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Design & FE Analysis of Sheet Metal While Bending

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***Abstract*:- The sheet metal bending, being an important sheet metal forming process, with proper tooling to produce different bend components. The flexibility of the bending process is improved. In which the different bend angles can be produced by solely controlling the punch travel in to the v-die without the need for changing tool sets. The sheet metal plate is modeled by using modeling software catiav5. By using this software the time spent in producing the complex 3- D models and the risk involved in the design and manufacturing process can be easily minimized. So the modeling of the sheet metal plate assembly is made by using CATIA. Later this CATIA modal is imported to ANSYS WORKBENCH 15 for analysis work. ANSYS WORKBENCH 15 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 15 software reduces the time compared with the method of mathematical calculations by a human. ANSYS WORKBENCH 15 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 respectively. In this analysis by observing the results obtained the non-linear material structural steel alloy is suggested as best material for sheet metal plate bending.**

INTRODUCTION

Forming process involve shaping material in the solid state whether the material is a continuous solid or powder. It is the essential property when the material is subjected to deformation .This process requires lot of energy depending on the type of metal, expenditure and capital investment to be formed differs.

A large variety of metallic parts are produced by deformation process. In fact, there are more than 1000 registered types of steels; each of these was originally designated for some specific use.

In sheet metal working operations, the cross-section of the work piece remains same and the material is subjected to shape changes. These operations are performed on thin sheets by means of a set of tools called punch and die. Forming can be done based on type of sheet, punch and die. Sheet metal forming involves bending, punching, drawing, stretching and some other processes. Out of various bending operations, V-die bending is chosen for the sheet metal to be formed. The common failures encountered during sheet metal forming, wrinkling, puckering, and shape distortion factors. They are generally characterized by a high ratio of surface area to thickness. Sheet metal forming operations are so diverse in type, extent and rate that no single test provides an accurate indication of the formability of a material in all situations. Processes can be successfully operated only when the forming properties of the work material are within narrow range. Certain factors which influence on overall operation of forming processes are stretching, elongation, anisotropy, grain size etc. Another important factor which influences sheet metal forming is Anisotropy or directionality of sheet metal. Anisotropy is acquired during the thermo-mechanical processing of the sheet. In other worlds, the same sheet metal can have good or bad formability depending upon the components of the forming system. It is interesting to contrast this to a typical mechanical property of sheet metal which is dependent on the sheet metal only rather than on the system conditions such as sheet thickness, process conditions, surface finish, sheet metal properties etc.

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

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.

OBJECTIVE, SCOPE AND METHODOLOGY

The design of sheet metal while bending has to choose the variety of parameters which include geometrical parameters, different types of sheet materials, size of sheet etc. Hence it is of interest to analyze 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 .and total deformation

The proposed work include following step.

1) Study of literature review on various work reported.
2) Selecting some of sheet materials are available.
3) The geometrical model shall be prepared for the varied geometrical parameter like sheet thickness, size of sheet etc.
4) CAD Model is prepared using various tool – catia version-5 i.e. extrude, revolve, mirror etc .

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5) The analysis results obtained shall help to identify the region of stress concentration and variation material of sheet metal shall be plotted and appropriate conclusion shall be drawn.

NUMERICAL METHOD

Problem:

A certain sheet metal material of structural steel NL having tensile strength 2400 Mpa having thickness of plate 0.5 mm, length 50 mm, width 10 mm, is subjected to bending in v-die with opening of angle 83 degree .

What is the bending force required?

Given data:-

Density of material,

ρ =7850 kg/m^3

K=1.33 for v-die opening of 8 times thickness (8t)

Ultimate tensile strength (S) =2400 Mpa

Length of sheet metal plate l = 50 mm

Width of plate w = 10mm

Thickness of plate t = 0.5mm

Bending radius R= 5 mm

To Find:- Calculate required bending force (Fb) = ?

Solution:-

Bending force (Fb) = $\frac{KLSt2}{4}$

Bend allowance, b = α (R + K t)

$= 2\pi \times \frac{83}{360} \times (5 + 1.33\times0.5)$

b = 5.96 mm

Total length, L = 24.25+24.25+5.96

L = 54.46 mm

Bending force, (Fb) = $\frac{KLSt2}{4}$

$= \frac{1.33\times54.46\times2400\times0.5^2}{4}$

= 10864.47 N

Fb = 10.86 KN

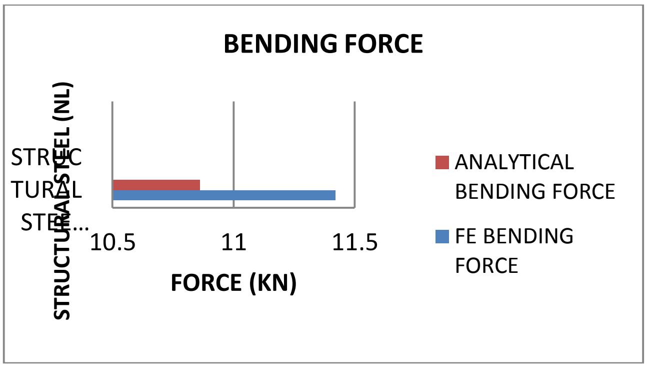
The above numerical results are varied with the help of comparison of result FE analysis software.

