International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 03, March-2015

Optimization of Process Parameters for Developing Stresses in Square Cup by Incremental Sheet Metal (ISM) Technique uses Finite Element Methods

Neeraj Kumar Sharma
Department of Mechanical Engineering
Rajasthan Institute of Engineering & Technology,
Jaipur, Rajasthan, India

Sharad Shrivastava
Department of Mechanical Engineering
Rajasthan institute of Engineering & technology,
Jaipur, Rajasthan, India

Pawan Whig
Rajasthan institute of Engineering & Technology,
Jaipur, Rajasthan, India

***Abstract* - For producing the complex three dimensional part without using the specific tooling for this incremental sheet forming process is best process. in the incremental forming process the process id done without the help of die. So it's also called dieless forming process. by helping this we produce the low volume production in a better manner and economically. In this the movement of the tool is main component of the process. By helping the movement of the tool we get the maximum forming limit with respect to conventional machining process. in this study we consider the effect of tool diameter, punch velocity, thickness etc. on developing the stresses in the material. This all work done with the help of Fem methods.**

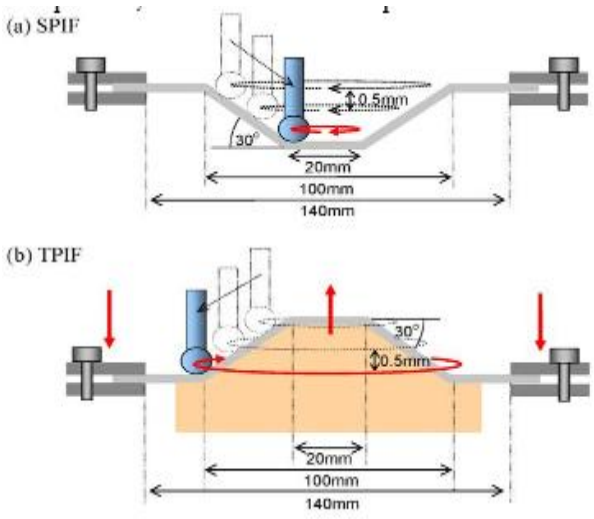
Keywords: Incremental forming; forming strategy; Finite Element Methods, Anova Analysis, D.O.E

INTRODUCTION

In the conventional machining process we need tooling for object due to this cost will be increase. Due to this factor along the increasing in demand with respect to variety. So we need very flexible manufacturing system for completing all tasks with minimum cost and time. So all the researcher developed a low cost forming process called as incremental sheet metal forming process. It's also called die less forming process. This process is best suitable for small production.

The incremental sheet forming divided into two categories: Single point incremental forming process and two points incremental forming process. The single point incremental forming process further divide in two part first called positive and other is called negative forming process.

In the TPF, sheet metal also move vertically on bearing, in the direction of z means the move on sheet metals post. This process called TPF because in this two contact point between tool and the sheet. The first point where forming tool presses down on the sheet metal to cause locally plastic deformation. The second point is a contacting point between a static post and the sheet creating when the tool pressed into the sheet. Although TPIF process used a partial die, it is often called as dieless forming.



LITERATURE REVIEW

According to J. León, D. Salcedo et al [1] ISF method may be open in the field of sheet metal forming process, but regularly in asymmetric incremental deformation process. Many type of studies has been done out on the influence of different parameters in the process. Some publisher explains the influence of these parameters using design of experiments by finite element. Different parameters (design factors) have been selected, their influence on several study variables (response variables) has been evaluated through the use of both design of experiments and FEM simulations. As design factors, the following of them have been selected: the sheet thickness, the friction coefficient, the tool radius and the number of turns for the tool modeling.

Researcher name as Y. Fang and B. Lu et al [2], they detailed a methodical representation for SPIF process to develop a mechanism known as localized deformation mechanism which is considered as both bending and strain is hardening. Their result is used to clarify the stress which is developing in deformation zone. According to the result we know that the deformation occurs not only in the contact resign but also the neighboring wall. The product also reveals that in between the transitional zone and the contact area along with formed wall there is a fractured will occurred. So to analyze methodical result, utilize the SPIF simulation and experiment result.

DESIGN OF EXPERIMENT AND RESULT

In the incremental forming process, the product quality mostly affected by different parameter like punch velocity, tool Diameter, feed rate etc. from the last few year many researcher are study on this topic but experimental performing is very difficult. So the Design of Experiment is the best tool for getting the result in lowest time and cost. Square cup shape products using Design of experiment techniques and regression analysis to find out model equations for further use. Ansys Explicit dynamics modeling software was used for simulation purpose Main responses from this study were following, which discussed in next sections of this chapters.

ANOVA Analysis
Deformation Analysis
Forming limit Curves (FLC)

Magnitude of FEM based simulation was very high and it was not possible to show all cases in this chapter so only most critical cases and their results were discussed in this chapter, other data was given in appendix section for further study. To find most important critical factors and their responses of this study first of all ANOVA analysis was carried out in this study and discussed in following section, Minitab software was used for ANOVA and regression analysis in this study. Summary table of four factors and their four levels were shown in table 4.1.

