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FINITE ELEMENT ANALYSISOF PERFORATED SHEET METAL (PSM) FOR OPTIMUM FORMING PROCESS

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Abstract: *Perforated sheet metal is having less weight and same strength compare to plain sheet. It is widely used in screens, filters, shields and guards. It is also used in architectural design. Wrinkling and stress intensity at the curved portion are the major problems which decreases the life of the product. This work is about to identify optimum forming parameters like punch velocity and co-efficient of friction to reduce wrinkling and stress intensity. Experimental results by UTM Machine will be validated with simulated results by DEFORM-3D software. RSM is used for relationship between input process parameters and responses.*

Keywords: *Deep Drawing, Simulation, RSM.*

INTRODUCTION

Forming is a manufacturing process to produce required shapes by plastic deformation of the material. The force is applied beyond its yield strength which causes the material to deform plastically and it does not fail. The force may be compressive, tensile, bending or combination of both. Stresses induced in it is less than fracture strength and greater than yield strength. This process is good as it gives desired size, shape and surface finish can also be obtained without loss of material.

Good control is required in this process for material properties. To obtain desired size and shape, the material should have to flow plastically in solid state without losing control in their properties.

The forces applied to the material is above elastic limit in plastic deformation. The material is more rigid as it is done at room temperature. So greater force is needed in cold state than hot state. The deformation depends on the ductility of the material.

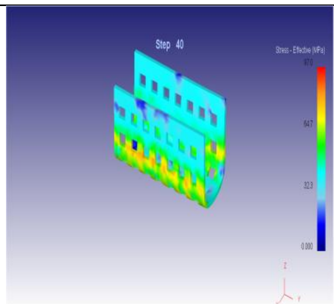
Forming is widely used manufacturing process in many industries for fabrication of wide range of products. This process is used more because metal can be formed in any useful shape easily by plastic deformation.

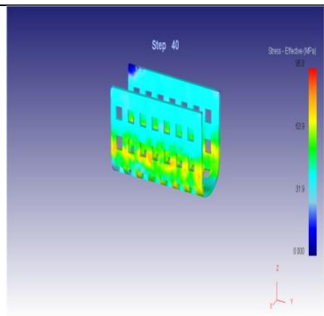
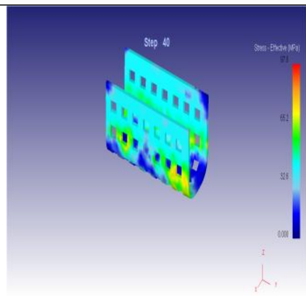
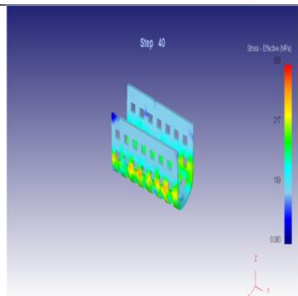
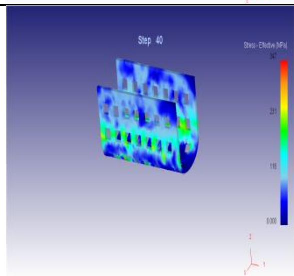
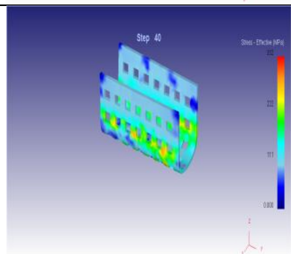
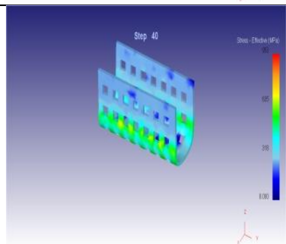
Deep drawing is forming process in which sheet metal is radially drawn into a die by mechanical action of punch and used to produce shells, cups, boxes, etc. In deep drawing shape transformation is there and material is not removed.

