Optimization of Die Design Parameters in Blanking Operation Using Genetic Algorithm

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Abstract *- In the blanking operation, the quality of the product and the tool life is mainly depends upon the punch and die clearance. The main objective of the study is to improve the quality of the product and also the tool life by optimizing the punch and die clearance and sheet thickness. The quality of the product and tool life mainly depends upon the punch and die clearance. If the punch and die clearance is too large leads to large burrs and poor quality, otherwise the clearance is too small results in part with poor edge quality, reduce the tool life and leads to more frequent tool component replacement. By using optimal amount of die clearance, the shear cracks join; this balances the punching force and optimizes part quality and tool life. By getting the optimal amount the optimization is used; in that genetic algorithm is a simple but powerful tool to get the optimal clearance value. This experimentation is carried out with the help of regression equation and genetic algorithm is used to optimize the punch and die clearance.*

Keywords: *Blanking, Punch and Die clearance, Optimization, Genetic algorithm.*

I.INTRODUCTION

Blanking is a process in which the punch removes a portion of material from the larger piece or a strip of sheet metal. The small removed piece is the useful part and the rest is scrap, the operation is called blanking. Blanking is a common sheet metal manufacturing process used in the production from the range of small components to high strength materials. The sheet range from the 0.2-20mm thickness can be used for the applications.

In blanking, punch and die clearance is the important factor to give the better quality of the product and improve the tool life. The Fig.1 shows the effect of excessive and insufficient clearance that affects the quality of the product. If the punch and die clearance is too large leads to large burrs and poor quality, otherwise the clearance is too small results in part with poor edge quality, reduce the tool life and leads to more frequent tool component replacement.

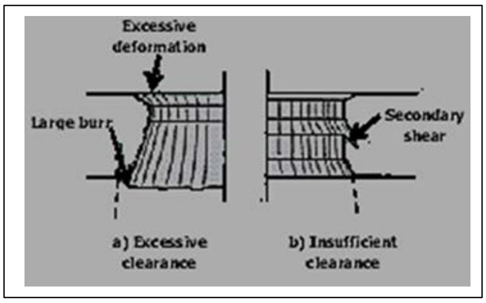

Fig.1. Effect of clearance on output product

II.LITERATURE REVIEW

The literature review indicates that many studies have been conducted to understand the effect of punch and die clearance on tool life and the quantity of the part.

Emad-Al-Momani et al [1], investigates the effect of potential parameters for two identical products manufactured from two different materials (ST 12 and stainless steel) blanked with a reasonable quality on the same mold. They use Design of Experiments (DOE) technique by selecting the experimental levels for each selected factor, i.e. the clearance to be in five levels (5, 10, 15, 20, 25) % of the sheet metal thickness, blank holder force to be in two levels (0, 3000N) and sheet metal thickness to be in four levels (0.5, 0.6, 0.7, 0.8) mm. Perform a factorial experimental design in order to take high-level interactions. As the result, in order to minimize the burrs height, the clearance should be set at about 2% with almost no blank force.

Pankaj G.Dhoble et al [2], determines the optimal parameters such as sheet thickness, clearance and wear radius in blanking to find out the variations in three performance characteristics such as burr height, accuracy and circularity value of the medium carbon steel. For that they conduct the experiment using the Taguchi's Grey Relational Analysis. With the help of L-9 half factorial method, determines the burr height using the parameters like thickness, clearance and wear radius. As the result, the wear of punch and the dies should be reduced for increasing the life of punching dies.

R.Hambli [3], study the effects of the interaction between the clearance, wear state of the tool and the sheet thickness on the evolution of blanking force and the geometry of the sheared profile using the Design of Experiment. An experiment was carried out using tools with four different wear states (wear radius 0.01, 0.06, 0.012, 0.2 mm) and four different clearances (5%, 10%, 15%, 20%). As a result, in order to minimize the blanking force, the clearance should be set at 10%; however, to minimize the fracture angle and the fracture depth, it is preferable to set the clearance at 5%. When the clearance is set at 10%, the process is slightly more robust to tool wear, as far as the blanking force response is concerned.