Result is plotted shown in below Table

SR. NO	MATERIAL	ANALYTICAL BENDING FORCE (Fb)	FE BENDING FORCE (Fb)
1	STURCTURAL STEEL NL	10.86 KN	11.41 KN

Table 1: Comparison of bending force value Material of structural steel NL

COMPARISON OF RESULT BY USING CHART



Graph 1: Comparison of Result Bending force value of material structural steel NL

SHEET METAL PLATE BENDING VIEW ASSEMBLY NOMENCLATURE

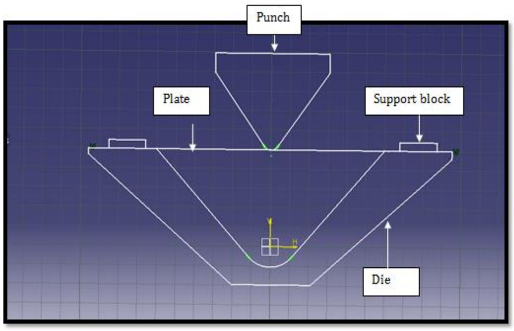


Figure 1: Sheet metal plate bending assembly view Nomenclature

SHEET METAL PLATE BENDING VIEW NOMENCLATURE

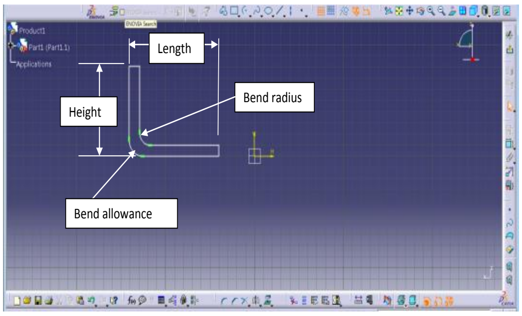


Figure 2: Sheet metal plate bending view Nomenclature

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CREATING THE ASSEMBLY OF ABOVE ALL PART

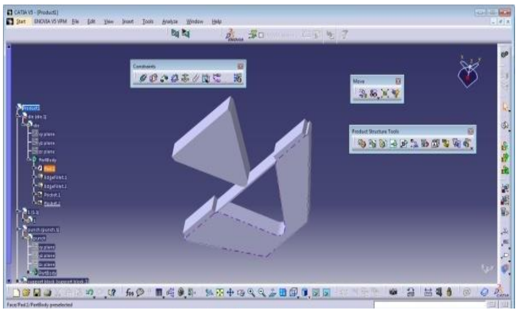

Figure 3: Assemble view of die, plate, punch & support block

VARIOUS VIEWS OF SHEET METAL PLATE BENDING ASSEMBLY

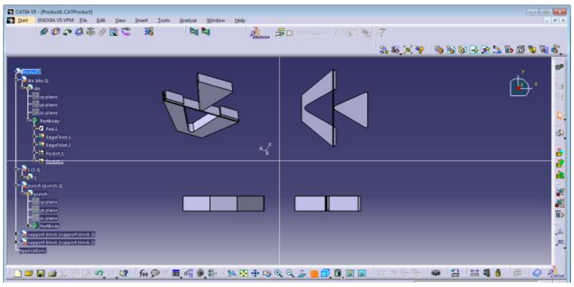

Figure 3: various views of sheet metal plate bending assembly

MATERILS SELECTION

SR.NO.	MATERIALS NAME	DENSITY (ρ) Kg/m^3	YOUNGS MODULUS (E) Pa	POISSONS RATIO (1/m)
1	STRCTURAL STEEL	7850	$2*10^{11}$	0.3
2	ALUMINUM ALLOY	2770	$7.1*10^{10}$	0.33
3	MAGNESIUM ALLOY	1800	$4.5*10^{10}$	0.35

Table 1: Types of non linear materials to be used and its property.

FINITE ELEMENT ANALYSIS OF SHEET METAL PLATE WHILE BENDING

Meshing of model

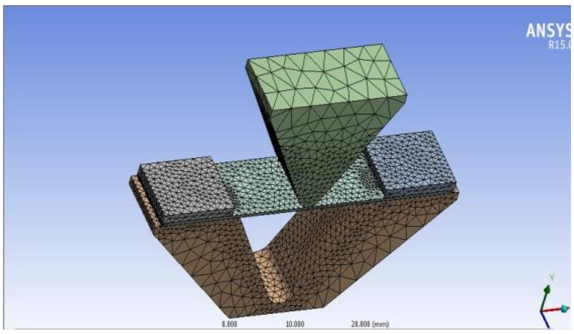

Fig 5. Meshing of Sheet metal plate assembly
The element used is tetrahedron Element.

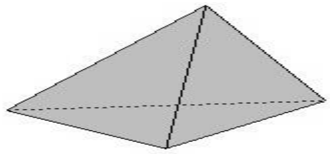

Fig 6: Tetrahedron Element

SUPPORT OF SHEET METAL BENDING ASSEMBLY

The die portion of sheet metal bending assembly is fixed. The sheet metal plate is mounted on die. The die is fully constrained. In the present work transient structural analysis is performed out to calculate the bending stresses in sheet metal plate.

