Finite Element Analysis of Sheet Metal Works for Deep Drawing in Manufacturing of Fly Wheel Cup*

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***Abstract*-Fly wheel cup is used in rotor of generator of internal combustion engine of automobiles. An improved flywheel cup of rotor for magneto generator of an internal combustion engine. The construction offers is employed for securing all of the component, which includes a protective shield for the permanent magnets together a fly wheel rotor of a magneto generator as set forth in claim further including a permanent magnet protection casing generally in the shape of a cup received within the flywheel in close contact with inner surface of the permanent magnets and affixed to said flywheel. The study of stress-strain and anisotropic behavior of sheet metal for deep drawing process. To achieve a successful deep drawing process, a study of the stress-strain and anisotropy behavior of the sheet metal to be used is inevitable. Brass or Aluminum sample was used as a specimen using a Bi-axial tester to perform various experiments to ascertain this behavior. In order to achieve this problem by using the finite element technique. The key is consistent studies according to the systematic methodology in which FE-analysis were used for the virtual tool design and compensation. The analysis method had been hand calculations and empirical curves. New computer advances have made finite element analysis (FEA) a practical tool in study of flywheel cup, especially in determining stress. In this project we have used ANSYS software to do the analysis on the flywheel cup.**

Keywords: flywheel cup, FE-Analysis, Deep drawing, vonmisses stress, Anisotropy

1. INTRODUCTION

Sheet metal is simply metal formed into thin and flat pieces. It is one of the fundamental forms used in metalworking, and can be bent into a variety of different shapes. Countless everyday objects are constructed of this material. Thickness can vary significantly, although extremely small thicknesses are considered foil or leaf, and pieces thicker than 6mm are considered plate. The thickness of the sheet metal is called its gauge.

In today's practical and cost conscious world, sheet metal parts have already replaced many expensive cast, forged and machined products. The common sheet metal forming products are metal desks, file cabinets, appliances, car bodies, aircraft fuselages, mechanical toys and beverage cans. Due to its low cost and generally good strength and formability characteristics, low carbon steel is the most commonly used sheet metal. For aircraft and aerospace applications, the common sheet materials are aluminum and titanium.

1.1 Drawing:

In drawing, a blank of sheet metal is restrained at the edges, and the middle section is forced by a punch into a die to stretch the metal into a cup shaped drawn part. This drawn part can be circular, rectangular or just about any cross-section. Drawing can be either shallow or deep depending on the amount of deformation. Shallow drawing is used to describe the process where the depth of draw is less than the smallest dimension of the opening; otherwise, it is considered deep drawing. Drawing leads to wrinkling and puckering at the edge where the sheet metal is clamped. This is usually removed by a separate trimming operation.

1.2 Deep Drawing:

Another method of great importance is deep drawing, which is commonly used to manufacture cooking utensils and other containers made from metal (and also cans of soda drinks such as Coke etc.) shows the deep drawing process in several steps, as the punch pushes the blank down into the die cavity, and finally retracts; the part is finally ejected out of the cavity by an ejection pin (not shown in the figure). The blank is a piece of sheet-metal cut to the required shape. The die has a cavity in the shape that is required (the most common shape is cylindrical). The punch is of the same shape, but the difference in the size of the punch and the cavity is just sufficient to allow the sheet to be pushed by the punch into the die. As the punch pushes the sheet into the cavity, the upper portions of the sheet will tend to deform in wrinkled shapes – this is avoided by keeping the top part of the sheet pressed down by a blank holder.

