Experimental Validation of Cutting Edge Quality for Blanking Process Modelled by Ls-Dyna – Introducing A Novel Burr Free Technology (BFT)

K.H. Boey, M.R.Muhamad, Sivaraos

ABSTRACT: An experimental validation was established to evaluate the cutting edge by Burr Free Technology (BFT) implemented on the blanking tool design. The output of the BFT is presented in this paper with the optimized tool design factors. The combination of the conventional positive tool-die clearance and the negative tool-die clearance was introduced in this BFT tool design to derive the predicted experimental results. The sequences of the entire BFT concept was introduced in this paper. The BFT tool design with lower punch protrusion of 0.700mm and the combination of the positive punch-die clearance for upper punch and lower die and the negative punch-die clearance for lower punch and upper die respectively concluded the most optimized results.

KEYWORDS: Burr Free Technology (BFT); LS-Dyna; Negative punch-die clearance; Positive punch-die clearance; Punch penetration (pp) value.

1. INTRODUCTION

The challenges on precision metal stamping parts of its process cost competitiveness, productivity and shorter lead time requirements strongly navigate the needs to eliminate the cost of secondary process namely - burr removal. Burr is the surplus residue of the sheet metal cutting operation. There are extensive studies on minimizing the burr condition as they are very costly to be fully eliminated even by employing various high end secondary de-burring processes.

Revised Manuscript Received on June 01, 2019.

K.H. Boey, ***Solid Precision Engineering Sdn Bhd, Kedah, Malaysia.***

M. R. Muhamad, Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka (UTeM).

Sivaraos, Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka (UTeM).

Therefore, the ability to produce a burr-free metal stamped part in-one-go, especially in stamping process of thin sheet metal exhibit much advantages in manufacturing process optimization and improvement of cutting edges quality both aesthetically, safety handling and enhancing reliability of the tiny mating parts on micro-electro-mechanical system (MEMS) assembly. The effect of the sheared edge quality in relation to clearances between punch and die, the blank holder force and punch and die radius have been extensively revealed [1-3].

Series of finite element analysis (FEA) by commercial code LS-Dyna was performed on the blanking process for JIS G3313 SECC grade of work material with the thickness of 1.000mm. The concluded baseline model details [4] were used as a foundation for the development of BFT blanking tool. The BFT blanking tool structure as in Figure 1 consist primarily with a pair of well-designed and nominated punch and die.

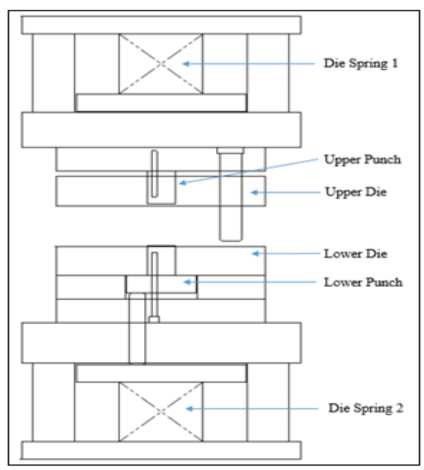

Figure 1: BFT Tool design structure

Published By:
Blue Eyes Intelligence Engineering & Sciences Publication

Retrieval Number: A00230681S519/19©BEIESP

1.0 BURR FREE TECHNOLOGY BLANKING TOOL (BFT)

The numerical and experimental validation on the blanking process was concluded that, a set of punch and die with designated clearance is able to generate set of die roll (DR) at the nearside of punch penetration. The formation of smooth shear zone (SSZ) and the ductile fracture initiation and eventually propagated to the opposed surface until the workpiece was completely sheared. Conventionally, the punch is always smaller in the offset geometry to the die opening so that during the metal separation operation such as blanking, both of these tool components, the punch and die will not collide. This interference gap between the punch and die opening is known as punch-die clearance. Commonly, most of the blanking tools in the metal stamping industries are designed based on positive clearance concept [5].

