Optimization of Punching Process Parameter using RSM based on Face Center Design and Analyze Effect of Parameter on the Behavior of Stress using ANOVA

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Abstract— The objective of this research is simulate the punching process parameters and to do analysis of all the parameters, to find out the most effective among all three selected parameter thickness, hardening exponent, punch tool velocity on the behavior of equivalent stress and strain on a punching product are analyzed using DOE based RSM,& ANOVA and give a model equation which can shows the effecting parameters or the value which effects the punching process or by which there is deformation or change in the mechanical properties of the process and the parameters which effecting the quality of the sheet comes out from the punching process parameters. The whole research can be performed to improve the quality of the process parameters or to improve the quality of the product also.

Key words: Sheet metal SS303, Parameters, DOE based Response Surface Methodology, ANOVA

I. Introduction

Sheet metal forming process like punching, blanking, stamping and bending are commonly used in the manufacturing of sheet metal parts and it takes the combination of different process to manufacturing sheet metal parts. During punching process thickness of sheet, punching tool velocity, hardening exponent of the sheet metal, friction between punch tool and sheet metal, punch force etc. greatly influence the formability of SS303 material for manufacturing of washer.

Hence it is very necessary to determine the degree of influence of process parameter on the punching in order to optimize appropriate condition to maximize the product quality and minimize stress and strain on output product. MOHAMED ACHOURI et al. (2014), analysis of micromechanical damage in the punching process for High-Strength Low-Alloy steels by analysis result obtained as decrease in the stress concentration at the cutting edge of the tools, and therefore improves their operational lives. MIN KUK CHOI et al. (2014) studied the effect of the punch speed on the amount of spring back in U-bending of auto-body SPCC and DP780 steel sheets from an experimental and numerical. U-bending tests and finite element analysis techniques has been used to evaluate spring back evaluation at different punch speeds with the geometry adopted from the NUMISHEET ’93 benchmark problem. Results revealed that the amount of spring back of SPCC decreases but that of DP780 increases as the punch speed increases that means the amount of spring back of DP780 is larger than that of SPCC.MICHAEL KRINNINGER et al. (2016) investigated influence of different bending parameters on the spring back and the flat length of bending components. A parameter study has been implemented with two steel materials. The impact of the different parameters has been worked out. The influence of the punch velocity should not be neglected in the design process of bending tools, otherwise the required dimensional accuracy cannot be realized. The results of the study have been used as supporting points for a metamodel, which has been validated through further experiments. VADITAKE SUKHADEO SATOBA et al. (2016) studied wearing phenomena of press tool and development of process robustness with respect to burr formation, DOE techniques were used for optimization of all three parameter sheet thickness, clearance, and tool wear radios for burr formation in sheet metal blanking. As result concluded that wear radius of tool is most influencing parameter on burr height in sheet metal blanking.

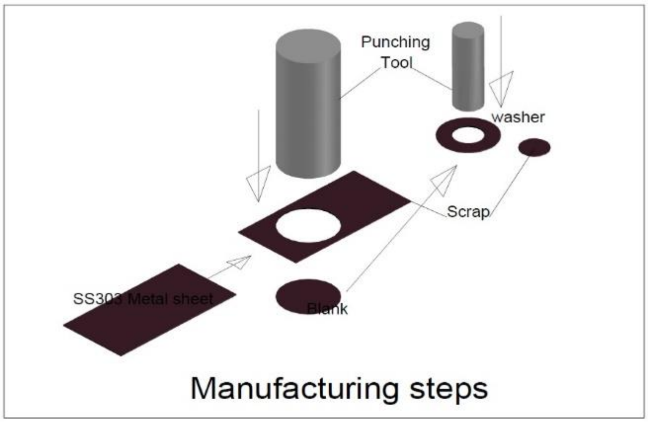

Fig. 1: Manufacturing Steps

R. SHAIKH et al., (2013) investigate the effect of potential parameters, influencing the blanking process and their interactions. Designs of experiments (DOE) approach by Taguchi method is used to evaluate the influence of tool clearance, sheet thickness and sheet material thus optimizing clearance which affects other process parameters. This investigation shows that, in order to minimize the burrs height, the clearance should be set at about 5 % with almost no blank holder force. This research work is to determine the degree of influence of each of the process parameter on the behavior of stress during punching operation on sheet using ,based on Response surface methodology and ANOVA techniques was adopted.