T.Z.Quazi et al [4], determines the influence of tool clearance, sheet thickness, and sheet material thus optimizing clearance which affects other process parameters. The experimental investigation was carried out by the three different clearances (5%, 10%, and 15%) with

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three different thicknesses (0.8mm, 1.2mm, 2mm) and with the two different materials (Aluminum, Brass). The tool used for determining the blanking process optimization was Design of Experiments (DOE) approach by Taguchi method. The authors can take the experimental data's for nine values to determine the optimum results. As a result of this experiment investigation shows that, in order to minimize the burr height, the clearance should be set at above 5% with almost no blank holder force.

Soumya Subramonian et al [5], studied the influence of punch-die-clearance on the non-symmetric shapes. Due to the non-symmetric shapes the variable punch-die-clearance is to be used. Experiments were conducted using the plastic at thickness of 0.25mm and 0.8mm. The material of the punch is AISI D2, corner radius is 0.0127mm, and the clearance is varied from the 5% to 20%, because they uses variable punch-die-clearance. The main aim is to improve the tool life by minimizing the tool wear. The tool wear is monitored by the Finite Element Method. And also they compare effects of the uniform clearance and the variable clearance. As a result, punch-die-clearance variables at the contour of a part gives a more uniform punch stress and hence punch wear, thereby improving punch life considerably.

III.Objective

The main objective of the present study is to illustrate how to

- Improve the tool life,
- Improve the quality of the product,
- Reduce the burr height.

by selecting the optimal punch-die-clearance using the genetic algorithm.

IV.Methodology

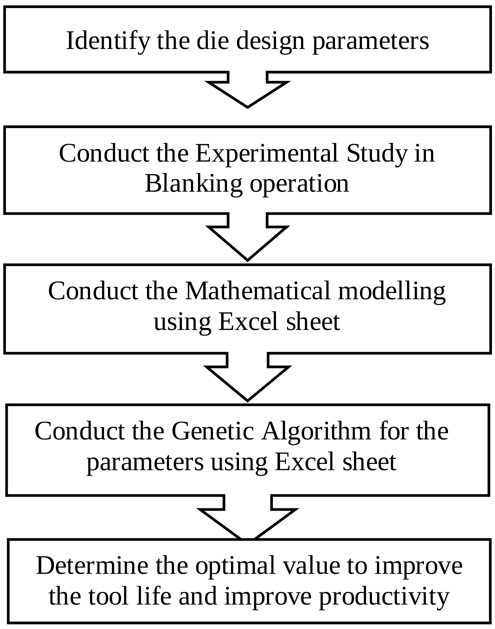

Fig.2. Methodology of the study

V.Materials Selected & Their Chemical Composition

There are two materials are used for this study. They are:

- AISI 1020 (Low Carbon Steel-cold rolled)
- AISI 304 (Stainless Steel)

TABLE: I CHEMICAL COMPOSITION OF AISI 1020 AND AISI 304

1. AISI 1020

Element	Carbon	Manganese	Sulfur	Phosphorus
Weight %	0.23	0.60	0.04	0.05

2. AISI 304

Element	Carbon	Manganese	Sulfur	Phosphorus
Weight %	0.08	0.75	0.03	0.05

VI.Experimental Result

TABLE: II EXPERIMENTAL RESULT

Sheet Thickness (mm)	Punch and die clearance (mm)	AISI 1020		AISI 304	
		Tool life (No. of Strokes)	Burr Height (mm)	Tool life (No. of Strokes)	Burr Height (mm)
0.5	0.025	120000	0.060	135000	0.08
0.5	0.10	300000	0.040	170000	0.05
0.5	0.22	345000	0.080	240000	010
1.0	0.025	130000	0.09	228000	0.01
1.0	0.10	204000	0.05	385000	0.03
1.0	0.22	224000	0.18	400000	0.12
1.5	0.025	185000	0.12	46000	0.06
1.5	0.10	400000	0.10	200000	0.12
1.5	0.22	480000	0.20	350000	0.18

VII.Mathematical Modeling

Multiple regression analysis is used in the mathematical modeling. The multiple regression analysis is used in the ***Microsoft Excel 2010***. Multiple regression analysis is a powerful technique used for predicting the unknown value of a variable from the known value of two or more variables.