Table 4.1 Factors and Levels for square cup

Level	Plate Thickness	Tool Diameter	Punch Velocity
1	0.25	0.50	2500
2	0.5	0.75	5000
3	0.75	1.00	7500
4	1	1.25	10000

Unit: Plate thickness, and tool diameter was in mm and velocity was in mm/sec

DESIGN OF EXPERIMENT ANALYSIS (TAGUCHI METHOD)

In this study the Taguchi method (DOE technique) was used to determine the effect of Stress due to three process parameters used as input parameters.

Table 4.2 Summary of Strain of square cup

Ex No	Plate Thickness	Tool Diameter	Punch Velocity	Stress
1	0.25	0.50	2500	476.59
2	0.25	0.75	5000	537.47
3	0.25	1.00	7500	573.39
4	0.25	1.25	10000	564.75
5	0.50	0.50	5000	566.17
6	0.50	0.75	2500	597.81
7	0.50	1.00	10000	580.64
8	0.50	1.25	7500	618.29
9	0.75	0.50	7500	424.46
10	0.75	0.75	10000	385.92
11	0.75	1.00	2500	473.15
12	0.75	1.25	5000	582.30
13	1.00	0.50	10000	543.62
14	1.00	0.75	7500	457.63
15	1.00	1.00	5000	449.01
16	1.00	1.25	2500	449.01

Signal to noise ratio was simple method to predict the effect of changing of factors according their levels to find effect on product quality. In this study only "smaller is better" was adopted as quality indicator for S/N ratio, this was done because in conventional sheet metal forming process von misses strain was less comparative ISM forming process and that's why great deformation was not achieved by conventional forming process but ISM process can achieve this deformation (FLC diagrams review, RP Effect of process parameters on formability in incremental forming of sheet metal)

Table 4.3 S/N ratio (Larger is better) for square cup

Levels	Plate Thickness	Tool Diameter	Punch Velocity
1	54.59	53.97	53.91
2	55.42	53.77	54.50
3	53.27	54.25	54.19
4	53.50	54.80	54.19
rank	1	2	3

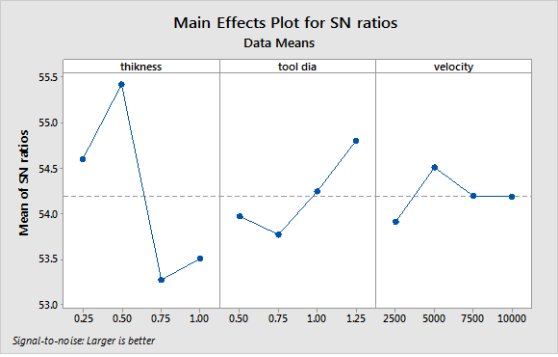


Fig. 3 S/N ratio (Larger is better) for square cup

ANOVA Analysis - The analysis of variance was calculated for square cup product and results were shown in table 4.20 respectively. In ANOVA analysis F-Test was conduct to compare a model variance with a residual variance. F value was calculated from a model mean square divided by residual mean square value. If F value was approaching to one means both variances were same, according to F value highest was best to find critical input parameter.

Table 4.4 ANOVA results for strain rate for square cup

Source	DF	Adj. SS	Adj. MS	F-Value	P-Value
Regression	3	26357.1	8785.7	2.12	0.152
Model					
Plate Thickness	1	19715.1	19715.1	4.75	0.050
Punch Velocity	1	378.1	378.1	0.09	0.768
Tool Diameter	1	6263.9	6263.9	1.51	0.243
Error	12	48819.4	4151.6		
Total	15	76176.6			

Regression Equation – In this study regression equations were also developed for square cup case for strain rate output parameter based on surface response and FEM results.

Stress = `stress = 523.2 - 125.6 thikness + 0.00174 velocity + 70.8 tool dia`

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
64.4331	34.60%	18.25%	0.00%

CONCLUSION

In the result we discuss the all the result for the Square Cup. On the basis of all result we mainly consider the best condition for developing the strain in the product for different geometry.
So the Main results are summarized as follows:

1. Best parameter combination for Square Cup were following respectively
   Case_1 best Set: **A2-B4-C2**

Table 6.2 Summary of best cases for Square Cup

A Plata thickness	B Tool Diameter	C Punch Velocity
0.50	1.25	5000

2. Signal to noise ratio predict a rank for most responsible factors for von misses strain rate are following for both design respectively

Table 6.4 the response table for S/N ratio for Square cup

Levels	Plate Thickness	Tool Diameter	Punch Velocity
1	54.59	53.97	53.91
2	55.42	53.77	54.50
3	53.27	54.25	54.19
4	53.50	54.80	54.19
rank	1	2	3

3. ANOVA results indicate that the plate thickness were most significant factors for stress developing in the Square cup.
4. A model equation for stress rate was predicted accurately with Minitab software.

REFERENCES

1. Y.H. Kim, J.J. Park, "Effect of process parameters on formability in incremental forming of sheet metal", Journal of Materials Processing Technology 130–131 (2002) 42–46.
2. Suresh Kurra, Srinivasa Prakash Regalla, "Experimental and numerical studies on formability of extra-deep drawing steel in incremental sheet metal forming", J mater res techno, 2 0 1 4; 3(2):158–171.
3. J. Leóna,*, D. Salcedoa, C. Ciáurriza, C.J. Luisa, J.P. Fuertesa, Puertasa, R. Luria, "Analysis of the influence of geometrical parameters on the mechanical properties of incremental sheet forming parts'', Procedia Engineering 63 (2013) 445 – 453.