Design And Analysis of Deep Drawing Using Punch And Die With Various Materials By FEM Method

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Abstract- *The goal of this research is to identify the variables that affect a drawing process by altering the Die radius while maintaining constant the Friction, Punch radius, and Blank Thickness. Using the SolidWorks program, punches, blank thicknesses with the same shape, and dies with varying geometries were designed for this study. Additionally, an attempt is made to use finite element analysis to examine the simulation impact of the primary process variable, the die radius. The simulated findings and those from the analytical model agreed rather well. Finite element calculations show that the hydro forming deep drawing approach reduces the danger of ripping while providing a more uniform thickness distribution than traditional deep drawing. various loads put on the punch tool, with optimal deformation and stresses put on the metal sheet. Materials utilized include structural steel, aluminum alloys, and magnesium alloys.*

Keywords- Deep drawing,FEM, Aluminum alloy, Magnesium alloy, Punch tool.

I. INTRODUCTION

To shape sheet metal, use deep drawing. A punch is used to insert a flat piece of metal between the punch and the die. The friction factor, tools, and equipment are the most critical factors in the Deep Drawing process that influence how sheet metal can be molded. Controlling these factors improves the material's shapeability and reduces the amount of flaws in deep drawing procedures.

Deep-drawn pieces aren't limited to cylinders or boxes. They can also be formed into more complex shapes. Making more sophisticated shapes becomes increasingly difficult. The Deep Drawing Process involves using a punch and die. The punch geometry depicts a replica of the object to be drawn with only minor modifications. The hole in the die is the same size as the punch, but it is a little wider to allow for the punch to fit through while also allowing for the thickness of the sheet. The blank is a piece of sheet metal work that is placed over the opening in the die. A blank holder that wraps around the punch and presses on the entire surface of the blank holds the blank flat against the die (except where the punch is). The punch is directed toward the blank. When the punch strikes the work, the sheet metal is pushed into the die cavity, giving it shape.

II. FINITE ELEMENT ANALYSIS

The purpose of using finite element analysis is to discover a solution to a difficult issue in a method that is relatively straightforward. The use of the finite element analysis as a technique for the numerical solution of a broad variety of engineering problems has shown to be rather effective. Applications range from deformation and stress analysis of automotive, aircraft, building, defense, missile, and bridge structures to the field of analysis of dynamics, stability, fracture mechanics, heat flux, fluid flow, magnetic flux, seepage, and other flow problems. Applications can be found in a variety of industries, such as automotive, aircraft, building, defense, missile, and bridge. Because of advancements in computer technology and CAD systems, it is now possible to simulate even the most complicated situations using relative case. Before the first prototype is ever created, a computer may be used to test out a number of different possible configurations. The fundamentals of the engineering profession are necessary in order to idealize the existing structure in order to achieve the desired behavior. It is vital to have expertise that has been shown in the usual issue area, modeling methodologies, data transmission and integration, and computational components of the finite element method. In the finite element approach, the solution area is thought of as being constructed up of a large number of smaller subregions that are also called finite elements and are linked.

III. MATERIAL PROPERTIES

The following describes the material qualities of bending punch tools and die tools:

Structural steel, aluminum alloy, and magnesium alloy are the materials used to make die tools and metal sheets; table 1 lists their qualities.

Table 1: Properties of used Material

Material Properties	**Aluminum Alloy**	**Structural Steel**	**Magnesium Alloy**
Density	2770 kg/m^3	7850 kg/m^3	1800 kg/m^3
Young's Modulus	71000 Mpa	200000 Mpa	45000 Mpa
Poisson ratio	0.33	0.3	0.35
Tensile yield strength	280 Mpa	250 Mpa	193 Mpa
Tensile ultimate Strength	310 Mpa	460 Mpa	255 a

IV. MODELLING OF PUNCH TOOL AND DIE

Figure show the design and geometry of punch tool and die and applied boundary conditions on it.

