ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 8, Issue 9, March 2019

Experimental Study on the Effect of Clearance on Shearing Surface in Sheet Metal Shearing

Dong Hwan Park[a,]*, Hyuk Hong Kwon[b], Jun Hyuk Seo[c]
[a] Gyeongbuk Hybrid Technology Institute, South Korea
[b] Department of Computer Aided Mechanical Engineering, Daejin University, South Korea
[c] Youngjin Co., Ltd., South Korea

Abstract: ***The purpose of this study is to investigate the effect of clearance on shearing surfaces in fine blanking and general blanking by applying carbon steel sheets, and to investigate the effect of clearance on shearing surfaces in general blanking by applying magnesium alloy sheet. To do this, we performed material property test such as tensile test and FLD test. A general blanking die was fabricated to compare rollover, burnish surface, fracture surface, and burr of the general blanking process. In order to research the influence of clearance on the shearing surfaces in general blanking, we adopted clearance between punch and die in 7%, 10%, and 13%.***

Keywords: **Clearance, Shearing surface, Sheet metal shearing, Blanking, Burr.**

I. BACKGROUND/ OBJECTIVES AND GOALS

Fine blanking is a press process that produces a fine shearing profile and good product accuracy required for obtaining a thickness of the product with one-time blanking. However, in shearing, burr, fracture surface, burnish surface, and rollover are generated on the shearing surface of the material. That is, in the general blanking, it is extremely difficult to obtain burnish surface of more than 50% since burr and fracture surface are generated during shearing. Generally, the clearance is controlled at less than 10% of the materials' thickness to maintain burr at an appropriate level. The methods to reduce the burr include shaving, chamfering, and cutting or fine grinding by machining. However, these processes need two or more machining steps, which increase production cost.

Manuscript received: 20 February 2019
Manuscript received in revised form: 17 March 2019
Manuscript accepted: 04 April 2019
Manuscript Available online: 10 April 2019

During shearing in the general blanking, when the punch touches the material, the plastic deformation over the elasticity limit, that is bending, is started. Once the punch penetrates the material further, shearing occurs due to pressing by bending. As shearing is advanced, the stress is concentrated on the punch and the die and causes a fracture, while the material is split by both ends. Rollover occurs when the punch penetrates surface of the material at the shearing surfaces of general blanking and occupies around 10-20% of the material's thickness. The burnish surface is a fine surface where the punch and the die directly shear the material and occupies 25-50% of the thickness of the material. The fracture surface is ruptured at the tensile part and creates an extremely rough profile. Since burr is always generated according to the bluntness of the punch and die blade edge in the shearing process, it is necessary to maintain the amount of burr at the optimum level and to control it to be lower than 10% of the material's thickness.

In this study, the effects of clearance on the shearing surface of the structural alloy steel sheet in the fine blanking and general blanking were investigated. In addition, the effect of clearance on the shearing surface of the magnesium alloy sheet in the general blanking was investigated.

II. EXPERIMENTS FOR THE PHYSICAL PROPERTIES OF THE MATERIALS

A. Tensile Strength Test

A structural alloy sheet SCM415H having a thickness of 4mm was used for the experiment after wire cutting. Tensile strength test was carried out to find out the mechanical properties of the sheet. The specimens for the

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 8, Issue 9, March 2019

tensile experiments were collected from the rolling direction of the sheets. The tensile experiment was carried out while the cross head in the universal testing machine was maintained at a constant speed until the material was fractured. The mechanical properties of SCM415H determined by the tensile experiment are shown in Table 1 below. From the tensile experiment results, the average yield strength of 344.4MPa, tensile strength of 477.6MPa, and fracture elongation of 31.4% could be obtained.

The material used in the tensile experiment was the magnesium alloy sheet AZ31B, having thicknesses of 1mm and 2mm each to investigate the basic physical properties. The specimen of AZ31B (1mm) was prepared with ASTM E8M specifications, while the specimen AZ31B (2mm) was prepared per the specifications of KS 0801 13B. The tensile experiment was conducted with the specimens prepared from 0°, 45°, and 90° from the rolling direction of the sheet using hydraulic fatigue tester. The yield strength, tensile strength, and elongation of the material are presented in Table 2.

