International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 11 | Nov 2018 www.irjet.net p-ISSN: 2395-0072

Optimisation of Draw-Bead Design in Sheet Metal Forming of an Asymmetric Part Using RSM and LSDYNA

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Abstract: *Draw-bead pioneering the sheet forming process as it solely contributes for the material flow control in order to get high preciseness in parts. Proper draw-bead (in terms of its own dimension as well as from the surrounding reference i.e. die or punch holder) installation is of great importance. This work mainly shows the draw-bead design optimization in an asymmetric type of part. The vital optimization technique has been carried out by Response Surface Methodology coupled with MINITAB software solution after importing data from LS-POST (GL/GRAPH).The basic operation of the project mainly concerning to the modeling of an asymmetric part (typically a pentagon) using DYNAFORM and which is imported to LS-DYNA solver for elemental/nodal wise analysis and consequently the whole operation simulation observed by LS-POST (GL/GRAPH). Among various input parameters like groove radius of draw-bead, its distance from die cavity, length, depth and the applied and restraining forces, only draw-bead length and depth have been interactively verified and the suitable combination of duo opted in order to find the optimum value of shell thickness and mean* strain, keeping other *parameters constant. Ultimately the global shell thickness has come up to a value of 1.768mm and mean strain of 0.204 keeping length 93mm and depth 0.65mm.*

Keywords: Draw-bead, LS-DYNA, MINITAB, Mean strain, Sheet Forming Process, Shell thickness

1. INTRODUCTION

Sheet metal forming or drawing in accordance with Makinouchi [1], refers the forming of parts where plastic flow occurs over a curved axis. This is so called operation due to its starting stock is in the sheet form.

Material below the punch remains largely unaffected and becomes the bottom of the cup as per Nine[7] . The cup wall is formed by pulling the remainder of the blank inward and over the radius of the die. As the material is pulled inward the circumference decreases. Since material volume remains constant, the decrease in circumference dimension must be compensated by buckling or wrinkling.

One means of suppressing the wrinkles is to compress the sheet between the die and a blank holder surface during forming, hopefully forcing an increase in either radial length or thickness.

The variables mainly considered in consent with Levy[8] are as below,

a) the blank diameter b) the punch diameter c) the die radius d) clearance between the punch and die e) the thickness of the blank g) lubrication h) the hold down pressure.

Draw-bead is a rib like projection and mating grooves in the die and blank holder. The added force of bending and unbending provided by the draw bead restricts the flow of material and the degree of constraint can be varied by adjusting the height, shape and size of the bead and bead cavity .

2. LITERATURE SURVEY

According to Davi Sampaio Correia, Cristiene Vasconcelos Gonçalves et.al.[3], it can be inferred the analytical comparison between two optimization techniques in order to provide the maximum effectiveness in the process of GMAW optimization. Technical issue has been incorporated as comparison between Genetic Algorithm and Response Surface Methodology considering a particular case of experiment. As a whole inference, GA provides better result, over the RSM technique, in an irregular experiment region since forbidden or unreachable combinations of the factor settings can be put aside with another run of the program or in a less recommended way, by assuming undesirable values for the response in that particular region.

3. MODELING OF IRREGULAR CUP

Height of the component is 30mm. Initially the component is modeled with DYNAFORM and analyzed with LS-Dyna without the presence of draw-bead. Finally draw-bead is introduced at appropriate places and again simulated.

Tool Input Information

Unit system: mm, Sec, Ton, N

Blank: Material R37 (anisotropic, elasto- plastic Material)

Thickness: 2mm

Punch: Material rigid shell

Static friction coefficient: 0.14

Dynamic friction coefficient: 0.0

Travel speed: 3m/sec

Total travel distance: 34mm

Tooling clearance: 1.15t mm

Binder: Material rigid shell

Static friction coefficient: 0.14

Dynamic friction coefficient: 0.0

Force: 200kN

Die: Material rigid shell

Static friction coefficient: 0.1

Dynamic friction coefficient: 0.0

Draw bead: Material rigid shell

Draw bead depth: 1mm, 0.5mm, 0.6mm, 0.65mm and 0.7mm

Draw bead length: 86mm, 52mm

Entrance radius : 1.5mm

Groove radius: 1.5mm

The material considered for this is cold rolled steel and its properties are given below:

Young modulus: 2.07×10^5 N/mm^2

Poission ratio: 0.28

Yield stress: 230 MPa

Blank thickness: 2 mm

Static friction coefficient : 0.14

Velocity of punch: 3000 mm/sec

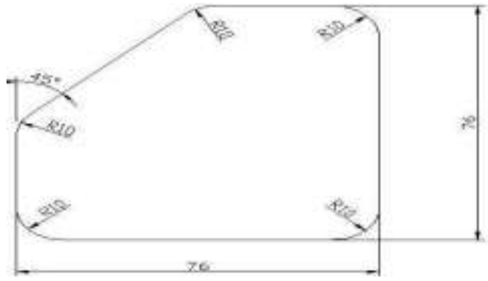
Stroke length: 34 mm

Binder Force: 200kN

Contact gap: 2 mm

Punch nose radius: 10 mm

Die nose radius: 10 mm



Force Calculation

Punch force and Blank Holding force are playing an important role in this simulation. So, these factors have been calculated.