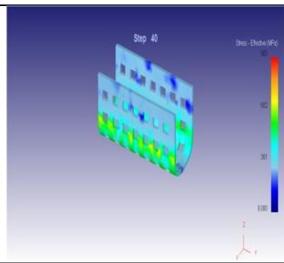
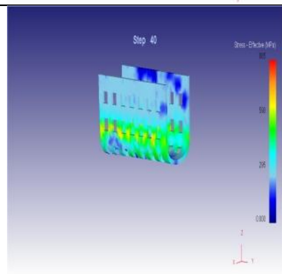
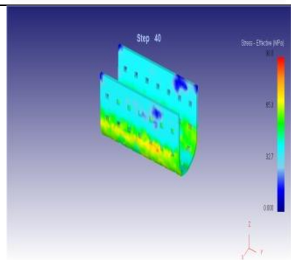
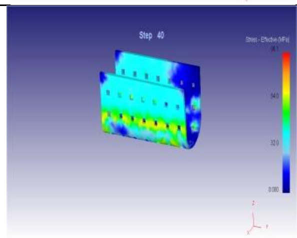
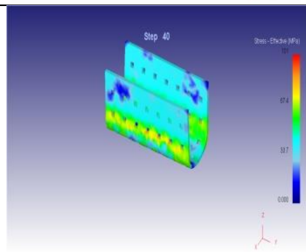
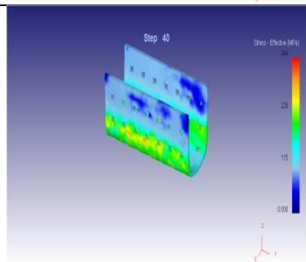
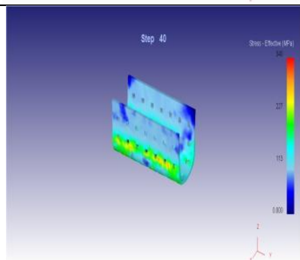
Perforated sheet metal (PSM) has relative advantage of having less weight and same strength compared with plain sheet metal. In order to have a practical application of PSM, it is required to impart the desired shape. The deep drawing process is one such forming process which could be used to shape the PSM. The forming process parameters vary considerably for PSM due to the changes in the contour of the sheet. The PSM behavior has to be characterized for different sets of inputs during forming process e.g. Punch velocity, coefficient of friction, workpiece thickness.

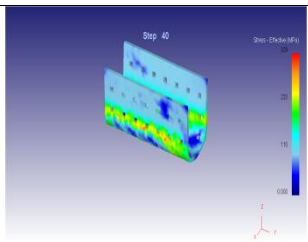
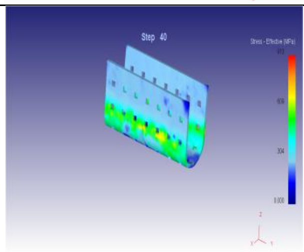
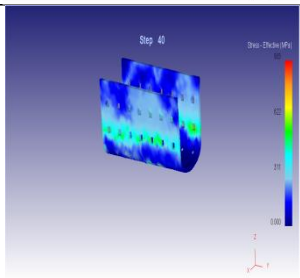
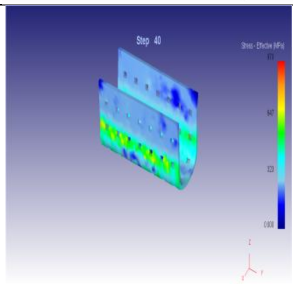
SIMULATION

Table 1Simulation

Simulation	Material	Punch Velocity (mm/sec)	Punch Radius (mm)	Stress Analysis (MPa)	Figure
1	Aluminum	5	5	97	

2	Aluminum	10	5	95.8	
3	Aluminum	15	5	97.8	
4	Brass	5	5	326	
5	Brass	10	5	347	
6	Brass	15	5	332	
7	Stainless Steel	5	5	953	

8	Stainless Steel	10	5	903	
9	Stainless Steel	15	5	885	
10	Aluminum	5	7	98	
11	Aluminum	10	7	96.1	
12	Aluminum	15	7	101	
13	Brass	5	7	344	
14	Brass	10	7	340	

