Numerical investigation of the process parameters' effect in the deep drawing simulation using the Taguchi method

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Introduction

The present study describes simulation modeling of the deep drawing process using the finite element method (FEM). Three significant process parameters, coefficient of friction (cof), punch nose radius, and punch forces, are used to investigate the impact of the stress results on the workpiece.

Workpiece Material for Simulation Method

The annealed 5182 aluminum alloy was used during the FEM simulation of deep drawing process. Chemical composition is given in the Table 1. The blank thickness was chosen as 0.96 mm for each simulation model and 0.2 mesh size was generated.

Table 1 Chemical composition of 5182 aluminium alloy

Al (%)	Mg (%)	Mn (%)	Fe (%)	Zn (%)	Si (%)(	Cu (%)	Cr (%)
95.2	4-5.00	0.35 max	0.35 max	0.25 max	0.20 max	0.15 max	0.1 max

Design of Experiment for Simulation

Taguchi method with L9 (3 ^ 3) was conducted to provide reduced variance for the with optimum control parameters setting.

Table 2 Control parameters and their levels

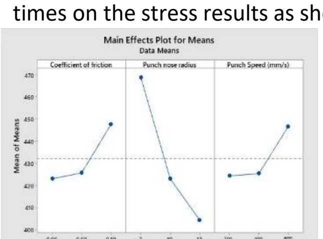
Symbol	Main control parameters	Unit	Level 1	Level 2	Level 3
A	Coefficient of friction	-	0.06	0.08	0.1
Rp	Punch nose radius	mm	7	10	13
V	Punch speed	mm/s	200	400	600

Table 3 Input parameters and Max. stress results in the simulations

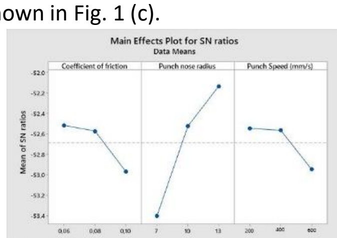
Trial number	Coefficient of friction	Punch nose Radius (mm)	Punch Speed (mm/s)	Max. Stress (MPa)
1	0.06	7	200	445
2	0.06	10	400	422
3	0.06	13	600	402
4	0.08	7	400	448
5	0.08	10	600	424
6	0.08	13	200	405
7	0.10	7	600	514
8	0.10	10	200	423
9	0.10	13	400	406

Main Effect Plots

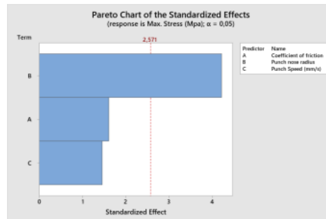
The main effect plots are indicated in Figure 1 for the deep drawing process simulation of 5182 aluminum alloy. It is observed that the punch nose radius has a dominant influence factor compared to cof and punch speed. Stress increases considerably with the punch nose radius sample because of increasing the strain rate. The Pareto chart indicates that punch nose radius significant effect statistically more than two times on the stress results as shown in Fig. 1 (c).



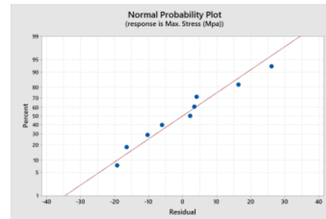
(A)



(B)



(C)



(D)

Fig. 1. (A) Main effect plots for the max. Von Mises stress in deep drawing process (B) Interaction effect for the max. Von Mises stress (C) Pareto Chart effects on max. Stress and (D) Normal probability plot

Regression Equation

The developed multi-linear regression for the max. Stress (Mpa) result:

SNRA1 = -52,689 + 0,169 A1+ 0,115 A2- 0,284A3- 0,716Rp1 + 0,162 Rp2+ 0,554 Rp3 + 0,141 V1+ 0,121 V2- 0,262 V3

Finite Element Results

2D Shell-wire axisymmetric analytic process was performed

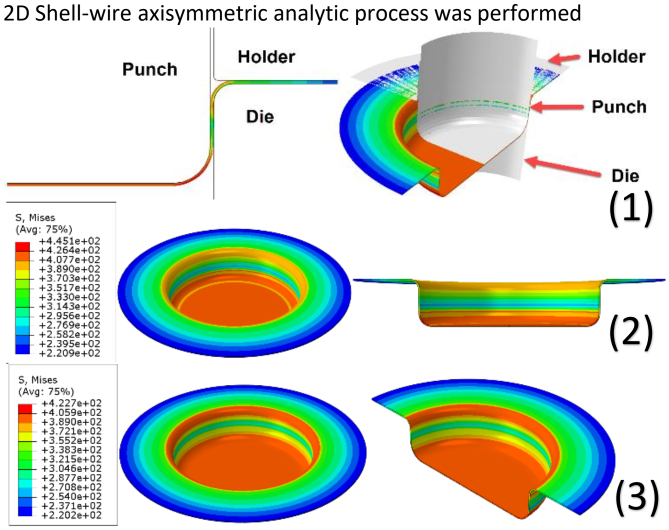


Fig. 3. (1) Process view, (2) Von Mises stress results of Trial number 1, (3) Von Mises stress results of Trial number 2 simulation

Conclusions

The following conclusions were drawn from this study:

1. The punch nose radius is the predominant factor on the stress results, followed by cof and punch speed parameters.
2. The minimum stress results was found as 402 MPa. With trial number 3 process simulation.
3. The max. stress results was obtained as 514 MPa with 0.1 cof, 10 mm punch nose Radius and 600 mm/s punch speed rate when performing deep drawing simulation of 5182 aluminum alloy. It is predicted that this process will be fracture due to the high stress.
4. The max. maximum stress are occurred on the Radius section and bottom side of the plates after the forming process.

References

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