Punch Force

The force required for drawing depends upon the, the diameter and thickness of the cup.

Punch Force = t .S_u (2 x 3.14 x R x Ka + L.K) = 130Kn

Where, S_u = tensile strength of the material, t = thickness of the cup (mm) R=Corner Radius (mm)

L=Sum of the lengths of straight sections of the sides (mm)

K_a & K = Constants.

Blank Holder Force = 2 x lpo x t x TS = 127kN

lpo = Length of punch opening

t = Material Thickness

TS = Tensile strength

Clearance

Clearance = 1.1 x Blank Thickness = 2.2mm

Meshing of Parts

All the parts naming punch, die, blank and binder are meshed and displayed in the figure.

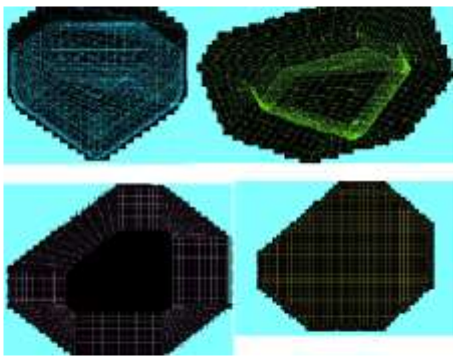


Figure 1: Meshing Parts

4. METHODOLOGY

After the five sided cup modeled by using DYNAFORM, it is imported to LS-DYNA solver where it has been analyzed considering certain parameters constant and simultaneously varying certain parameters. Particularly, force value, draw- bead distance from the die centre and shell thickness i.e. 200kN, 65mm and 2mm respectively are kept constants.

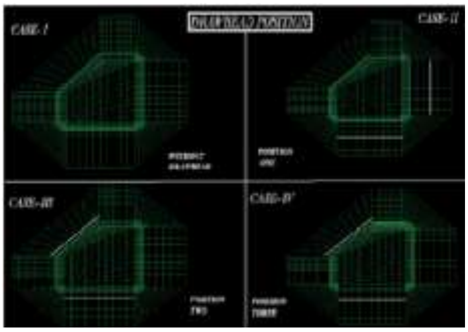


Figure 2: Draw-bead Positions

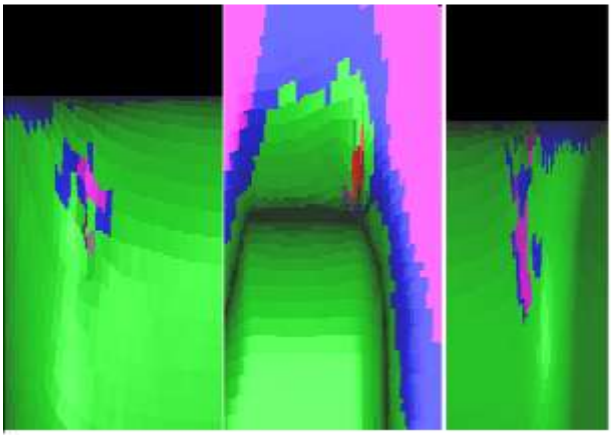


Figure 3: Defects in Forming

Table- Selected elemental values

0.5mm. depth+ length 52mm.		0.6mm. depth +length52mm.		0.65mm. depth+length52	
S.T. in mm.	M.S.	S.T. in mm.	M.S.	S.T. in mm.	M.S.
2.027	0.161	2.024	0.163	2.026	0.164
1.982	0.174	2.018	0.168	1.937	0.181
1.834	0.195	1.851	0.193	1.648	0.22
1.586	0.228	1.61	0.225	1.522	0.234
1.494	0.239	1.467	0.242	1.409	0.248
1.612	0.225	1.543	0.235	1.548	0.234
1.639	0.223	1.628	0.225	1.612	0.227
1.724	0.212	1.726	0.212	1.726	0.212
1.796	0.202	1.777	0.204	1.774	0.205

1.736	0.09	1.655	0.153	1.517	0.235
1.658	0.164	1.545	0.222	1.464	0.255
1.522	0.241	1.471	0.253	1.451	0.261
1.643	0.189	1.552	0.22	1.534	0.227
1.554	0.224	1.575	0.226	1.551	0.232
1.556	0.231	1.553	0.232	1.533	0.235
1.555	0.233	1.54	0.234	1.546	0.233
1.546	0.234	1.565	0.231	1.537	0.234
1.553	0.229	1.538	0.233	1.537	0.233

S.T.- Shell Thickness, M.S.- Mean Strain

5. RESULT AND DISCUSSION

The excel data sheet carrying the customized design as well as optimal design values has been imported to MINITAB worksheet for undergoing RSM, which is given below in table .

