# Study on Deep Drawing Process Parameters - A Review

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**Abstract**— Deep drawing is one of the most important processes for forming sheet metal parts. It is widely used for mass production of cup shapes in automobile, aerospace and packaging industries. The quality of the product is influenced by the many of the process parameters like blank holder force, co efficient of friction, strain rate, thickness, temperature, punch force and punch speed etc. So a good knowledge is required to produce good quality of deep drawing products by minimizing the defects. In this review paper importance is given to gather the recent research work and developments in the area of deep drawing.

**Index Terms**— deep drawing, thickness, temperature, stress and strain, friction coefficient, blank holding force, strain rate, blank shape, punch force and punch speed.

## 1 Introduction

SHEET metal forming is a significant manufacturing process for producing large variety of automotive parts and aerospace parts as well as consumer products. In sheet metal forming a thin sheet is subjected to a plastic deformation using forming tools to get the designed shape as shown in fig. 1. During this process if the process parameters are not selected properly the blank sheet develops some defects. Therefore, it is very important to optimize the process parameters to reduce the defects in the parts and to minimize the production cost.

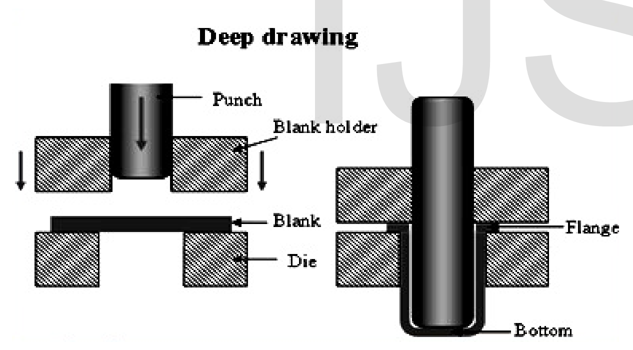


Fig. 1. Typical tool setup for deep drawing.

The objective of this paper is to review the basic process parameters which control the deep drawing process to make good quality products.

## 2 Influence of Process Parameters

The following important process parameters are are discussed elaborately:

- Stress and strain
- Temperature
- Strain rate
- Thickness
- Friction co efficient
- Blank holding force
- Punch force and punch speed
- Blank shape

### 2.1 Stress and strain

Reddy [1] has investigated that the effective stress of cups is decreases with increase in thickness and temperature of the blank sheet. Thuillier et al.[2] has simulated the deep drawing process to predict the strain path change for the punch force. In this research Hill's yield criterion has been used to perform three-dimensional numerical simulations of the process. Different hardening laws have been used to simulate process in different ways. Strain hardening models take into account transient behaviours recorded during strain path changes. Jaisingh et al.[3] has done sensitivity analysis of four parameters like strain hardening exponent, plastic strain ratio, coefficient of friction, blank holding force for deep drawing process on the basis of peak thinning strain developed as the main parameter. In this research, plain strain analysis of bell shaped geometry has been done using Taguchi's robust design technique. This research has suggested that the blank holding force has maximum effect on thinning strain. Other parameters i.e. coefficient of friction, plastic strain ratio, strain hardening exponent follows the blank holding force. Cwiekala et al.[4] has proposed a method, which combines different analytical approaches to an accurate and fast deep drawing simulation. The developed simulation method is applicable to axisymmetric and prismatic deep drawing processes. Consideration of material behavior, process parameters and deformation paths is possible in the proposed method. Due to the multistep simulation, even time dependent effects can be considered. The developed method gives a higher accuracy in calculating strain distributions than numerical one step solvers. Mori and Tsuji [5] were found that the yield stress, tensile strength and hardness are decreased by the annealing and the elongation, reduction in area, n-value and r-value are increased, this leads

