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Effect on the product finish in deep drawing process due to supremacy of punch force

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Abstract: Forming process plays a significant role in manufacturing a product. Deep drawing among the forming process is considered superior because of its low wastage. The appropriate parameters to have an optimized drawing process must be found. A slight change in these parameters will cause major change on positive or negative side. In this, the punch forces mainly focused. This is the force used to draw the object. An experiment by varying punch force is made and investigate what happens in that resulting product. During the application of excessive force some failure like fracture thinning and cracks would occur. Experiment by varying load is done, and the outcomes are observed. The outcome of the experiment was noted. From this experiment it’s found that the optimistic load to draw the object and to improve the processing speed. By this, the productivity and accuracy is improved. By doing this for various loads, many results were obtained which gave reliability of the results. These findings are also theoretically and analytically examined.

Keywords: Deep Drawing, lubricant, varying punch force, Sheet metal

1. Introduction

Deep drawing is the most economical and fastest way of producing final goods. This kind of manufacturing produces the final products with zero scraps. This type of metal forming process is widely being used in all industries for various applications. From the business world, the method was found to be appealing for low-cost applications. Due to its simple setup and the ability to generate a formed part, it meets high criteria for visual quality. An explicit model of different punch forces is taken, and the drawn cup anisotropy and plasticity is taken with the finite element analysis method [1].

Thus, the model of the three-dimensional (X, Y, Z) deep drawing was verified with all the data, and the numerically calculated force are compared with the practical hydraulic press. The given material parameter is studied, and the solid blank element is considered as a sheet, which is a more realistic way to draw a cup. The simultaneous contact on the punch to the blank, blank holder to blank and punch, and die to punch on both sides of the sheet metals are natural. And the shell thickness of the blank is given on render shell thickness as input data. The simulation requires a certain CPU time to do the simulation process. Furthermore, the thickness of the blank should be specified on both sides of the blank to ensure symmetry. The drawn cup aspects like stress obtain and strain occurred is to collect with a term of CPU time and Energy obtain to do the process[3].

An isoperimetric has eight nodes, eight gauss equation points for a complete integration solution, and one of the reduced integration techniques (2). It uses the same interacting methodology to each coordinate and then the incremental drawn blank height is given as input data as a vector quantity of the three-dimensional view of blank on y-direction. The stress induces on the flange and drawn cup shells direction are detailed view on each node specification can be done with fine-meshed of deformable and non-deformable components [4].

The material properties of derived from the various test on various machines the data are collected and verified data and given as input data of mechanical, physical, and elasticity properties of the given sheet metal used as blank. Then the elongation properties of the material are derived from the induced yield stress calculated on the universal testing
machine with the change in length by original length as strain. The induced yield stress changes according to the change in strain the graph is plotted [5].

It is calculated with the coulomb's frictional law. The phenomenon of contact conditions is always connected. The number of steps to be drawn in the cup to be described by the coulomb's friction laws, and they are also formulated under unilateral condition process. The interaction properties of the blank and punch are set to tangent behavior and coefficient friction of 0.15 Of viscosity lubricant is used. The numerical simulation of the metal forming process involves the three-dimensional model that matted with each other has a frictional condition between the tool and the deformable object (blank), then blank and blank holder, and with blank and die.

The common aspects are the punch, blank holder, and Die is considered as rigid surface. But blank is considered as a deformable surface. They are assembled as independent of each other [6]. The blank and punch are dependent on the relative movement with it since they may not be in the same position. The vector quantity of the numerical value of punch is given input as displacement or velocity or by the acceleration in the formula of V= U +AT. The boundary condition of the blank is set free on the y-direction and interlocked on the x and z-direction. And at the procedure punch is also locked. Die is held in three directions of the dimensional. The non-stationary problems are changed strongly in the boundary condition since the boundary condition is usually updated by LaGrange kinematic formula [7].

The deformable body with applied load will simulate the stress induced in it. The main aspect is the smaller radius of the die, the drawing force is higher induced. Due to the greater drawing force, the drawn metal on sidewall thinning has occurred. The simulated cup drawing shows a definite difference from the originally drawn cup in terms of natural and manufacturing properties. The initial result of the simulated finite element analysis is equal to the derived data. That is giving a reasonable accuracy for punch force and metal thickness. The wrinkling of the deep-drawn cup is said to be more responsive to an increase in the displacement of the drawn material [8].

Anisotropic effects and values of the flange can be predicted by the simulated data. Need to be more concentrated on refining the model database and attending the quality of friction value by adjusting the coefficient of friction for each contact surface.

| Table 1. Constant Parameters |
|-----------------------------|
| **Blank Material** | Cold roll Steel IS513 |
| **Blank Thickness** | 1.25mm |
| **Coefficient of Friction** | 0.163 |
| **Modulus of Elasticity** | 295000 |
| **Lubricant** | Tectyl Press 108 |
| **Punch Diameter** | 81.55mm |
| **Die Diameter** | 84.05mm |
| **Blank Diameter** | 133mm |
| **Blank Holder Force** | 1.50E+04 |

The table-1 displays the parameters that have been maintained constant while performing this experiment.

This simulation process is carried out to verify the deformable force acted on reaction force obtain on the deviation of the analytical results there is grain over the blank thickness. The homogenous deformation changes on friction behavior [9].
2. Experimental Analysis

2.1. Design of process

To begin with calibrating the machine and setting the desired force to punch drive. Then we set the effort to grasp the workpiece. Amid the drawing handle we move the punch towards the blank. we are going to control the machine in two modes: manual and programmed. moves down and up is completely controlled physically by means of buttons. The stamp moves when the button is squeezed and returns when the button is discharged in programmed mode. It's security sensors on each side to specifically punch and identify human intrusion amid the process.

