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Analysis of CR4 Metal forming by deep drawing force

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***Abstract*: One of the method to form sheet metal components is deep drawing. In the deep drawing process they are used to make 3D parts from thin metal sheets. In the deep drawing process, there are some factors that affect the process called process that influence the deep drawing parameters. Lubrication, die corner radius, punch corner radius, punch force, material properties, material thickness, blank size, punch and die edge, punch speed, etc. Is the most important parameter.**

Wrinkles and thinning of the material surface are the most common defects in parts. The edge of the die and the perforation radius are most affected in the deep drawing of the sheet. The friction between the punch, the cavity and the material is also affected by the formation of wrinkles. The force of the punch and the entrance of the punch thin the material. This article presents the deep drawing sheet metal forming analysis. Analysis tool Ansys is being used for the result of behavior. The main objective of this article is to find out theoretically the force required for deep drawing operations. The cup-shaped product was tested on a mechanical press. It also shows the machine capabilities required to meet production requirements. Taken from the company's life-size punch and die. Use these dimensions to generate a CAD model in CATIA. Convert the model to igs format and import it to Ansys. The force, deformation and defects required for part development can be obtained by simulation, such as breaks, wrinkles, etc. With this, it is easy to find part defects, material waste, and material deformation, die life, punch and die friction.

Keywords: ***Deep drawing,punchspeed and force,Ansys simulation, punchforce.etc.***

1. Introduction

Deep drawing is a sheet metal forming process in which the mold is formed with the help of a punch. The metal in area of the sholder of the mold bears the stress. If an edge press is not used to control the material flow in the mold, wrinkles will occur. Material we used fordeep drawing is thick as possible as in the area where the metal loses contact with the punch. This process is used to produce metal objects. The height of these objects exceeds half of their diameter. First, the metal is by stretching around the plug also then moved into the mold. During this process, the punch deforms the blank under the clamp. The main problem in this industry is optimizing different process parameters to obtain a complete stuffed product with minimal defects. During the deep drawing process, the deep drawn parts will fail as wrinkles, cracks or breaks. The influence of the blank shape and the resistance of the support on wrinkles and fractures was studied. Increase, the fracture limit is determined currently process conditions. Method of BFHC were developing to improve formability and increase the achievable cup height. Wrinkle defect on the flange, which is caused by the bending of the blade due to excessive compressive stress. To define the limits of the deep drawing process, use folding and tearing. The objective has more variable that affect the deep drawing process, including properties of materials, design of dies, conditions of frictions, stretch ratio, BHFC, die corner radi and speeds, punch. The production of stamping parts is completed by a forming machine, and pressure is applied to the blank through a forming die. Understanding the force parameters of the deep drawing process enables technicians, molding process designers, and molding machine designers to determine the dimensions of the molding machine and mold components.

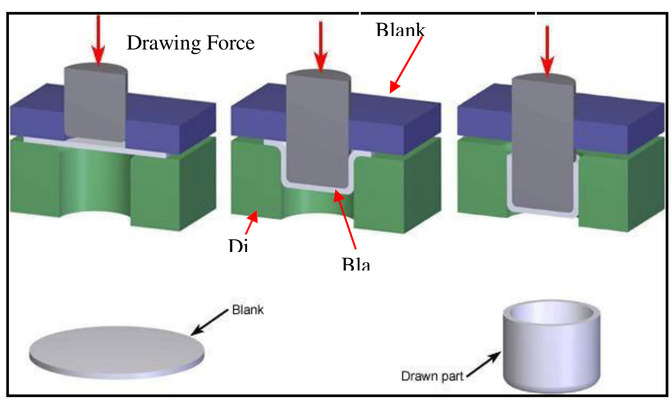


Fig1Draw Tool Nomenclature

1.1 Advantages of laser hardening process

1. Optimize blankdiameter.
2. Design Die andPunch.
3. Optimize punch force as per requirements of drawingdepth.
4. Optimize part using Ansys and Altair Inspire Formsoftwares.

2.*Objectives*

1. Select the proper material for the component.
2. Investigate effects of Punch forces with depth of drawing using Ansys
3. Interactive Variables That Influence Forming Process
4. Elimination of Wrinkling, surface scratches & Thinning from the components.

