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An Overview of Effect of Punch Tool Wear Radius on Burr Formation In Sheet Metal Blanking

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ABSTRACT:- *Sheet metal blanking is a widely used process in high volume production of metal component. In sheet metal blanking, quality of the blanked surface are greatly affected by process parameters such as clearance between punch-die set, punch tool geometry and properties of the work piece material as like blank thickness, mechanical properties, microstructure, etc. High volume of production at lowest possible cost is the driving potential of sheet metal industries globally. The press tool design involves optimization of tool life and the product quality parameters. The obvious wearing phenomena of press tool and development of process robustness with respect to burr formation is of technical importance. Burr formation is common sheet metal defect, which leads to rework and quality problem of blanked part. As the burr minimization is the quality issue, this paper reviews specially wear states of punching tool and its effect on sheared surface quality of blanked part with a case study on copper sheet metal by using Design Of Experiments.*

Keyword:- *Burr formation, Design Of Experiment, optimization of tool life, sheet metal blanking, press tool design, tool wear,*

I. INTRODUCTION

In sheet metal industry, blanking contributes large amount of share. To meet global quality requirement, control of blanking operations aims to improve the monitoring and control of the quality of components. Reducing manufacturing cost and increasing quality of product is motivation which forces to have reduction of reject volume, the reduction of manual quality control and the high cost of tools after failure [1]. Various experimental studies [2-3] showed that the mechanical and the geometrical aspect of the sheared edge during the blanking operation for a given material are affected by some parameters like the blanking clearance, the wear state of the tool, tool geometry, ductility of the material, blanking load, tool penetration during punching, shear strength of material and the thickness of the sheet. The errors on blanks are influenced by material, tool geometry, process parameters, machine accuracy, skill of operator.

The errors represented in fig.1 are connected to geometry of the sheared edge such as roll over depth, the fracture depth, the smooth sheared depth, the burr formation and the fracture angle. Burr minimization in sheet metal blanking is an important issue for industrialist and engineers. Tool wear is one of the reasons for burr formation, so from industrial point of view, the need for measuring the effect punching tool wear is determined on the basis of allowable burr height on the final product. Therefore based on this criterion, the analysis the shearing process must take into account tool wear influence in order to predict the quality of sheared blanked product. Various research works is done for optimization of process parameters of sheet metal blanking by using experimentation, computer simulations, numerical analysis, neural networks and algorithms. This paper reviews effect of punch tool radii on quality of sheared surface of blanked component.

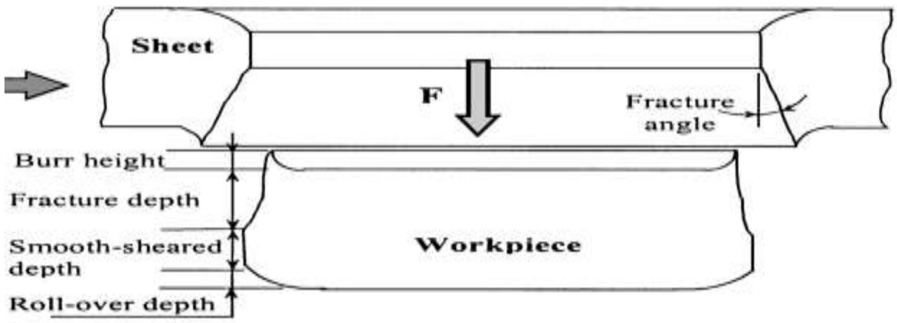

Figure 1 Geometry of sheared edge of blanked part. (Ridha Hambali, 2003)

II. LITERATURE REVIEW

Identification of tool wear influence on process parameters of sheet metal blanking includes an exhaustive literature review of various authors. For literature review research papers are collected from various research journals.

Ridha Hambali et. al [4] studied the influence of the tool wear on the punching force and on the evolution of the sheared profile was accounted for by changing the values of the edge radii of punch and die set by simulation and experimentation. The comparison between the result obtained by simulation and experimentation shows that for various states of punch wear, there is no difference between maximum blanking loads.

M. Samuel [5], have done experimental analysis by using punches and dies with different radii for sheet metal materials Al-killed cold rolled and annealed under different conditions. The experimental result shows that maximum blanking force and the punch penetration at crack initiation and load required to separate the blank from the sheet stock are sensitive to tool geometry, clearance and conditions of material such as cold rolled and annealed.