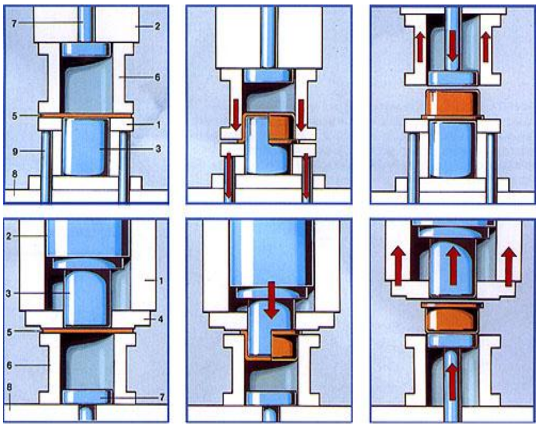

Figure1: Deep Drawing Process.

2. THEORETICAL BACKGROUND:

Shearing is the method of cutting sheets or strips without forming chips. The material is stressed in a section, which lies parallel to the forces applied. The forces are applied by means of shearing blades or punch and die.

In the fabrication of a sheet metal part a suitable intermediate flat shape or blank is first cut from a strip of sheet metal. Shearing operations are conventionally subdivided into (1) shearing, which employs general purpose shearing machines and usually cuts along a straight line, and (2) the die shearing processes, SHEARING THEORY which employs punches and dies of various shapes.

The metal is brought to the plastic stage by pressing the sheet between two shearing blades so that fracture is initiated at the cutting points. The fracture on either side of the sheet further progressing towards each other with downward movement of the upper shear, finally result in the separation of the slug from the parent strip. The metal under the upper shear is subjected to both compressive and tensile stresses. In an ideal shearing operation, the upper shear pushes the metal to a depth equal to about one third of its thickness. Because of pushing of the material into the lower shear, the area of cross section of the metal between the cutting edge of the shears decreases and causes the initiation of the fracture. This portion of the metal which is forced into the lower shear is highly burnished and would appear as a bright band around the blank lower portion.
The fractures which are initiated at both the cutting points would progress further with the movement of upper shear and if the clearance is sufficient, would meet, thus completing the shearing action.

Stresses caused in the metal by the applied forces	Name of the processes
Shearing	Blanking, piercing, trimming, notching, shearing
Tension and Compression	Drawing, Redrawing, Spinning
Bending (Tension and Compression)	Forming
Tension	Stretching
Compression	Coining, Sizing

2.1. Drawbility

During forming two major kind of deformation involved is drawing and stretching. The properties of the sheet metal required for good Drawability are not the same as those for good stretch ability. The identification of formability should only be based on those cases of material failure caused as a result of displacement or cleavage fractures where no further deformation is possible without failure. If, therefore, a material breaks before reaching maximum force as a result of a cleavage fracture, this characteristic may be taken as a point of reference in the determination of formability (for example, during a tensile test). However, cases of failure in which the stability criterion between the outer and inner forces is indicative of the achievable deflection, cannot be used as a basis for determining formability such cases include for example the uniform strain of material differs even though other conditions are equal. Thus, it is that some materials are described on the characteristics revealed in tensile testing for fracture due to shrinkage or elongation.

2.2 Drawing Variables:

a. Punch radius –This is created by draw punch. This radius is same as the cup radius in last redraw. A sharper radius means higher bending forces
b. Die radius – This is created by die ring. Sharper die radius means higher bending as well as straightening forces.
c. Degree of bend – This is normally 90 degrees. Positive angle means less than a 90degree bend at the die radius and a lesser force.
d. Friction variables–These variables change the normal force or the coefficient of friction Lubricant which is applied to sheet metal or die surfaces prior to drawing. Lubricant with high slip properties reduces friction. Lubricant with high- pressure resistance may increase friction.
e. Blank holding force – which is normal force causing more friction if increased.
f. Surface finish – on both sides of sheet metal, punch, die, and blank holder, higher the roughness value greater the friction force.

