umerical nal sis of Parameters ffecting Forma ilit in Micro alf lan ing Using Thin heet Metal

*부이 히엔 빈 [1], 김상목,김화영 [2], 구태완 [3], #강범수 [3]
*B. V. Hien[1], S.M. Kim[1], H.Y. Kim[2], T. W. Ku[3] , #B. S. Kang(bskang@pusan.ac.kr)[3]
[1] 부산대학교 항공우주공학과 대학원, [2]㈜일광켄테크, [3] 부산대학교 항공우주공학과

Key words : Micro Half-Blanking Operation, Finite Element Method, Punch-Die Radius, Clearance, Damage Value.

1. Introduction

Micro half-blanking process is an operation in which the shape of product is obtained by shearing force. Micro half-blanking operation is also used in push-back blanking method to prevent blank from burr [1]. The process of micro half blanking and the shape of product are not only depended on material mechanic properties but also the geometry of punch-die and clearance. The formability of sheet metal in half-blanking process depends on the fracture phenomena. The fracture phenomena occur when the history of stress meets the threshold value of fracture criterion. Therefore, analysis of parameters affecting the history of stress is very important to predict the shape of product and formability of sheet metal. In recent years, numerical simulations have been performed based on the finite element method to reduce the time and cost for production and optimal processes.

In this study, research of the effects of changing punch-die clearance and punch-die radius to the history of stress and roll-over in micro half-blanking operation were carried out. The simulated product was a center hole of CID filter, this device was used to prevent battery from explosion, which operated by half-blanking operation with the depth of hole was 0.36 mm and hole diameter is 2.4mm. The commercial code used to simulate is Deform 2D [2].

2. F M imulation method

2.1 imulation model

In this simulation, the blanked part to be analyzed was assumed to be plane strain. The material of sheet metal was considered as rigid-plastic object, the punch and die were defined as rigid bodies. The process was considered quasi-static, and hence the effects of strain rate were neglected.

The mesh of sheet consisted of 4,000 isoparametric quadratic elements. Unlike sheet metal forming such as deep drawing and punch stretching, the elements in the clearance zone in half-blanking operation undergo very much deformation, so this zone needed to have the mesh density that is four times as dense as other zones for more accuracy and re-meshing was needed in the simulation process. Fig.1. is the cross section of center hole of product after micro half-blanking process.

The simulation model for a half of center hole of CID filter in half-blanking process was depicted in Fig.2. Blank holder and bottom die were fixed. The bottom die was used to flat the surface of product.

Fig.1. The center hole of CID filter.

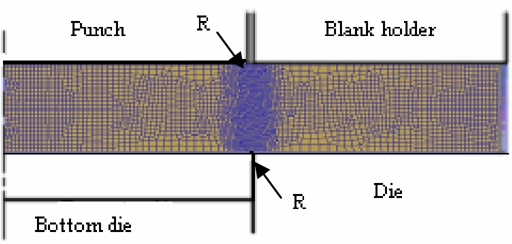


Fig.2. Initial mesh used for simulation.

Table 1 Material properties of Al 1050H16 by uni-axial tensile test.

Yield stress, σ (MPa)	117.44
Ultimate stress, σ (MPa)	126.49
Yield strain, ε	0.0039
Elongation (%)	5.25

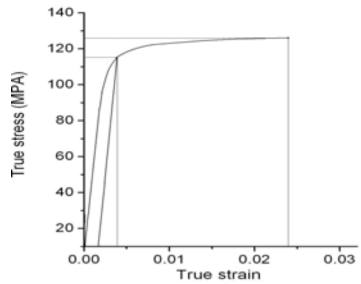


Fig.3. Stress-strain curve

2.2 imulation condition

The used material was Aluminum 1050-H16 of 0.5mm thickness. The punch stroke was 0.36mm. It was assumed that the material is isotropic and its yielding point follows the Von-Mises yield criteria. The flow stress equation used in this study is given with a constitutional model as below:

$$\bar{\sigma} = f(\bar{\varepsilon}, \dot{\bar{\varepsilon}}, T)$$

where, $\bar{\sigma}$ is the effective stress, $\bar{\varepsilon}$ the effective strain, $\dot{\bar{\varepsilon}}$ the effective strain rate, and T is the temperature.

The tensile properties of the material in uni-axial tensile test are shown in Table.1 and Fig.3 is the stress-strain curve.

The friction contact between sheet and tool follows Coulomb's law:

$$\tau_f = \mu\sigma$$

where, τ_f is the friction force, σ the normal stress, and the friction coefficient. The friction coefficient between the tool and the material was assumed to be 0.2, which corresponding to the no-lubrication condition.

In order to know the effects of punch-die radius and clearance, the finite element method will be linked with fracture criteria. In this analysis, the Cockcroft and Latham expression [3] modified by Jeong et al.[4] was used to calculate the history of stress, implied by damage value:

$$_1 = \int_0^{\bar{\varepsilon}_f} \frac{\sigma_{max}}{\bar{\sigma}} d\bar{\varepsilon}$$

where, $\bar{\varepsilon}_f$:the equivalent fracture strain, σ_{max} the maximum principle tensile stress, $\bar{\sigma}$ the equivalent stress, C_1 the damage value. The fracture occurs when C_1 meets the threshold value. The crack model is not simulated here and the damage value will be calculated by finite element method instead.

3. Results

3.1 Influence of punch-die radius

The corner radius plays an important role in finite element modeling. It produces a normal force against the stock material.