Figure 2 summarized both the numerical and experimental results for the blanking process which found by our previous work [4]. As noted on Figure 3, the compressive load of 5kN needed to overcome the elastic force of the work material for the formation of die roll (DR) of 0.145mm. The compressive load increases as the punch further descending into the die ring until the peak of 25kN was recorded where the punch displaced to the region between 0.800 to 0.880mm. This peak denotes the ultimate tensile strength of the work material. Subsequently, the compressive load experiencing a sharp drops as the fracture phase initiated on the sheared edge of the work piece.

Parameter	Numerical Simulation	Experimental Result	Delta %
Die Roll	0.142	0.145	2.20%
SSZ	0.626	0.683	9.20%

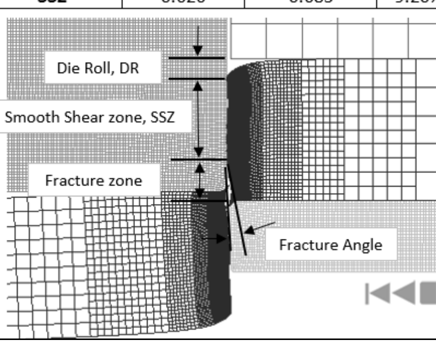

Figure 2: Results comparison

Figure 3 shows the blanking load profile established during the experimental studies which derived set of useful information for the BFT blanking tool design and development. The establishment of the test requirement and procedures are conducted in an ambient temperature, validated and reviewed to establish best practices to support the accuracy of the data captured [6].

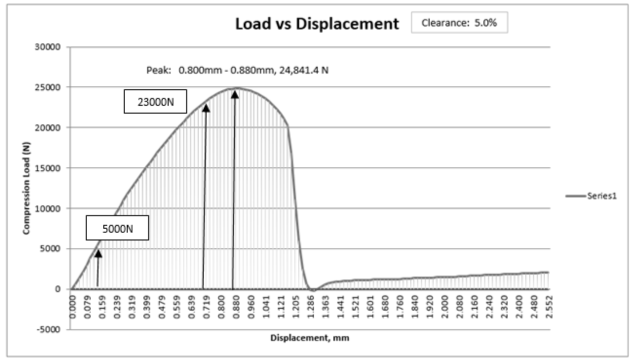

Figure 3: Blanking load profile

2. BFT BLANKING PROCESS DETAILS

The lower punch was protruded by 0.700mm (pp=0.7) from the die plate surface level as noted in Figure 4(a). The pp value was set with the reference on the numerical and experimental results that fracture initiation starts at 0.818mm and 0.839mm respectively [4]. The objective is to derive a smooth shear zone (SSZ) before the fracture being initiated so as to have sufficient on remaining blank thickness to be blanked by the counter shearing action. The blank holder pushes down the work material towards the die plate as the upper die set descending due to the press ram cycle. The blank holder load was set to 5kN by properly used of the right numbers and type of mechanical die springs which noted as die spring 1. As noted from the Figure 3, the load for 0.700mm punch penetration was 23kN. Therefore, the lower punch was supported by a set of mechanical die spring with the combined load of 25.4kN.