3. Finite element analysis for Cup deep draw force

The finite element method (FEM) is a numerical method for solving problems in engineering and mathematical physics. Typical problem areas of interest include structural analysis, heat transfer, fluid flow, mass transport, and electromagnetic potential. Analytical and calculating solution these problems require the solution of limitvalue problems for partial differential equations. The construction of the problem and of the finite element method goes to a system of algebraic equations. To have a nice solution to this break down a huge systems into smaller, simpler parts called finite elements. The ample equations which model these finite elements are then assembled into a larger system of equations which models the whole problem. Finite elements methodology then uses variationals methods of calculating variations to approximate lot solution by minimizes associated error function.

3.1 Material Data for Blank

Low carbon materials are required to minimize the occurrence of defects in this process. In general, Extra Deep Draw (EDD) materials are used in the deep drawing process. Grades materials CR1CR2 CR CR4CR5, etc. The chemical and mechanical properties of the material are presented in the following table.

Table 1: Chemical Composition of Material

Sr. No.	Quality		Constituent, Percent, Max			
	Designation	Name	Carbon	Manganese	Sulphur	Phosphorous
01	CR4	Extra Deep Drawing Aluminum Killed(Non-ageing)	0.08	0.4	0.03	0.02

Table 2: Mechanical Properties of Material

Sr. No	Quality		Yield Stress Re Mpa	Tensile Strength hmMpa	Elongation Percent A Min		Hardness Max	
	Designation	Name	Maximums		LO = 80 mm	LO = 50mm	HRB	HR (30_T)
01	CR__4	Deep Draw Al Kill(Non-ageing)	200	350	33	29	44	46

According to the requirements and proposals of the company (AIM Global Solutions, Kolhapur), It is suitable for cold forming process. The current part manufacturing process is using a 30 ton press made of CR4 material. The next developed part will have some defects. To minimize this defect, the tensile force will try other materials. Since it is not possible to perform this iteration experimentally, first use simulation software such as Ansys to generate the simulation results.

Tangential coefficients are required for nonlinear analysis. Tangential modu l the slope the stress-strain curve. The tangential coefficient is equal to the zero coefficients at the proportional limit. If limit of proportional is exceeded, the modulus changes with the strain and is calculated using the test data. Equation of ramargod the relationship between E youngverses tangential velocity, which is one way to obtain tangential velocity. The tangential modulus plays a vital role , the behavior of materials under stress beyond the elastic region. No linear (line) relationship between the stress and deformation when the material is plastically deformed.

It is like elastic deformation. The tangential modulus determining terms like the "softening" and "hardening" of a material. This usually happens when the material begining yield. The tangential coefficient (Et) is calculated using the RambergOsgood equation. When the yield stress of 210 Mpan is 5, E is the elastic modulus of 200 GPa, and the ultimate tensile stress of 350 MPa.

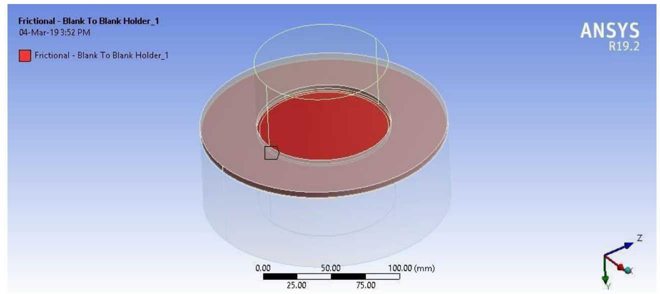
$$Et = \frac{E * \sigma ys}{\sigma ys + 0.002 * n * E\left(\frac{\sigma}{\sigma ys}\right)^{n-1}}$$

$$\text{Et} = \frac{200 \text{ x } 10^3 \text{x } 210}{210 + 0.002 \text{ x } 5 \text{ x } 200\left(\frac{350}{210}\right)^4}$$

$$= 2685.061 \text{ MPa}$$

igs format assemblies Solid Work generated files can be imported into Ansys software. Since the Ansys material library does not have CR4 material properties such as density, elastic modulus, Poisson's specific volume of modulus, modulus of shearness, modulus of tange, yield strength, ultimate UTS strength, etc you need to create the material properties defined in the material library CR4.

