

Study About Effects of Oblique Angle of Die Surface to the Product Quality in the Deep Drawing

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ABSTRACT

Deep drawing is one of the special methods for the sheet metal forming in the pressure processing field. This method is applied to manufacture the mechanical products with the deep and complex shapes. The influences of oblique angle of die surface to the product quality of the metallic forming are discussed. This study uses the Abaqus software to simulate for four cases of the oblique angle of the die surface in the sheet metal forming processes. With each the simulation cases, the result shows that the wall thickness, material distribution and forming pressure are different for each various products. Moreover, the simulation results support a useful data table for the research and manufacturing in the deep drawing field.

Keywords: Abaqus software; Deep drawing; Sheet metal; Product quality; Oblique angle

1. INTRODUCTION

Deep drawing is one of the most popular and widely used sheet metal working processes and is used for producing cups from sheet metal at a very high rate. The deep drawing process is affected by many design parameters, such as blank shape, formability characteristics of material, blank holder force and clearance between punch and die, etc. The forming process deforms the shape, dimension and the status of the sheet metal by the direct impact force to form up the necessary shape and dimension products such as the circle, parallelepiped and complex shape [1-5].

Many researches performed for the deep drawing technology because this method is adopted to form the effectively sheet metal. The deep drawing process is affected by many design parameters such as blank shape, formability characteristics of material, blank holder force and clearance between punch and die, etc. In the drawing process, blank holder and die geometry are very important formability factors for obtaining the optimal products [6-10].

Most of the effective factors which impact to the deep drawing were studied. However, the parameters as the effects of oblique angles of blank holder and die surface to the product quality in deep drawing have superficially researched. Therefore, the main objective of this research will concentrate to discuss for the various cases about magnitudes of oblique angles of blank holder and die surface to give out the most optimization in the sheet metal forming.

2. MODEL AND RESEARCH METHOD

2.1. Research model

Model of deep drawing process is a combination of die, blank, blank holder and punch as Fig. 1

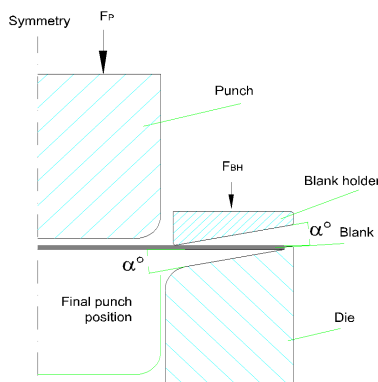


Fig 1. Deep drawing model

The simulation parameters using the finite element model are described in Table 1, including the model dimension and physical quantities.

Table 1. Dimensions and parameters table of finite element model

Blank diameter (D _b)	100 mm
Blank thickness (t)	1 mm
Punch diameter (D _p)	50 mm
Clearance between punch and die (C)	1.1 mm
Draw depth (d)	25 mm
Punch force (F _p)	60 KN
Friction coefficient between punch and blank	0.015
Friction coefficient between die and blank	0.015
Friction coefficient between blank holder and blank	0.015

2.2. Research method

This study used the finite element method to establish the mesh for the simulation model. The sheet metal is divided into many small elements which are connected by common nodes. We only need to simulate and analyze for all these elements to get exact and detailed results more than the biggest model.

Abaqus software is adopted to perform the simulations in this research. The obtained results show the obvious effects of technologies such as blank holder and oblique die angle on the quality of the deep drawing products.

In the drawing process, the sheet metal is subjected to the influences of the longitudinal and cross-axis tensile stresses. In addition, the compression stress of the blank holder also impacts on the metallic sheet.

The value of the punch force [11] is calculated by formula (1).

$$F_p = \pi \cdot d \cdot t \cdot (\sigma_{TS}) \cdot \left(\frac{D}{d} - 0.7\right) \tag{1}$$

- Which: d = Punch diameter
- D = Blank diameter
- t = Blank thickness
- σ_{TS} = ultimate tensile stress of material

The magnitude of the blank holder force [12] is calculated by formula (2).

$$F_{BH} = \frac{\pi}{4} [D^2 - (d_p - 2R_p)^2] \cdot P_d \tag{2}$$

- Which: D = Blank diameter
- d_p = Product inside diameter
- R_p = Punch radius
- t = Blank thickness
- $P_d = (2.04 \div 5.1)$ MPa is blank holder pressure

3. RESULTS AND DISCUSSION

Four cases of the oblique die angles are studied in this paper. The parameters for each case are provided to establish the simulation model as in Table 2.

