The Seventeenth International Symposium on Artificial Life and Robotics 2012 (AROB 17th '12),
B-Con Plaza, Beppu, Oita, Japan, January 19-21, 2012

The Forming Parameter Analysis of the Circular Plate by Using Computer-Aided Engineering

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Abstract: This paper is investigation of the effect of the large deformation on the forming parameter for the circular plate forming. This analysis tool of this paper is the ANSYS LS DYNA software. The forming parameter of the paper includes the punching velocity and die material property. From the analysis result, this can be known the variable result can be got under the differential parameter condition. When the punching velocity is increasing, the extrusive material will appear. When the die material strength increase, the forming thickness of the forming shape becomes small. When the deform velocity of the die material is increasing, the forming thickness of the forming shape becomes small. Therefore, the effect of the die material effect on the thickness of the forming shape is very clear. This analysis tool can effectively predict the forming shape.

Keywords: ANSYS LS DYNA , die material property, Oil Seal Cover, punching velocity,

1 INTRODUCTION

Now, the manufacturing velocity of the industry is very fast. So, the plastic injecting forming is used in many lifting field. But, the plastic structure strength is very weak. Therefore, the high structure product can not use the plastic material. The metal material is good material for the high structure product. The injecting forming method can not be used for the metal material. The fast forming method of the metal can use punching forming or deep drawing. This object of the punching forming is the forming shape for the beforehand plane plate or the undeveloped product. The forming shape include square, circular, rectangle, triangle …, etc. The punching forming action is by way of the mold interaction. The die material have the metal flow. This cause the die plate into the mold, then the die plate have pressured into the inside of the mold. In order to pressure the die plate forming, the die material cause metal flow.

In the process of the metal deep forming, the metal flows include the bending, stretching, friction and compressed. This can cause the deformation of the die plate. In general, the forming of the circular cup shape can cause the crack of the cup well in the place of the subjected force and transportation. When the plate material extend by using the force, the plate material thickness become thin. The thickness of the sheet plate on the place of the interaction between sheet plate and the corner of the punch pin become too thin. When the plate material is formed, the status of the forming force and transportation can be controlled. The forming shape can be get the best result.

From the literate, this can be known the parameter can be controlled to get the best forming result.[1] J.P.Fang etc [2] use the ABAQUS software to analyze the deep forming to understand the wrinkle of the plate material. This is closed compare between the experiment result and analysis result. Manabe etc [3] analyze the thickness variation of the plate material by using the 「LS-DYNA90」 soft ware. From the analysis result, this can be known that the LS-DYNA90 can be used to analyze the thickness variation. Natarajan and Venkataswamy[4] analyze the circular cap forming by using the finite element method. Compare the experiment result and analysis result, this can be found that the thickness of the plate material in the compressed plate and the flange of the mold become thin. This can be known that the finite element method can to analyze the forming process. In 2002, the Naval Kishor and Ravi Kumar[5] use the LSDYNA software to explore the forming shape optimization. This tool is used to reduce the ratio of the wrinkle shape. This result is close to the experiment result. In 2006, Yang [6] used the DEFORM software to analyze the semi circular deep. This simulate the thickness variation and the effect of the forming force. From the analysis result, this can be known that as the blank holder force and friction force become great, the forming force become great and the thickness of the plate become thin. Kirby and Wild[7] use the MARC software to analyze the deep forming. From the analysis result, this can be known that the effect of the friction coefficient and the

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blank holder gap on the principal strain of the blank material is very small. When the friction coefficient increase linearly, the maximum punch force increase linearly. When the blank holder gap increases, the blank hold force and punch force decrease. Therefore, this can be known that the effect of the friction coefficient on the maximum punch force is very clear. The effect of the blank holder gap on the maximum blank holder force is very clear. From the above literate, this can be known that the computation add engineer can be used to predict the forming shape.