A.M. Goijaerts et al [6], shows a change in cutting radii of the tools, which shows a drastic change in punch displacement at fracture whereas a change in clearance which does not exhibit a drastic change in punch displacement.

Ridha Hambali [7], uses neural network modeling with predictive finite element approach predicts burr height of blanked parts against tool wear and punch die clearance. As the punch tool wear changes punch – die geometry and clearance, the process of shearing and the form of the sheared surface are influenced. In addition, tool wear has adverse effect on the dimensional accuracy and surface finish of the product. Tool wear increases the time and cost required during production. The author proposed finite element method coupled with Artificial Neural network can be used in order contribute toward the development of a system for the online assessment of burr height evolution during blanking process.

Felix Faura et al. [8], applies computer graphical interface named DSS (Decision support System) has been developed allowing decision makers to compare, justify and evaluate different alternatives in a friendly environment..DSS helps to take decision on tool life for number of blanking operations. This system provides a useful addition to the facility planner’s toolkit and interesting application of the DSS approach in new area.

Miguel Vaz Jr et al [9] presents a general framework for numerical simulation of blanking process using finite elements. The work discusses some computational issues on modeling blanking process and investigates the effect of clearances between the punch and die in the stress distribution during the penetration stage of the cutting process. Smaller clearance produces high compressive stress near the punch tip whereas on the other hand, larger clearance caused greater tensile radial stress over an extensive region on at the lower face of the metal blank and relatively smaller compressive stress near the punch tip. The high stress near the punch tip, promotes excessive tool wear after successive cutting operation.

E. Falconnet [10], his work presents a combination of finite element simulations of copper alloy thin sheet blanking and a wear algorithm based on Archard formulation for abrasive wear of the punch. Firstly, a tribometer has been specifically designed to measure wear coefficient, and punch worn profiles have been extracted by means of a double-print method. Secondly, the blanking process has been simulated through the finite element method by using an elasto-plastic constitutive model and the shear failure model. Thirdly, a wear algorithm has been programmed using experimental wear data and mechanical fields computed from blanking simulation. Then, a damage criterion, namely the shear failure model, has been calibrated by an original method based on stress triaxiality analysis and shear height value measured from blanked edge profile. Finally, punch wear predictions have been discussed and compared to experimental results.

R. Hambli et al [11], investigated the blanking process using tools with four different wear states, four different clearances and studied the effects of the interaction between the clearances, the wear states of the tool and sheet metal thickness on the evolution of the blanking force and the geometry of the sheared surface. In this investigation, it is assumed that the clearance is optimum when the direction of crack propagation coincides with the line joining the points of crack initiation in the punch and die, giving cleanly blanked surfaces without secondary crack formation. In this case, the total separation of the sheet is obtained for a lower value of punch penetration. If the cracks generated by the punch and die do not coincide, the formation of secondary cracks exists.

Soumya Subramonian [12], Finite Element Modeling of the blanking process along with experimental testing is used in this study to study the influence of various process parameters on punch and die life and blanked edge quality. Parameters like punch-die clearance, punch corner radius, application of stripper pressure and blanking velocity affect the blanked edge quality. As punches and dies wear, the punch-die clearance and punch corner radius increase, causing the blanked edge quality to deteriorate by increasing the rollover and burr.

H.Y. Chan et al. [13], highlighted few observations that die clearance and material properties are the most influential process/design parameters that may cause to the formation of burr. Present discoveries on development of a method of producing burr-free technology using counter blanking process gives hope but the mechanism is still difficult to be used for mass production at lower cost.

III. EXPERIMENTATION

From the literature review the blanking process parameters which are predominant are enlisted are die punch clearance, tool wear radius, sheet metal thickness, and material type. While, less influencing parameters are material properties, micro-structural inconsistency and geometric conditions of blanking (such as shape, sheet metal internal defects and internal stresses), friction, stroke rate or blanking speed, and punch-die alignment. Experimental investigation into the blanking process was carried out using punches with different wear states.