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to the improvement in drawability. Ahmad et al.[6] has studied the effect of normal stress on hydrodynamic deep drawing process. Analytical model has been developed by considering classical theory of plasticity and geometrical relationships. In this study, the influence of normal stress on the variation of blank thickness, stress and strain fields and punch force has been studied. The differences have been observed in thickness distribution, in stress and strain in both radial and circumferential direction and also in punch force with and without the normal stress. Higher thickness has been observed in the 2D stress state than in the 3D stress state. Also higher values of radial and circumferential strain have been observed in case of normal stress. This article suggests that the normal stress component should be considered in the deformation of HDD process to achieve accuracy in design. Chandini and Reddy [7] were found that the effective stress increases with an increase in strain rate. The effective strain decreases with an increase in the thickness of blank sheet. The Fisher's test column establishes that the influence of process parameters on effective stress are the thickness parameter contributes 10.71% of variation, temperature assists 85.78% of variation, and strain rate contributes 3.34% of variation on the effective tensile stress. Srinivas and Reddy [8] were concluded that the ANOVA summary gives that the parameters accepted at 90% confidence level. The percent contribution indicates that the thickness parameter contributes 24.67% of variation, temperature assists 61.74% of variation, coefficient of friction influences 2.91% of variation and strain rate contributes 10.17% of variation on the effective tensile stress.as the strain rate increases the effective stress increases.

### 2.2 Temperature

In the deep drawing process, temperature of the sheet plays a vital role in the reduction of the defects. When the temperature increases ductility increases results in reduction in the stresses developed. Reddy [1] has investigated that the increase of temperature reduces the effective stress. This is owing to the softening of material with an increase in temperature. Reddy [9] has conducted a statistical approach based on Taguchi Techniques and finite element analysis was adopted to determine the formability of conical cup (AA1050-H18) using warm deep drawing process. The temperature had an effect of 7.15% on effective stress. The effective stress was incresase with increase of temperature from 3000C to 4000C and thereafter decreased from 4000C to 5000C. When the deep drawing was carried out above the recrystallization temperature the metal had reduced yield strength, also no strain hardening was occurred as the material was plastically deformed. This might be the reason for the reduction of effective stress above 4000C. The damage in the conical cup was increased with an increase in the temperature. It is found that the temperature has contributed 5.7% of the total variation in the cup height drawn. Reddy [10] has investigated that the effective stress decreases with increasing of temperature. This is owing to the softening to the material with an increase of temperature. As the temperature increases the damage of cup is also increases because of softening of the material. Yamuna and Reddy [11] were investigated that the effective stress of the cups decreases with increase in temperature. This is owing to the softening of material with an increase in the temperature. As temperature increases the damage increases because of softening of material. Yoshihara at al [12] were studied a circular cup deep drawing process using a magnesium alloy material and graphite was applied to the blank as a lubricant. From the tensile test, they found that strength coefficient and strain hardening exponent decreases with increasing temperature. Mori and Tsuji [5] was developed a cold deep drawing process for commercial AZ31 magnesium alloy sheets. They studied with oil based lubricant for deep drawing of aluminium sheets, molybdenum disulfide, Teflon sheets and Teflon spray. They found that as the temperature increases, the limiting drawing ratio increases, whereas the annealing temperature was up to 5000C because of severe oxidation. Chandini and Reddy [7] were found that the effective stress decreases with increase in sheet temperature as shown in fig. 2. Srinivas and Reddy [8] were found that the effective stress decreases with increase in sheet temperature. The volume of the cup increases with an increase in the temperature.

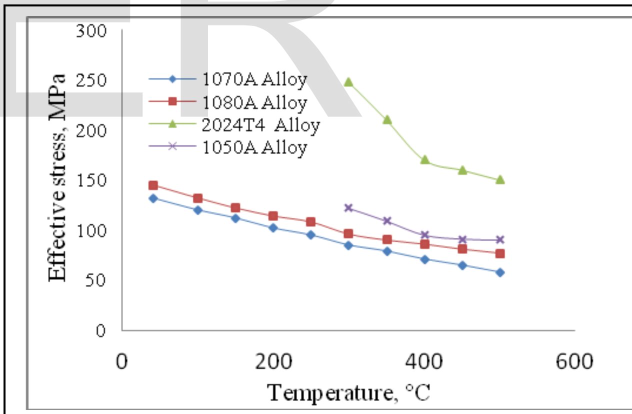


Fig.2. Influence of temperature on the effective stress.