g. Compression variables–The variables that affect the required squeezing to reduce the diameter nearer of the edge of the blank.
h. Percentage of reduction–Percentage of reduction in diameter or perimeter, which is calculated using the blank diameter and the punch or cup wall diameter. It gives approximate value of squeezing
i. Depth of draw or height of cup–A deeper cup will require a larger blank, and therefore higher squeezing will be necessary.
j. Ductility–Ductility of sheet metal or the ability to undergo a change in shape without fracturing. If it is high possibility of drawing is more.
k. Yield strength-Yield strength, which is the point at which permanent change of shape occurs in a metal. Low yield strength is desirable for this operation so that the drawing action can begin without high tearing loads near the punch radius. The strength can be lowered by annealing the sheet or by passing age-hardened sheet through temper or flex rollers.
l. Blank thickness–Blank thickness as related to the blank diameter affects the compression load situation. A thicker blank has less tendency to wrinkle, may not need a blank holder. This variable also reduces friction by reducing blank holding needs.

2.3 Component Details:

Name of the component	: FLY WHEEL CUP
Material	: Mild Steel
Thickness of Component	: 3.65 mm
Diameter of the cup	: 116.1 mm (Outside)
Diameter of the cup	: 109.1mm (INSIDE)
Approximate draw depth	: 38.0mm
Shear Strength of material (fs)	: 36kgf/mm2
Density	: 7850 Kg/m^3
Young's Modulus	: 205000Mpa

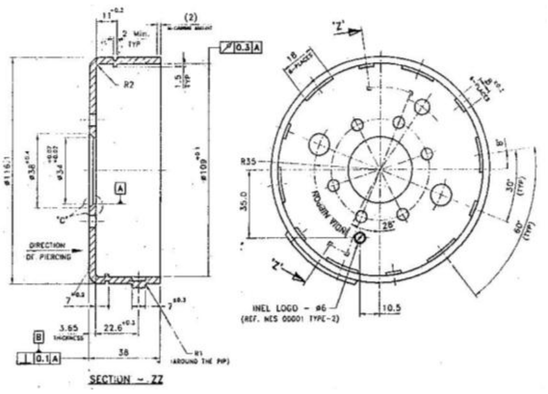

Fig: Drawing of the flywheel cup

3. METHODOLOGY:

- 'Fly Wheel Cup' Component details. The component detail is studied and prepared 3-D model in PRO-E software.
- The component is studied for the operations required to manufacture the component in the required shape and dimensions. By studying we knowing that the operations required are Blanking, Deep Drawing, Piercing, Semi Piercing and Pep.
- Press tool calculations are carried for above sequence of operations with the help of material properties which are specified by the company.
- Analysis work is carried by importing 3-D model into Ansys software. A FEM model of Punch and die are created by using Ansys processor. The material properties loads and boundary conditions are also specified in the Ansys Processor.
- Analysis work is done by applying loads on the Fly wheel cup without holes and with holes then the results such as Displacement and Von-Mises stresses obtained.
- The results are compared with material properties of the material used for the component. Then we find that results obtained by using FEM are within the material properties. There we find that there is no tearing in the material during forming operations.
- By the tool press calculations we started the manufacturing of the fly wheel cup and succeed in manufacturing.

3.1 Design Calculations:

Drawing force $F_D = \pi \times t \times d_o \times (T_{st} + Y_{st})/2$
= 64 T

Blank Holding force $F_b = 0.4 \times F_D$ = 25.6 Tons.

Pressure required for Drawing with blank holder $F_N = 1.3 \times F_D$
= 83.2.

120 Tons press has been taken for Drawing Operation

P = Number of draws

No of draws required, λ = h/d_i
= 0.35 i.e., <0.75

No. of draws required = 1

Punch Radius Rp = 2mm.

For better material flow Die radius $R_d = 4 \times t$ = 14.6 mm.

Die punch clearance= 1.15t = 4.19 mm per side.
(For t> 3mm.)

