Jurnal Teknologi

Full Paper

SPRINGBACK EFFECT OF AUTOMOTIVE LOWER ARM COMPONENT PREPARED VIA BURRING PROCESSING

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Article history
Received
14 January 2015
Received in revised form
28 April 2015
Accepted
09 June 2015

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Graphical abstract

Abstract

Complex components of the sheet metal forming process need to be designed with high precision and accuracy in order to prevent defects and misalignment of the end products. One of the sheet metal cool stamping process for these complex automotive components is burring which is the forming of a flange around a hole made in a piece of sheet metal. Springback is a common defect during the burring process. The aims of this paper are to investigate the springback effect and improve shape accuracy of hole burring by inner burring process of lower arm part for automotive lower arm part. The springback defects at hole burring usually happened on the inner burring process. Experimental stretch flanging for cold stamping process of inner burring process was used to investigate the reasons of springback effect around the burred hole for a lower arm part of high strength steel (HSS) sheets SPFH590. From the two designs of burring punch dies, the result shows the values of springback effect for clearance -0.15 which have a big gap at hole burring A arm and B arm diameters, are larger than clearance -0.34 which have small gap for inner burring process of lower arm part. The experimental analysis shows that springback is proportionally related to the punch-die clearance parameter of the tool profile where the springback increase as the clearance increases.

Keywords: Burring process, cool stamping process, springback, part lower arm, experimental

1.0 INTRODUCTION

The automotive manufacturers are competing and striving to improve and increase their production of automotive components through the reduction of production costs in line with technological innovations. At the same time, automotive manufacturers are continuously researching and developing ways to reduce the weight in order to improve fuel efficiency while improving the crashworthiness of the vehicles. Therefore, the application of High Strength Steel (HSS) is increasing in the automotive industry, due to the demand of lightweight construction, in order to improve fuel economy[1]. Lightweight materials of HSS such as SPFH590 are now being used in modern automotive structure due to their best combination of metallurgical and physical properties. However, one of the major constraints in forming HSS is the occurrence of high springback caused by elastic relaxation after loading, which causes illness-fitting in part assembly and geometric deviation of the intended design [2].

The springback deformation of sheet metal parts is the natural result of a sequence of deformation experienced in metal forming processes. As the sheet

metal slides over a die shoulder, it undergoes bending-unbending deformation developing cyclic bending loads on the sheet sections, and as a result an unbalanced stress distribution is developed over the thickness [3]. It will affect the parts finishing shape. Many researcher have studied the influence of the process parameters on the springback phenomenon in sheet metal forming process through experimental and numerical analysis [4, 5]. X. K Zhang *et al.* [6] studied on predictive compensation factor method to predict the factors influencing springback on fortified B-pillar using experimental and numerical simulation. Kanghwan Ahn *et al.* [7] evaluated the macro-performance of the automotive TWIP sheet in conjunction with springback using experimental and numerical method where the sheet mechanical properties were characterized.

However, there have been very few studies on correlation between springback effect and clearance parameter of punch and die in hole burring by inner burring process of lower arm part for automotive. The clearance between punch and die in a stretch flanging (burring process) is a very important design factor that influences defect on springback at hole burring which usually happen on the inner burring process. In this paper, the lower arm hole burring part with various punch diameters was designed and investigated. High strength steel (SPFH590) is material that used for produce an automobile left and right hand (LH and RH) suspension lower arm in this study. The characteristics of springback effect on the hole burring lower arm part were analyzed by assigning various clearances to the inner burring process of products.

2.0 EXPERIMENTAL

2.1 Automotive Lower Arm Part.

This paper reports a practical industrial problem. It investigates the springback effect occurring hole burring on inner burring process at the lower arm part made using a high strength steel plate as shown in figure 1 with diameters Ø59 (-0.1/-04). The steel sheet used was manufactured by Nippon Steel & Sumitomo Metal Corporation and supplied by the Bright Steel Sdn. Bhd related to steel (JIS-SPFH590) and the data chemical composition and mechanical properties of 3.6 mm thickness are shown in Table 1 and Table 2.