Experimentation is conducted on mechanical press of 10 Tonne capacity. Punches of appropriate diameters with wear radius are designed to achieve different clearances. The following readings are taken for Copper sheet with different clearances and thickness. The numbers of replications are five for each experiment and readings are taken of each blank at five different positions by rotating the blank and average of that is taken as the burr height reading of that blank. In all tests, the burr height was measured with precision digital height gauge having least count 0.001 mm. The nature of the problem is “Smaller-the-Better”, as burr height is not a desirable feature. Process parameters and their levels for experimentation is shown in Table 1.

Table 1 Levels of process parameters

Parameters	Levels of parameters		
	Level 1	Level 2	Level 3
Sheet Thickness (mm)	0.8	1.2	1.5
Clearance (%)	5	10	15
Tool wear radius (mm)	0.01	0.15	0.3

To meet intended objectives, Taguchi method by using Minitab software 17 is used for this study and collected experimental data is shown in Table 2 for which L-9 array is used.

Table 2 Experimental data for Copper Sheet

Sheet Thickness	Clearance	Wear Radius	Mean of 5 readings of burr height	SNRA
0.8	5	0.01	0.0836	21.55587
0.8	10	0.15	0.2796	11.06677
0.8	15	0.3	0.6239	4.096865
1.2	5	0.15	0.2158	13.31736
1.2	10	0.3	0.5460	5.255193
1.2	15	0.01	0.2637	11.57714
1.5	5	0.3	0.3625	8.813361
1.5	10	0.01	0.1018	19.84163
1.5	15	0.15	0.3598	8.877328

IV. RESULT AND DISCUSSION

4.1 Analysis of Variance (ANOVA).

The main aim of ANOVA is to investigate the design parameters and to indicate which parameters are significantly affecting the output parameters.

Table 3: ANOVA result for burr height for Copper sheet					
Parameter	Degree of freedom (DOF)	Sum of Squares (S)	Mean Sq.	F-Ratio (F)	P-Value (P)
Sheet Thickness	2	0.007623	0.003812	6.50	0.133
Clearance	2	0.057315	0.028657	48.86	0.020
Wear radius	2	0.199697	0.099848	170.24	0.006
Error	2	0.001173	0.000587		
Total	8	0.265808			
Model summary **S= 0.0242182, R-Sq=99.56%, R-Sq(adj)=98.23%**					

Table -4: Response Table for mean for burr height for Copper			
Level	Sheet Thickness A	Clearance B	Wear C
1	0.3291	0.2207	0.1497
2	0.3419	0.3092	0.2851
3	0.2747	0.4158	0.5108
Delta	0.0671	0.1952	0.3611
Rank	3	2	1

Table- 5: Response Table for S/N ratio for burr height for Copper sheet			
Level	Sheet Thickness A	Clearance B	Wear C
1	12.240	14.562	17.658
2	10.050	12.055	11.087
3	12.511	8.184	6.055
Delta	2.461	6.378	11.603
Rank	3	2	1