In general, the multiple regression equation (1) of Y on X_1, X_2, …, X_k is given by:

$$\boldsymbol{Y = b_0 + b_1 X_1 + b_2 X_2 + \ldots\ldots\ldots\ldots\ldots\ldots + b_k X_k} \quad (1)$$

Multiple regression analysis is used when one is interested in predicting a continuous dependent variable from a number of independent variables. If dependent variable is dichotomous, then logistic regression should be used.

	Coeff	Std. Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-0.01968	0.03	-0.54	0.59	-175336	278439.7
Sheet Thickness	0.08	0.02	2.74	0.23	-84736	284736.9
Punch and die clearance	0.364341	0.14	2.45	0.04	50335	1928476

VIII. Multiple Regression Outputs

A. Material: AISI 1020

- *PARAMETER: Tool Life*

	Coeff	Std. Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	51551.6	92724	0.55	0.59	-175336	278439
Sheet Thickness	100000	75497	1.32	0.23	-84736	284736
Punch and die clearance	989405.7	383777	2.57	0.04	50335	1928476

Multiple Regression equation for the material AISI 1020 (2) is

$$Y_{TL1} = 51551.68+100000*X1+989405.7*X2 \quad (2)$$

Where,

X1 = sheet thickness;

X2 = Punch &die clearance

TABLE: III REGRESSION OUTPUT FOR THE PARAMETER TOOL LIFE

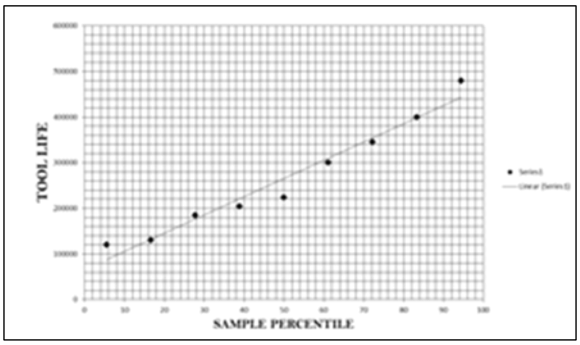

Fig.3. Normal Probability Plot for the parameter tool life

- *PARAMETER: Burr Height*

Multiple Regression equation for the material AISI 1020 (3) is

$$YBH1 = -0.01968+0.08*X1+0.364341*X2 \quad (3)$$

Where,

X1 = sheet thickness;

X2 = Punch &die clearance

TABLE: IV REGRESSION OUTPUT FOR THE PARAMETER BURR HEIGHT

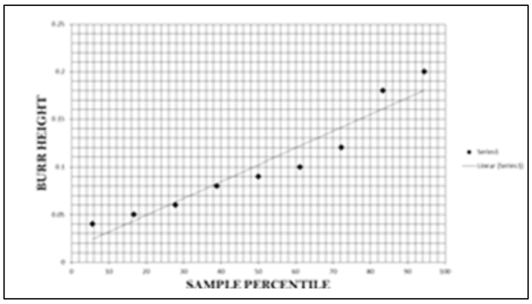

Fig.4. Normal Probability Plot for the parameter burr height

B. Material: AISI 304

- *PARAMETER: Tool Life*

Multiple Regression equation for the material AISI 1020 (4) is

$$YTL2 = 111761+17000*X1+961498.7*X2 \quad (4)$$

Where,

X1 = sheet thickness;
X2 = Punch &die clearance

TABLE: V REGRESSION OUTPUT FOR THE PARAMETER TOOL LIFE

	Coeff	Std. Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	51551.6	92724	0.55	0.59	-175336	278439.7
Sheet Thickness	100000	75497	1.32	0.23	-84736	284736.9
Punch and die clearance	989405.7	383777	2.57	0.04	50335	1928476

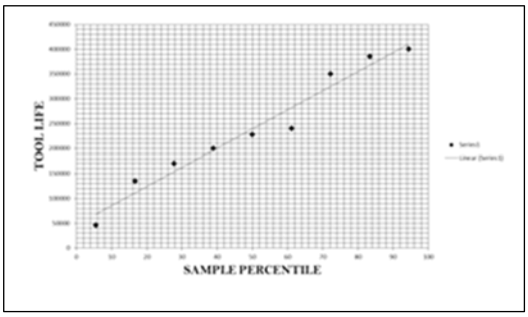

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Fig.5. Normal Probability Plot for the parameter tool life