Figure 1 Hole burring of inner burring process at lower arm part

Table 1 Chemical composition of SPFH590 (in wt. %)

Element	C %	Mn %	P %	S %
Bright Steel Sdn. Bhd.	0.04	1.35	0.007	0.003

Table 2 Mechanical properties of SPFH590.

Thickness [mm]	Yield Strength [MPa]	Tensile Strength [MPa]	Elongation [%]
3.6	566	618	26

2.2 Experimental Procedures.

The current operation process plan of left and right hand (LH and RH) lower arm part is as described in Table 3. This experimental work study was done by stretch flanging for cold stamping process on 500 tonne an SUMITOMO mechanical press machine which was developed by Sumitomo Heavy Industries Ltd. The process start at OP10 where the blank material will formed with forming die at the earlier stage and produce forming part of lower arm. After the forming process, the forming part of lower arm will take to the next operation OP20 at piercing die. In this piercing die, a few holes with certain diameters will piercing on the forming lower arm. After piercing a few holes, a product of lower arm will transferred to the next level OP30 where the process burring and restrike will forming. In this burring process stage, the springback happen. Springback happened at the diameter of the hole burring in operational plan OP30 after the burring punch die pull out from the hole burring die (unloaded process). The result of diameters Ø59 mm for hole burring on inner burring process at lower arm part not exceeding the manufactures standard needed. Figure 2(a) and 2(b) show the most important parameters needed to be considered to control the springback effect:

a. Punch-die clearance : considered to be (-0.15 ~ -0.34mm)
b. Punch radius (*Rp)* value : 10 mm

The 2 types of clearance assigned for the inner burring process are -0.15 and -0.34 mm. In addition, two burring punch dies were designed according to the clearance values with punch radius of 10 mm. 5 samples for each RH and LH for lower arm parts were analyzed for each clearance and vernier caliper was used to take the measurement. Each data were recorded in a standard form issued by the manufacture

Table 3 Operation process plan of lower arm part

Operation Plan	Process	Operation Plan	Process
OP10	Forming 	OP30	Burring/Restrike 
OP20	Piercing 		 Burring Punch

3.0 RESULTS AND DISCUSSION

3.1 Analysis of Springback At Lower Arm

Table 4 shows the result of analysis springback on diameters hole burring of inner burring process lower arm part which have been determined experimentally for the various punch-die clearance. From Table 4, for punch-die clearance -0.34 mm which punch-die gap is 3.26, the value for (A arm diameter) are close to the standard Ø59 where 58.806 mm in average. The difference value from the standard is 0.194 mm. Meanwhile, the value (B arm diameter) is 58.315 mm in average. The difference value is 0.685 mm from the standard diameter. Springback effect value of punch-die clearance -0.34 mm on hole burring for (A arm diameters) is 0.194 in average and for (B arm diameters) is 0.685 in average.

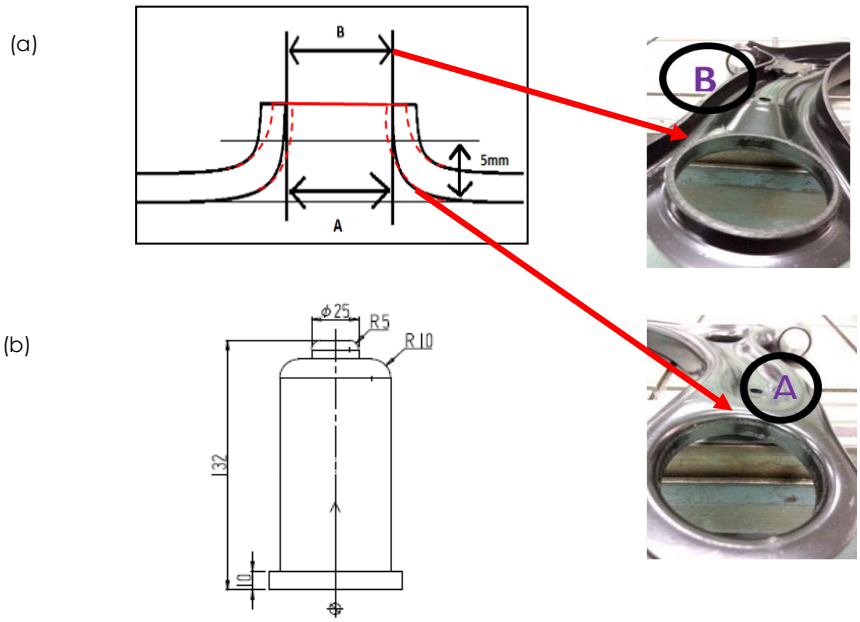

Figure 1 Springback parameters:
(a) Clearance Ø 59.0 between punch and die (-0.15 ~ -0.34)
(b) Punch radius (*Rp*) = 10mm