### 2.3 Strain rate

Strain rate is the time required to accumulate the given strain. Strain rate plays a dominant role in the forming process. Reddy [1] has investigated that the effective stress decreases with an increase in the strain rate for for 2024T4 aluminum alloy. Reddy [9] has concluded that the flow stress increases with the increase of strain rate. Here, a different phenomenon was observed. The effective stress was decreased with the increase of strain rate. In every instance, the flow stress increases with increasing strain during the initial stage of deformation. However, having reached a peak value, the stress reduces as the strain is increased further. This reduction in stress takes place

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when the strain and strain rate hardening effect is outweighed by the softening effect induced by the heat generated during plastic deformation. The requirement of drawing load was also decreased with the increase of strain rate and above the recrystallization temperature. The damage of conical cup was decreased with an increase in the strain rate. It is found that the strain rate has contributed 83.41% of the total variation in the cup height drawn. Reddy [10] has investigated that the effective stress is increases with an increase in the strain rate as shown in fig. 3. The height of the cup decreases with an increase of strain rate. Strain rate controls 9.62% of variation in height of cup. The damage in the cups decreases with an increase in the strain rate. Yamuna and Reddy [11] were investigated that effective strain is decreases when thickness of the sheet decreases. Effective strain increases when the working temperature increases. Effective strain increases when the coefficient of friction increases. Effective strain increases when the strain rate is increases.

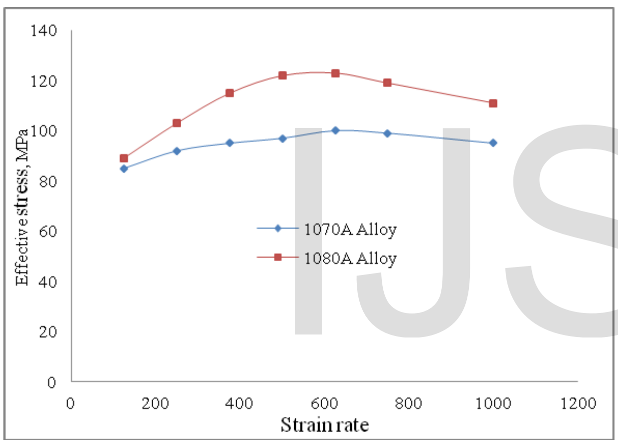

Fig.3. Influence of strain rate on the effective stress.

## 2.4 Thickness

In deep drawing, the sheet metal thickness vary throughout the process. Thickness variation depends on process parameters. Several research works have been reported to evaluate thickness variation. Reddy [1] has optimized the warm deep drawing process for 2024T4 Aluminum alloy using Taguchi technique for circular cups. In this work, he concluded that the increasing of sheet thickness of sheet reduces the effective stress of the cups. The height of cup increases with the increase in thickness of the sheet. The damage of cup decreases with the increase of sheet thickness. Reddy [10] has conducted a statistical approach based on Taguchi Techniques and finite element analysis were adopted to deter-mine the parametric consequence on the formability of cup using warm deep drawing process for 1050A Aluminum alloy. He investigated that the effective stress decreases with the increase of thickness. The height of cup increases with increase in the thickness of sheet. The sheet thickness gives 68.28% of variation height of cup. The damage of cup decreases with an increase in the thickness of the sheet. The average distribution of the blank thinning increases with an increase in the blank thickness. Ironing can be defined as thinning of the blank at the die cavity. The main reasons for the damage of cups were due to ironing and the coefficient of friction. Yamuna and Reddy [11] were conducted a statistical approach based on Taguchi and Anova techniques and fininte element analysis were adopted to determine the merit of sheet thickness, temperature, coefficient of friction and temperature on the formability of cups from 1080A aluminum alloy using warm deep drawing process. They investigated that the effective stress of the cups decreases with increase in thickness of the sheet. The damage decreases with an increase of the thickness of the sheet. Brabie et.al.[13] has investigated the thickness variation in the case of micro/milli- cylindrical drawn cups made from sheets, called foils, having thicknesses from 0.05 to 0.20 mm. A mathematical model has been proposed based on experimental and numerical simulation results to control and minimise the thickness variation in the part wall where the variations of part diameter, wall inclination and wall curvature can generate negative effects. Thiruvarudchelvan et al. [14] has carried out theoretical analysis, finite element analysis and experimental work to determine correlation between the forming parameters of the process and to determine the mechanics of the process. The process has been simulated using the commercial FEM code MARC considering elastic-plastic behaviour. The Experimental work has been conducted using the tooling assembled on a 200 ton press. This investigation has suggested that the wall thickness is quite uniform except for the area near the punch nose radius when drawing cups at the three draw ratios 3.0, 3.3 and 3.5. This research suggests as drawing ratio increases thinning increases. Dao et al. [15] has investigated effect of process parameters on thickness distribution of trapezoid cup. In this research, the optimum values of process parameters like punch speed, chamber pressure and coefficient of friction has been investigated using FEM and Taguchi method. Chandini and Reddy [7] were conducted a statistical approach based on Taguchi and Anova techniques and fininte element analysis were adopted to determine the degree of importance of sheet thickness, temperature, coefficient of friction and temperature on the formability of cups from 1070A aluminium alloy using warm deep drawing process. The experimental results were validated using a finite element software namely D-FORM. The Erichsen deep drawing test was conducted to study the formation of wrinkles in the cups. They concluded that the increase in sheet thickness will results in decrease in effective stress. The volume of the cup increases with an increase in thickness of the sheet. Srinivas and Reddy [8] were conducted a statistical approach based on Taguchi and Anova techniques and fininte element analysis were adopted to determine the degree of importance of each of the process parameter on the formability of cup using warm deep drawing process. The process paprameters were thickness of balnk, temperature, coefficient of friction and strain rate. The experimental results were validated using a finite lement software namely D-FORM. The Erichsen deep drawing test was conducted to study the formation of wrinkles in the cups. They concluded that the increase in sheet thickness will results in decrease in effective stress as shown in fig. 4. The volume of the cup increases with an increase in thickness of the sheet. The percent contribution indicates that thickness of sheet gives 100%of variation and rests of the factors have negligible influence of variation.