Retrieval Number: A00230681S519/19©BEIESP

Published By:
Blue Eyes Intelligence Engineering & Sciences Publication

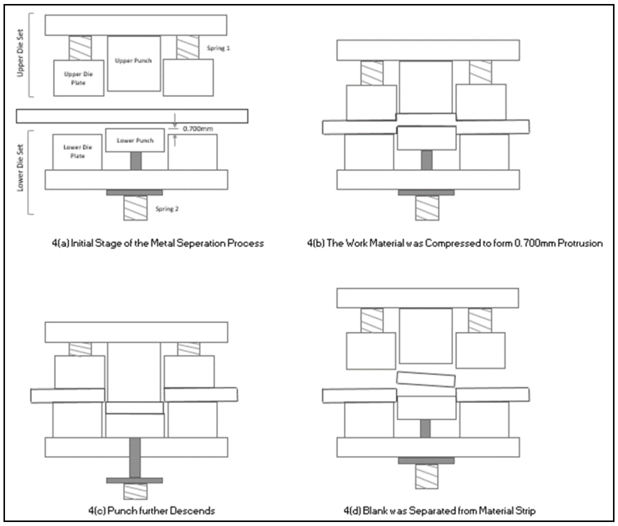

Figure 4: Process sequences (4a, 4b, 4c & 4d)

The lower punch load sheared the work material to the depth of 0.700mm where the portion of the work material was pushed into the upper die plate as illustrated in Figure 4(b). The lower punch and the upper die were designed on negative clearance concept. The negative clearance was considered important and essential as noted from the preliminary numerical and experimental trials where the fracture propagated toward the punch corner. Therefore, in order for the fracture to meet the endpoint of smooth shear zone, the lower punch has to be on negative clearance in relevance to the upper die. The descending power press ram has caused the upper punch to push the partially sheared blank to the opposed direction as illustrated in Figure 4(c).

The combined load on spring 2 was overcome by the power press tonnage (110 tones). After the complete mechanical crank cycle of the power press, the upper die set was ascending to the initial position from the dead bottom cycle of the press ram. At this stage, the blank was perfectly ejected from the work material strip by the restored action of spring 2 as illustrated in Figure 4(d). The entire cycle of the BFT blanking process was a resultant effect of the shear localization and strain concentration [7].

3. FINDINGS

The fracture initiated at 0.828mm from the origin work material surface of the punch penetration. Figure 5 shows that the fracture angle of approximately 80 degree inclined towards the punch corner [8].

Therefore, in the BFT blanking tool design, the lower punch was designed to protrude 0.700mm (pp=0.7) which was also set at a point just before the fracture initiated [9]. Referring to Figure 1, the upper die spring (die spring 1) for the upper punch was set at 5kN and the total die spring load (die spring 2) set for the lower punch was finalized at 25.4kN which is equivalent to the used of two heavy load type with the Ø60mm brown code mechanical die springs. The selection of the lower die spring must be able to accommodate the required deflection ratio during the blanking process [10].

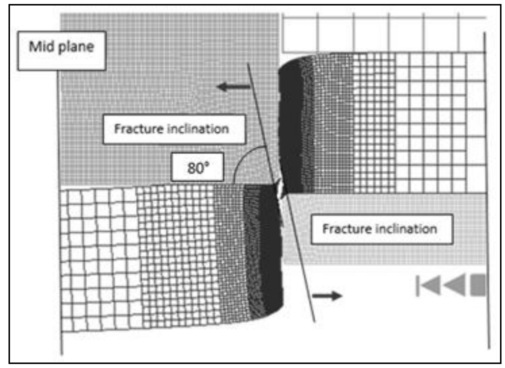

Figure 5: Full punch penetration phase

Figure 6 shows the set of experimental tool used in the burr-free blanking. The upper die set consist a set of upper punch and upper die while the lower die set consist of a set of lower punch and lower die. The blanking tool was mounted onto the 110 tones C-frame air clutched Power Press to perform the burr-free blanking operation. The upper punch and lower die were designed with the positive punch-die clearance of 5% and the lower punch and upper die was designed with the negative punch-die clearance of 5%.