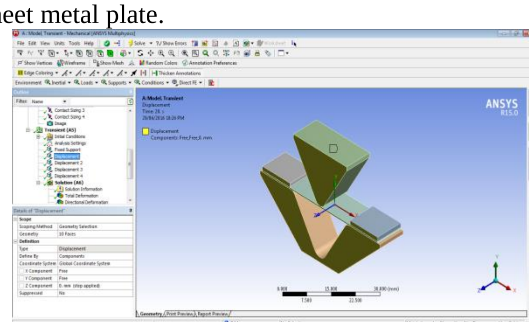

Figure 7: Constraints on a die

DISPLACEMENT ON ASSEMBLY

In static loading condition on the sheet metal bending assembly the displacement is provided to the V-die, punch, support and sheet metal as shown in figure

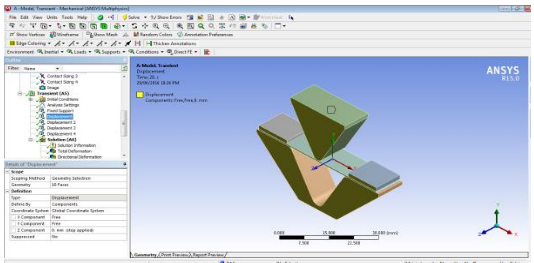

Figure: 8 Displacements 1

i) Displacement 2 is applied along Y-axis on top portion of punch in down word direction as shown in figure

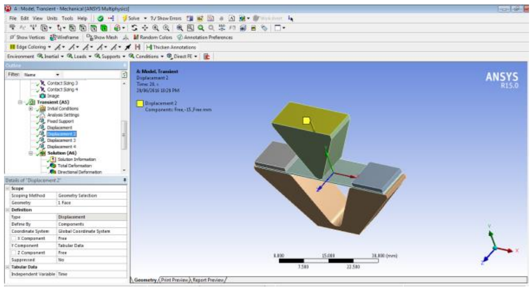

Figure 8: Displacement 2 on punch

ii) Displacement 3 and Displacement 4 act along X-axis on the support and this support slide over the sheet metal plate as shown in figure.

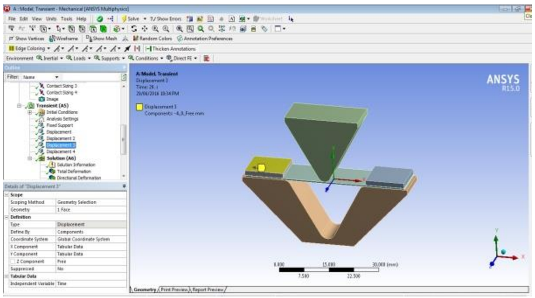

Figure 9: Displacement 3

iii) Displacement 4 is also applied in along X-axis on the support by selecting the top surface of the support .This support slide over the sheet metal as shown in figure.

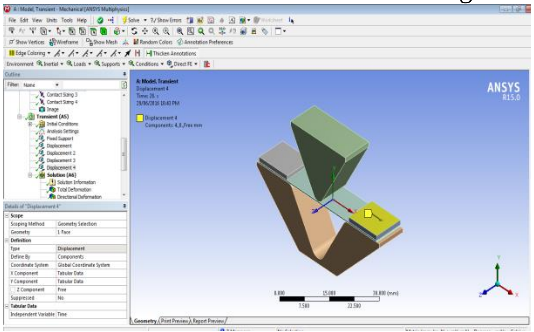

Figure 10: Displacement 4

All the Boundary condition (i), (ii), (iii) are applied in combine manner on sheet metal bending assembly as shown in figure.

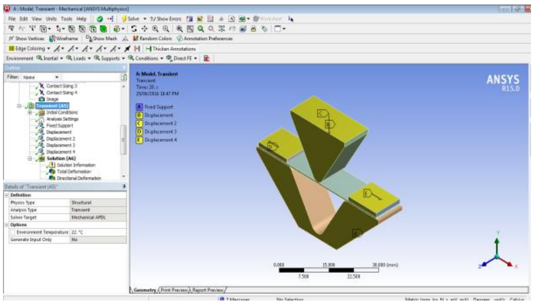

Figure 11: Combination of all the Boundary condition

The first doing the analysis setting and time setting find out the total deformation, directional deformation and equivalent stresses, reaction force for different materials.

Click on solution to find particular solution i.e. click on stress then select intensity and equivalent stress. Then click on solve for generation of solution.

TOTAL DEFORMATION OF SHEET METAL PLATE

i) Material aluminum alloy.NL

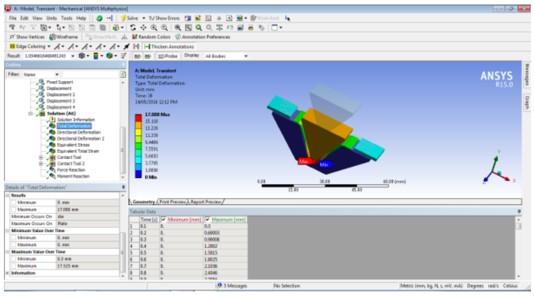

Figure 12:-Total Deformation (Al) NL

ii) Material magnesium alloy (NL).