2 Theory Analysis

In order to get the correct analysis result, the real material measurement is very important. The material test is satisfying the ASTM standard. The test material show in Fig. 1. The thickness of the blank plate material is 2.62mm. The test result show in Fig. 2. The test result is the displacement and force curve. In general, the analysis model property must is the real stress-strain curve. The relation of the engineering material property and the real material property can be get from equ. (1)-(4), shown in following:

$$\sigma = \frac{F}{A_0} \tag{1}$$

$$\varepsilon = \frac{l - l_0}{l_0} = \frac{\Delta l}{l_0} \tag{2}$$

$$\sigma_t = \frac{F}{A_0}(1+\varepsilon) \tag{3}$$

$$\varepsilon_t = \ln(1+\varepsilon) \tag{4}$$

Where σ is the engineering stress, σ_t is the real stress, ε is the engineering strain. ε_t is the real strain. F is the extend force. l_0 is the length of the test material. l is the length of the test material after extending. A_0 is the area.

Fig. 1. Flat sheet of material testing standard map

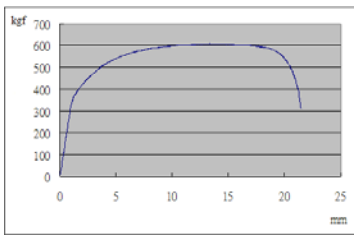

Fig. 2. Pull test of strength and displacement application diagram Flat sheet of material testing standard map

From the tensile test, the coefficient of elasticity is 593kgf/mm^2, yielding stress 168MPa limited strength is 273.5MPa, ratio of the extension 49.5%. The stress strain curve can be get, show in Fig 3. The relation of the punch forming velocity is shown in Fig.4.

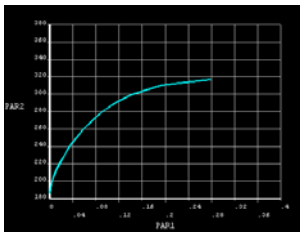

Fig. 3. Stress-strain diagram

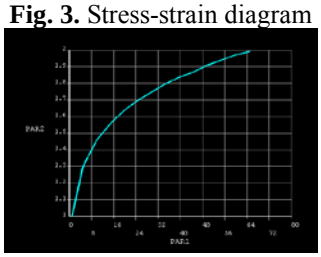

Fig. 4. Speed and strain rate graph

This paper uses the ANSYS/LS-DYNA software to build the solid modeling. This modeling includes the punch mold, draw die and blank plate. Due to, the analysis object is the thickness and Flange of the circular cup. The blank plate use the shell 163 element of the ANSYS, this element is show in Fig.5. The punch and die element is the solid 164 of the ANSYS, this shows in Fig.6.

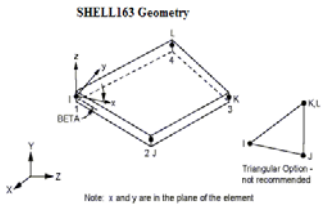

Fig. 5 shell163 of the ANSYS diagram [8]

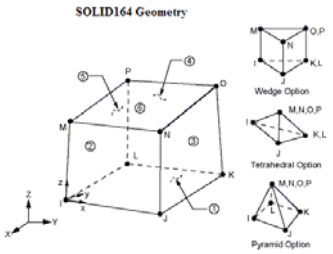

Fig. 6 solid164 of the ANSYS diagram[8]

3 Analysis Result

In order to understand the effect of the punching velocity on the forming shape, this consider the constant distant of the punching and die with the variation time. The trip of the punch from the top to down is 0.05m. These six times of the punching 0.05m trip include 0.05s、0.1s、

0.2s、0.3s、0.4s and 0.5s. These analysis results show in following:

. **(a) T=0.05** This consider the punching time is t=0.05s. The punching velocity is very fast. This analysis result shows in Fig.7. Fig. 7 show the deformation shape of the circular cup and the thickness contour of the circular cup. From the Fig. this can be found that the flange of the circular cup appear. The thickness of the circular cup become very thin (0.053mm). In order to understand the effect of the material strength on the deformation shape, the Fig.8 show the deformation shape curve of the circular cup with the differential multiplicand of the stain rate of the material (in Fig.4). From Fig.8, this can be found the effect of the strain rate of the material on the deformation shape curve is very small.