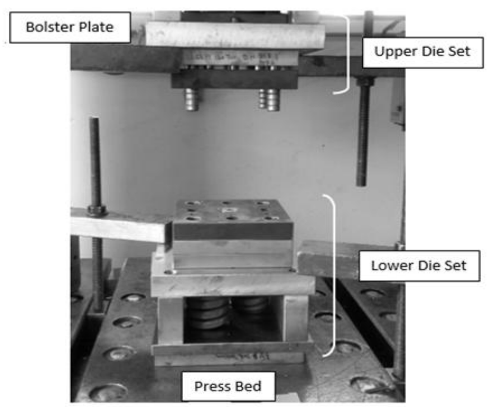

Figure 6: Experimental BFT blanking tool

Published By:
Blue Eyes Intelligence Engineering & Sciences Publication

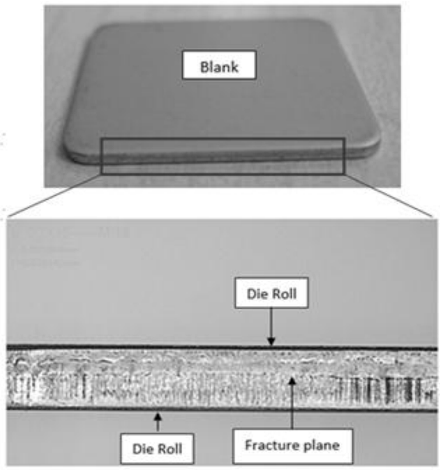

Figure 7: Burr-free blank

The resultant of the blanking process by BFT blanking tool, a burr-free blank was successfully achieved. Figure 7 postulates the output of the burr-free blank. The presence of die rolls (DR_1 and DR_2) as shown in Figure 8 and Figure 9 on both of the surfaces of the blank signifies the absence of burr edge which usually presence of the conventional blanking or any metal separation processes on the oppose side of the punch direction. The fracture zone was sandwiched between the two smooth shear zones (SSZ1 and SSZ2) which were derived by the designated set of upper and lower punch and die. Figure 8 shows the 79X magnified view of the sheared edge of the burr free blank. This is the optimum results from a series of trial with lower punch protrusion (pp) values of 0.700mm. Punch protrusion value lower than 0.700mm does not promise a good results. Severe galling observed on the fracture zone and smooth shear zones (SSZ_1 and SSZ_2) were reduced on the trial result by setting the pp value of 0.500mm. The galling effect results in poor edge quality and workpiece dimensional instability.

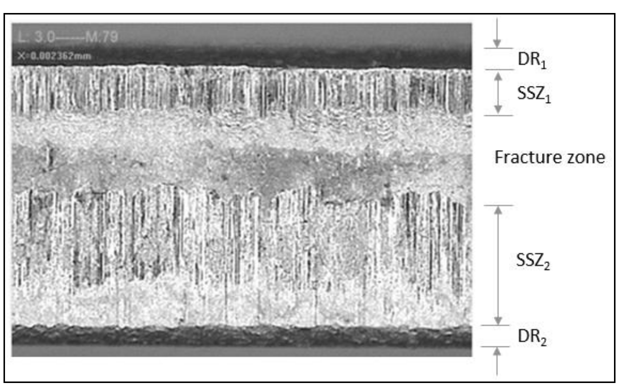

Figure 8: Burr-free blank edge on pp=0.7 (magnified 79X)

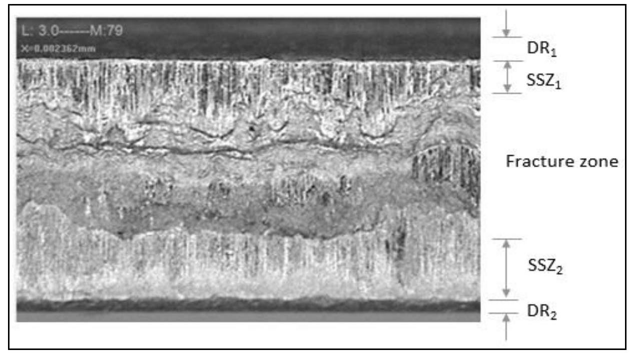

Figure 9: Burr-free blank edge on pp=0.5 (magnified 79X)