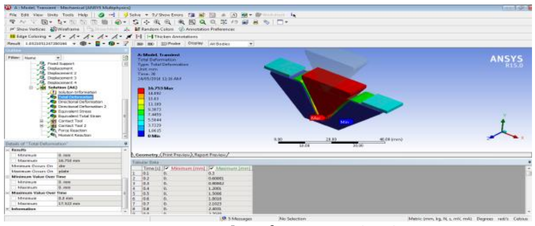

Figure 12: Total Deformation (Mg) NL

iii) Material structural steel (NL).

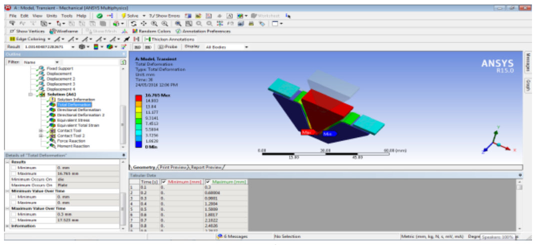

Figure 13:-Total Deformation (ST) NL

DIRECTIONAL DEFORMATION OF SHEET METAL PLATE

i) Material aluminum alloy NL

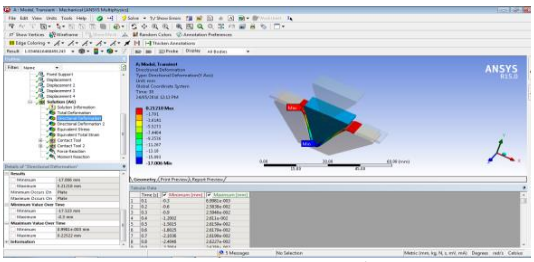

Figure 14: Directional Deformation (AL)

ii) Material magnesium alloy NL

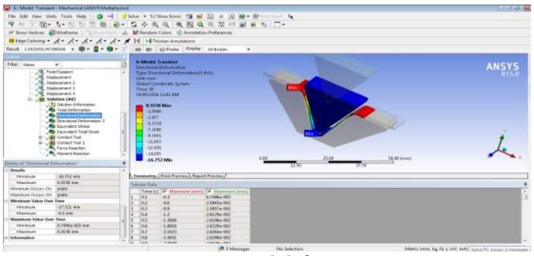

Figure15: Directional deformation (Mg)

iii) Material structural steel NL

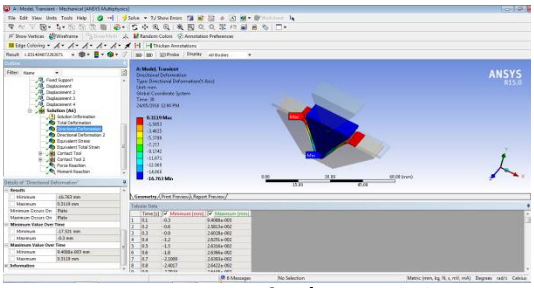

Figure16: Directional Deformation (ST)

DIRECTIONAL DEFORMATION2 ON SHEET METAL PLATE

i) Material aluminum alloy NL

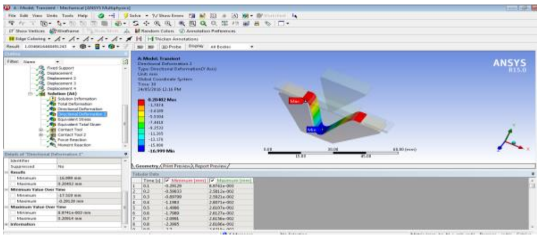

Figure 17: Directional deformation2 (Al)

ii) Material magnesium alloy NL

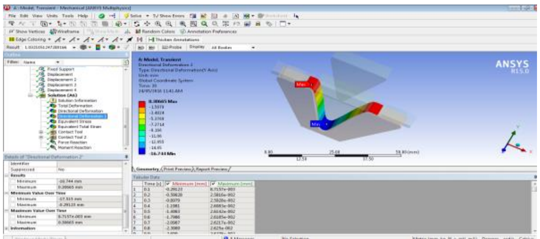

Figure 18:-Directional deformation2 (Mg)

iii) Material structural steel NL

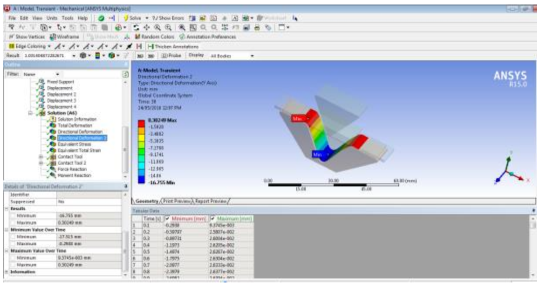

Figure 19:- Directional deformation2 (ST)