II. Methodology

The behavior of stress on a sheet metal work depends upon the process parameter such as thickness, mechanical property of material, punch velocity, die-punch clearance, blank temperature etc. For this research work only three parameter thickness of sheet metal, hardening exponent of sheet, velocity of punch, are chosen to evaluate the most affecting parameter.

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The material used for present investigation is SS303.The major alloying element are .15C, 2Mn, 1Si, .20P, .15S, 18Cr, 9Ni, remaining is ferrous.SS303 is one of the most popular material, SS303 offers good strength, corrosion resistance and high machinability.

In this research Design of experiment (DOE) is created for three factor for its three different levels of each factor (thickness, hardening exponent and velocity), no of replicates used is one and center points are three, and plan is created through response surface methodology (RSM) based on central composite face centered method. Conventional experimental design methods are too complex and expensive. A large number of experiments have to be carried out to study the process. By using these parameter and there levels the complete table of 20 experiment are generated.

The steps involved are:

1) Understand the response function and the process parameter.
2) Determination of the number of levels for the process parameters and possible interaction between them.
3) Development a methodology for optimization of all parameter using RSM based on Face center design and analyze all the effect of punching parameter, Thickness, Hardening exponent, Punch tool velocity using ANOVA for equivalent stress and strain.
4) Understand the effect of all parameter using contour plots on behavior of stress on the product.
5) Establish a relation between thicknesses (work piece), hardening exponent (work piece), and punch tools velocity for achieving uniform stress on the output product.

The present work is on identification of process parameters namely sheet metal thickness, hardening exponent and punching velocity and also to determine the role played by these parameters on the stress on the washer SS303. Table 1 shows the chosen process parameters with their levels used in analysis.

Factors	Name	Low	Medium	High
A	Thickness (mm)	0.2	0.5	0.8
B	Hardening Exponent	0.30	0.35	0.40
C	Velocity (m/s)	150	175	200

Table 1: Process Parameter and there levels for the Punching of SS303 material

By using these parameter and there levels the complete table of 20 experiment are generated through response surface methodology based on central composite face centered method by using Minitab software 17 and to find out equivalent stress for each experiment as shown in table (2).

S.NO	Thickness	Hardening Exponent	Velocity	Stress (MPA)
1	0.8	0.30	200	967.16
2	0.5	0.35	175	1150.00
3	0.8	0.40	150	1342.80
4	0.2	0.30	150	735.47
5	0.5	0.35	200	1158.40
6	0.8	0.40	200	1361.60
7	0.8	0.35	175	1145.20
8	0.5	0.35	175	1150.00
9	0.2	0.40	200	834.80
10	0.5	0.35	175	1150.00
11	0.2	0.40	150	802.53
12	0.5	0.35	175	1150.00
13	0.8	0.30	150	963.54
14	0.5	0.40	175	1360.20
15	0.5	0.30	175	969.20
16	.2	.35	175	616.71
17	0.5	0.35	175	1150.00
18	0.2	0.30	200	510.34
19	0.5	0.35	150	1140.2
20	0.5	0.35	175	11500.00