Contact relation between the punch, blank holder, blank and die. Fig 1 shows the contact between blank and blank holder with coefficient of friction is 0.35. Fig shows the contact between the blank and punch with same coefficient of friction 0.35. Fig shows the contact between blank and die which is frictionless.



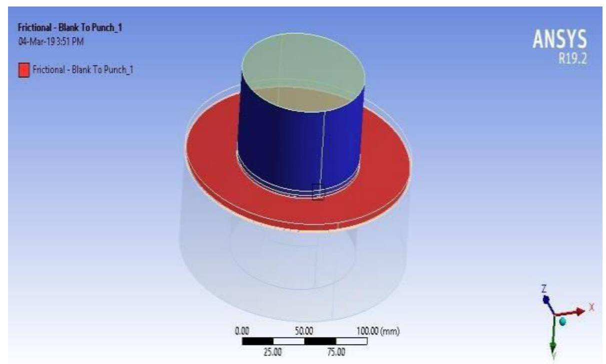


Fig 2 – Blank and Blank Holder Contact

Fig 3 – Blank and Punch Contact

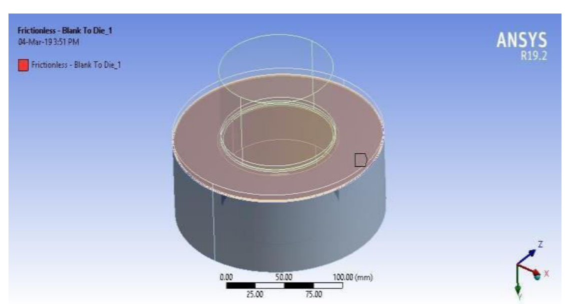


Fig 4 – Blank and Die Contact

Translation joint is set to blank holder with x direction because it changes it position along X axis due to the blank holding force shown in fig 4

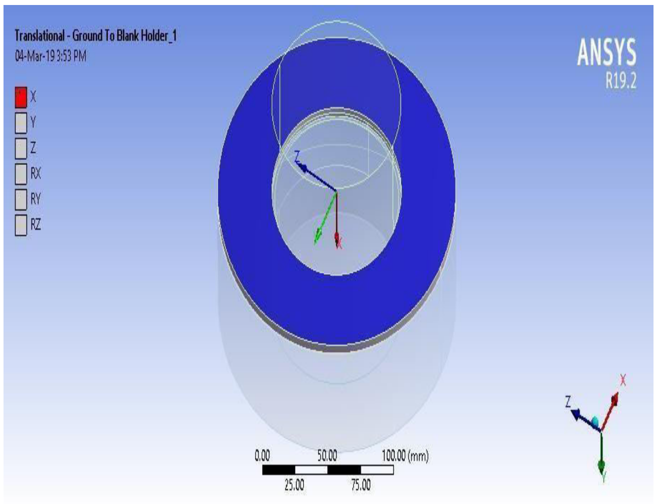


Fig 5 – Joint Condition for Blank Holder

Translation joint is set to the punch as shown in fig with only one degree of freedom. i.e. punch can move along x axis but other 5 degree of freedom are blocked such as translation toward Y and Z axis

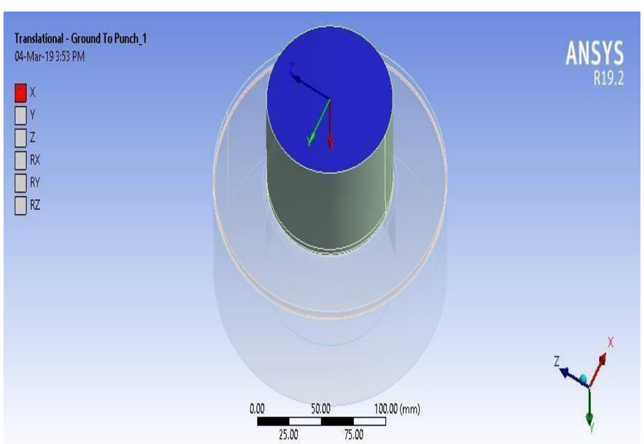


Fig 6 – Joint Condition for Punch

As shown in below figure fixed joint is set to die i.e. die cannot translate or rotate along any axis.

