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Optimization of Blanking Parameters for AISI 1018, A 653, AISI 304 Using Genetic Algorithm

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Abstract:
The blanking process and structure of the blanked surfaces are mainly affected by the sheet thickness, material properties, clearance and punch stroke. In this study, we introduce blanking parameters on shear zone and burr height. The objective of the work is maximizing shear zone length and minimizes burr height of the blanked part. Blanking process is subjected to a variety of process parameters. In every production process quality of the part mainly depends on process parameters so parameter selection is very critical part of the process. To achieving better results proper selection of parameters is necessary. Various material coefficients and process factors affect the quality of the blanked part. The main objective of the process design in metal blanking are choose the leading process parameters in an optimal way to ensure high quality parts. Design of experiments is a tool for increasing quality of the process by eliminating causes of variation without eliminating causes. Experimentation is carried out with the help of DOE by full factorial method. The aim of the study is to examine effect of the sheet thickness and punch stroke on different materials. GA optimization technique used to optimize process parameters.

Keywords*: Blanking, Optimization, Genetic algorithm, Sheet metal*

1. Introduction

Blanking is one of the most commonly used sheet metal manufacturing processes in the industry. Having a good understanding of the fundamentals and science behind this high deformation shearing process can help to improve the blanked edge quality in various ways. The sheet metal blanking process consists in separating a blank from sheet in punch and die interface. It combines material plastic flow and ductile fracture. Given a blanking configuration defined by the blanking material, the sheet thickness, and the part shape. There are some relevant parameters like punch shape, clearance, punch stroke (punch penetration). The choice of these parameters is generally based on the empirical knowledge. Design of experiments the blanking process along with experimental testing is used in this study to study the influence of various process parameters on blanked edge quality.

2. Literature Review

Many methods are used to study the blanking process to achieve the optimal combination of its parameters. This consist of Finite Element Method [1, 3,4,7,14,]; Design of Experiment [1,2]; Analytical approaches [7,8]; and Neural Networks Modeling [9,23]. Literature shows that the mechanical characteristics of the blanking process and the geometrical aspect of the sheared edge are affected by different parameters. These parameters include clearance, wear state of the tool, tool radii and geometry, thickness of the sheet, blank geometry, or layout, material prosperities such as hardness and ductility, friction, tools surface finish or lubricant type, sheet metal coating, and stroke rate or blanking speed [5,8,9,11,12]. Hambli et al. [2] investigated the blanking process using tools with four different wear states and four different clearances and studied the effects of the interaction between the clearances, the wear state of the tool and the sheet metal thickness on the evolution of the blanking force and the geometry of the sheared profile. A review of the literature on the blanking process shows that while a large number of analytical techniques have been used to study the process, the amount of theoretical and practical work done is relatively insufficient and thus further investigation is still needed. One reason for this may be the difficulty of simulating the shearing process because of the narrowness of the shear band formed and the lack of an appropriate fracture criterion. The most recent studies in the field of manufacturing processes show that, despite the increasing progress in blanking process analysis, there is still a lack of models allowing for the optimal design of sheet metal shearing processes.

3. Process Parameters and Their Levels

In this paper, design of experiments is done by full factorial to determine the blanking process parameters and their levels. This is because the full factorial method is a systematic application of design & analysis of experiments for the purpose of designing & improving the quality at the design stage. In recent years, the full factorial method has become a powerful tool for improving productivity during research & development so that high quality products can be produced quickly and at low cost. For this experimental study we choose thee different types of materials. As the different materials have different mechanical and chemical properties. Full factorial method set 9 no. of runs for each material.

Level	Sheet thickness(mm)	Punch stroke(mm)
Low	1	30
Middle	1.5	60
High	2	90

Table 1: Parameters and their operating levels

4. Chemical Compositions of Materials

AISI 1018

Composition	Carbon	Manganese	Sulfur	Phosphorus
%	0.18	0.6	0.05	0.04

A 653

Composition	Carbon	Manganese	Sulfur	Phosphorus
%	0.3	0.75	0.05	0.04

AISI 304

Composition	Carbon	Manganese	Sulfur	Phosphorus
%	0.08	0.75	0.03	0.05

Table 2 chemical compositions of materials

5. Experimental Result

Sheet thickness	Punch stroke	Shear zone	Burr height	Shear zone	Burr height	Shear zone	Burr height
(mm)	(mm)	AISI 1018		A 653		AISI 304	
1	30	0.5	0.27	0.6	0.31	0.5	1
1	60	0.55	0.29	0.4	0.34	0.3	0.89
1	90	0.6	0.28	0.3	0.34	0.2	1.1
1.5	30	0.7	0.2	0.8	0.13	0.5	0.52
1.5	60	0.7	0.18	0.5	0.22	0.3	0.42
1.5	90	0.9	0.16	0.4	0.2	0.2	0.45
2	30	0.9	0.1	0.8	0.05	0.6	0.07
2	60	1	0.1	0.6	0.11	0.5	0.05
2	90	1	0.11	0.5	0.06	0.3	0.1

