International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 10 | Oct 2023 www.irjet.net p-ISSN: 2395-0072

Design & Structural Analysis of Sheet Metal Bending Operation in Ansys Workbench

Shubham Patil[1], D.H.Nimbalkar[2], Vikramsinh Mane[3]

[1]M.Tech Student Dept. of Mechanical Engg. College of Engineering Osmanabad, Maharashtra, India
[2]Professor Dept. Of Mechanical Engg. College of Engineering Osmanabad, Maharashtra, India
[3]Principal College of Engineering Osmanabad, Maharashtra, India

---***---

Abstract -*The sheet metal bending is an important sheets metal forming process in which sheets were securely clamped, stretched over rigid punches, and strain distributions measured for different conditions of lubrication and punch form. In general, the development of strain in the various elements of a sheet was marked at some stage of the stretching by a discontinuous increase in e_r the algebraically largest component.The sheet metal plate is modeled by using modeling software catiav5. By using catia V5 software the time required for producing the solid models and the complicated process involved in the design and manufacturing process can be easily minimized. So the modeling of the sheet metal plate assembly is done by using CATIA V5. Later this CATIA modal is imported to ANSYS WORKBENCH 2021 for analysis work. ANSYS WORKBENCH 2021 is the latest software used for simulating the different forces acting on the component and also calculating and viewing the results. By using ANSYS WORKBENCH 2021 software reduces the time compared with the method of mathematical calculations by a human. ANSYS WORKBENCH 2021 transient structural analysis work is carried out by considered three different non-linear materials namely aluminum alloy, magnesium alloy and structural steel and their relative performances have been observed respectivelyis suggested as best material for sheet metal plate bending.*

***Key Words*: Sheet Metal, Bending operation, CatiaV5, Ansys2021**

1. INTRODUCTION

There have many applications using sheet metal such as ductwork, airplane wings, car bodies, medical tables and storage units, steel sheets, tubing and signs. It is one of the important forms used in metal industry and it can be bent into a variety of shapes for industrial application. Bending is a manufacturing process that is mostly used to produces a V-shape, U-shape, or channel shape along a straight axis in ductile materials, commonly used equipment includes box and pan brakes, brake presses, and other specialized machine presses. Different types of products that are made with this are boxes such as electrical enclosures and rectangular ductwork. Forming is a mechanical process involves shaping material in the solid state whether the material is a continuous solid or powder. Sheet metals come in flat pieces or coils and are measured by their thickness or gauge. Very thin pieces of metal are called foil or leaf and thick metals are called plate. Some of the industries using bending machine as their process to produce their product. Figure 1 shows the actual setup of sheet metal bending operation.

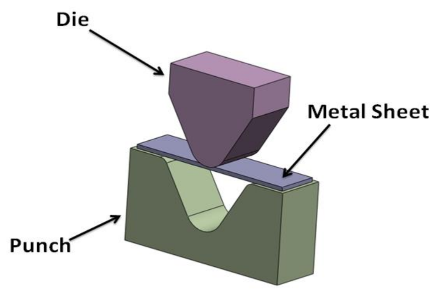

Fig -1: Sheet metal bending operation

In our project work bending test is done by using press brake machine. In this test, bottoming u-die bending is selected since there has many types of die in bending process. 30 degree of die angle is functioning as a reference angle and this project only considers the different sheet materials and bending directions.

1.1 Classification of basic sheet forming processes

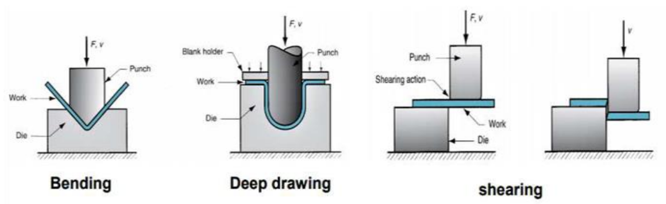

Fig -2: **Classification of sheet forming processes**

1) Forming: Sheet metal forming involves forming and cutting operations performed on metal sheets & strips. In this process the surface area-to-volume ratio of the starting metal is relatively high. Alsoit include punch & die that are used to deform the sheets.

2) Bending: In this, the sheet material is strained by punch to give a bend shape (angl e shape) usually in a straight axis.

3) Deep (or cup) drawing: In this operation, forming of a metal sheet into a hollow or cup shape is performed by stretching the metal in some regions. In this process a blank-holder is used to clamp the blank on the die, while the punch pushes into the sheet metal. The metal sheet is drawn into the die hole taking the shape of the cavity.