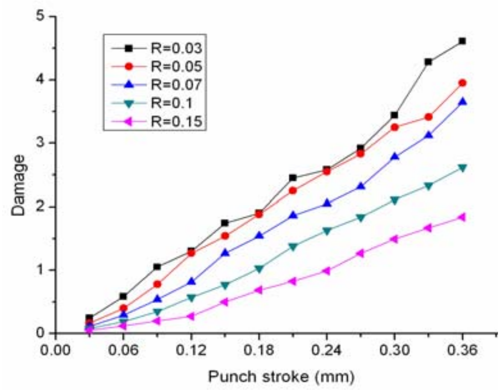


Fig.4. Effect of punch-die radius on damage value

The damage values for various cases of punch-die radius were compared in each step. The clearance maintained C=0% of thickness while the punch and die radius was changed 0.03, 0.05, 0.07, 0.1 and 0.15mm, respectively. Fig.4 shows the damage versus to punch penetration for the changes of punch-die radius

The results of simulation indicate that the damage value in each step decreases with the increasing punch-die radius. Therefore, the increase in punch and die radius causes an increase in the punch penetration of crack initiation.

3.3 Influence of clearance parameter

Another important parameter is the punch-die clearance. The clearance plays an important role in forming the shape of product. The clearance was changed -4, -2, 0, 2, 4, 6, 8 and 10% of thickness while the punch-die radius was R=0.05 in the study of effect of clearance on damage and roll-over.

It is seen in simulation result that the roll-over depth increases with the increase of clearance. Figure 5 indicates the effect of clearance on increase in roll-over depth. The roll-over increases strongly for cases above C=6% and increased slowly with the clearance smaller than C=6%.

The effect of clearance on damage value is depicted in Fig.6. The simulation result indicates that the damage will decrease with the increase of clearance for clearance larger than C=6% and decrease for decreasing clearance from C=2% to C=-2%.

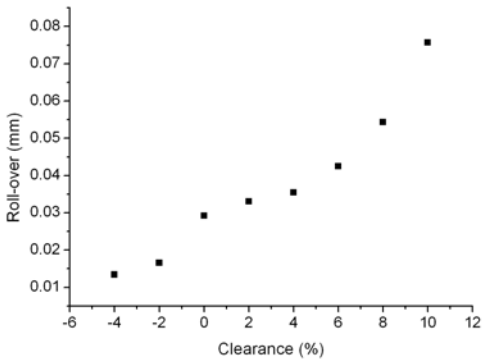


Fig.5. Effect of clearance on increase in roll-over depth.

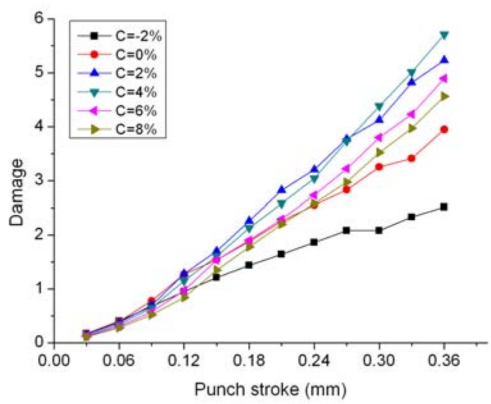
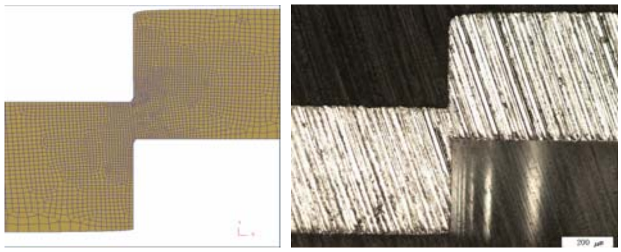


Fig.6. Effect of clearance on damage value.



(a) Simulation (b) Experiment

Fig.7. Example of roll-over shape (clearance=0)

The comparison of roll-over between simulation result and experience is depicted in Fig.7 and the results show the depth of roll-over in simulation result and experiment coincides well.

4. onclusion

In this study, finite element method was applied to the micro half-blanking operation, the sheet was a thin aluminum sheet. The comparison between the simulation results can be concluded:

1. By finite element method, we can predict the depth of roll-over of sheet metal in half-blanking process instead of the experiment because the experiment and finite element method coincide well.
2. The damage value can be used to evaluate the effect of the geometry of tool and clearance to formability of product.
3. The damage value reduces with the increase of punch-die radius. In other words, the increase in punch and die radius cause an increase in the punch penetration of crack initiation.
4. The clearance between punch and die causes the effect in roll-over depth. The increase in clearance induces the increase in roll-over dept. Otherwise, the increase in clearance above 4% of thickness will reduce the damage value and the decrease in clearance below 2% also reduces the damage value.

c no ledgements

This work was completed with the support of the project of the Laboratory of Excellence by the MOE, the MOCIE and the MOLAB. The second author would like to acknowledge the support of the research program, the second stage of Brain Korea 21 project in 2006. And the last author would like to thank the partial support by grants-in-aid for the National Core Research Center Program from MOST/KOSEF (No. R15-2006-022-02002-0).

References

1. I. Aoki, “Burr-Free micro blanking using Piezoelectric Actuator,” Journal of manufacturing science and engineering, vol.126-653, 2004.
2. DEFORM user’s guide, Science forming technologies corporation, Columbus, OH, 1993.
3. M.G Cockcroft, D.J. Latham, National Engineering Laboratory, Report No.240, 1996.
4. S.H. Jeong, J.J. Kang, S.I. Oh, in: Proceeding of the Fifth ICTP II, 1996, p.631.