ultimate tensile strength in N/mm2
T =Thickness of blank in mm
W = Span

Span,
W = RE + C +RP
= 8 + 8 +7
= 23mm

Where,
RE = Edge Radius in mm
RP = Punch radius in mm
C = Die clearance in mm

6. NUMERICAL SIMULATION

FE Model

For simulation the bending process, commercial FEA software COSMOS was used. 3D solid model was used for work piece (blank). The tool set (punch, Bottom plate and Die ejector) was modelled and assembled.

Static analysis has been carried out in which Bottom Plate is set as fixed geometry. Forming force is applied on the Work piece (blank). Finer mesh is created in the same software and is shown in Fig.4.

Geometric parameters of forming die are shown in table 2. A Die Ejector is used to apply opposite force (Die cushioning) on the flat bottom of blank. The simulations were carried out with various value of Die cushioning. First case without Die cushion and another four cases have values (10%, 20%, 30% and 40% of bending load).

Table 2 Tool Geometry data

Punch corner radius (Rp) mm	7
Die corner radius (Rd) mm	8
Punch-die clearance (C) mm	8
Workpiece thickness (t) mm	8

7. SIMULATION RESULTS.

Two different condition simulation results and correspondence stress, strain and displacement photos of are illustrated below,

1. Without Die cushion,
2. With die cushion force i.e, 40% of forming force has been applied.

Other three conditions, i.e, 10%, 20%, 30%, results are tabulated in the Table 3.

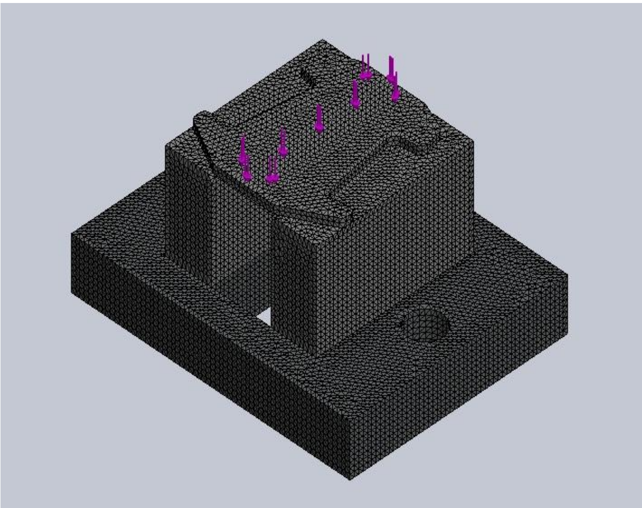

Fig.4 Fine mesh

Table 3 Result Table

	Stress in N/mm^2	Displacement in mm
Without Die cushion	561.3	0.343
With Die cushion (10%)	164.1	0.047
With Die cushion (20%)	146.2	0.042
With Die cushion (30%)	128.3	0.037
With Die cushion (40%)	110.4	0.032