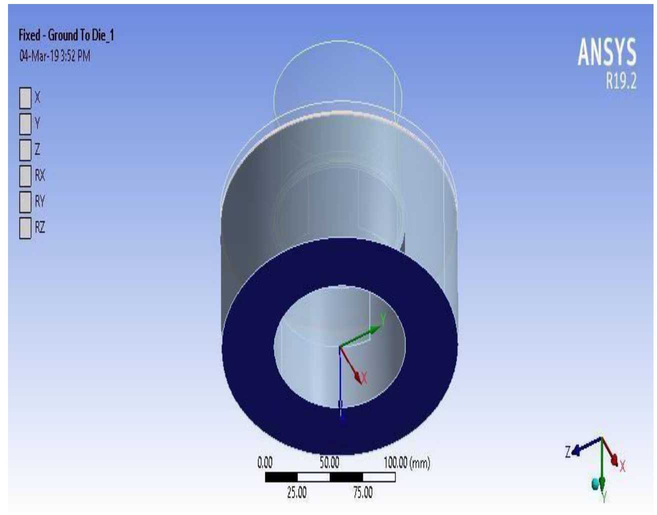


Fig 7– Joint Condition for Die

3.2 Total Deformation

Deformation across cup is shown in fig 6.9. Fromm the fig it is found that deformation is maximum at cup base which is 33.989 mm

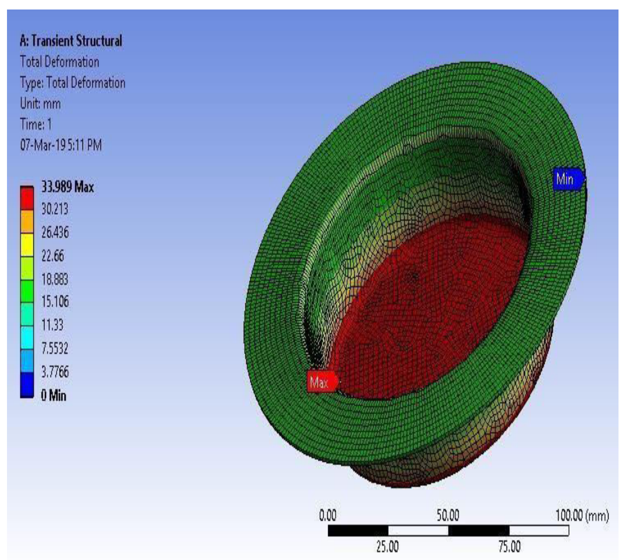


Fig 8 – Total deformation

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3.3 Equivalent Elastic Strain

Equivalent strain i.e. ratio of change in dimension to the original dimension is shown in fig. It is maximum at bending area which is 0.00095 and minimum at cup base