Table 1 Mechanical properties of SCM415H

Direction		Yield strength [MPa]	Tensile strength [MPa]	Elongation [%]
0°	1	363	483	31
	2	357	486	31
	3	345	475	31
	4	320	485	31
	5	337	459	33
Average		344.4	477.6	31.4

Table 2 Mechanical properties of AZ31B

Thicknes s/ Roll direction		Yield strength [MPa]	Tensile strength [MPa]	Elongation [%]
1mm	0°	189	272	25
	45°	197	271	23
	90°	205	273	19
2mm	0°	195	276	17

The tensile experiment for the magnesium alloy sheet showed that the yield strength was in the range of 189-205MPa, the tensile strength was in the range of 271-276MPa, and fracture elongation rate was in the range of 17-25%.

B. FLD Experiment

FLD (Forming Limit Diagram) refers to a forming limit diagram, and makes die modification easy by finding out material flow and strain at the strain concentrated part during die try out. That is, it can be used as means to predict difficulty of strain scientifically. Forming limit diagram is an index representing an amount of strain during breakage for the strained area where breakage can be occurred in the steel sheet. Universal sheet forming testing machine was used for the forming test to obtain FLD curve as shown in Fig. 1. Fig. 2 shows the Nakajima specimens after FLD test, while Fig. 3 shows FLD curve of the SCM415H material. FLD curve presents a maximum limit that can deform the material without necking or crack. The FLD0 where minor strain value becomes 0 in the FLD was 0.13 in SCM415H material as a major strain as shown in Fig. 3.

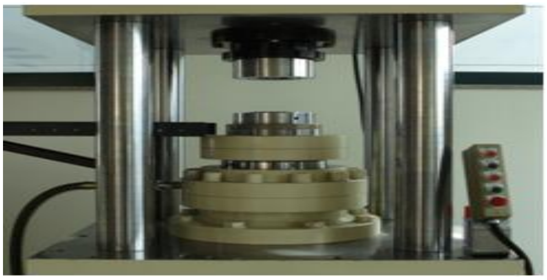


Fig. 1: Universal sheet forming test machine

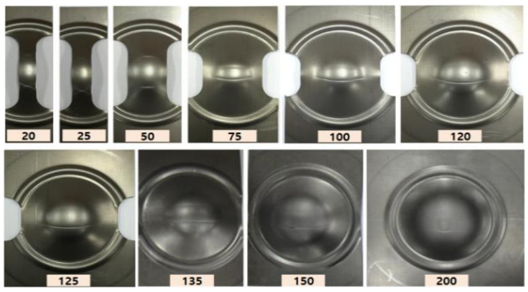


Fig. 2: Nakajima specimens after FLD test

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 8, Issue 9, March 2019

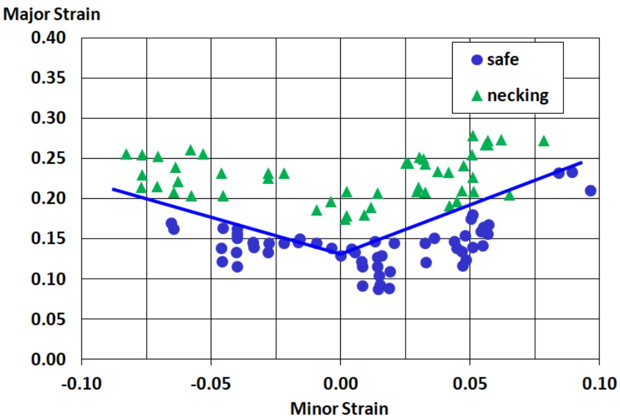


Fig. 3: FLD curve of SCM415H

III. FABRICATION OF SHEARING TOOL

A. Designing and Fabrication of Shearing Tool

Seat recliner fine blanking die was designed as a progressive type with two lines. Fine blanking die is more complicated compared with general blanking die, while the machining of the tool parts should be executed as precisely as possible. Compared with the precision degree of general blanking die, a high precision of ±0.005mm is required for the fine blanking die. For the major punch and dies, wire cutting was performed to achieve a high-precision machining quality and the clearance was maintained as small as 0.5% compared to the general blanking. Fig. 4 shows the 3D model for the seat recliner product, while Fig. 5 shows the fine blanking die for the seat recliner.

A general blanking die was fabricated to compare the rollover, burnish surface, fracture surface, and burr of the general blanking process. In order to investigate the effect of clearance on the shearing surface in the general blanking, the clearances between the punch and the die were set as three types: 7%, 10%, and 13%. In general blanking die, punch and die were heat treated using STD11 material. Fig. 6 shows the 3D model in the general blanking, while Fig. 7 shows the general blanking die.