4) Shearing: In this operation cutting of sheets by shearing action.

1.3 Objectives

1. To study and perform structural analysis on sheet metal with different material and frictional coefficient.
2. To prepare the geometrical model for the varied geometrical parameter like sheet thickness, size of sheet etc.
3. To identify the region of stress concentration and variation material of sheet metal shall be plotted and appropriate conclusion shall be drawn.
4. To calculate the equivalent stress, deformation and internal energy absorption for different materials.

2. Methodology

The design of sheet metal while bending operation had to choose the variety of parameters which include different types of sheet materials, size of sheet etc. Hence it is analyzed some of the sheet while bending in v shape by varying some all of the parameters like plate thickness, various sheet material, sizes of sheet compare to the numerical analysis on various loading condition, finding various stresses on it & total deformation.

The proposed work include following step.

1. We have Studied literature review on various work reported.
2. Selecting different sheet materials are available in the market:
   a) Aluminum Alloy 1199
   b) Copper Alloy
   c) Magnesium Alloy
3. Bending Force calculation is done using different formulas.
4. The geometrical model shall be prepared for the varied geometrical parameter like sheet thickness, size of sheet etc.
5. CAD Model is prepared using various tool – catia version-V5 i.e. extrude, revolve, mirror etc.
6. The evaluation outcomes acquired shall assist to become aware of the area of stress concentration and variation material of sheet metal shall be plotted and appropriate conclusion shall be drawn.
7. Equivalent stress, total deformation, maximum principal stress, and maximum principal elastic strain are the parameters.

3. Selection of Material

An analysis was conducted for three different materials of the sheet metals namely

1. Aluminum Alloy 1199

Aluminum alloy is aluminum based. With a minimum of 99.99% aluminum, it is the purest and least alloyed of the commercial aluminum alloys. It is gentle and incorrect for machining. At the same time, it possesses excellent corrosion resistance, electrical conductivity, and thermal conductivity.

2. Copper Alloy

Copper and copper alloys are one of the fundamental companies of industrial metals. They provide a huge variety of properties, consisting of high-quality electric and thermal conductivity, notable corrosion resistance, good strength and fatigue resistance, and appearance. They can be readily worked, brazed and welded.

2. Magnesium Alloy

Magnesium alloys are mixtures of magnesium with other metals (called an alloy), often aluminum, zinc, manganese, silicon, copper, rare earth, and zirconium. Magnesium alloy trends have historically been pushed via way of means of aerospace enterprise necessities for light-weight substances to perform below more and more stressful conditions.Magnesium alloys have constantly been appealing to designers because of their low density, handiest thirds that of aluminum.

4. Bending Force Calculations

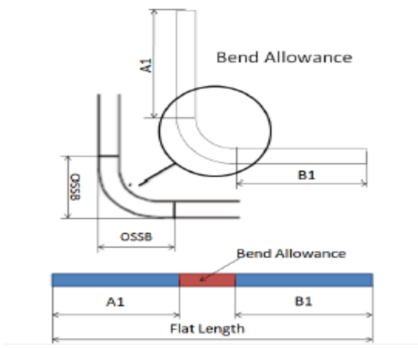

Fig -3: Bend Allowance

1. For aluminum Sheet

A sheet metal material of alluminum alloy having tensile strength 115 Mpa having thickness of plate 5 mm, length 150 mm, width 50 mm, is subjected to bending in v-die with opening of angle 110 degree.

Ultimate tensile strength (S) =2400 Mpa
Length of sheet metal plate l = 150 mm
Width of plate w = 50mm
Thickness of plate t = 5mm
Bending radius R= 5 mm

$$\text{Bend Allowance } (B_a) = \frac{\pi}{180} \times (R + K\times T) \times A$$

$$= \frac{\pi}{180} \times (5 + 1.33\times 5) \times 110$$

$$B_a = 36.5868\text{mm}$$

Total length, L = 50+50+36.58
L = 136.58 mm

$$\text{Bending force (Fb)} = \frac{KLT_s t^2}{D}$$

Where,
F=Bending Force, Ts= Tensile Strength of sheet metal, D= Dia opening diemension, K=1.33,

$$\text{Bending force, (Fb)} = \frac{1.33\times 136.58\times 115\times 5^2}{50}$$