Mean dia of draw piece M = $d_i + t$ =112.75 mm

Height of draw punch H = 0.75 M =85 mm

Bottom radius of draw die R_{min} =4 t=14.6 mm

Space between punch and die side walls, W =3.942

Diameter of die opening $D_o = d_i + 2W$ =116.984 mm

Die opening relief C = D + 0.005= 117.111mm

Theoretical values:

Thickness of die plate	= 55 mm
Thickness of top bolster	= 69 mm
Thickness of punch holder	= 27.5 mm
Thickness of bottom bolster	= 97 mm

Practical values:

Thickness of die plate	= 35 mm
Thickness of top bolster	= 40 mm
Thickness of punch holder	= 30 mm
Thickness of bottom bolster	= 50 mm

4. MODELING AND ANALYSIS:

The design software used to design the FLY WHEEL CUP is pro/engineering.

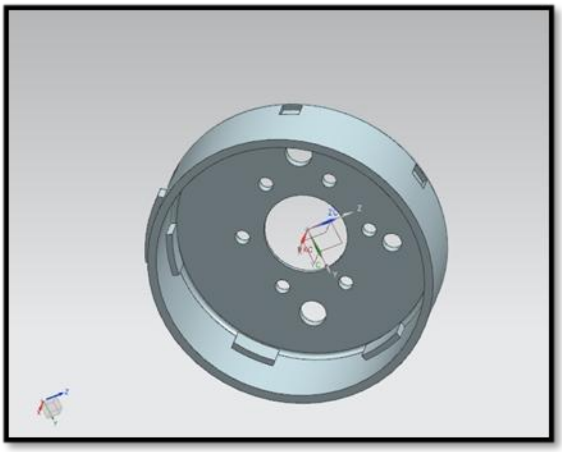

Figure2: Model of the component

The Analysis software used is ANSYS

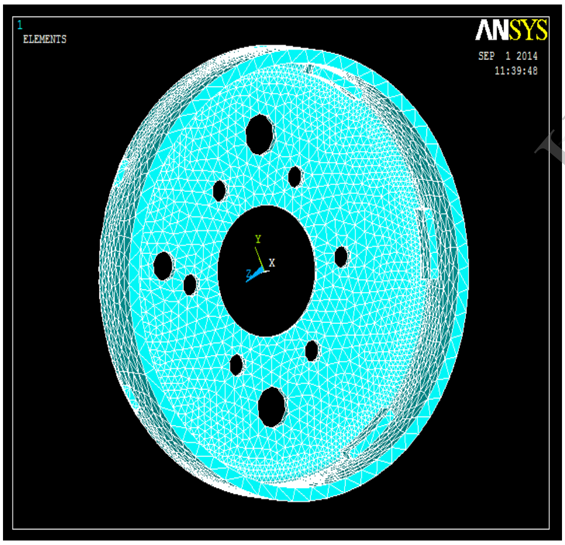

Figure3: Meshing of the Component

5. MANUFACTURING OF FLY WHEEL CUP

The component 'FLY WHEEL CUP" undergoes 6 major operations mentioned below.

- Blanking
- Drawing
- Piercing
- Shaving& Piercing
- Side semi piercing
- Single Pepping

Figure4: Fly Wheel Cup

6. RESULTS AND DISCUSSION:

The displacement in the Fly wheel cup due to load applying in the deep drawing operation is show in the image which is obtained from Ansys.