B. Experimental Methods

Fine blanking test was carried out by using a fine blanking press of 700 tons capacity to perform fine blanking while continuously feeding fine blanking oil suitable for the material. Fine blanking oil enables plastic flow of smooth material on the cross section to obtain a burnish surface. If lubrication oil is not used, cold welding is generated, which cannot achieve a good shearing surface, making dimensional accuracy difficult to achieve. A large load is imposed on the punch and die, consequently leading a severe wear and tear due to high pressure and temperature rise. Ultimately, tool life and product quality may be impaired.

The general blanking test was performed while inserting the workpiece into a mold using a 200 ton mechanical press. General blanking test was carried out with 3 kinds of clearance between punch and die without oil, such as 7%, 10%, and 13%. Fig. 8 shows the tryout operation of a general blanking die.

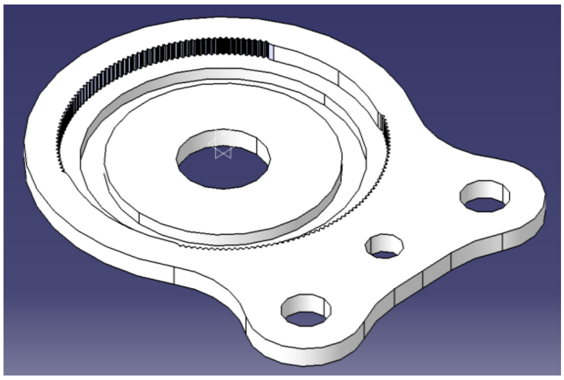


Fig. 4: Seat recliner product of fine blanking

Fig. 5: Fine blanking die

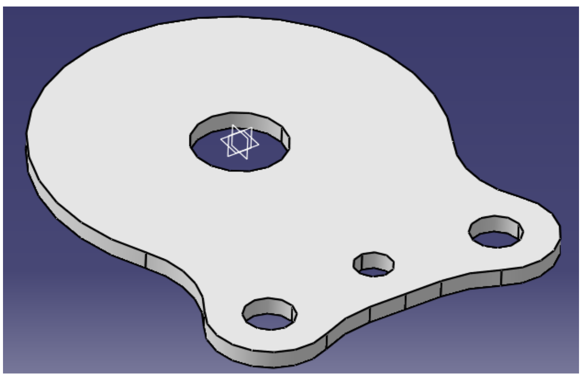


Fig. 6: General blanking product

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 8, Issue 9, March 2019

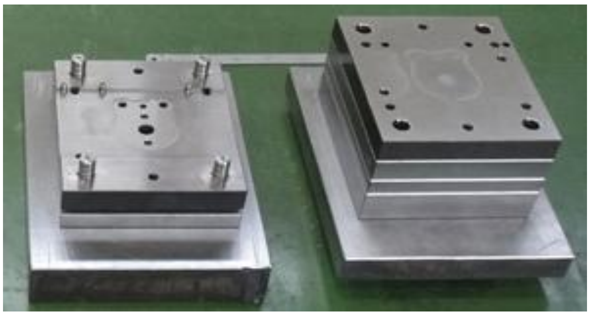


Fig. 7: General blanking die

Fig. 8: Press tryout of the general blanking die

IV. RESULTS AND DISCUSSION

For the seat recliner parts of fine blanking, a 700 ton fine blanking press was used. For the general blanking parts, a 200 ton mechanical press was used for die tryout. The material used for fine blanking was SCM415H structural alloy steel sheet in the form of coil. The lubrication oil used was a fine blanking oil (water soluble oil) suiting the material to conduct experiment under lubrication condition. Fig. 9 shows the seat recliner produced by the fine blanking process. The shearing surface was measured by the tool microscope as shown in Fig. 10. Measurement results showed that the total burnish surface was more than 95% and the burr height was in the range of 0.02-0.05mm.