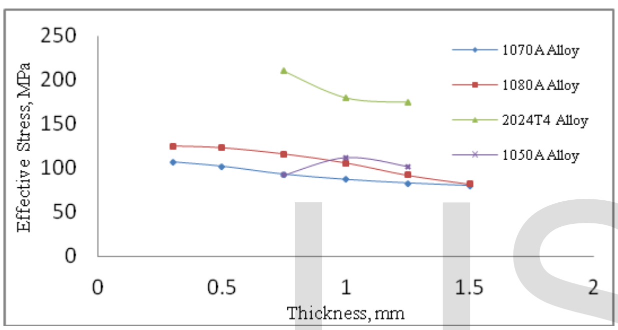


Fig.4. Influence of thickness on the effective stress.

### 2.5 Friction coefficient

Friction is the most important parameter which influences the deep drawing process. Surface finish, tool life and drawability of sheet are well dependent on the lubricant applied in between the contact surfaces. Reddy [1] has investigated that the increase of coefficient of friction reduces the wrinkling but high values of coefficient of friction can cause cracks and material breakage. Reddy [9] has varied the coefficient of friction from 0.05 to 0.1. The shear force due to friction varies from 0.05 to 0.1 times the normal pressure. The damage of conical cup was increased with an increase in the coefficient of friction. The effective stress was increased with the increase in coefficient of friction. It is found that the coefficient of friction has contributed 6.33% of the total variation in the cup height drawn. Reddy [10] has investigated that the influence of friction coefficient on the effective stress was found to be negligible. The height of the cup increases with an increase in coefficient of friction. Coefficient of friction contributes 14.41% of variation in height of cup. In the case of friction between the piece and the tool, the increase of the coefficient of friction determines the wrinkling to reduce, but high values of the coefficient can cause cracks and material breakage. The damage of cup increases with an increase in coefficient of friction. Yamuna and Reddy [11] were investigated that the case of friction between the piece and the dies, the increase of the coefficient of friction determines the wrinkling to reduce, but high values of the coefficient can cause cracks and material breakage. As the friction increases the damage also increases as shown in fig. 5. The tangential compression stress can lead to the risk of its wrinkling; a risk which is very likely to appear when the difference between the outer diameters of the blank and the finished piece is big and the sheet thickness is small. Yang [16] has simulated the deep drawing process to analyze friction coefficient and strain distribution by combining an elastic-plastic FEM code with a friction model. Numerical results are in accordance with the experimental results for the film thickness and the strain distribution. Liu Qiqian et al. [17] has simulated micro multi point forming process with cushion. A finite element model with the effect of size has been developed to simulate micro multi point forming process. This research dealt with the effect of parameters like effect of cushion material, cushion thickness, coefficient of friction on the thickness variation and surface finish of the product. In this research, results show non- uniform relative thickness distribution from centre to the edge in the deformed sheets. Also it has been found friction affects relative thickness distribution and surface quality in micro multi point forming process. Yang [16] has presented elastic-plastic FEM code to simulate deep drawing process with friction model. Numerical analysis has been done to analyze the friction coefficient and the strain distribution in lubricated deep drawing. In this research work, the surface roughness is taken into account by using Wilson and Marsault's