= 10444.95N

Fb = 10.44KN

Same calculations is done for other materials

1. For Copper Sheet

Fb = 15.44KN

1. For Magnesium Sheet

Fb = 25.43KN

5. Modeling & FEA Analysis of Sheet Metal

5.1 Modeling of Punch & Dia

The setup of die, punch and sheet metal is drawn in the catia V5 software which is shown in Figure 4

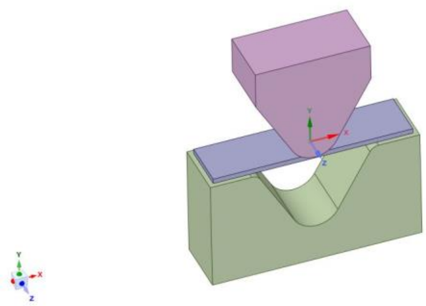

Fig -4: Catia Model

5.2 Ansys Geometry

Figure 5 shows the assembly file that is imported into the ansys workbench for the purpose of analysis and simulation.

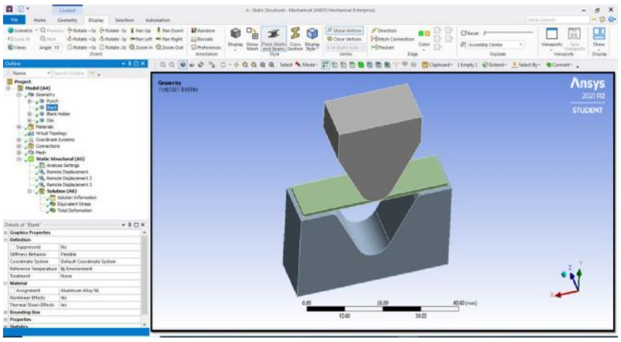

Fig -5: Imported assembly files in ANSYS

5.3 Meshed Model

The mesh metric is applied to identify the factors in line with their quality. The best of the mesh quality is appropriate as maximum of the factors lie inside a high variety of range 0.8-1.0.

The sheet metal and faces of punch and die which comes in contact with a sheet, the sheet has only meshed with an element size of 1mm. different components have meshed with an detail length of 4mm.