For the general blanking, structural alloy sheet SCM415H and magnesium alloy sheet AZ31B were used while setting the clearance between the punch and die at 7%, 10%, and 13%. Fig. 11 shows the general blanking of SCM415H according to the clearance, Fig. 12 shows the general blanking product for the magnesium alloy sheet AZ31B. Fig. 13 shows the shearing surfaces by general blanking for the SCM415H and AZ31B at a clearance of 10%. As far as the shearing surface of the general blanking product was concerned, the height of the burnish surface of the magnesium alloy sheet AZ31B was large. Meanwhile, the burnish surface of the structural alloy sheet SCM415H was clean. Fig. 14 shows the shearing surfaces of the general blanking product for SCM415 according to the clearance, Fig. 15 shows the shearing surfaces of the general blanking for the magnesium alloy sheet AZ31B according to the clearance. In the shearing surface of the general blanking product, the fracture surface was clean as the clearance was increased. The roughness of the fracture surface in the magnesium alloy sheet AZ31B was especially improved as the clearance was increased.

Fig. 9: Seat recliner product of fine blanking

(a) Tool microscope **(b) Burnish surface**

Fig. 10: Burnish surface measurement of fine blanking product

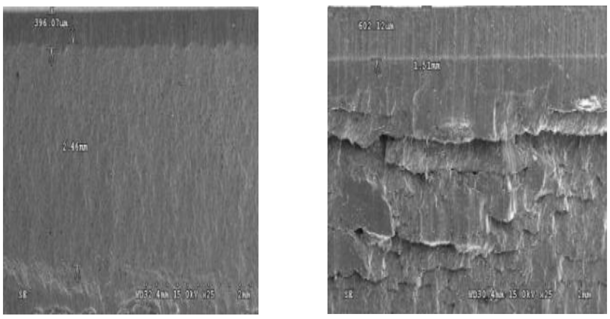
ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 8, Issue 9, March 2019

(a) Clearance 7% (b) Clearance 10% (c) Clearance 13%

Fig. 11: General blanking product of SCM415H according to clearance

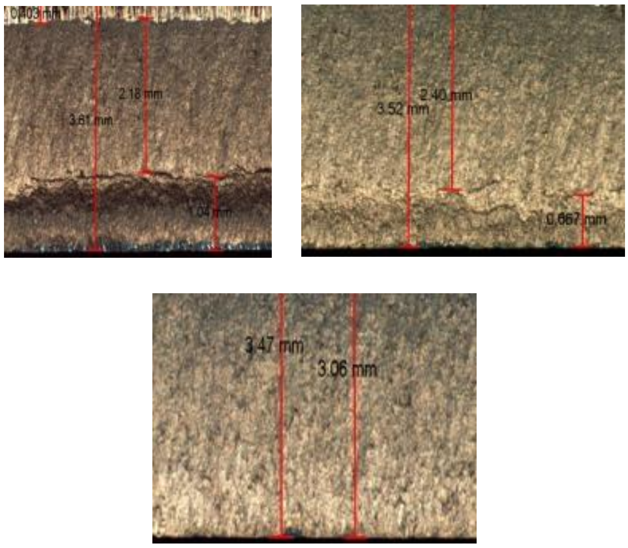
(a) Clearance 7% (b) Clearance 10% (c) Clearance 13%

Fig. 12: General blanking product of AZ31B according to clearance



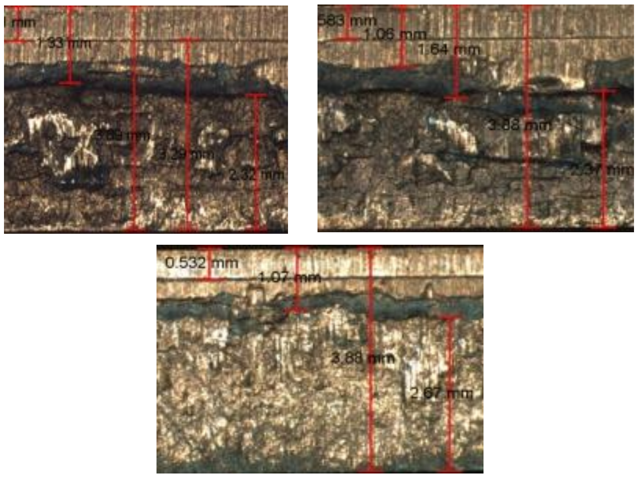
(a) SCM415H (b) AZ31B

Fig. 13: Shearing surfaces of general blanking product at a clearance of 10% according to material



(a) Clearance 7% (b) Clearance 10% (c) Clearance 13%

Fig. 14: Shearing surfaces of general blanking product of SCM415H according to clearance



(a) Clearance 7% (b) Clearance 10% (c) Clearance 13%

Fig. 15: Shearing surfaces of general blanking product of AZ31B according to clearance

V. CONCLUSION

This study was conducted to investigate and compare the effect of clearance on the shearing surface of the structural alloy steel sheet and magnesium alloy sheet in the general blanking and fine blanking process. The derived conclusions from the experimental results are as follows.