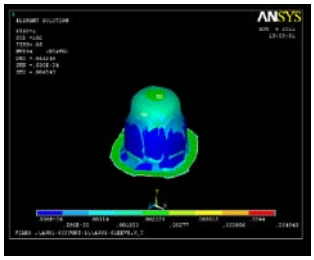

Fig. 7. The thickness contour and the forming shape diagram t=0.05s

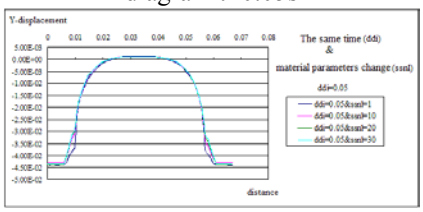

Fig. 8. The shape curve with variation strain ratio in t=0.05s

(b) T=0.1 The t=0.1s is applied in this system.

The analysis result show in Fig.9. From the Fig.9, this can be found that the flange of the circular cup appear. The flange of the punching time 0.1s is smaller than the punching time 0.05s. The thickness of the circular cup become very thin (0.225mm). In order to understand the effect of the material strength on the deformation shape, the Fig.10 show the deformation shape curve of the circular cup with the differential multiplicand of the stain rate of the material (in Fig.4). From Fig.10, this can be found the effect of the strain rate of the material on the deformation shape curve is not clear..

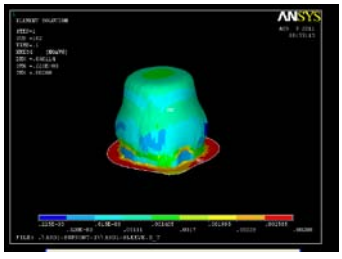

Fig. 9. The thickness contour and the forming shape diagram t=0.1s

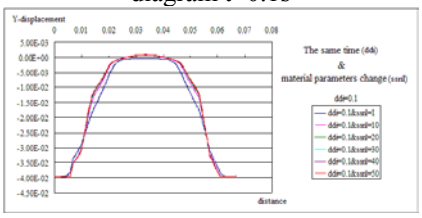

Fig. 10. The shape curve with variation strain ratio in t=0.1s

(c) T=0.2 The t=0.2s is applied in this system. The analysis result show in Fig.11. From the Fig.11, this can be found that the flange of the circular cup disappear. The thickness of the circular cup become very thin (0.915mm). The Fig.12 shows the deformation shape curve of the circular cup with the differential multiplicand of the stain rate of the material (in Fig.4). From Fig.12, this can be found the effect of the strain rate of the material on the deformation shape curve is not clear..

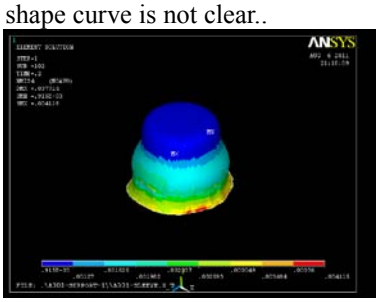

Fig. 11. The thickness contour and the forming shape diagram t=0.2s

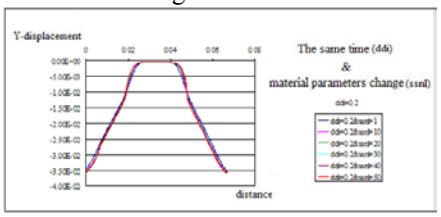

Fig. 12. The shape curve with variation strain ratio in t=0.2s

From the above analysis result, this can be known the effect of the train ratio of the material on the deformation shape is not clear. But, the thickness of the circular cup is too thin after the blank plate is formed, shown in Fig.13. From this can be found that the strain ratio of the material is great, the flow of the material is very difficult.