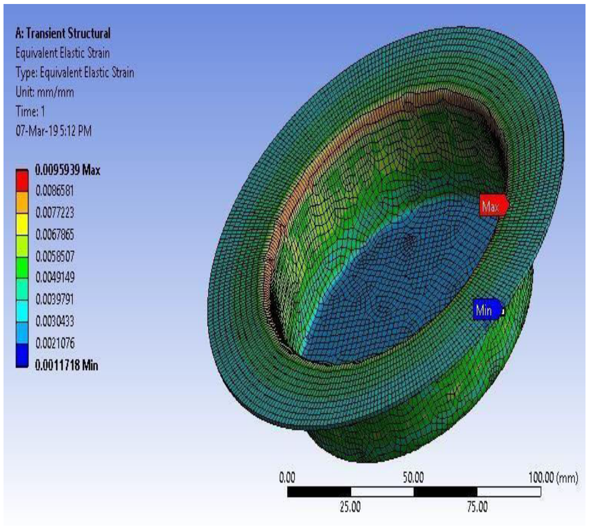

Fig .9 – Equivalent Elastic Strain of Cup

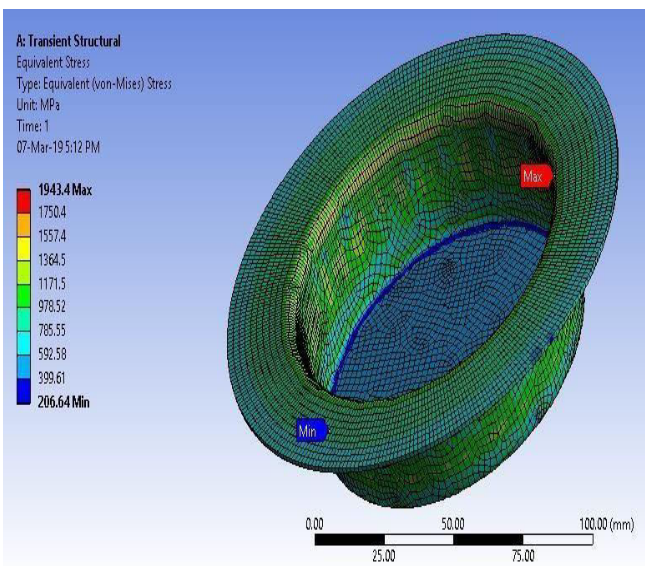

Fig 10 – Equivalent Stress of Cup

3.4 Equivalent (Von-Mises) Stress

Fig 1.10 shows the von misses stress distribution in cup. Von misses stresses is maximum at bending area which is found to be 1943.4 MPa and minimum at cup base.

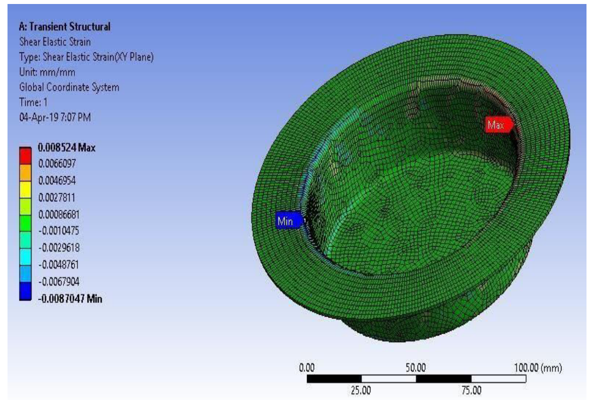

Fig 11 – Shear Strain of Cup

3.5 Shear Elastic Strain

Shear strain is defined as the length of deformation divided by the perpendicular length in the plane of the force applied. Maximum shear strain is found to be 0.00852 at bending area shown in fig 1.11.

3.6 Shear Stress

Fig 1.12 shows the shear stress on cup. It is found that the shear stress is maximum at bending area which is 676.78 MPa.

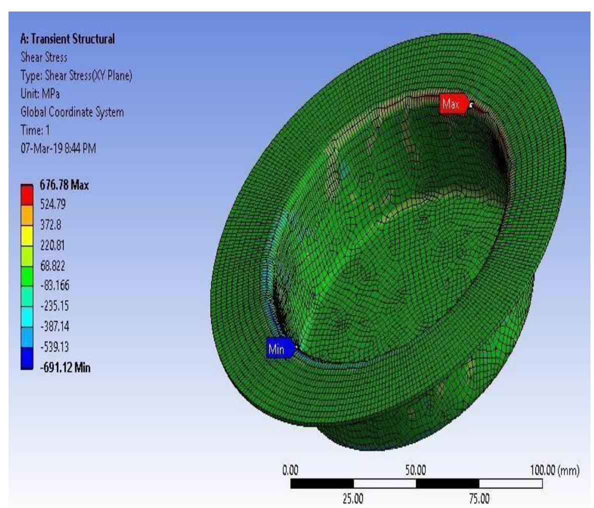

Fig 12– Shear Stress of Cup

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3.7 Formability of material

Formability of specific metal work piece in orderto undergo plastic(not elastic) deformation without being to damaged. The plastic deformation capacity of metallic materials, is limiting to a certain limit, at which point the material could experience tearing or fracture.