Table -Customized design cases

D mm.	L in mm.	S.T. in mm.	M.S.	Std. order	Run order	Blocks/ Point type	Optimum point
0.5	93	1.748	0.204	1	1	1	1
0.5	93	1.551	0.215	2	2	1	0
0.5	93	1.608	0.223	3	3	1	0
0.6	93	1.810	0.196	4	4	1	0
0.6	93	1.558	0.219	5	5	1	0
0.6	93	1.564	0.229	6	6	1	0
0.65	93	1.768	0.204	7	7	1	1
0.65	93	1.562	0.211	8	8	1	0
0.65	93	1.563	0.230	9	9	1	0
0.5	52	1.743	0.206	10	10	1	1
0.5	52	1.638	0.165	11	11	1	0
0.5	52	1.567	0.223	12	12	1	0
0.6	52	1.738	0.207	13	13	1	0
0.6	52	1.557	0.209	14	14	1	0
0.6	52	1.553	0.229	15	15	1	0
0.65	52	1.689	0.213	16	16	1	1
0.65	52	1.477	0.250	17	17	1	0
0.65	52	1.539	0.232	18	18	1	0

S.T.- Shell Thickness, M.S.- Mean Strain, D-Depth, L- Length

Table-Optimal design cases

Depth in mm.	L in mm.	S.T. mm.	M.S.	Std. order	Run order	Blocks/Point type
0.65	93	1.768	0.204	7	7	1
0.65	52	1.689	0.213	16	16	1
0.5	52	1.743	0.206	10	10	1
0.5	93	1.748	0.204	1	1	1

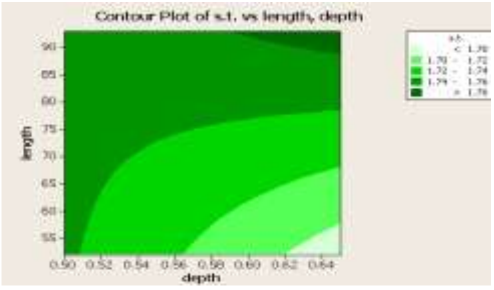


Figure 4:-Contour Plot of Shell Thickness

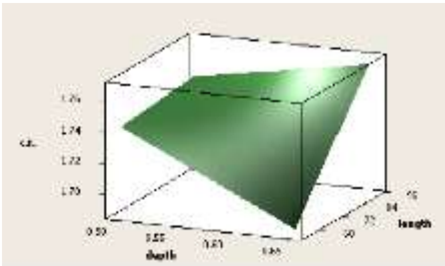


Figure 5: - Surface Plot of Shell Thickness

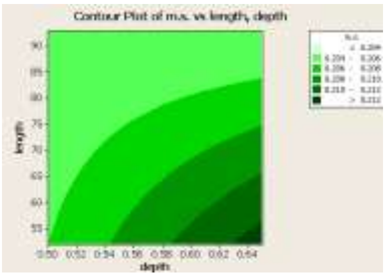


Figure 6- Contour plot of Mean strain

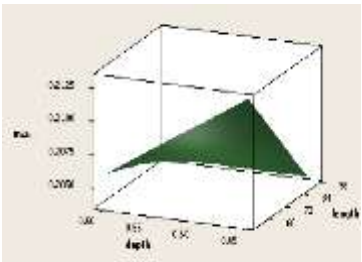


Figure 7- Surface plot of Mean strain

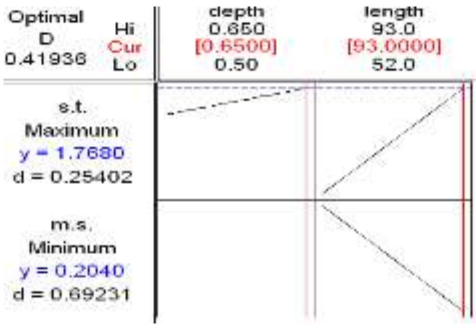


Figure 8- Response Optimizer Plot

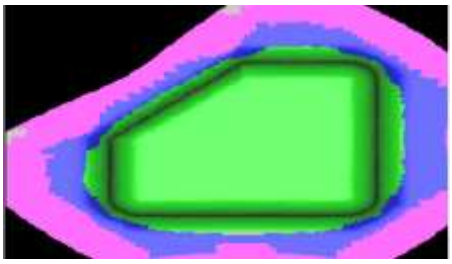


Figure 9 - FLD of global optimum

The above figure shows the response optimizer plot for the maximum shell thickness and minimum mean strain. As we can infer from the graph that depth parameter remain silent in the range of 0.50mm to 0.65mm for achieving optimal mean strain value i.e. 0.204. The following figure shows the preciseness of coming out responses which is free from any sort of defects.

6. CONCLUSIONS

Ultimately, abiding with LSDYNA and Response Surface Methodology the responses i.e. shell thickness and mean strain are come up to a fine précised value of 1.768mm. and 0.204mm correspondingly taking average length value of 93mm and depth 0.65mm.

In the beginning, RSM fed up with customized draw-bead values i.e. 0.5mm, 0.6mm, 0.65mm depth along with 52mm and 93mm average length values and consequently it arrived at the optimized values of responses considering the above independent variables.

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