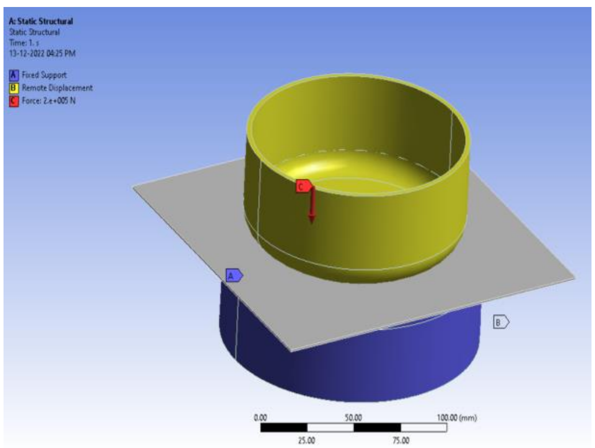

Figure 1: Deigned model of punch tool and die

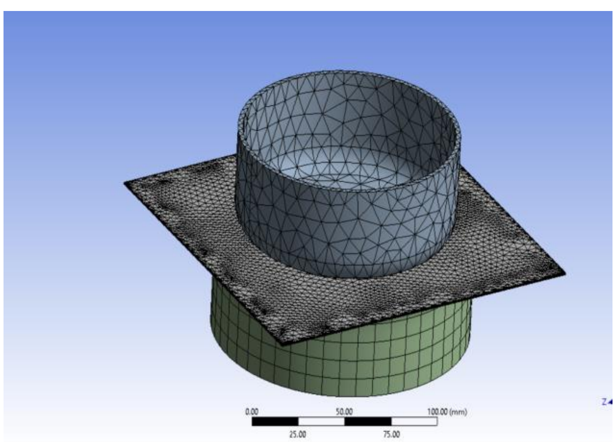

Figure 2: Meshed view of Punch tool and die

V. RESULTS AND ANALYSIS

There are many cycles involved in the deep drawing process used to create sheet metal. The following graphics illustrate how sheet metal is formed together with the tensions that arise. The deep drawing process of forming sheet metal with contact components at the interfaces of the punch, sheet metal, and die is examined using an axisymmetric method. Simulating the issue is done via displacement convergence. For better convergence of the issue for deflection, stresses, and contact pressure, the simulation is run with a number of stages.