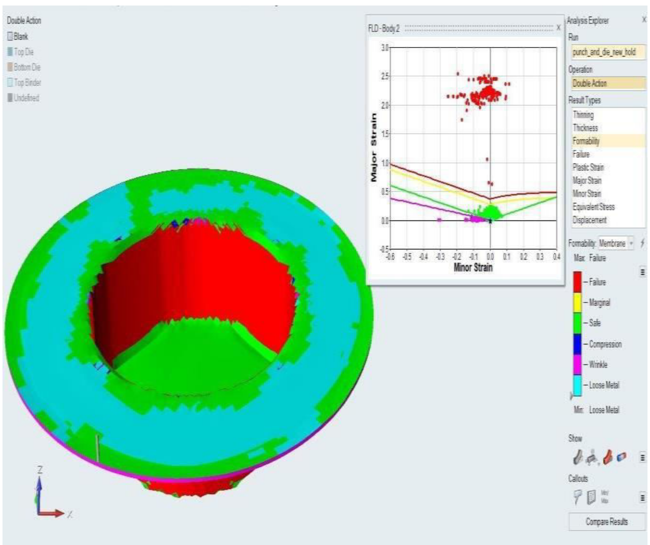

Fig 13 – Cup forma bility

3.8 Cup Wall Thickness

A certain level of thinning is usually unavoidable. Fig 1.14 shows the thinning effect on cup. Minimum thickness is 0.7 mm which is observed at the cup wall.

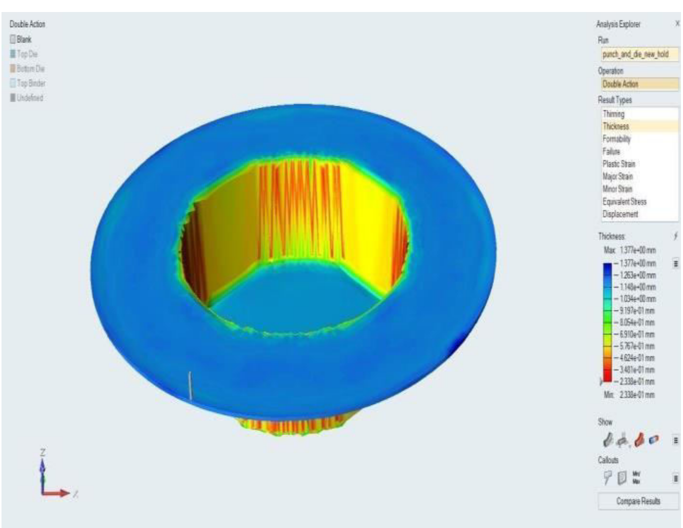

Fig 14 – Wall Thickness of Cup

1.1 mm to 0.8 mm so that thinning percentage is 42 percentage.

3.9 Computation of Punch Force

A joint defines the interface between blank and punch bodies. Blank is referred to as a reference body and punch as the mobile body. The results from the joint measures the total contact force of the mobile body with respect to the blank. Table 1.4 shows the maximum contact force on punch exerted in drawing simulation related to blank.

As stated above probe joint shows the force requiring to draw blankssinto desired shape,

i.e. RPunch Force equals is 2.978 x 105 Newton which is 30.37 ton. Factor of safety is taken as 1.5,Therefore, Draw Force (P) = 30.37 x 1.5 = 45.5 ton ≈ 46 ton

Table.3 : Results of punched jointed probe

Definition	
Type	Joint Probe
Boundary Constrains conditions	Translational to Ground To Punch
Options	
Result Type	Total Force
Axis vsResults	
X	2.93e+005 N
Y	-47.6 N
Z	764.7 N
Total	2.89e+005 N

Tonnage of Pressing = Drawing Force + Blanking Holding Force (B.H.F.C)

= 46 + 8

= 54 ton

Table 4: Results Obtained From Simulation

Total Deformation	Equivalent Elastic Strain	Equivalent (von-Mises) Stress
0.1198	1.50E-03	276.64
11.502	4.64E-03	1284.2
19.64	7.78E-03	1581.6
33.252	9.52E-03	1884.5
35.789	9.59E-03	1943.4
37.41	9.89E-03	2086.2

4.CONCLUSION

The results obtained from FEA and experimentation is discussed. It is found that results obtained from FEA are validated from experimental work. Hence proposed methodology is useful to predict the required punch force. The conclusion obtained from these is discussed below.

The ultimate force got in the deep drawing process from Analysis is 54 ton, and this force is validation done by conductingth experiments at 54 ton force obtained are similar.

We observed that the computational methodology of deep drawing is acceptable.

It has been observed, Fabricated part were wrinklness free so equa provides accurate blank holding force to produce defect free production of deep drawing forming parts.

It has been observed that tearing effect is zero.

Max thinning of cup is 33 % wall thickness is 0.8 mm accpetable

Acceptable ,limit of press machine 60 Tonn

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