Table 2. Cases of the finite element simulation in deep drawing

Cases	Oblique angle α (degree)	Clearances C (mm)	Punch radius R _{punch} (mm)	Die radius R _{die} (mm)	Blank holder F _{BH} (N)	Friction coefficient μ	Punch velocity V _p (m/s)
1	0°	1.1	5	5	3000	0.15	0.13
2	5°	1.1	5	5	600	0.15	0.13
3	10°	1.1	5	5	600	0.15	0.13
4	15°	1.1	5	5	600	0.15	0.13

The quality of the drawing product is appreciated through two criteria: the same wall thickness and the surface quality of the drawing product. The measurement positions are shown in Fig. 2.

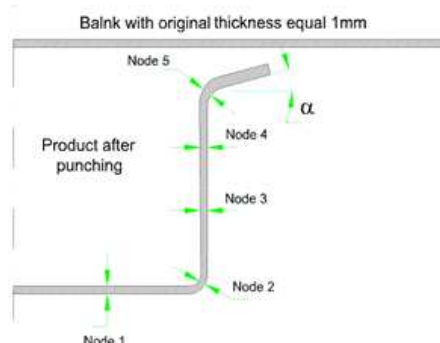


Fig. 2. Position of checking nodes for the product thickness

From the simulation results, with the same value of other parameters which a constant value of deep drawing ratio is as formula (3).

$$\beta = \frac{D_b}{D_f} = \frac{100}{50} = 2 \tag{3}$$

We have the graph of relation between oblique die angle α and blank holder force (F_{BH}) as Fig. 3.

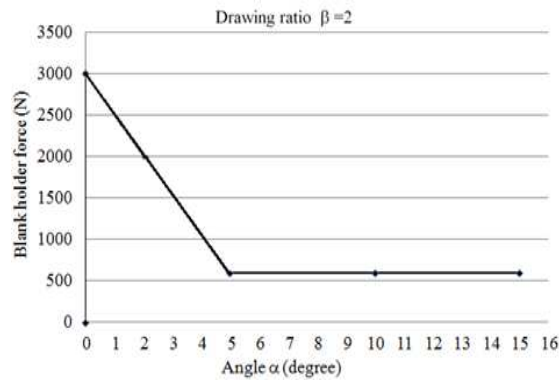


Fig.3. Influence of die angle on blank holder force

Fig.3. shows that the value of blank holder force is decreased from 3000 (N) to 600 (N) when value of oblique angle of die surface increases from 0 degree to 5 degree. And when increasing the α from 5 degree to 15 degree, the blank holder force is a constant value of 600 (N). Therefore, the value of blank holder force is converged when angle α is equal or exceeded 5 degree. This result presents that the angle α has influenced on blank holder force with the most optimal value of 600 (N). This is the evidence which improves the influence of oblique angles of die surface to magnitude of blank holder force.

The model of deep drawing products obtained from the simulation results with oblique angle of die surface in the order of 0°, 5°, 10° and 15° respectively as shown in Fig.4 (a), (b), (c), and (d).