5.1. Total Deformation Developed due to loading condition

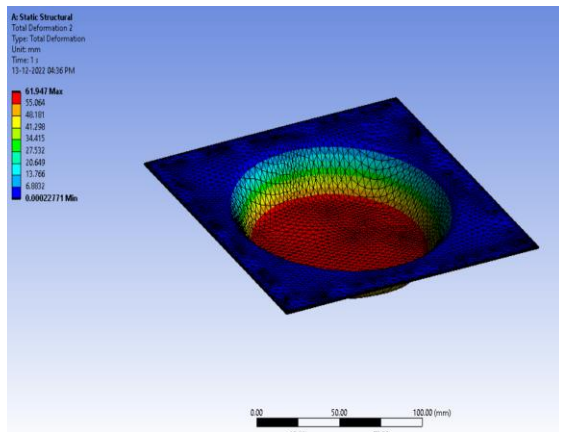

Fig. Fig. 3: Deformation of Aluminium alloy sheet

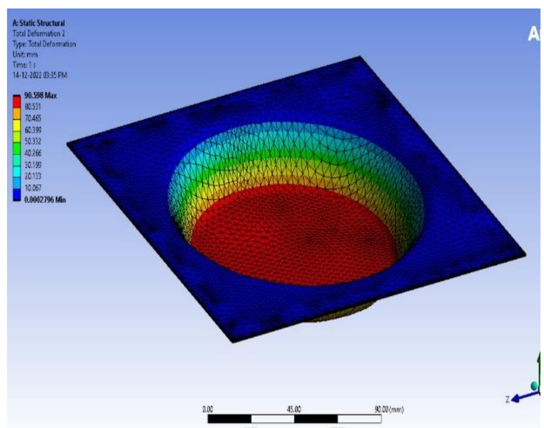

Fig.4: Deformation of Magnesium Alloy sheet

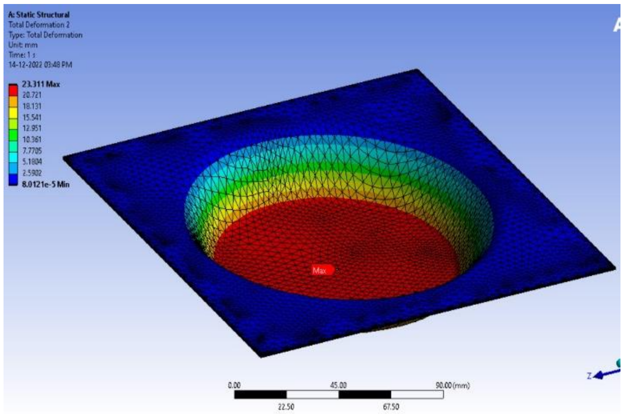

Fig. 5: Total deformation of Structural steel Sheet

5.2 Equivalent Stress Developed due to loading condition

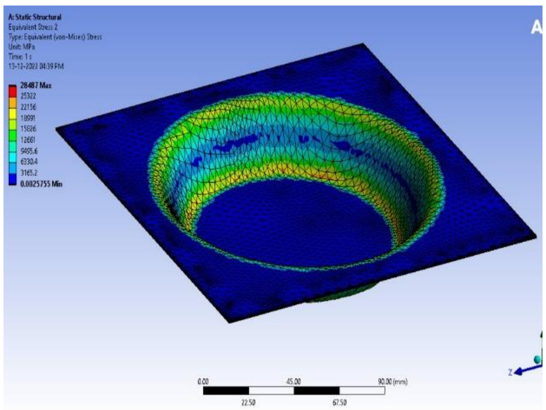

Fig. 6: Equivalent stress of Aluminum alloy sheet

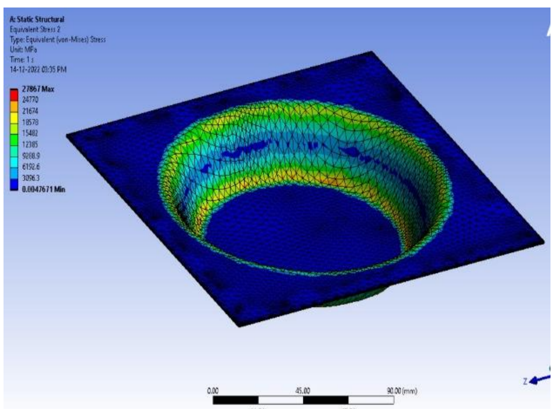

Fig. 7: Equivalent stress of Magnesium alloy

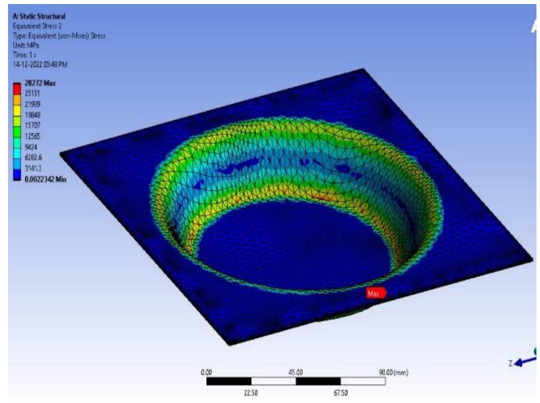

Figure 8: Equivalent stress of Structural Steel

5.3. Fatigue life due to loading condition and material variations

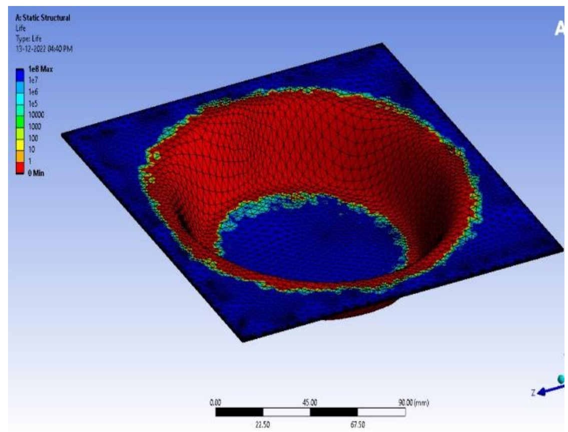

Fig. 9: Fatigue Life Aluminium Alloy

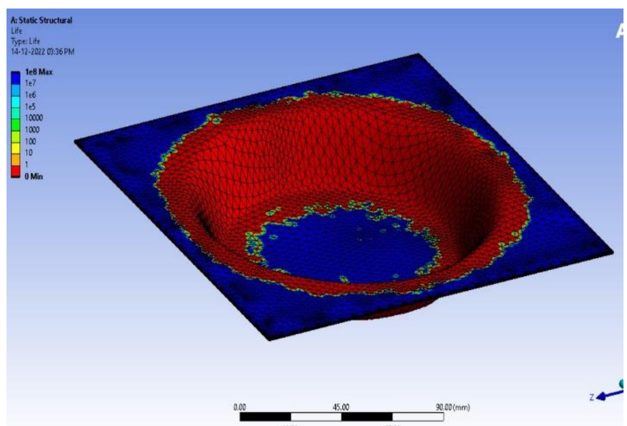

Fig.10: Fatigue Life Magnesium Alloy

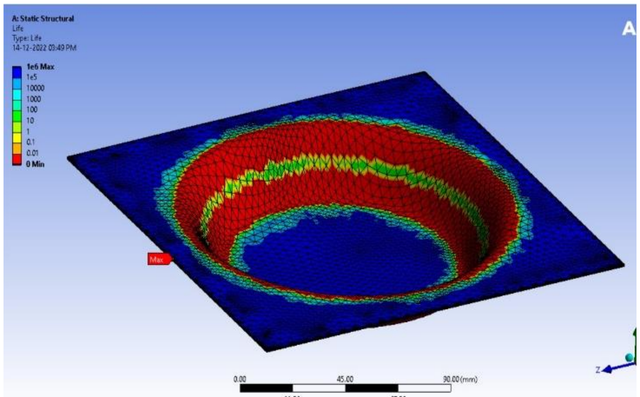