7.1 Without Die Cushion

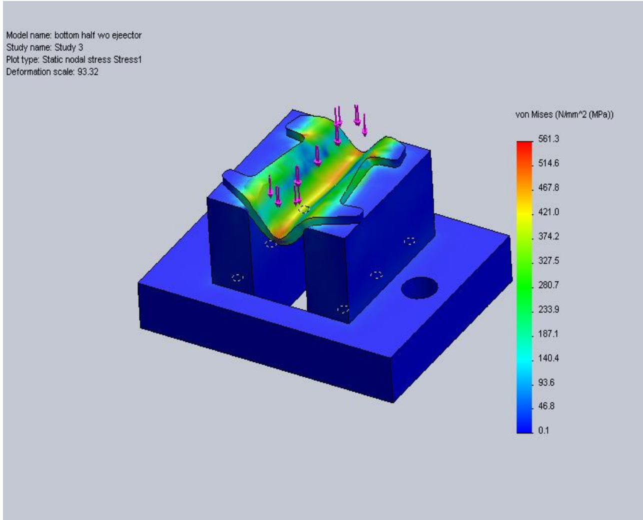

Fig 5 Stress distribution

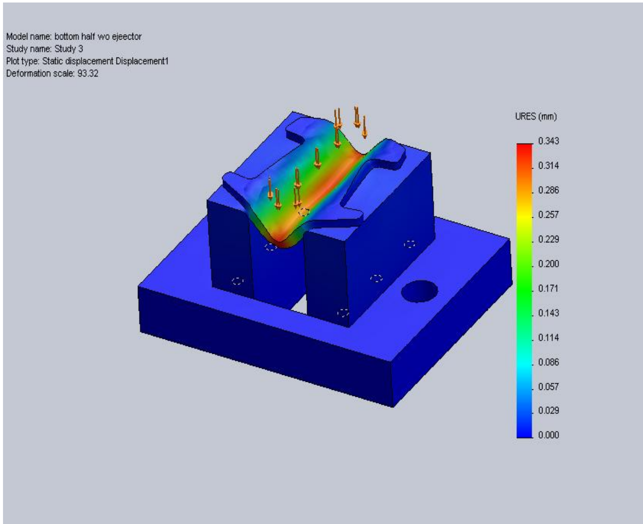

Fig 6 Total Deformation

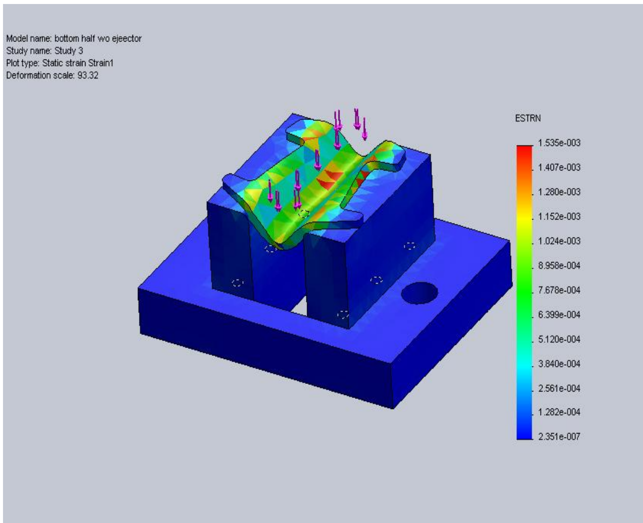

Fig 7 Strain

7.2 With Die Cushion (40% of Forming Force)

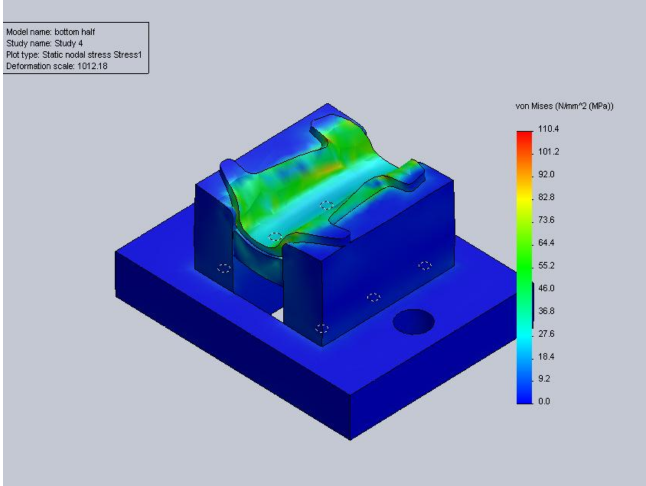

Fig8. Stress distribution

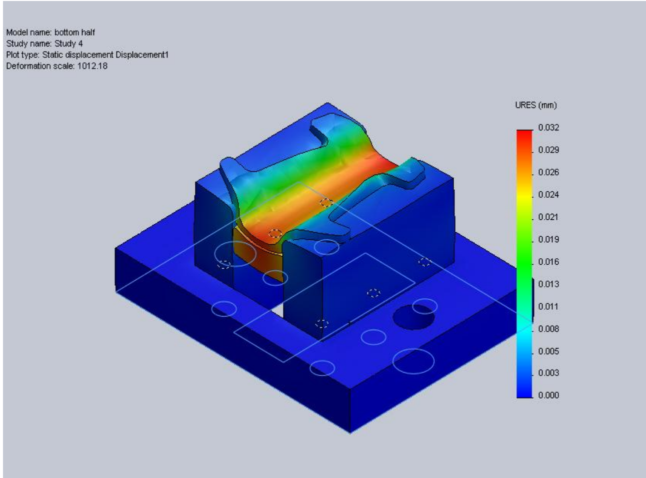

Fig 9 Total Deformation

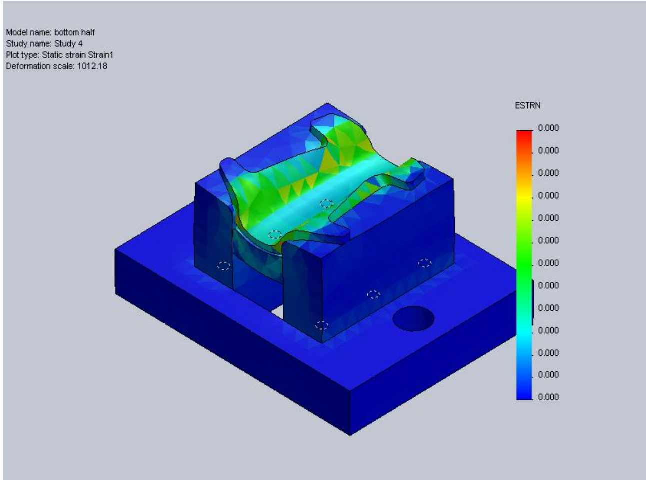

Fig 10 Strain

8. CONCLUSIONS

Detail study has been carried out on U-bending with die cushion and without die cushion. Correspondence analysis results are compared. The main conclusions, which can be deduced from the present work, can be summarized as follows:

1. Using of die cushioning has the effect on flatness in U-bending.
2. Without die cushion more stresses are acting on the component which is almost equal to yield stress in some areas, which causes the failure of component.
3. By having 10% of die cushioning force, total displacement can be reduced significantly.
4. Increase in Die cushion force will reduces the stress acting on the component

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BIOGRAPHIE

I am Avinash J, Doing M.Tech (Tool Engineering) in Government Tool Room and Training Centre, Mysore. Currently doing our final semester project work on Press Tool Design