EQUIVALENT STRESSES FOR SHEET METAL PLATE

i) Material aluminum alloy NL

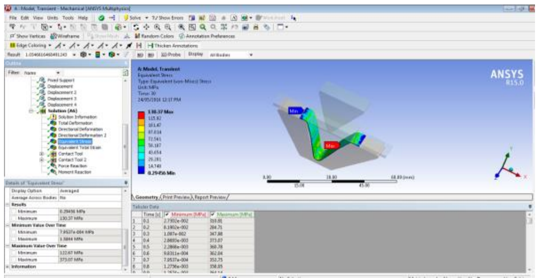

Figure 20: Equivalent stress (Al) NL

ii) Material magnesium alloy NL

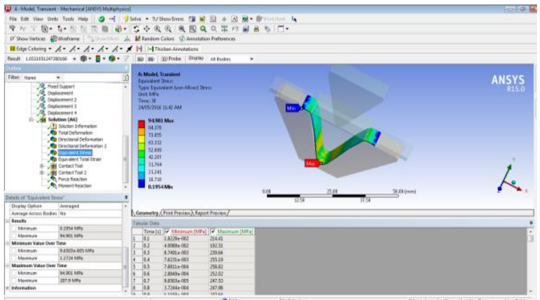

Figure 21: Equivalent stress (Mg) NL

iii) Material structural steel (NL)

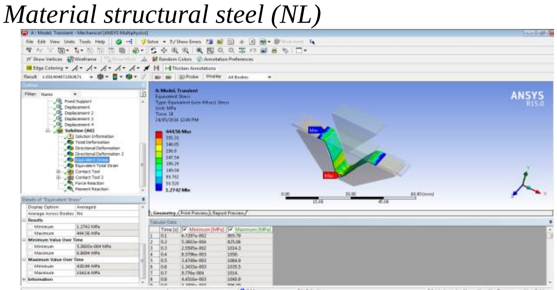

Figure 22: Equivalent stress (steel) NL

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EQUIVALENT TOTAL STRAIN FOR SHEET METAL PLATE

i) Material aluminum alloy (NL)

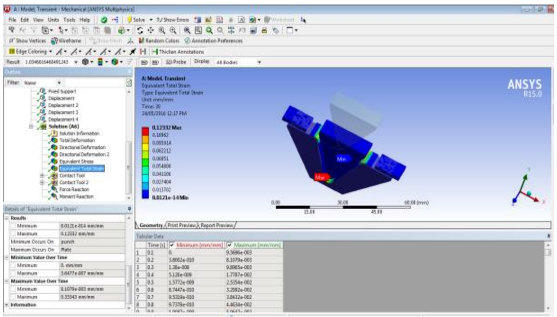

Figure 23:- Equivalent total strain (Al) NL

ii) Material Magnesium Alloy (NL)

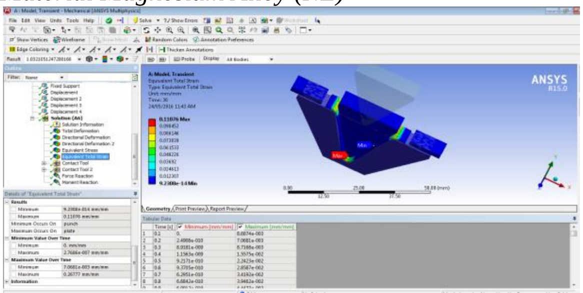

Figure 24: Equivalent total strain (Mg)

iii) Material structural steel NL

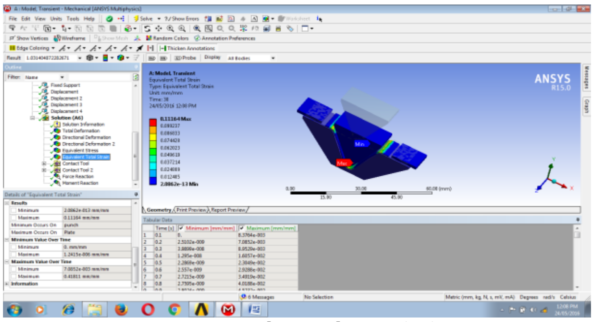

Figure25: Equivalent total strain (ST) NL

FORCE REACTION ON PUNCH

i) Material aluminum alloy NL

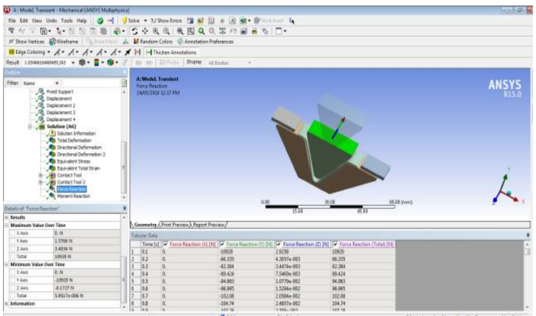

Figure 26:- Force reaction (Al) NL

ii) Material Magnesium Alloy (NL)