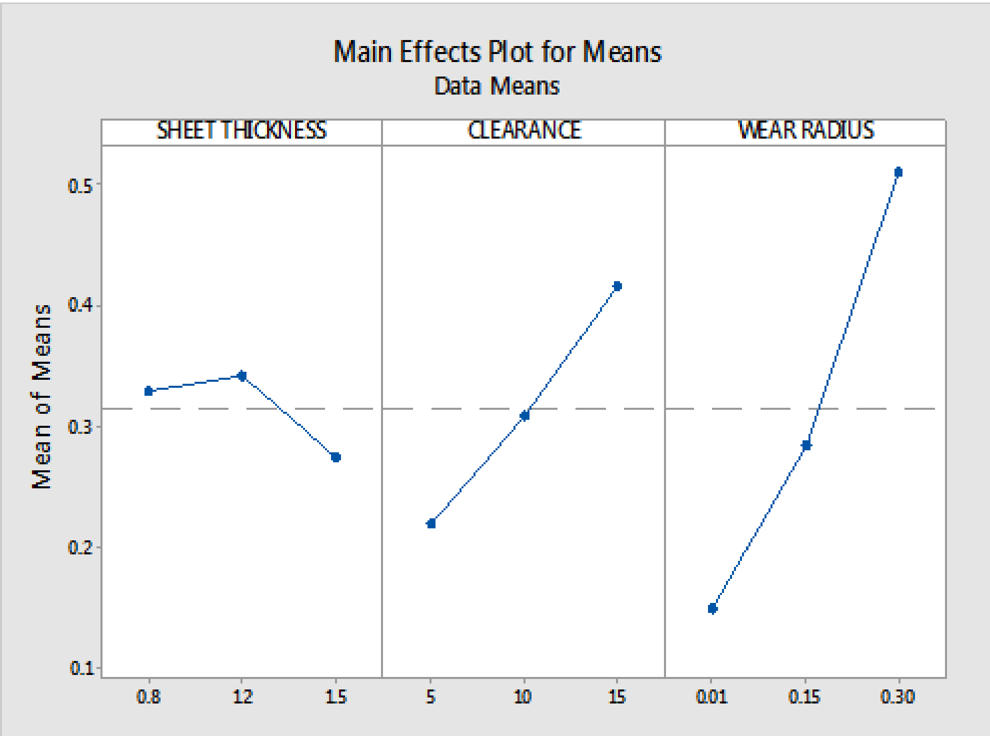

Figure -2: Graph of main effects of mean for copper sheet

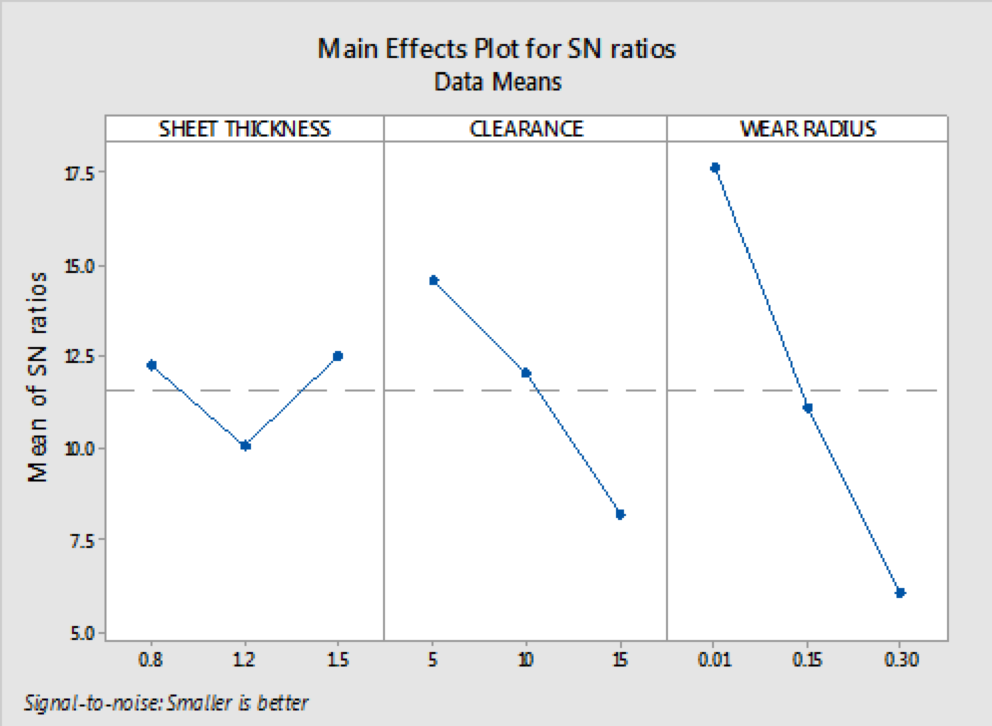

Figure- 2: Graph of main effects of S/N ratio for copper sheet

The result of ANOVA table for burr height is presented in Table 3. Statistically, larger F – value indicates that the variation of the process parameter makes a big change on the performance. According to this analysis, the most effective parameter with respect to burr height is wear radius and then clearance. The P-values test the statistical significance of each of the factors. It is observed from the above ANOVA table, there are two P-values are less than 0.05, these two factors that is wear radius and clearance have a statistically significant effect on burr height at the 98.23% confidence level.

From Table 4 and 5, from ranking it is concluded that wear radius of tool is most influencing parameter on burr height in sheet metal blanking. From figure 2 and figure 3 optimum process parameters for minimum burr height are thickness = 1.5 mm, clearance = 5% of sheet thickness and wear radius of tool = 0.01mm.

V. CONCLUSION

From case study it can be conclude that burr formation in sheet metal blanking is greatly affected by wear radius. As wear radius increases burr height also increases, so to have quality blanking product wear radius should be minimum.

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