Table 2: Design of experiment table for the Punching of SS303 material

III. RESULT AND DISCUSSION

A. Analysis Of Variance (ANOVA)

ANOVA analysis is one of the easy forms to show impact of each factor combination and identify which factor are most influent and plot visualize. ANOVA analysis is also helpful in simultaneous hypothesis test to determine if any of the effect are significant.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	9	1055539	117282	69.23	0.000
Linear	3	764545	254848	150.43	0.000
Thickness	1	520045	520045	306.97	0.000
Hardening Exponent	1	242182	242182	142.95	0.000
Velocity	1	2318	2318	1.37	0.269
Square	3	257656	85885	50.70	0.000
Thickness*Thickness	1	175670	175670	103.69	0.000
Hardening expo* Hardening exponent	1	2643	2643	1.56	0.240
Velocity*Velocity	1	669	669	0.40	0.544
2-Way interaction	3	33338	11113	6.56	0.010
Thickness*Hardening exponent	1	18258	18258	10.78	0.008
Thickness*Velocity	1	5793	5793	3.42	0.094
Hardening exponent* velocity	1	9287	9287	5.48	0.041
Error	10	16941	1694		
Lack of Fit	5	16941	3388		
Pure Error	5	0	0		
Total	19	1072481			

Table 3: Result from ANOAVA analysis for equivalent stress

S	R-sq.	R-sq.(adj.)	R-sq.(pred)
41.1600	98.42%	97.00%	77.35%

Table 4: Model Summery

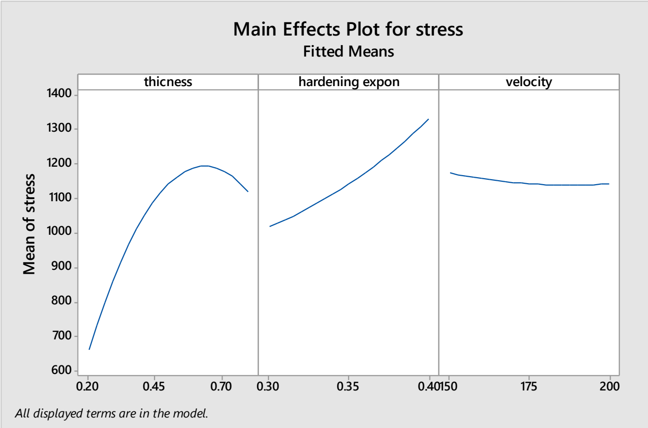

Fig. 2: Result Generated From Main Effect Plot for Stress

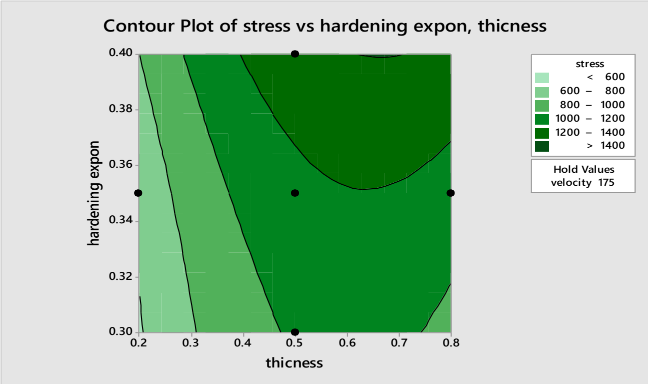

Fig. 3: Contour Plot for Stress/S Hardening Exponent, Thickness

The result of ANOVA table for stress is presented in table 3.satastically, larger the value F-value indicates that the variation of process parameter makes a big chance on the performance. According to this analysis, the most effective parameter with stress is thickness and the mechanical properties of the sheet hardening exponent. The P-Value test spastically significance of each of the factor. It is observed from above ANOVA table, there two P-value are less than 0.05, and these two factor is thickness and hardening exponent have a statistically significant effect on stress 97% confidence level. From fig 2&3 optimum process parameter for minimum stress are thickness .5mm, hardening exponent .34 and velocity 175m/s.

IV. Conclusion

The optimization of punching process parameter were conducted and conclude that in stress punching process is greatly affected by sheet thickness, as thickness increase stress are simultaneously increase up to 0.5mm after that it decrees. So to have quality blanking sheet of the thickness should be above .5mm.

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