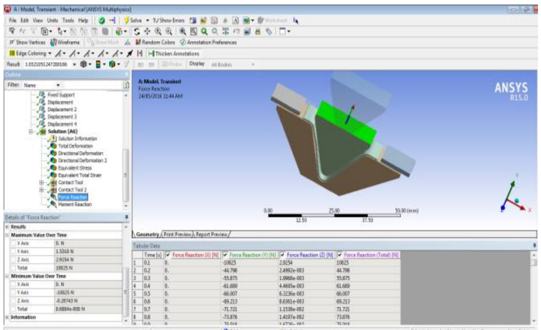

Figure 27: Force reaction (Mg) NL

iii) Material structural steel NL

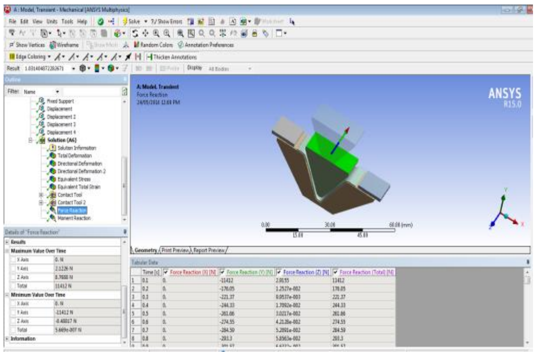

Figure 28: Force reaction (ST) NL

MOMENT REACTION ON PUNCH

i) Material aluminum alloy (NL)

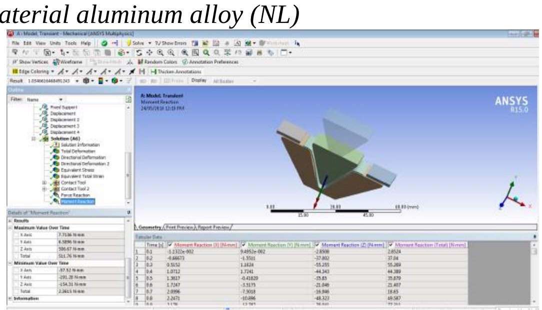

Figure 29:- Moment reaction (Al) NL

ii) Material Magnesium Alloy (NL)

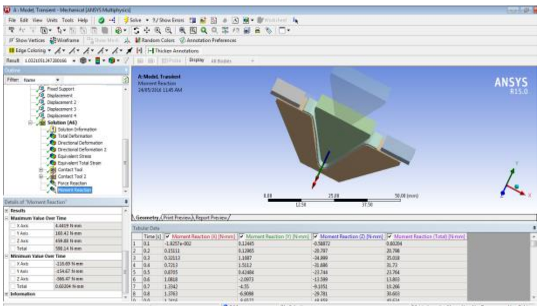

Figure 30: Force reaction (Mg) NL

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iii) Material structural steel NL

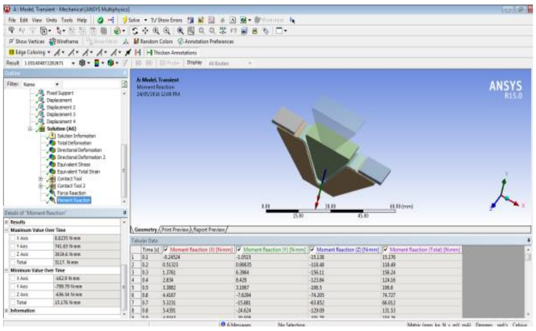


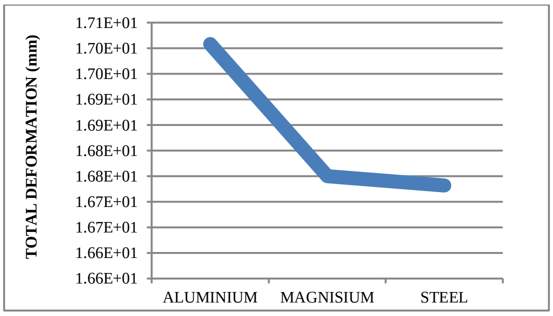
Figure 31: Moment reaction (ST) NL

RESULT OBTAINED FOR TOTAL DEFORMATION OF SHEET METAL PLATE BENDING ARE SHOWN IN GRAPH AND TABLE

SR.NO.	MATERIALS NAME	TOTAL DEFORMATION (mm)
1	ALUMINUM ALLOY (NL)	**17.008**
2	MAGNESIUM ALLOY (NL)	**16.753**
3	STRCTURAL STEEL (NL)	**16.723**

Table no.1: Variation in Total Deformation

COMPARISON OF RESULT BY USING CHART



Graph 2: Variation in Total Deformation due to change of Materials.

CONCLUSION FROM RESULT TOTAL DEFORMATION

The results obtained from the Table no. 1and Graph no. 2, are as follows.

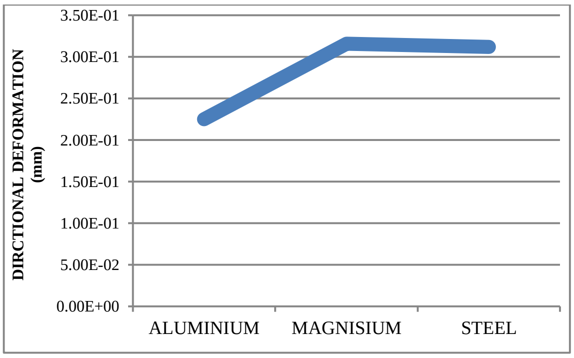
i) Total deformation in Structural Steel NL is minimum as compared to Aluminum alloy NL and Magnesium alloy NL.