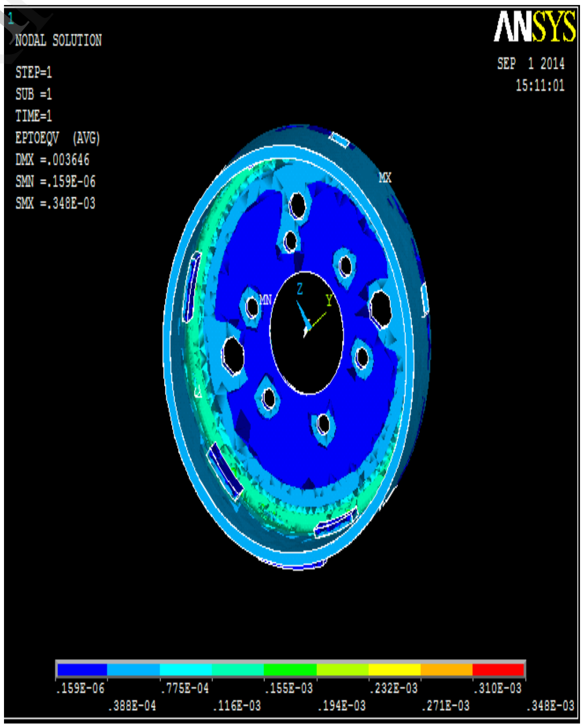

Figure5: Displacement results of flywheel cup

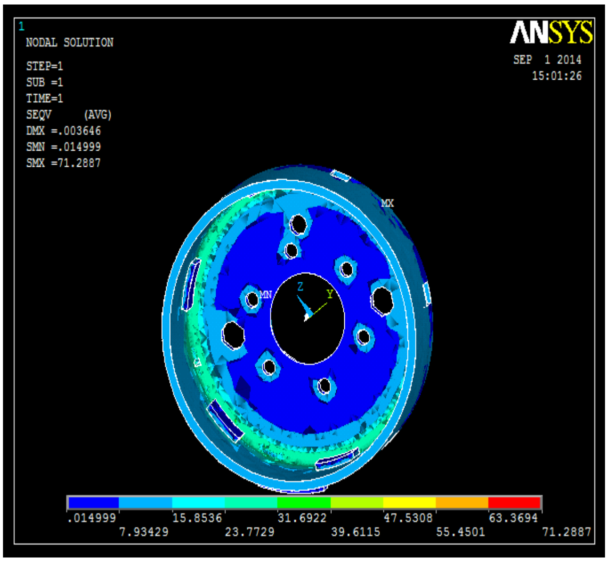

Figure6: vonmissess stress results of flywheel cup

7. CONCLUSION:

- Until recently the primary analysis method had been hand calculations and empirical curves. New computer advances have made finite element analysis (FEA) a practical tool in study of fly wheel cup, especially in determining stresses.
- In this paper we have used Ansys software to do the analysis on the flywheel cup. This tasks performed in this project are follows
- Design calculations done by the as per specifications
- According to design calculations develop the modeling by using PRO-E software.
- Done by the analysis by using ANSYS package.
- According to ANSYS results manufacturing flywheel cup.

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2. REFERENCES:

1. Hariharasudhan Palaniswamy, Gracious Ngaile, Mater. Process. Technology. 105 Volume146 (2004).
2. Vukota Boljanovic, Sheet metal forming process and Die design, volume 2004(july4).
3. Gnanavelbabu A and Panneerdhass R,"Fatigue and creep life prediction for composites using FEA", (2013), International Journal of Mechanical Engineering and Materials Sciences, Vol. 6, No.2, pp 171-180.
4. K. Suresh and A. Siddique Ahamed Ghias, (2013)," Investigation into cold upset forging of sintered Aluminium square Preforms", International Journal of Mechanical and Manufacturing Technology , Volume 2, Issue 2 pp. 170-175.
5. D.Y. Shahare, S. M. Choudhary , Design Optimization of Flywheel of Thresher using FEM, Advanced Materials Manufacturing & Characterization Vol3 Issue 1 (2013)
6. Akshay P. Punde, G.K.Gattani , Analysis of Flywheel, International Journal of Modern Engineering Research (IJMER) , Vol.3, Issue.2, March-April. 2013 pp-1097-1099
7. Sudipta Saha, Abhik Bose, G. Sai Tejesh, S.P. Srikanth , computer aided design & analysis on flywheel for greater efficiency, international Journal of Advanced Engineering Research and Studies, IJAERS/Vol. I/ Issue II/January-March, 2012/299-301