Table 4 Springback analysis on diameters inner burring process

Sample	Clearance : (-0.34) Punch : Ø58.50 Punch-die gap (2.26) Die : Ø63.03				Clearance : (-0.15) Punch : Ø58.13 Punch-die gap (2.45) Die : Ø63.03			
	Arm Diameter A (mm)	springback	Arm Diameter B (mm)	springback	Arm Diameter A (mm)	springback	Arm Diameter B (mm)	springback
1 RH	58.817	0.183	58.317	0.683	58.52	0.480	57.873	1.128
2 RH	58.777	0.223	58.295	0.705	58.505	0.495	57.865	1.135
3 RH	58.787	0.213	58.297	0.703	58.505	0.495	57.855	1.145
4 RH	58.782	0.218	58.255	0.745	58.465	0.535	57.873	1.128
5RH	58.775	0.225	58.277	0.723	58.52	0.480	57.895	1.105
6 LH	58.817	0.183	58.37	0.63	58.62	0.380	57.850	1.150
7 LH	58.813	0.187	58.297	0.703	58.625	0.375	57.855	1.145
8 LH	58.823	0.177	58.33	0.67	58.637	0.363	57.863	1.138
9 LH	58.840	0.160	58.345	0.655	58.632	0.368	57.865	1.135
10 LH	58.830	0.170	58.372	0.628	58.625	0.375	57.868	1.133
Average.	58.806	0.194	58.316	0.685	58.565	0.435	57.866	1.134

For punch-die clearance -0.15 mm which punch-die gap of 3.45, showed that the value for (A arm diameter) is 58.565 mm in average. It has 0.435 mm different value from standard diameter. For (B arm diameter), the value is 57.866 mm in average. It has 1.134 mm different value from standard diameter. Springback effect values of punch-die clearance -0.15 mm on hole burring for (A arm diameter) is 0.435 in average and (B arm diameter) is 1.134.

At the (A arm diameter), the diameter for hole burring with clearance -0.34 mm with smaller gap, shows much bigger result from diameter hole burring for clearance -0.15 mm with big gap, where 58.806 and 58.565 mm respectively. Meanwhile for (B arm diameter), diameters hole burring for clearance -0.34 and -0.15 are 58.316 and 57.866 mm respectively.

From the two design of burring punch dies, the result shown, the valued of springback effect for clearance -0.15 mm which have big gap, at hole burring A arm and B arm diameters, are larger than clearance -0.34 mm which have small gap for inner burring process lower arm part.

4.0 CONCLUSION

This paper has discussed the experimental result of the springback effect of punch-die for inner burring process lower arm part for high strength steel SPFH590 with 3.6 mm thickness. Base on the findings and observation made from this experimental study, the following conclusions can be drawn:

1. Springback is proportionally related to the punch-die clearance and punch radius parameter of the tool profile.
2. The springback after burring punch-die pushed out (unloaded) from the inner burring die relies on punch-die clearance which means with a larger clearance, there is a significant increase of springback value at final hole burring lower arm part.
3. Springback increases with an increase of punch-die clearance caused by the size of burring punch die. In case of small clearance, the springback will also decrease.

Acknowledgement

The authors of this paper would like to thank the Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM) Shah Alam, Ministry of Science, Technology and Innovation Malaysia for financial support under the e-Science Fund Project Grant No: 100-RMI/SF 16/6/2 (5/2014), Department of Polytechnic Education and Minister of Education Malaysia. Special thank also goes to an automobile industry in Shah Alam, Selangor for the permission and cooperation in this study and personally to Mr Azlan and Mr Zukri for their assistance.

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