average Reynold's equation that is appropriated for mixed lubrication with severe asperity contact. In this research, the film thickness and strain distribution for various tribological parameters are predicted and compared with the experiment. Numerical results show that the present analysis is in accordance with the experiments for the film thickness and the strain distribution. It has been suggested that the larger value of full film lubrication region results in the more uniform strain distribution. This research work also suggested that when film thickness is greater than composite roughness by three times, the lubrication is full film condition and contact area ratio is almost zero, the contact area ratio near the outer edge of die is about zero and the friction stress is small. The largest value of contact area ratio occurred when the surface asperity of die and blank comes into contact, and it will result in the larger value of friction stress. Generally, lower friction results in a more uniform radial strain distribution. The larger value of full film lubrication region results in the larger value of the low-friction part and the lower value of peak's strain. Thus, an effective lubrication can prevent direct contact of the surface asperity, which enhances the drawability of deep drawing. Padmanabhan et al. [18] has presented the effect of process parameters such as die radius, blank holder force and friction coefficient on deep drawing of stainless steel. In this research FEM with taguchi technique has been used to determine the proportion of contribution of three important process parameters in the deep-drawing process. Taguchi method of experimental design was used to plan the numerical simulations. In Taguchi design, using two levels of each factors form screening experiments to determine a model of the system to a linear approximation. After designing experiments with various combinations of process parameter levels, FE simulations were carried out to predict the deformation behaviour of the blank sheet. The results obtained from the FE simulations were treated using statistical approach namely, ANOVA method. The purpose of using ANOVA was to find most influential parameters that govern the deep-drawing process that markedly influence the thickness distribution. The analysis of variance (ANOVA) was carried out to examine the influence of process parameters on the quality characteristics (thickness variation) of the circular cup and their percentage contribution. The die radius (89.2%) has major influence on the deep-drawing process, followed by friction coefficient (6.3%) and blank holder force (4.5%). Kim et al.[19] has studied coefficient of friction for non uniform pressure by conducting draw bend tests. Tested coefficients of friction are used in FE code for local contact conditions such as the sliding speed, contact pressure and sliding direction at the macroscopic level. Validation of the results has been done by the circular cup drawing experiments and simulations. In this research the contact pressure maps were developed from simulations, which has been included in the analysis of test data to measure the pressure dependency of friction coefficient.

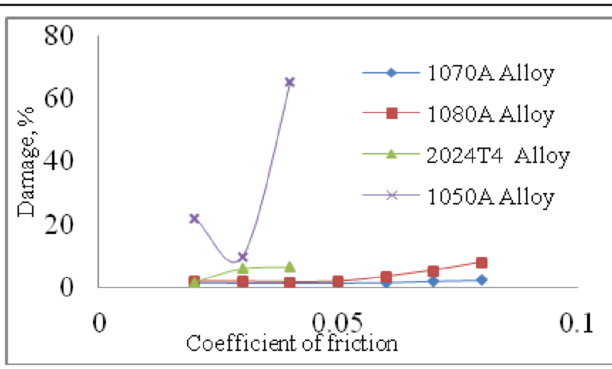


Fig.5. Influence of coefficient of friction on damage %.