Table 3: Experimental results

6. Mathematical Modeling

Mathematical modelling is done by using Minitab 16 software. Regression analysis gives correlation between multiple inputs and outputs. Regression is a statistical measure that attempts to determine the strength of the relationship between one dependent variable and a series of other changing variables. Regression analysis is used to investigate and model the relationship between a response variable and one or more predictors. It generates an equation to describe the statistical relationship between one or more predictors and the response variable and to predict new observations. Regression analysis is a statistical process for estimating the relationships among variables. It includes many techniques for modelling and analysing several variables, when the focus is on the relationship between a dependent variable and one or more independent variables. More specifically, regression analysis helps one understand how the typical value of the dependent variable changes when any one of the independent variables is varied, while the other independent variables are held fixed. Most commonly, regression analysis estimates the conditional expectation of the dependent variable given the independent variables i.e. the average value of the dependent variable when the independent variables are fixed.

AISI 1018

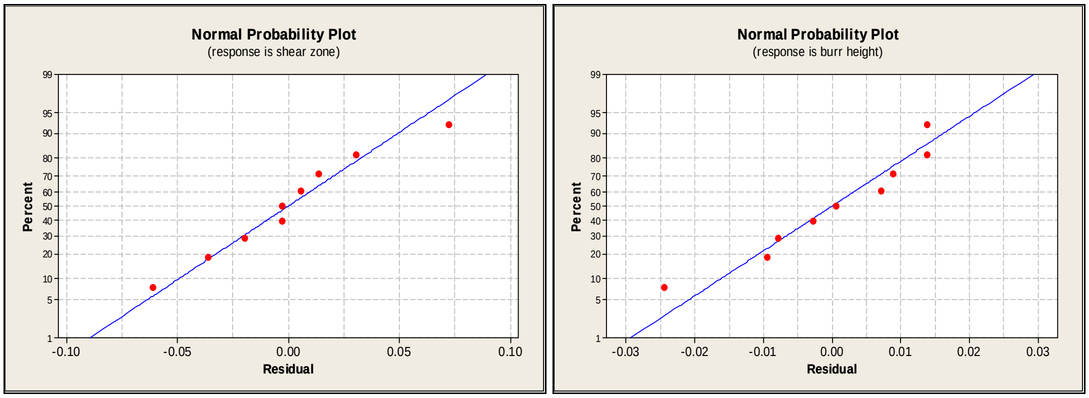

Figure 1: Normal probability plot of AISI 1018

Regression analysis
The regression equation is
Shear zone = 0.0028 + 0.417 sheet thickness + 0.00222 punch stroke

Predictor	Coef	SE Coef	T	P
Constant	0.00278	0..6695	0.04	0.968
sheet thickness	0.41667	0.03622	11.50	0.000
punch stroke	0.0022222	0.0006036	3.68	0.010
S = 0.0443576		RSq = 96.1%		RSq(adj) = 94.7%

The regression equation is
Burr height = 0.459 – 0.177 sheet thickness – 0.000111 punch stroke

Predictor	Coef	SE Coef	T	P
Constant	0.45944	0.02198	20.91	0.000
sheet thickness	-0.17667	0.01189	-14.86	0.000
punch stroke	-0.0001111	-0.0001982	-0.56	0.595
S = 0.0145615		R-Sq = 97.4%		R-Sq(adj) = 96.5%

A 653

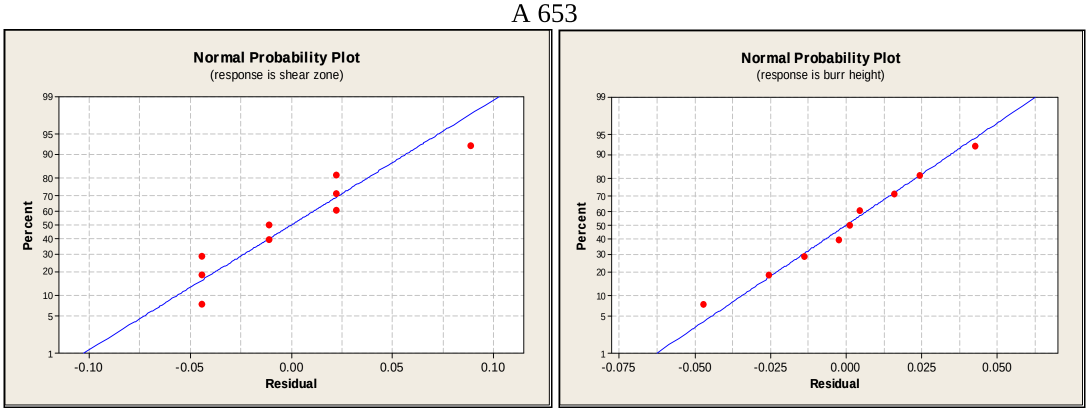

Figure 2: Normal probability plot of A653

Regression analysis
The regression equation is
Shear zone = 0.578 + 0.200 sheet thickness – 0.00556 punch stroke

Predictor	Coef	SE Coef	T	P
Constant	0.57778	0.07685	7.52	0.000
sheet thickness	0.20000	0.04157	4.81	0.003
punch stroke	-0.0055556	0.0006929	-8.02	0.000
S = 0.0509175 R		Sq = 93.6% R		Sq(adj) = 91.4%