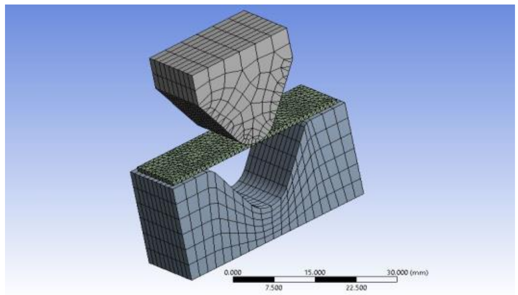

Fig -6: Mesh Model

5.4 Analysis Results for Alluminum Alloy 1199

A. Equivalent elastic strain

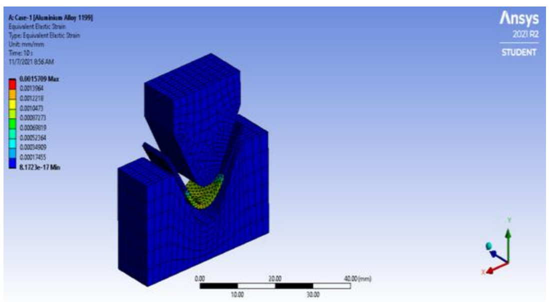

Fig -7: Equivalent elastic strain for Aluminium Alloy

B. Equivalent stress

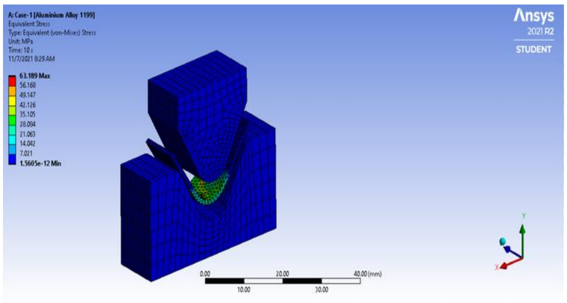

Fig -8: Equivalent stress

C. Total Deformation

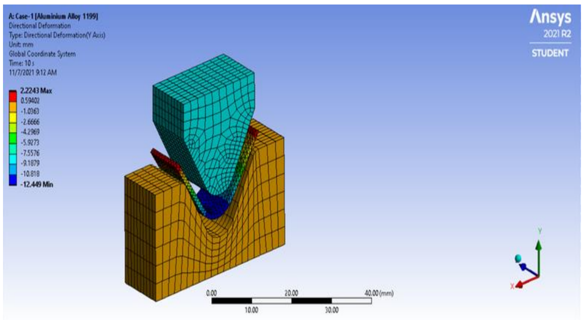

Fig -9: Total Deformation

5.5 Analysis Results for Copper Alloy

A. Equivalent elastic strain

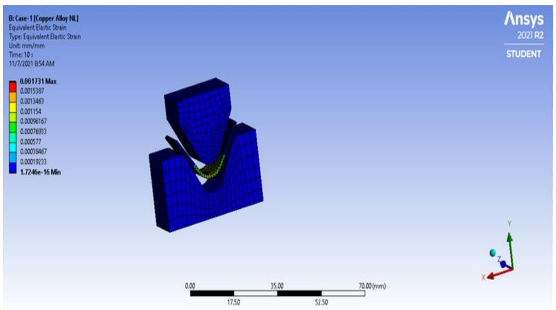

Fig -10: Equivalent elastic strain for Copper Alloy

B. Equivalent stress

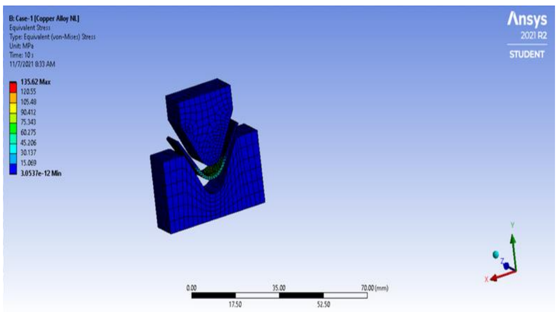

Fig -11: Equivalent stress

C. Total Deformation

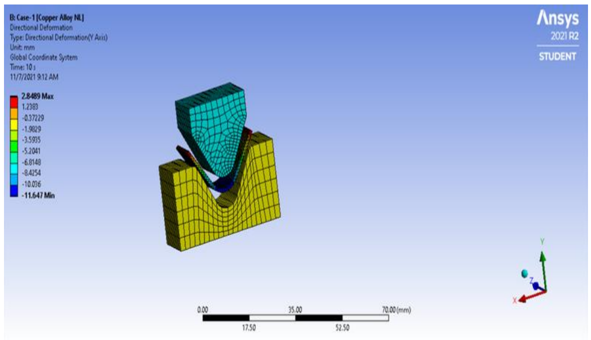

Fig -12: Total Deformation

5.6 Analysis Results for Magnesium Alloy

A. Equivalent elastic strain

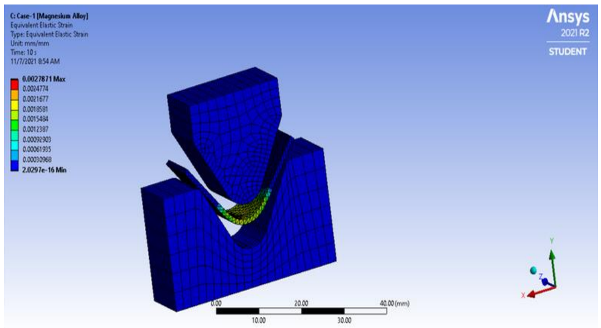

Fig -13: Equivalent elastic strain for Magnesium Alloy

6. RESULT & DISCUSSION

In this work methodology to perform static structural analysis on the sheet metal bending model with different materials considering the different frictional values to find out the equivalent von mises stress, total deformation and Equivalent Elastic Strain results.

- Hence the material has been defined for all the three cases.
- Hence the connections were defined to the Sheet Metal Bending Model.
- Hence the model has been solved for Von-Misses Stress, Equivalent Elastic Strain, Stress Intensity, Contact Tool and Directional Deformation by applying appropriate boundary conditions.

Table -1: Obtained Reslults

Title	Aluminum Alloy		Copper Alloy		Magnesium Alloy	
Values	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Equivalent Stress	1.5605 e^{-12}	63.189	3.0537 e^{-12}	135.62	3.1011 e^{-12}	89.05
Deformation (mm)	-12.449	2.224	-11.647	2.8489	-11.314	2.5285
Equivalent Strain	8.1723 e^{-17}	0.0015709	1.7246 e^{-16}	0.001731	2.0297 e^{-16}	0.0027871

According to above results while comparing the three materials Aluminium Alloy 1199, Copper Alloy and Magnesium Alloy.