Fig. 11: Fatigue Life Structural Steel

5.4. Shear Stress due to loading condition and material variations

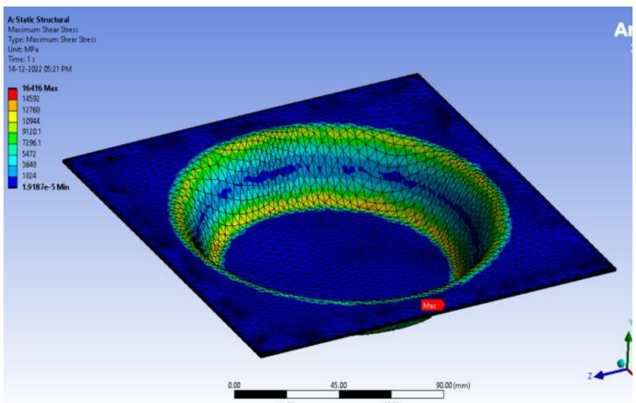

Figure 12: Shear stress developed in plate using Aluminium Alloy material

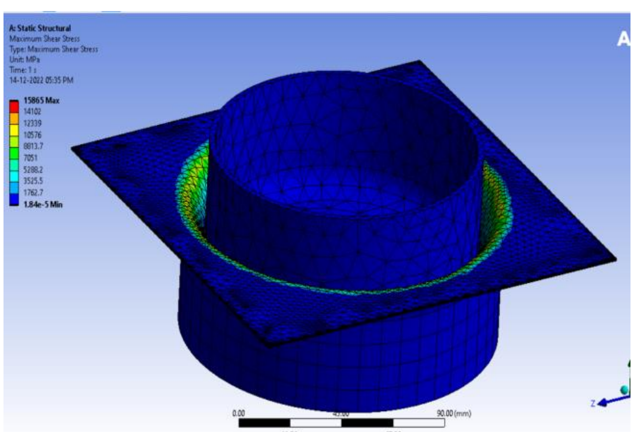

Figure 13: Shear stress developed in plate using Magnesium alloy material

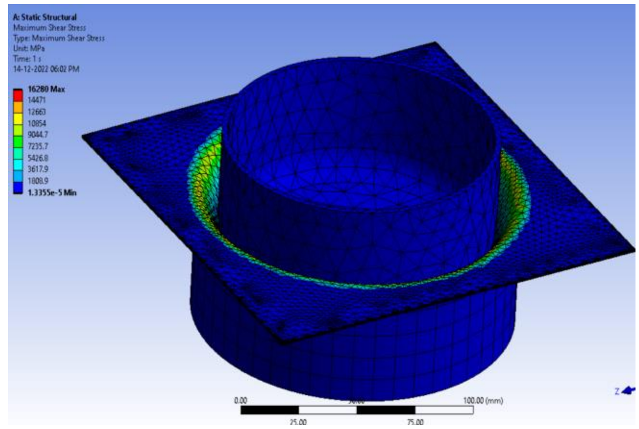

Figure 14: Shear stress developed in plate using Structural steel material

5.5. Comparison of Results

As per above study the figures 3 to 14 shows slow deformation process of sheet metal with the punch movement. From figure shows equivalent stress, deformation , shear stress generated in sheet metal. Results of materials used to design punch and die tool are described below.

Table 2: Results of Structural Steel with respect to various loads

Forces (KN)	**Structural Steel**			
	Equivalent Stress (MPa)	**Total deformation (mm)**	**Shear Stress (MPa)**	**Safety Factor**
200	28272	23.11	3154	0.0088
225	31806	26.22	3549	0.0078
250	35340	29.13	3943	0.0070
275	38874	32.05	4337	0.0064
300	42408	34.96	4732	0.0058

Table 5.1 shows the comparison of output data of deep drawing of metal using the structural steel material.

Table 3: Results of Aluminum Alloy with respect to various loads

Forces (KN)	**Aluminum Alloy**			
	Equivalent Stress (MPa)	**Total deformation (mm)**	**Shear Stress (MPa)**	**Safety Factor**
200	28487	61.94	16416	0.0098
225	31610	66.90	17943	0.0088
250	35123	74.34	19937	0.0079
275	38635	81.77	21931	0.0072
300	42147	89.20	23925	0.0066

Table 4: Results of Magnesium Alloy with respect to various loads

Forces (KN)	**Magnesium Alloy**			
	Equivalent Stress (MPa)	**Total deformation (mm)**	**Shear Stress (MPa)**	**Safety Factor**
200	27867	90.59	15865	0.0069
225	31350	101.92	17848	0.0061
250	34833	113.25	19831	0.0055
275	38317	124.57	21814	0.0050
300	41800	135.9	23797	0.0046