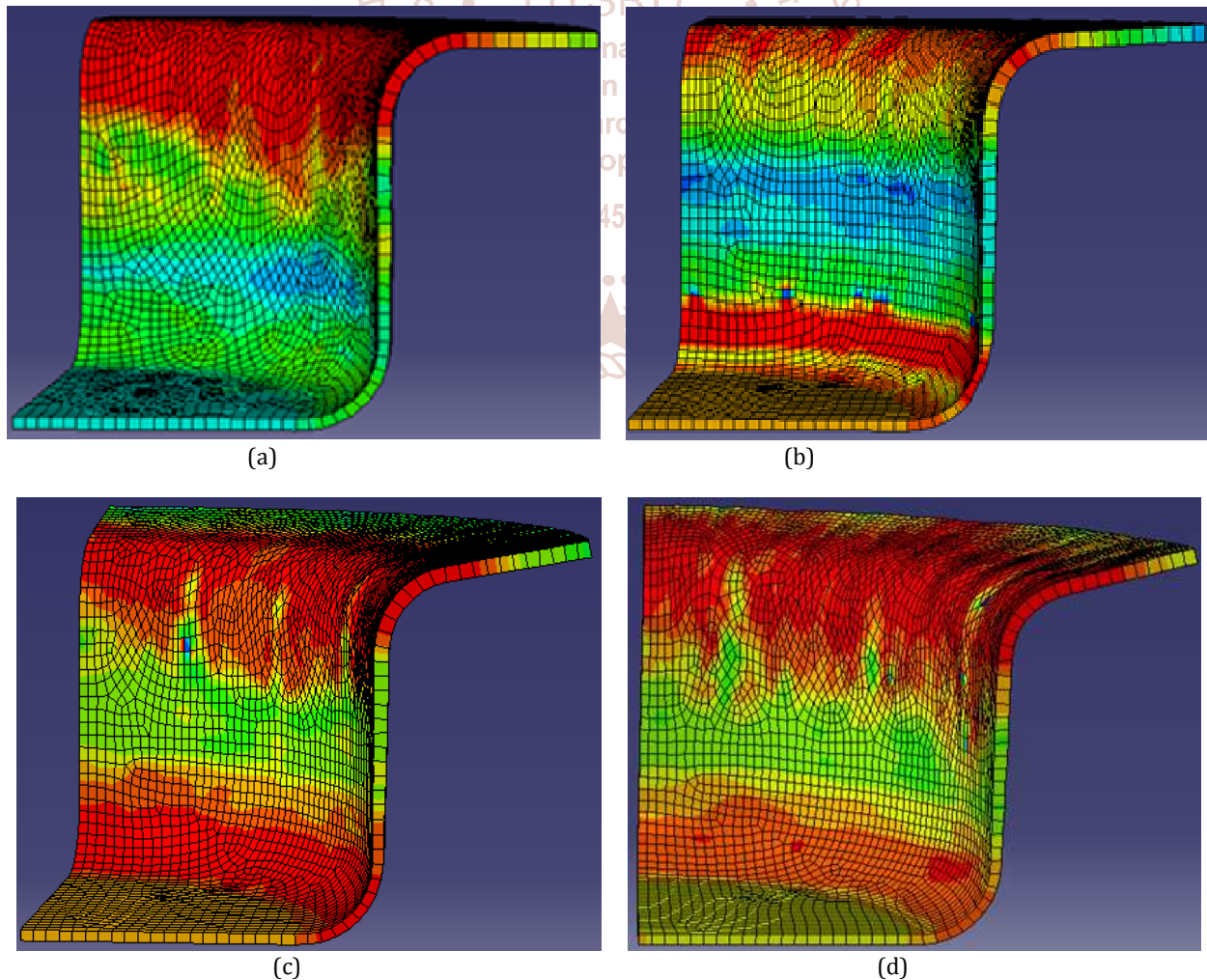


Fig. 4. The model of deep drawing products with oblique angle of die surface in the order of: a) 0°; b) 5°; c) 10° và d) 15°

Graphic presents the wall thickness of product which measures from the position of node 1 to the node 5 showing as in Fig.5.

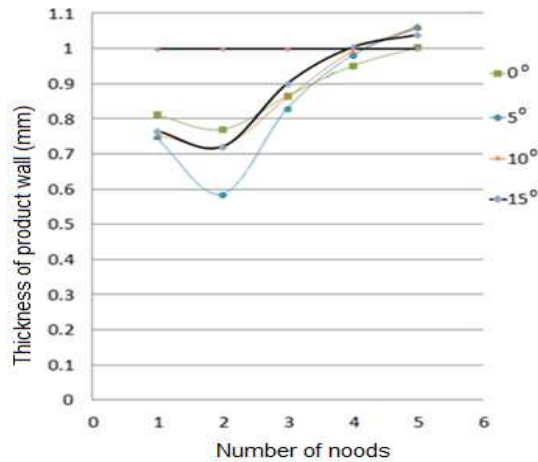


Fig.5. Thickness of drawing product wall

Plots in the Fig.5 show that the thicknesses of the obtained product wall are different for each various oblique angle cases of the die surface. The wall thickness reduces the center to around position of product bottom. In addition, the wall thicknesses increase from the position of node 1 to the node 5.

This research performs simulation for the four cases of oblique angles of die surface and blank holder. The obtained results are used to analysis, compare and discuss which purposes to take out the most optimal parameter. The criteria about the plastic competence, surface quality and thickness of regular product wall are used to appreciate and choose the most suitable parameters for obtaining the best quality of the drawing product.