![Deep Drawing Machine](image1.png)

The maximum capacity of load the machine can exert is up to 50 tons. It is powered with 5 hp motor. The bed size of the machine is 500 x 500 mm. The day light Gap is about 600mm.

2.2. Observation

Table 2. Varied Parameters in experiment

| Diameter (mm) | Punch Force (N) | induced stress (N/mm²) | Strain |
|---------------|----------------|------------------------|--------|
| 133           | 4.29E+04       | 1.32E+08               | 4.47E+02 |
| 133           | 4.63E+04       | 1.42E+08               | 4.83E+02 |
| 133           | 4.17E+04       | 1.28E+08               | 4.35E+02 |
| 133           | 4.34E+04       | 1.34E+08               | 4.53E+02 |
| 133           | 4.43E+04       | 1.36E+08               | 4.62E+02 |

The table-2 shows that parameters changed in addition to punch force during the experiment.

![Punch Force vs Displacement](image2.png)

The Figure 2 displays the variation of punch force and displacement during deformation.
2.3. Inference

When punch force is varied the displacement also varies. Punch is directly proportional to the displacement. When increase in punch force, displacement also increases.

3. MATHEMATICAL ANALYSIS

3.1. PUNCH FORCE (P)

We calculate the punch force by the below mentioned formula and the D is the diameter of the blank. And we take stress as 220Mpa

\[ \text{Punch force, } P = \pi D t \sigma \]

3.2. BLANK HOLDER FORCE (H)

One of the punch forces is blank holder force, we get the blank holder force by dividing punch load by 3

\[ \text{BHF} = \frac{P}{3} \]

3.3. PUNCH FORCE WITH RESPECT TO FRICTION FORCE (P)

By using the below formula, we could be able to find exact value

\[ P = \left[ \left( \pi dt (1 - 2\sigma) \ln \frac{D}{d} \right) + \frac{2Hdt}{D} e^{\left(\frac{ln \pi}{2}\right)} \right] + B \]

3.4. INDUCED STRESS

The induced stress during the drawing process can be find by

\[ \sigma = \frac{P_1}{\pi} \left( d - \frac{d_1}{2} \right) \]

3.5. Observation

| Punch Force(N) | Displacement (mm) | Blank Holder Force(N) |
|---------------|-------------------|-----------------------|
| 40000         | 20.45             | 120000                |
| 42000         | 19.47619048       | 126000                |
| 44000         | 18.59090909       | 132000                |
| 46000         | 17.7826087        | 138000                |
| 48000         | 17.04166667       | 144000                |

The table-3 shows that parameters changed in addition to punch force by calculation.
Fig 3: Displacement vs Punch Force

The Figure -3 shows the displacement with respect to punch force during the metal forming process mathematical calculation.

3.6. Inference

The blank holder force and the punch force is directly dependent to each other when the punch force is increased the blank holder force increases. During the constant work done the punch force is indirectly proportional to displacement. Hence the displacement is decreased due to increase in punch force.

4. Finite Element Analysis

Punches, blanks and dies are developed, and solid models are created. We then combine these components, place them in the correct position, and perform finite element analysis using ABAQUS software. Essential properties such as BHF, stock offset and material quality, and stock properties such as diameter and thickness are provided as input parameters. Depending on the dimensions, this section should be cleared. Blanks must be created as deformable components, the rest as separate fixed parts. Before instantiating the assembly, the material must be edited to determine its density, Young's modulus, poison modulus, yield strength, and plastic deformation. These parts are placed later by entering coordinates.

As already mentioned, input parameters such as workpiece material properties, workpiece diameter and thickness, workpiece holder force, displacement and viscosity values remain constant. Variation of penetration for different tests to achieve optimal penetration into defect-free products.

The model is meshed. Smaller the mesh size, higher accuracy data output can be obtained. The simulation is run and analyzed. The final necessary data obtained are represented in the form of tabulation and graph is plotted for the tabulation created.

Fig. 4. Model Analysis

The Figure 4 shows the analyzed model of deep drawing process.
4.1. Observation

Table 4. Parameters Varied During FEA Analysis

| Punch Force (N) | Thickness (mm) | Kinetic Energy (J) | Stress (N/mm²) |
|----------------|----------------|--------------------|---------------|
|                | Min            | Max                |               |
| 17900          | 0.00111        | 0.00127            | 46.6          | 5.74E+07 |
| 17700          | 0.001109       | 0.001285           | 47.3          | 5.77E+07 |
| 16100          | 0.00131        | 0.001485           | 46.1          | 5.91E+07 |
| 16000          | 0.00111        | 0.001275           | 46.86         | 5.78E+07 |

The table-4 displays the parameters that has been varied based on the input parameters during this process analysis.

Fig 5: Displacement vs Punch Force

The Figure - 5 shows the changes in minimum wall thickness when varying punch force.

Fig 6: Max & Min Thickness vs Punch Force

The Figure – 6 the minimum and maximum shell thickness formed with respect to the punch force applied during the metal forming process.

4.2. Inference

When a force is applied on the blank it gets deformed, during this the wall thickness of the formed product decreases. When more force is applied on the blank more compression occurs due to the increased force. Hence resulting in more wall thinning of the formed product.

5. Conclusion

In deep drawing, the punch force depends on the material and the thickness of the material used. Need of Punch force is directly dependent to the thickness of the blank material used. For the elongation of the product the punch force can be increased then the height can be increased at ease when operated at optimized conditions. Uneven speed leads to the distortion of the material and shell thinning.
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