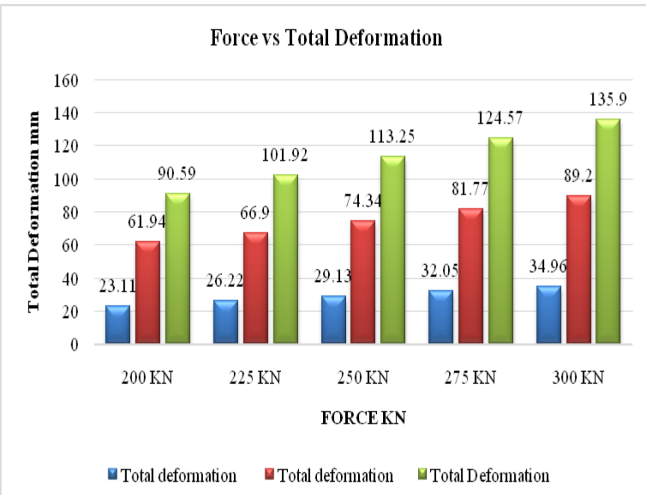

Figure 5.10: Comparison between Forces and Total deformation

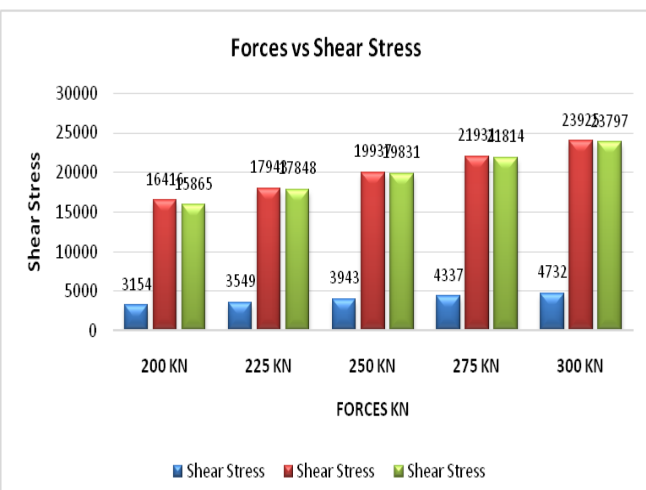

Figure 5.11: Comparison between Forces and Equivalent Stresses

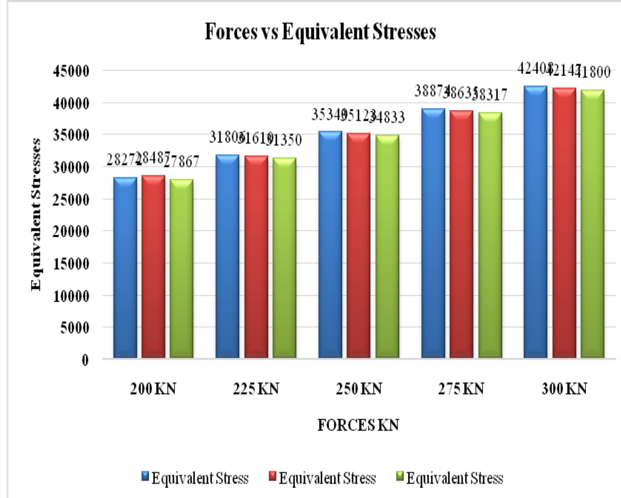

Figure 5.12: Comparison between Forces and Total deformation

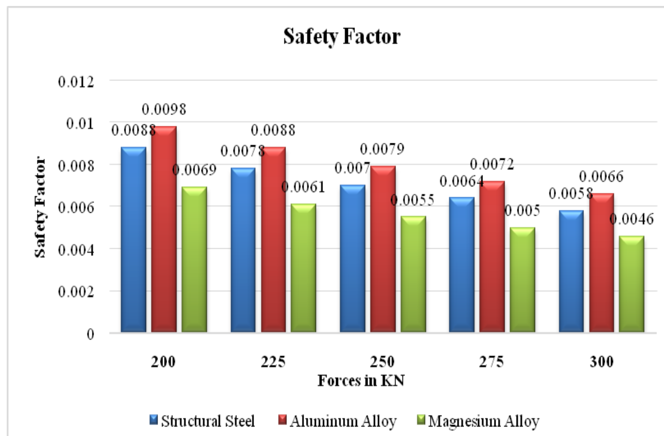

Figure 5.14: Comparison between Forces and Safety Factor

In this study, I have designed the deep drawing product assembly to check the output parameters while using sheet metal plate with 3 types of materials i.e. Aluminum alloy, Magnesium alloy and structural steel.

In the analysis phase studied the deformation generated in plate at various loads. Loads range varies i.e. 200 KN, 225 KN, 250 KN, 275KN and 300KN. After the complete output compare the results of different three metals.

As per table 2, shows that with Structural steel material, Equivalent stress increases with respect to load variations the maximum value of stress found 42408 MPa at 300 KN Load and minimum value of equivalent stress found 28272 MPa at 200 KN. In deformation section, minimum deformation found 23.11 mm at 200 KN load and maximum deformation found 34.96 mm at 300 KN load. Deformation increases as per load increase.