- Equivalent stress is maximum in the Copper alloy, The Maximum Stress occured is **135.62 Mpa** It is high when compared to the other two materials and minimum stress in the Aluminum alloy which is **63.189 Mpa.**
- The maximum directional deformation is also occured in the Copper Alloy.The maximum directional deformation occured is **2.8489 mm**, it is also higher when compared to the other two cases.
- The maximum von misses stress occured in the **Aluminium Alloy 1199 is 63.189 Mpa,** It i slow when compared to other two cases, the maximum directional deformation occured in the **Aluminium Alloy 1199 is 2.2243 mm,** and it is low when compared to the other two cases.
- So the stress and deformation occured in Aluminium Alloy is low while in comparison to the other two materials, so the Aluminium Alloy is best material whilst as compared to two different material.

6. CONCLUSION

1) Performed a structural analysis on sheet metal with different material and frictional coefficient, the sheet metal had to bend for this project, and any stresses or strains that resulted from that bending had to be examined.

2) Three distinct goals were used to complete the task. For the primary goal, 3 different sheet steel materials' stresses and different elements have been examined. Out of aluminum alloy 1199, copper alloy, and magnesium alloy, it became located that aluminum alloy 1199 must be the popular material.

3) Aluminum alloy is easily formed and the coefficient of friction between contact surfaces was raised from 0.1 to 0.19 for the second aim. However, it had little imact at the outcome.

4) We have concluded that, the Aluminium Alloy 1199 is preferable when compared to other two cases, Cause the stress and the deformation occured is very less when compared to the other two cases.

REFERENCES

1. D. Davies RJ., Liu YC., 'Control of springback in flanging operation', Journal of applied Metalworking, 3, (1984) 142-14
2. Todoroki A. and Ishikawa T., 'Design of experiments for stacking sequence optimizations with genetic algorithm using surface approximation', Composites Structures, 64, (2004) 349-357
3. Suha K. Shihab et.al, 'SHEET METAL FORMING PROCESSES FOR VARIOUS MATERIALS USING FINITE ELEMENT ANALYSIS' International Conference on Advances in Mechanical and Mechatronics Engineering 1st International Conference on Advances in Mechanical and Mechatronics Engineering ICAMMEN 2018 8-9 Nov 2018,
4. Yasar, M. Gas detonation forming process and modeling for efficient spring-back prediction. J. Mater. Process. Technol. 2004, 150, 270–279.
5. Sandeep P. Patil 'Experimental and Numerical Studies of Sheet Metal Forming with Damage Using Gas Detonation Process'. www.mdpi.com/journal/metals Metals 2017, 7, 556; doi: 10.3390/met7120556.
6. You-Min Huang, 'An elasto-plastic finite-element analysis of sheet metal camber processes'. Journal of Materials Processing Technology 140 (2003) 432–440
7. Mark Colgan, John Monaghan, "Deep Drawing process: analysis and experiment", Journal of Materials Processing Technology,132, 2003, 35 41.
8. Kopanathigowtham, K.V.N.S. Srikanth&k.L.N. Murty, "Simulation of the effect of die radius on deep drawing process, International Journal of Applied Research in Mechanical Engineering ISSN: 2231 –5950, Volume-2, Issue-1, 2012.
9. R. Padmanabhan, M.C. Oliveira, J.L. Alves, L.F. Menezes, "Influence of method parameters at the deep drawing of stainless steel", Finite Elements in Analysis and Design 43 (2007) 1062 – 1067.

10. R. Venkat Reddy, Dr T.A. Janardhan Reddy, "Effect of Various Parameters on the Wrinkling In Deep Drawing Cylindrical Cups", International Journal of Engineering Trends and Technology- Volume3 Issue1- 2012.

11. Y. Marumo, H. Saiki, L Ruan, "Effect of sheet thickness on Deep Drawing of Metal Foils", Journal of Achievements in Materials and Manufacturing Engineering VOLUME 20 ISSUES 1-2 January-February 2007, 479-482.

12. A. R. Joshi, K. D. Kothari, Dr. R. L. Jhala, "Effects Of Different Parameters On Deep Drawing Process"; International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 3, March – 2013 ISSN: 2278-0181.54

13. Young Hoon Moon, Jeen Wook Park, Sung Rak Gong, "Deep Drawing With Internal Air-Pressing to Increase The Limit Drawing Ratio of Aluminum Sheet", KSME International Journal; VoL 15 No.4, pp. 452- 464, 2001