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Bl to reduce the wrinkles. To minimize the wrinkles BHF should be as high as possible. Product quality, material flow, stress distribution, thinning and thickening of sheet metal can be controlled by controlling the BHF. Reddy [9] has concluded that the increase in the nominal contact pressure would crush the surface asperities of the blank giving rise to more real contact area. Hence, the result was the requirement of high drawing pressure to draw the conical cup. This increased drawing pressure results in increased drawing force. The effective stress was decreased with the increase of blank holder velocity. Because there would be less restraint to the plastic deformation and the metal flow into the die. As a result the effective stress was reduced with the increase of blank holder velocity. The damage of conical cup was decreased with an increase in the blank holder velocity. It is found that the blank holder velocity has contributed 4.27% of the total variation in the cup height drawn. Jaisingh et al.[3] has suggested that the blank holder force has the maximum effect on the thinning strain, the coefficient of fiction, plastic strain ratio. Also the strain-hardening exponent depends on BHF. Van Tung Phan [20] has simulated the deep drawing process for ferritic stainless steel and investigated the effect of variation of blank-holder pressure and friction on earing profiles. The simulation results compared with experimental data. Blank holding force and punch speed affect product quality and production rate. Shoichiro Yoshihara at,al [12] were studied From deep drawing test, they found that in the case of constant BHF, the punch load is higher than the variable BHF test and the fracture at the straight wall part of the drawn cup occurred at 15mm of the punch stroke. In the case of variable BHF, the BHF remains low at the initial stage and increases from the middle stage to the last stage. In the case of constant BHF test, thinning takes place from the punch shoulder part to the wall part and thickening at the end site of the drawn cup. In the case of the variable BHF, thinning and thickening of the drawn cup is suppressed. Tommerup et al. [26] has investigated the effect of blank holder pressure on strain path in the sheet during forming process. A tooling system has been developed to investigate material flow, which is capable of controlling the distribution of blank holder pressure. This tooling system was integral to press and capable to run eight different pressure schemes. The tooling system consisting of a controller to regulate the process parameters, an actuator system to control BHF, a tool with embedded hydraulic cavities. The strain path has been checked by applying variations in the cavity pressures. In this research the drawing of rectangular specimen has been carried out. Volk et al. [22] has simulated deep drawing process to investigate, optimized blank holder force (BHF) for an asymmetrical work piece from household appliances industry. In this research work the specific blank holder forces have been identified for minimum wrinkling and for the improve quality product. It has been suggested that the quality of a work piece can be improved with a better holding system. It is evident that even small changes in BHF can lead to failure during the process. These failures can be avoided if a variable BHF is applied, but the correct trajectories need to be chosen.

### 2.7 Punch force and punch speed

Reddy [10] has investigated that the maximum forming load decreases as the working temperature is increases. Yamuna & Reddy [11] were investigated that the maximum forming load decreases as the working temperature is increases. Fan et al. [23] were studied the elasto-plastic constitutive equation accounting for isotropic hardening coupled with material dam-

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age has been implemented in the finite element code ABAQUS. The deep drawing of a mild steel square cup was simulated using the ABAQUS with a specially designed VUMAT subroutine. A square blank is deep drawn to form a square cup with the size of the square blank of mild steel sheet is 200mm by 200mm with 1 mm thick, a blank holding force is 2-20 kN and the coefficient of friction 0.01 to 0.2 has been used to investigate their effects on the deep drawing process. They conducted simulations for four different punch speeds of 5, 10, 30 and 45m/sec and they found that the damage initiates at the location where large warp deformation is produced by the corner of the punch, further increase in the punch stroke, damage also starts to grow near the flange and the higher the punch speed, higher the punch force. They found that there are two cores of damage, those are near the edge of the blank where wrinkling occurs and near the flange of the drawn cup. The damage zone propagates and the magnitude of damage increases as the punch stroke increases and wrinkling can also cause material damage. The smaller the frictional coefficient then the stronger will be the degree of wrinkling. However, the wrinkling cannot disappear when the frictional coefficient is increased. Friction should be minimized as far as possible in a sheet metal forming process. Fereshteh Saniee F and Montazeran [24] were studied different methods of analysis such as analytical, numerical and experimental techniques. They conducted an experiment for deep drawing test of a circular DIN 1.0347 plate with 1 mm thickness and grease as lubricant. They found that the yield and ultimate strengths of DIN 1.0347 are 220MPa and 325MPa. They conducted a test for punch travel of 20mm and found that the maximum drawing force occurs at a punch travel about 17mm. This maximum force is equal to 18,390N. They conducted numerical simulations in ANSYS for two different materials of visco solid-4node plus 106 and shell 51, where Young's modulus and Poisson's ratio of the sheet is 200GPa and 0.3, friction coefficient was 0.15. They found that from the experimental and numerical comparison that the load displacement curves are increasing until a punch travel of about 17mm, where the drawing force becomes maximum, then the forming force gradually decreases and the intensity of force reduction in the experimental curve is less than the numerical result. They concluded that, among different analytical relationships, Siebel's formula provided the most accurate maximum drawing force for the process under consideration and Siebel's formula is more sensitive to friction compared with the finite element simulations performed in ANSYS. Mori and Tsuji [5] was found that the Teflon sheets having good lubrication, the drawing load are small, whereas the ironing load becomes large due to the increase in the amount of ironing by the Teflon sheet thickness and thus the fracture occurs around the edge of the flange. The ductile fracture is prevented by the action of compressive hydrostatic pressure; the blank holder force was increased to prevent the fracture around the flange edge, whereas the fracture was not prevented by the increase in blank holder force. The cold deep drawing of magnesium alloy sheets is very difficult due to low formability, a cold deep drawing process of commercial magnesium sheets was successfully developed by selecting proper annealing conditions. The cold drawability of the magnesium alloy sheets can be improved by controlling microstructure during rolling and annealing.