As per table 3, shows that with Aluminium Alloy material, Equivalent stress increases with respect to load variations the maximum value of stress found 42147 MPa at 300 KN Load and minimum value of equivalent stress found 28487 MPa at 200 KN. In deformation section, minimum deformation found 61.94 mm at 200 KN load and maximum deformation found 89.20 mm at 300 KN load. Deformation increases as per load increase.

As per table 4, shows that with Aluminium Alloy material, Equivalent stress increases with respect to load variations the maximum value of stress found 41800 MPa at 300 KN Load and minimum value of equivalent stress found 27867 MPa at 200 KN. In deformation section, minimum deformation found 90.59 mm at 200 KN load and maximum deformation found 135.9 mm at 300 KN load. Deformation increases as per load increase

VI. DEEP DRAWING MECHANISM DESIGN

The die profile and the blank holding mechanism were the key deep drawing design elements that drew various researchers to improve their design. Improving the design of the deep drawing elements helps to reduce die wear, prevent manufactured part failure, and improve material flow in general.

Shim, H. B. (2004), studied the die's profile optimization to prevent fracturing. A mathematical nonlinear programming model was used to formulate the problem. An optimization procedure based on regression curve fitting and constrained optimization was created because of the intricacy of that model.

Ragab and Sommer (1984) The flange contact conditions and forces of the drawn component's flange were researched, as well as the optimization of the blank-holding mechanism and its design parameters, which included the construction of the holding down plate. These parameters are investigated using the finite element method in the case of deep drawing cylindrical parts. Alexeevich (1992) proposed adding an elastic element beneath the blank holder to enhance the pressure utilized to hold sheet metal blanks during deep drawing. As a result, the blank holder deflects and generates the unique contact forces near the internal contour of the blank, whereas the contact forces near the external contour are weaker. This reduces the visibility of wrinkles.

Eriksen (1997) The relationship between die edge geometry and wear distribution over the die edge was examined. He developed a numerical model to describe this relationship, and physical experiments was utilized to validate the model. Based on the developed model, various die edge geometries are studied, including a standard circular edge, an elliptical edge, a tractrix edge, and an edge geometry specifically designed to make the wear distribution more uniform. His research reveals how die edge geometry impacts maximum wear.

VII. CONCLUSION

The deep drawing process is simulated using finite element software, and analysis is done to determine the load needs when the deep drawing process is increased. Here is a summary of the findings. The punch, sheet, and fixed die are first modeled in accordance with the requirements. The element has the plastic properties to depict a significant amount of deflection. The load requirements for sheet metal forming have been analyzed. The result demonstrates that drawing process depth increases together with an increase in load needs. The area of thinning and likely locations of failure may be determined using the finite element simulation. The primary failure zones are those with higher stresses. Avoiding prototype construction and verifying the necessary load estimates are made easier by finite element simulation.

According to the research, structural steel has greater equivalent stress than other materials, whereas magnesium alloy exhibits more deformation when compared to other materials. Structural steel also exhibits lesser deformation when compared to other materials. Therefore, magnesium alloy is the optimum material for the deep drawing process since high deformation materials are employed. Additionally, it is less stressed than other materials.

- As per comparison of deformations based on different materials used in study found that the magnesium alloy material shows maximum deformation as per increase the load value. Minimum deformation found on the Structural steel material
- Minimum shear stress found on the structural steel material is 3154 MPa at 200KN load and maximum shear stress founds on the aluminum alloy material is 23925 MPa at 300KN load.
- Equivalent stress increases as per the increment in load but the difference in material wise not shows larger difference it shows nearly similar, or we can say that material variations does not impact on the equivalent stress or von mises stress.
- As per study, the safety factor of deep drawing of metal sheet in desired products shape, fund maximum aluminum alloy material and structural steel material.
- At the end, final conclusion shows the requirement of the study, so we have to focus on the deformation and shear stress to produce defect free product of less wear and tear to increase productivity. So minimum shear stress gives structural steel material and

minimum, deformation shows the structural steel material and then magnesium alloy material, so as per study most suitable material is structural steel and magnesium alloy for deep drawing process in manufacturing unit.

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