4. CONCLUSION

The design of punch protruding 0.700mm from the lower die plate (pp=0.7) generated the most desirable results and edge quality of the burr-free blank. The fracture zone was sandwiched by both the smooth shear zones (SSZ) from both the upper and lower planes of the sheared edges. Figure 8 shows the condition of the die roll of almost equal parameters were observed on both the upper and the lower surfaces of the blank. This signifies the successful experimental outcomes of meeting the burr-free objective; which was to derive the optimum condition on the burr-free edge finishing. The present of these die rolls (DR_1 and DR_2) eliminated the formation of burr edge, therefore burr-free blank was successfully derived. The higher the requirement on the edge quality, the greater will the part cost to produce. Therefore, burr-free technology eliminates all these factors in order to call for higher edge quality on blanking parts with a controlled manufacturing cost. The developed burr-free technology on blanking tool provides greater advantages over a wide span in the future map of green manufacturing in precision metal stamping industries.

ACKNOWLEDGMENT

This research was carried out at Solid Precision Engineering Pte. Ltd. Special thank is extended to engineering staffs for their assistance rendered towards the entire phase of the experiment. This acknowledgement is also extended to the Academic Supervisors from UTeM and MOHE for the scholarship of myPhD.

REFERENCES

[1] A., Totre, R., Nishad and S. Bodke, 2013, An overview of factors affecting in blanking processes, International Journal of Emerging Technology and Advanced Engineering 3(3), p.p. 390-395.

[2] Shakeel, P.M., Tolba, A., Al-Makhadmeh, Zafer Al-Makhadmeh, Mustafa Musa Jaber, "Automatic detection of lung cancer from biomedical data set using discrete AdaBoost optimized

Published By:
Blue Eyes Intelligence Engineering & Sciences Publication

ensemble learning generalized neural networks", Neural Computing and Applications,2019,pp1-14.https://doi.org/10.1007/s00521-018-03972-2

[3] Farzin, M, Javani,H.R., Mashayekhi, M and Hambli,R, 2006, Analaysis of blanking process using various damage criteria, Journal of Materials Processing Technology 177, p.p. 287-290.

[4] Boey, K.H., Muhamad, M.R, Sivarao, S, Effect of Pressure Pad Load on Die Roll Formation on Part and Material Strip in Blanking Processes, Proceedings of the International Symposium on Research in Innovation and Sustainability 2014, UTEM, Melaka-15-16 October 2014.

[5] Panwala, Fenil C., R. Kumar, and P. Mohamed Shakeel. "An analysis of bacteria separation and filtration from blood sample using passive methods." Measurement (2019).https://doi.org/10.1016/j.measurement.2019.02.037

[6] Wood, P.K.C, Schley, C.A., Strain Rate Testing of Metallic Materials and Their Modelling for Use in CAE based Automotive Crash Simulation Tools, 1st ed., UK, iSmithers.

[7] Kai, W., Lars, G. and Tomasz, W., 2015, FE Simulation of edge fracture considering pre-damage from blanking process, International Journal of Solids and Structures 71, p.p. 206-218.

[8] Shakeel PM, Baskar S, Dhulipala VS, Jaber MM., "Cloud based framework for diagnosis of diabetes mellitus using K-means clustering", Health information science and systems, 2018 Dec 1;6(1):16.https://doi.org/10.1007/s13755-018-0054-0

[9] J, Manuel,Xavier, F and Manuel, F, 2010, Theoretical and numerical issues on ductile failure prediction-An Overview, Computer Methods in Material Science 10(4), p.p. 279-293.

[10] Subramonian, S, Atlan, T, Campbell, C, Ciocirlan, B, 2013. Optimum selection of variable punch-die clearance to improve tool life in blanking non-symmetric shapes. International Journal of Machine Tools and Manufacture, 75, pp.63 - 71.

Retrieval Number: A00230681S519/19©BEIESP

Published By:
Blue Eyes Intelligence Engineering & Sciences Publication