### 2.8 Blank shape

To minimize the process defects and optimize the process, knowledge of the process and material variables are required. Blank shape is one of the important parameter in deep drawing process as the quality of deep drawn product, thickness distribution, forming limits, minimizing the defects can be improved by having optimum blank shape, also material cost of product reduced if proper blank shape is selected. Molotnikov et al [25] has investigated the size effect on maximum load and limit drawing ratio for deep drawing of copper. Numerical analysis and experimental analysis have been done to study the effect of ratio of blank thickness to grain size on blank thickness. Through mathematical modelling and experimental work it has been suggested that size effect play an important role in deep drawing when grain size kept constant and dimensions of work-piece get reduced. This research has suggested the dislocation density based model to take into account for the effect of the specimen dimensions on its mechanical response. Talic et al. [26] has determined an optimum blank shape that has not caused earing. In this research the forming process has been simulated using Abacus CAE. Blank shape influences forming load, material requirement and possibility of defects. It has been concluded that optimum blank shape reduces forming load, increases forming limits and reduces possibilities of wrinkling and tearing.

## 3 Conclusion

The blank thickness by itself has a substantial effect on the effective stress and the height of the pyramidal cup drawn. With the increase of temperature the cup material becomes soft and thereby the stress induced in the cup material decreases due to reduction of the drawing force. The effective stress increases with the increase of friction due to increase of normal pressure between die and blank. Blank holder force controls metal flow, it also affects thickness variation, strain path, stress path and wrinkling behaviour. Strain path is well affected by blank holder pressure.by selecting the optimum blank holder force we can obtain best cups. It is observed that the optimum blank shape reduces forming load, increases forming limits and reduces possibilities of wrinkling and tearing. Friction affects relative thickness distribution and surface quality in forming proces.

## REFERENCES

[1] A. Chennakesava Reddy "Parametric Significance of Warm Drawing Process for 2024T4 Aluminum Alloy through FEA", International Journal of Science and Research, vol. 4, no. 4, pp. 2345-2351, 2015.

[2] S. Thuillier., P.Y. Manach, L.F. Menezes "Occurrence of Strain Path Changes in a Two Stage Deep Drawing Process", Journal of Material Processing Technology, vol.. 210, pp. 226-232, 2010.

[3] F Fereshteh Saniee and M.H Montazeran, "A Comparative Estimation of the Forming load in the deep drawing process", Journal of Materials Processing Technology, 140 pp: 555-56, 2003.

[4] T Cwiekala., Brosius A., A.E Tekkaya. "Accurate Deep Drawing Simulation by Combining Analytical Approaches, " International Journal of Mechanical Sciences, vol.53, pp 374-386, 2011.

[5] K Mori and H Tsuji, "Cold Deep Drawing of Commercial Magnesium Ally Sheets", Annals of the CIRP Vol. 56, pp 285–288, 2007.

[6] Assempour Ahmad, Taghipour Ehsan, "The Effect of Normal Stress on Hydrodynamic Mechanical Deep Drawing" International Journal of Mechanical Sciences, vol.53, pp 407-416, 2011.

[7] Kothapalli Chandini, A.Chennakesava Reddy, Parametric Importance of Warm Deep Drawing Process for 1070A Aluminium Alloy: Validation through FEA", International Journal of Scientific & Engineering Research, vol 6, no 4, pp 399-407, 2015.

[8] Thirunagari Srinivas, A. Chennakesava Reddy , Parametric Optimization of Warm Deep Drawing Process of 1100 Aluminum Alloy: Validation through FEA" , International Journal of Scientific & Engineering Research, vol 6,no 4, pp425-435,2015.

[9] A. Chennakesava Reddy, Formability of Superplastic Deep Drawing Process with Moving Blank holder for AA1050-H18 Conical Cups, International Journal of Research in Engineering and Technology. vol 4, no 8, pp.124-132, 2015.