(1) In the tensile test for the structural alloy steel sheet and magnesium alloy sheet, the stress according to strain

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 8, Issue 9, March 2019

could be confirmed. In addition, the FLD curve could be obtained to find out the forming limit.

(2) The fine blanking parts and general blanking parts to produce the seat recliner with the structural alloy steel sheet were compared. The effect of the clearance on the shearing surface was analyzed for the general blanking parts.

(3) For the shearing surface of the general blanking product, the height of the burnish surface was large in the magnesium alloy sheet AZ31B whereas the fracture surface in the structural alloy sheet SCM415H was cleaner than magnesium alloy sheet.

(4) The fracture surface was clean as the clearance was increased in the shearing surface of the general blanking. Particularly, in the magnesium alloy sheet AZ31B, the roughness of the fracture surface was improved as the clearance was increased.

REFERENCES

[1] Han, K. T.(1999). A Study on the Forming of Parts for Automobile using Fine Blanking Process, Journal of the Korean Society of Machine Tool Engineers, 8(2) 56-61.

[2] Kim, J. D., Kim, H. K.(2011). A Study on the Change of Die Roll Size by the Shape of Die Chamfer in Fine Blanking Die for Automobile Door Latch, Journal of the Korea Academia-industrial Cooperation Society, 12(2) 565-570.

[3] Kim, J. D.(2012). An Experimental Study on the Effect of V-ring Position and Die Chamfer Shape on the Die Roll Height in Fine Blanking Tool, Journal of the Korea Academia-industrial Cooperation Society, 13(5) 2009-2014.

[4] Lee, C. K., Y. Kim, C. A.(2013). A Study on the share Surface Size Deformation of Fine Blanking Process, Journal of the Korea Academia-industrial Cooperation Society, 14(8) 3650-3655.

[5] Kim, Y. J., Kwak, T. S., Bae, W. B.(2000). Finite Element Analysis on Effect of Die Clearance on Shear Planes in Fine Blanking, Trans. Mater. Process, 9(2) 152-158.

[6] Kim, G. T.(2013). A Study on Edge Bridge Minimization of Fine Blanking Process, Journal of the Korean Society of Manufacturing Technology, 12(4), 108-113.

[7] Bahn, G. S., Suh, E. K., Lee, G. H., Mo, C. K.(2004). A Study on the Characteristics for the Blanking of Lead Frame with the Nickel Alloy, Journal of the Korean Society of Machine Tool Engineers, 13(6), 87-93.

[8] Lee, I. K., Lee, S. Y., Lee, S. K., Jeong, M. S., Seo, P. K., Lee, K. H., Kim, B. M.(2015). Prediction of Shearing Die Life for Producing a Retainer using FE Analysis, Trans. Mater. Process, 24(4) 264-271.

[9] Yoo, C. K., Won, S. T.(2015). A Study of the Shearing Force as a Function Trim Punch Shape and Shearing Angle, Trans. Mater. Process, 24(2) 77-82.

[10] Choi, H. S., Lim, W. S., Kang, C. G., Kim, B. M.(2011). A Local Softening Method for Reducing Die Load and Increasing Service Life in Trimming of Hot Stamped Part, Trans. Mater. Process, 20(6) 427-431.

[11] Yoo, J. H., Rhim, S. H., Oh, S. I.(2003). A Study on Shear Behavior of Metal in Micro Hole Punching Process, Trans. Mater. Process, 12(4) 314-319.

[12] Park, D. H., Kwon, H. H.(2015). Development of the Compound Die Forming Technology United between Semi-Progressive and Transfer Die, Journal of the Korean Society of Manufacturing Process Engineers, 14(4), 126-133.

[13] Yoon, I. C., Ko, T. J., C. L, Kim, H. S., Park, D. H.(2009). Small Electrode Ring Forming by Multi-Forming Process, Journal of the Korean Society of Manufacturing Process Engineers, 8(3), 38-45.