Comparison for the plots in Fig.5 and models in Fig.4 which shows that the thickness of product wall are the least transformable and the same original blank thickness with the oblique angle case of 0°. However, the plastic competence and surface quality of the simulation product are poor than other cases. Otherwise, the blank holder of this case is 3000 N which is greater than the blank holder of remained cases.

With the all above results, the oblique angle case of 15° is the most satisfactory for the requirement criteria as the plastic competence, surface quality and thickness of regular product wall. The best product model is shown in Fig.6.

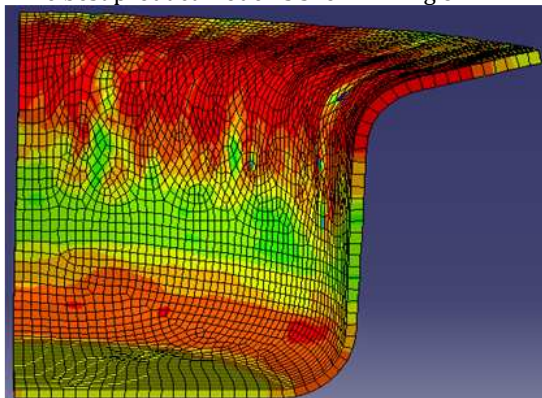


Fig.6. The model of deep drawing product with oblique angle of die surface of 15°

Fig.6 is the best simulation result of four research cases about the oblique angle of die surface. The blank holder of 600 N is the least use in this case. Moreover, the surface quality of simulation product is better in comparison with other cases. Therefore, the oblique angle of die surface of 15° the most suitable value to adopt for the deep drawing of the sheet metal. The research parameter of this case can refer and apply in the experiment works and the real manufacturing.

4. CONCLUSION

The four cases of the oblique angle of die surface and blank holder were studied in this paper. The obtained results were used to analysis, compare and discuss which purposes to take out the most optimal parameter base on the requirement criteria. The optimal parameter can be referred and applied in the experiment works and the real manufacturing.

Through the simulation performance, the results show that the blank holder force decreases from 3000 N to 600 N when the oblique angle of die surface increases from 0° to 15°.

The blank holder is a constant when the oblique angle of die surface is greater or equal 5°.

With the oblique angle of die surface and blank holder is 0° which the thickness of product wall are the least transformable with the oblique angle case of 0°. However, the plastic competence and surface quality of the simulation product are poor and the blank holder is the greatest of 3000 N.

Therefore, the oblique angle of die surface of 15° the most suitable case to use for the deep drawing of the sheet metal which can obtain the product quality as the requirement criteria and the blank holder is the lowest of 600 N.

REFERENCES

- [1] Trương Tích Thiện, 2007. Lý thuyết dẻo kỹ thuật. NXB đại học quốc gia TP HCM.
- [2] Nguyễn Mậu Đăng. Công nghệ tạo hình kim loại tấm, NXB khoa học và kỹ thuật Hà Nội.
- [3] V. L. Martrenco, L. I Rudman. Sổ tay thiết kế khuôn dập tấm, NXB Hải Phòng.
- [4] B. Wassilieff, Emboutissage, người dịch Nguyễn Ngọc, 1981. NXB công nhân kỹ thuật Hà Nội.
- [5] Lê Nhung, 1981. Kỹ thuật dập nguội, NXB công nhân kỹ thuật Hà Nội.
- [6] Swift W, Chung SY, 1951. Cup drawing from a flat blank experimental investigation. Proc Int Mech Eng.
- [7] Danckert J, 1995. Reduction of residual stress in deep drawing by modeling the draw die profile. Ann CIRP.
- [8] Fereshteh-Saniee F, Montazeran MH, 2003. A comparative estimation of the forming load in the deep drawing process. J Mater Process Technol.
- [9] Korhonen AS, 1982. Drawing force in deep drawing of cylindrical cup with flat-nosed punch. J Eng Ind.
- [10] K. Hanaki, K. Kato, 1984. Pressure peak in bending and unbending process, Adv. Technol. Plastic.
- [11] V. Boljanovic, 2004. Sheet metal forming processes and die design, New York 10016.
- [12] H. E. Theis, 1999. Handbook of Metal Forming Processes, New York, NY 10016