RESULT OBTAINED FOR DIRECTIONAL DEFORMATION OF SHEET METAL PLATE BENDING ARE SHOWN IN GRAPH AND TABLE

SR.NO.	MATERIALS NAME	DIRECTIONAL DEFORMATION (mm)
1	ALUMINUM ALLOY (NL)	0.2252
2	MAGNESIUM ALLOY (NL)	0.3158
3	STRCTURAL STEEL (NL)	0.3119

Table no.2: Variation in directional deformation

COMPARISON OF RESULT BY USING CHART



Graph no. 3: Variation in directional deformation due to change of material

CONCLUSION FORM RESULT DIRECTIONAL DEFORMATION

The results obtained from the Table No.2 and Graph No.3 and are as follows.

i) Directional deformation in Material aluminum alloy NL is minimum as compared to Magnesium alloy NL and Structural steel NL.

RESULT OBTAINED FOR DIRECTIONAL DEFORMATION2 OF SHEET METAL PLATE BENDING ARE SHOWN IN GRAPH AND TABLE

SR.NO.	MATERIALS NAME	DIRECTIONAL DEFORMATION 2 (mm)
1	ALUMINUM ALLOY	0.20914
2	MAGNESIUM ALLOY	0.30665
3	STRCTURAL STEEL	0.30249

Table no.3: Variation in Directional Deformation 2

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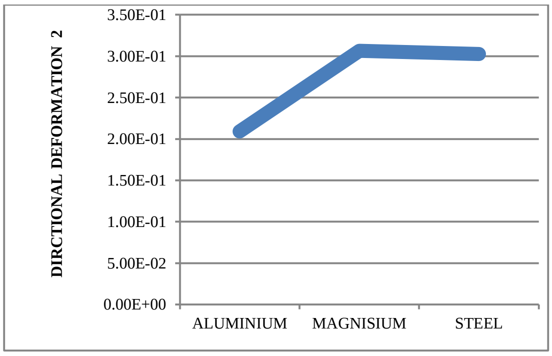
COMPARISON OF RESULT BY USING CHART



Graph no.4: Variation in Directional Deformation2 due to change of Materials.

CONCLUSION FORM RESULT DIRECTIONAL DEFORMATION 2

The results obtained from the Table No. 3 and Graph No.4 and Table are as follows.

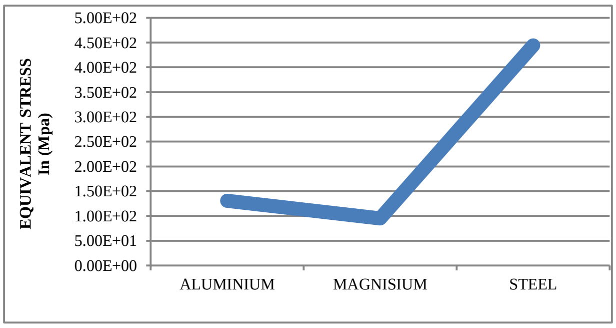
i) Directional deformation2 in Aluminum alloy NL is minimum as compared to Magnesium alloy NL & Structural Steel NL.

RESULT OBTAINED FOR EQUIVALENT STRESS OF SHEET METAL PLATE BENDING ARE SHOWN IN GRAPH AND TABLE

SR.NO.	**MATERIALS NAME**	**EQIVALENT STRESS (Mpa)**
1	ALUMINUM ALLOY	130.37
2	MAGNESIUM ALLOY	94.901
3	STRCTURAL STEEL	444.56

Table no.4: Variation in Equivalent stress (Mpa)

COMPARISON OF RESULT BY USING CHART



Graph no.5: Variation in Equivalent stress varying in material

CONCLUSION FORM RESULT EQUIVALENT STRESS

The results obtained from the Table No 4 and Graph No.5 and are as follows.

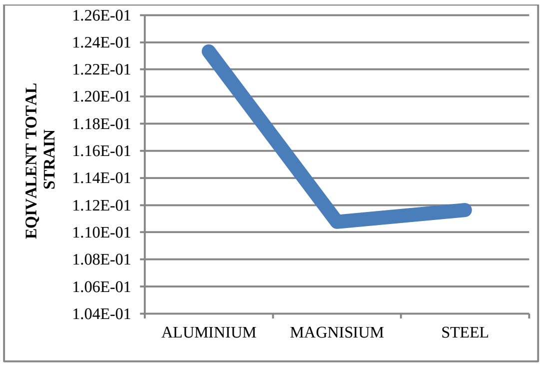
i) Equivalent stress is maximum Structural steel alloy NL as compared to Aluminum alloy NL and Magnesium alloy NL.

RESULT OBTAINED FOR EQUIVALENT TOTAL STRAIN OF SHEET METAL PLATE BENDING ARE SHOWN IN GRAPH AND TABLE

SR.NO.	MATERIALS NAME	EQUIVALENT TOTAL STRAIN
1	ALUMINUM ALLOY	0.12332
2	MAGNESIUM ALLOY	0.11076
3	STRCTURAL STEEL	0.11164

Table no.5: Variation in Equivalent total strain for different material

COMPARISON OF RESULT BY USING CHART



Graph no.6: Variation in Equivalent total strain for different material.