[10] A. Chennakesava Reddy, Homogenization and Parametric Consequence of Warm Deep Drawing Process for 1050A Aluminum Alloy: Validation through FEA, International Journal of Science and Research, vol 4, no 4, pp.2034-132, 2015

[11] Balla Yamuna, A.Chennakesava Reddy, Parametric Merit of Warm Deep Drawing Process for 1080A Aluminium Alloy: Validation through FEA, International Journal of Scientific & Engineering Research, vol 6, no 4, April- pp.416-424,2015.

[12] Shoichiro Yoshihara, Ken ichi Manabe and Hisashi Nishimura, "Effect of blank holder force control in deep drawing process of magnesium alloy sheet", Journal of materials Processing Technology 170, pp: 579-585, 2005.

[13] G Brabie., E.M Costache., N Nanu., Chirita Vasile Alecsandri B., "Prediction and Minimisation of Sheet Thickness Variation During Deep Drawing of Micro/Milli Parts", International Journal of Mechanical Sciences, vol.68, pp 277-290, 2013.

[14] S Thiruvarudchelvan., H.B Wang., G Seet., "Hydraulic Pressure Enhancement of the Deep-Drawing Process to Yield Deeper Cups", Journal of Materials Processing Technology, Vol. No. 82, pp. 156–164, 1998.

[15] Dao Thanh-Phong, Huang Shyh-Chour, "Study on Optimization of Process Parameters for Hydro-Mechanical Deep Drawing of Trapezoid Cup", Journal of Engineering Technology and Education, vol. 8, Issue No.1, pp. 53-71, 2011.

[16] T.S. Yang "Investigation of the Strain Distribution with Lubrication During the Deep Drawing Process", Tribology International, vol. 43, pp 1104–1112, 2010.

[17] Liu Qiqian, Lu Cheng, Fu Wenzhi, Tieu Kiet, Li Mingzhe, Gong Xuepeng "Optimization of Cushion Conditions in Micro Multi-Point Sheet Forming" Journal of Material Processing Technology, vol.212, pp 672-677, 2012.

[18] R Padmanabhan., M.C Oliveira., J.L Alves., L.F Menezes. "Influence of Process Parameters on the Deep Drawing of Stainless Steel", Finite Elements in Analysis and Design, vol.43 pp 1062 – 1067, 2007.

[19] Y.S Kim., M.K. Jain, D.R Metzger "Determination of Pressure Dependent Friction Coefficient From Draw Bend Test and its Application to Cup Drawing", International Journal of Machine Tools and Manufacture, vol 56, pp 69-78, 2012.

[20] Van Tung Phan, Jochen Katja, Bohlke Thomas "Simulation of Sheet Metal Forming Incorporating EBSD Data", Journal of Material Processing Technology, vol.212, pp 2659-2668, 2012

[21] Tommerup Soren, Endelt Benny "Experimental Verification of a Deep Drawing Tool System for Adaptive Blank Holder Pressure Distribution", Journal of Material Processing Technology, Vol. 212 pp 2529- 2540, 2012.

[22] Volk Mihael, Nardin Blaz, Dolsak Bojan, "Application of Numerical Simulations in the Deep-Drawing Process and the Holding System with Segments' Inserts", Journal of Mechanical Engineering, vol. 57, no. 9, pp 697-703, 2011.

[23] J P Fan, C Y Tang, C P Tsui, L.C Chan and T C Lee (2006), "3D Finite Element Simulation of Deep Drawing Development", International Journal of Machine Tools & Manufacture 46 , pp: 1035-1044, 2006

[24] F Fereshteh Saniee and M.H Montazeran, "A Comparative Estimation of the Forming load in the deep drawing process", Journal of Materials Processing Technology, 140 pp: 555-56, 2003.

[25] A Molotnikov., R Lapovok., C.F Gu., C.H.J Davies. Davies, Y Estrin., "Size Effects in Micro Cup Drawing", Material Science and Engineering, vol. 550, pp 312- 319, 2012.

[26] Talic Amra, Suad Hasanbegovic Suad, Uzunovic Nermina Zaimovic, "Determination of the Optimum Blank Shape in Rectangular Cup Drawing", "Trends in the Development of Machinery and Associated Technology", pp 881-884, 2009.