The regression equation is
Burr height = 0.544 – 0.257 sheet thickness + 0.000611 punch stroke

Predictor	Coef	SE Coef	T	P
Constant	0.54389	0.04688	11.60	0.000
sheet thickness	-0.25667	0.02536	-10.12	0.000
punch stroke	0.0006111	-0.0004227	1.45	0.198
S = 0.0310615		R-Sq = 94.6%		R-Sq(adj) = 92.8%

AISI 304

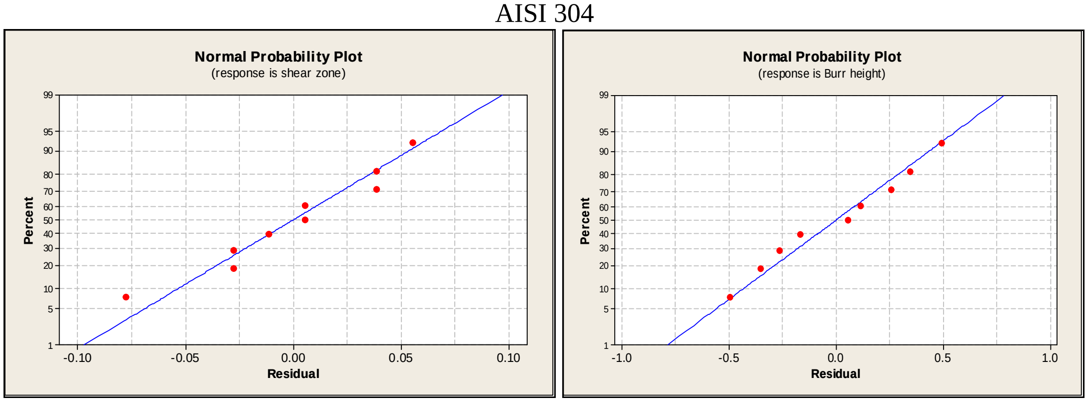

Figure 3: Normal probability plot of AISI 304

Regression analysis
The regression equation is
Shear zone = 0.478 + 0.133 sheet thickness – 0.00500 punch stroke

Predictor	Coef	SE Coef	T	P
Constant	0.47778	0.07261	6.58	0.001
sheet thickness	0.13333	0.03928	3.39	0.015
punch stroke	-0.0050000	-0.006547	-7.64	0.000
S = 0.0481125		R-Sq = 92.1%		R-Sq(adj) = 89.5%

The regression equation is
Burr height = 1.88 – 0.923 sheet thickness + 0.00033 punch stroke

Predictor	Coef	SE Coef	T	P
Constant	1.8761	0.1205	15.56	0.000
sheet thickness	-0.92333	0.06521	-14.16	0.000
punch stroke	0.000333	0.001087	0.31	0.769
S = 0.0798668		R-Sq = 97.1%		R-Sq(adj) = 90.9%

7. Genetic Algorithm Optimization

All technique has certain characteristics that describe their performances relative to the requirement. The characteristics of the blanking process are the ability to increase the height of burnished surface. Therefore, it was extremely important to investigate shear zone length in this study. For the optimization of shear zone length and burr height GA is proposed in this study. Genetic algorithms are a part of evolutionary computing, which is a rapidly growing area of artificial intelligence. Optimization of process parameters is done by Genetic Algorithm. In this work, initial population of desired size is generated randomly, for crossover and mutation, the strings are selected using reproduction operator. G.A. is usually suitable foe maximization and minimization problem by some suitable transformations. In general fitness function is first derived from the objective function and used in successive generic operations. Here objective function of shear zone to be maximized and burr height to be minimized. A genetic algorithm largely uses three basic operators i.e. Reproduction, Crossover, Mutation. The performance is influenced mainly by these two operators. Crossover and mutation are two basic operators of GA. Performance of GA very depend on them.

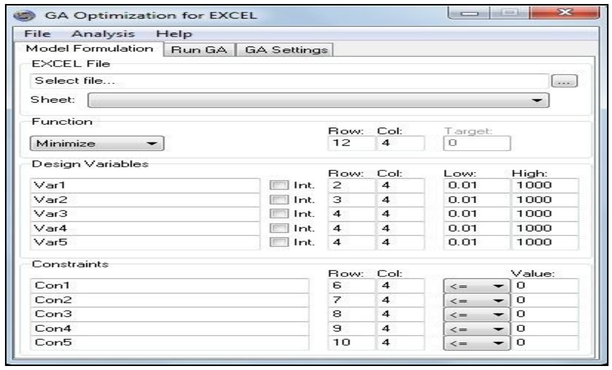

Figure 4: GA optimization model formulation

8. GA Optimised Result

MATERIAL	SHEET THICKNESS	PUNCH STROKE	SHEAR ZONE	BURR HEIGHT
AISI 1018	2	60	1	0.1
A 653	2	30	0.8	0.05
AISI 304	2	34	0.6	0.05

Table 4: Optimised Values

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