CONCLUSION FORM RESULT EQUIVALENT TOTAL STRAIN

The results obtained from the Table No. 5 and Graph No.6 are as follows.

i) The Equivalent total strain in Aluminum alloy (NL) is maximum as compared to Magnesium alloy NL and Structural steel alloy (NL).

RESULT OBTAINED FOR FORCE REACTION OF SHEET METAL PLATE BENDING ARE SHOWN IN GRAPH AND TABLE

SR.NO.	MATERIALS NAME	FORCE REACTION (KN)
1	ALUMINUM ALLOY	10.920
2	MAGNESIUM ALLOY	10.825
3	STRCTURAL STEEL	11.412

Table no.6: Variation in force reaction (KN)

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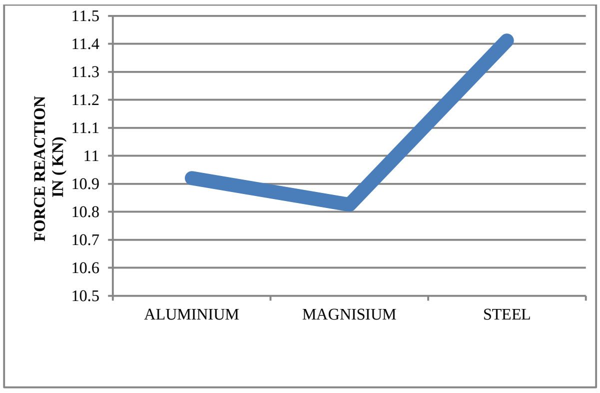
COMPARISON OF RESULT BY USING CHART



Graph no.7: Variation in force reaction for different Materials.

CONCLUSI6ON OF RESULT FORCE REACTION ON PUNCH

The results obtained from the Table No. 6 and Graph No.7 are as follows.

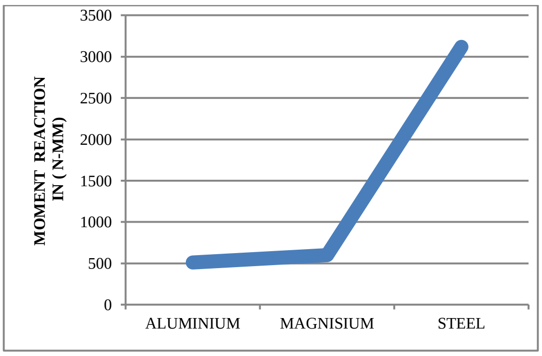
i) Force reaction on punch in Structural Steel Alloy (NL) is maximum, as compared to Aluminum alloy (NL) and Magnesium alloy (NL).

RESULT OBTAINED FOR FORCE REACTION OF SHEET METAL PLATE BENDING ARE SHOWN IN GRAPH AND TABLE

SR.NO.	MATERIALS NAME	MOMENT REACTION (N-MM)
1	ALUMINUM ALLOY	511.76
2	MAGNESIUM ALLOY	598.14
3	STRCTURAL STEEL	3117

Table no.7: Variation in Moment Reaction

COMPARISON OF RESULT BY USING CHART



Graph no.8: Variation Moment reaction for different Materials.

CONCLUSION OF RESULT FORCE REACTION ON PUNCH

The results obtained from Table no.7 and Graph No.8 and are as follows.

i) The Moment reaction in Structural Steel alloy NL is maximum as compared to Aluminum alloy NL and Magnesium alloy NL.

CONCLUSION

CAD model of the sheet metal bending assemblies is generated in CATIA V5 and this model is imported to ANSYS 15 for processing work. For different Non-linear materials like ALUMINIUM ALLOY, STUCTURAL STEEL ALLOY AND MAGNESIUM ALLOY.

Following are the conclusions from the results obtained:

1. Total deformation in Structural Steel NL is minimum as compared to Aluminum alloy NL and Magnesium alloy NL.
2. Directional deformation in Aluminum alloy NL is minimum as compared to Magnesium alloy NL and Structural steel alloy NL.
3. Directional deformation2 in Aluminum alloy NL is minimum as compared to Magnesium alloy NL & Structural Steel alloy NL.
4. Equivalent stress is maximum Structural steel alloy NL as compared to Aluminum alloy NL and Magnesium alloy NL.
5. The Equivalent total strain in Aluminum alloy (NL) is maximum as compared to Magnesium alloy NL and Structural steel alloy (NL).
6. Force reaction on punch in Structural Steel Alloy (NL) is maximum, as compared to Aluminum alloy (NL) and Magnesium alloy (NL).
7. The Moment reaction in Structural Steel alloy NL is maximum as compared to Aluminum alloy NL and Magnesium alloy NL

We have analyses above result the structural steel (NL) Material are best for using sheet metal plate bending.

FUTURE SCOPE

Following work may form the scope for future work

- Stress analysis by varying thickness of sheet metal plate.
- Further work on different sheet metal plate materials, for different bending analyzed by using experimental data.

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