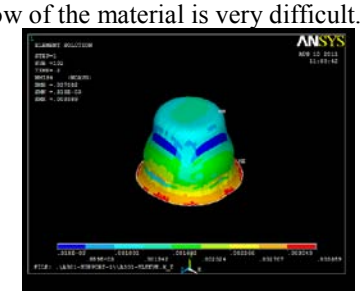

Fig.13. The thickness contour and the forming shape diagram t=0.2 with multiplicand of the strain ratio 50

(c) T=0.3 The t=0.3s is applied in this system. The analysis result show in Fig.14. From the Fig.14, this can be found that the flange of the circular cup disappears. The

thickness of the circular cup becomes very thin (1.16mm). The Fig.15 shows the deformation shape curve of the circular cup with the differential multiplicand of the stain rate of the material (in Fig.4). From Fig.15, this can be found the effect of the strain rate of the material on the deformation shape curve is not clear.

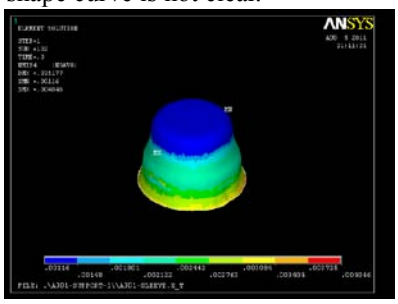

Fig.14. The thickness contour and the forming shape diagram t=0.3

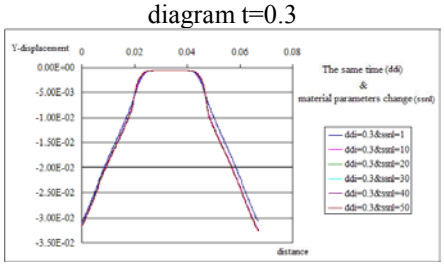

Fig.15. The shape curve with variation strain ratio in t=0.3s

(d) T=0.4 The t=0.4s is applied in this system.

The analysis result show in Fig.16. From the Fig.16, this can be found that the flange of the circular cup disappears. The thickness of the circular cup becomes very thin (1.395mm).

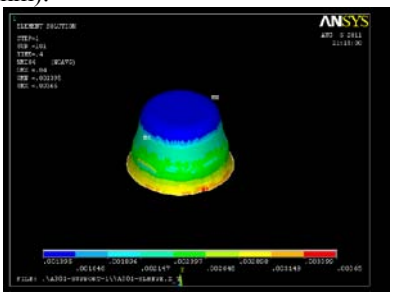

Fig.16. The thickness contour and the forming shape diagram t=0.4

(e) T=0.5 The t=0.5s is applied in this system. The analysis result show in Fig.17. From the Fig.17, this can be found that the flange of the circular cup disappears. The thickness of the circular cup becomes very thin (1.598mm).

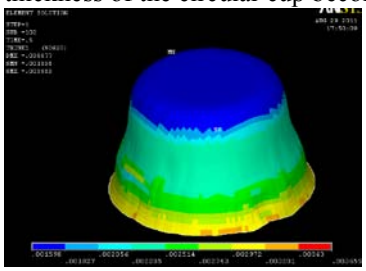

Fig.17. The thickness contour and the forming shape diagram t=0.5s

4 CONCLUSION

This object of the paper is analysis of the plate forming by using the CAE software. This uses the AN SYS LS-DYNA to analyze the circular cup forming. Fr om the above analysis result, this can be get this follo wing:

1. This can get the good analysis result by using the CAE.
2. From analysis result, this can be found that the differential result can be get as the differential forming parameter.
3. In the deformation shape, the effect of the punching velocity is very clear. As the punching time is smaller than 0.2s, the flange of the circular cup appers.
4. In the thickness of the forming product, the effect of the punching velocity is very clear.
5. When the stain ratio of the blank material is great, the thickness of the circular cup is thin. When the punching time is greater, the thickness of the circular cup become big.

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