- *PARAMETER: Burr Height*

Multiple Regression equation for the material AISI 1020 (5) is

TABLE: VI REGRESSION OUTPUT FOR THE PARAMETER BURR HEIGHT

	Coeff	Std. Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-0.01052	0.03	-0.28	0.78	-0.10	0.08
Sheet Thickness	0.043333	0.03	1.43	0.20	-0.03	0.11
Punch and die clearance	0.439276	0.15	2.86	0.02	0.06	0.81

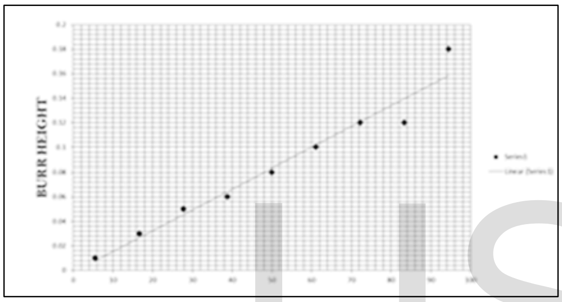

Fig.6. Normal Probability Plot for the parameter burr height

IX. Genetic Algorithm

The Quality of the product is mainly depends upon the proper clearance and reduction of burr height, and productivity is mainly depends upon the tool life, often changing the tool indirectly affects productivity. The main objective of the study is to maximize the tool life and minimize the burr height.

To achieve this Genetic Algorithm is used. Mostly authors select the software as MATLAB or GA related software's to find out the optimal value, but in this study, the software used is MICROSOFT EXCEL 2010 in that the add-on called SolveXL is used to find the optimal value.

X. Experimental Procedure

Step: 1 .Select the No. of Objective. (Multi-objective)

Step: 2. Select the population size. (N=50)

Step: 3. Set the Cross over Rate. (CR=0.95)

Step: 4. Set the Mutation Rate. (MR=0.05)

Step: 5. Set the Upper bound. (X_1=1.50, X_2 = 0.22)

Step: 6. Set the Lower bound (X_1=0.50, X_2=0.03)

YBH2 = -0.01052+0.043333*X1+0.439276*X2 (5)

Where,

X1 = sheet thickness;

X2 = Punch &die clearance

Step: 7. Set the Objective Type (Max or Min)

The experiment is carried out in the software EXCEL 2010 with the Add-on called SolveXL; it is especially for the Genetic Algorithm with less cost compared to other Genetic Algorithm software's.

Fig.7. Selection of No. of objective in Solve XL

Fig.8. Selection of Objective type

Fig.9. Set the Lower and Upper bounds

Material	Sheet thickness (mm)	Punch and die clearance (mm)	Tool life (No. of Strokes)	Burr height (mm)
AISI 1020	0.5	0.032	131233.851	0.03125023
AISI 304	0.5	0.025	144298.4675	0.0221284

Fig.10. Cross over ratio selection

XI.Experimental Results

The experimental results shows that the material AISI 1020 have 0.5mm thickness with the 0.032 punch and die clearance gives that the improvement in tool life as 131233.851 strokes and reduce the burr height as 0.03 mm from the experimental study. For the, material AISI 304 have 0.5mm thickness with the 0.025 punch and die clearance gives that the improvement in tool life as 144298.4675strokes and reduce the burr height as 0.02mm. Thus the AISI 304 have better Tool life and less Burr height compared to AISI 1020. The optimal value is, the parameters in the AISI 304 material is to be selected. The Table VII shows the optimal values for the both the materials taken for the study.

TABLE: VII Optimal Values for the Both Materials

XII.Conclusion

In blanking, the tool life is an important factor for improve the productivity and improvent in quality, and also burr height is to optimal value to improve the quality of the product. Thus these two parameters are taken for the study and kept the objective as the Maximization of Tool life and Minization of Burr height. Thus the output shows to attain the objective of this study. The tool life and the burr height is mainly depends upon the sheet thickness as well as the punch and die clearance, it directly relates to the improvements in productivity and tool life.

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