15	Brass	15	7	329	
16	Stainless Steel	5	7	913	
17	Stainless Steel	10	7	933	
18	Stainless Steel	15	7	970	

RESULTS AND DISCUSSION

- From simulation-1, 2, 3 of aluminum material of punch radius 5 mm and punch velocity 5 mm/sec, 10 mm/sec and 15 mm/sec respectively, the less stress intensity is obtained in simulation-2 of punch velocity 10 mm/sec and its value is 95.8 MPa.
- From simulation-4, 5, 6 of brass material of punch radius 5 mm and punch velocity 5 mm/sec, 10 mm/sec and 15 mm/sec respectively, the less stress intensity is obtained in simulation-4 of punch velocity 5 mm/sec and its value is 326 MPa.
- From simulation-7, 8, 9 of stainless steel material of punch radius 5 mm and punch velocity 5 mm/sec, 10 mm/sec and 15 mm/sec respectively, the less stress intensity is obtained in simulation-9 of punch velocity 15 mm/sec and its value is 885 MPa.
- Now, with simulation-1 to 9 of punch radius 5 mm, the minimum stress intensity is obtained in aluminum material and its value is 95.8 MPa.
- From simulation-10, 11, 12 of aluminum material of punch radius 7 mm and punch velocity 5 mm/sec, 10 mm/sec and 15 mm/sec respectively, the less stress intensity is obtained in simulation-11 of punch velocity 10 mm/sec and its value is 96.1 MPa.
- From simulation-13, 14, 15 of brass material of punch radius 7 mm and punch velocity 5 mm/sec, 10 mm/sec and 15 mm/sec respectively, the less stress intensity is obtained in simulation-15 of punch velocity 15 mm/sec and its value is 329 MPa.
- From simulation-16, 17, 18 of stainless steel material of punch radius 7 mm and punch velocity 5 mm/sec, 10 mm/sec and 15 mm/sec respectively, the less stress intensity is obtained in simulation-16 of punch velocity 5 mm/sec and its value is 913 MPa.
- Now, with simulation-10 to 18 of punch radius 7 mm, the minimum stress intensity is obtained in aluminum material and its value is 96.1 MPa.
- Now, from all the above simulation i.e. 1 to 18, the minimum stress intensity is obtained in aluminum material of punch radius 5 mm and punch velocity of 10 mm/sec. The value of minimum stress intensity in aluminum material of punch radius 5 mm and punch velocity 10 mm/sec is 95.8 MPa.

RESPONSE SURFACE METHODOLOGY

Response surface modelling is used to establish the mathematical relationship between the responses, yu and the various parameters, with the eventual objective of determining the optimum operating conditions for the system. A general second-order polynomial response surface mathematical model is used to analyze the parametric influences on the various response criteria as follows.

$$y_u = \beta_0 + \sum_{i=1}^{k} \beta_i x_{iu} + \sum_{i=1}^{k} \beta_{ii} x_{iu}^2 + \sum_{i<j} \beta_{ij} x_{iu} x_{ju}$$

Where, yu is the corresponding response for the temperature and material removal rate (MRR), xiu is the coded value of the ith machining parameter of the uth experiment, k is the number of machining parameters, βi, βii, βij are the second-order regression coefficients.

In this case, k=2 due to two process parameters: punch velocity and punch radius. For punch velocity and punch radius respective coded values are X1 and X2. Coded variables are calculated using following equation,

$$x_{ij} = \frac{\left\{ X_{ij} - \left[\frac{(\max X_{ij} + \min X_{ij})}{2} \right] \right\}}{\left[\frac{(\max X_{ij} - \min X_{ij})}{2} \right]},$$

In the above equation, Xij is the ith natural variable for jth experimental run.

Table 2 Coded values for process parameters

Exp. Runs	X1	X2
1	-1	-1
2	0	-1
3	1	-1
4	-1	-1
5	0	-1
6	1	-1
7	-1	-1
8	0	-1
9	1	-1
10	-1	1
11	0	1
12	1	1
13	-1	1
14	0	1
15	1	1
16	-1	1
17	0	1
18	1	1

MINITAB 14 software has been used to establish mathematical models and for parametric optimization to achieve optimum punch radius and punch velocity for response of minimum stress. Using MINITAB 14 software the values of regression coefficients are found as follows.

Constant: 452.483
Punch velocity (V): -1.350
Punch Radius (R): 4.861
V*V= 1.333
V*R= 8.850
Response is modelled as below:
Y = 452.483 – 1.350 * V + 4.861 * R + 1.333 * V * V + 8.850 * V * R
Above equation shows the relationship between input parameters and response.

CONCLUSION

- From all the above simulations, the minimum stress intensity is obtained in aluminum material of punch velocity 10 mm/sec and punch radius 5 mm and the value of stress intensity is 95.8 Mpa.
- The blank holding force has major influence on Deep drawing process.
- The die radius also has an influence in the process which is followed by punch nose radius.

REFERENCES

1. Krupal Shah, Darshan Bhatt, Twinkle Panchal, Dhruv Panchal, Bharat Dogra. Influence of the Process Parameters in Deep Drawing, International Journal of Emerging Research in Management & Technology ISSN: 2278-9359 (Volume-3, Issue-11) (2014)
2. Li-Ping Lei, Sang-Moon Hwang, Beom-Soo Kang. Finite element analysis and design in stainless steel sheet forming and its experimental comparison, Journal of Materials Processing Technology 110 (2001) 70-77
3. Anupam Agrawal, N. Venkata Reddy, P.M. Dixit. Determination of optimum process parameters for wrinkle free products in deep drawing process, Journal of Materials Processing Technology 191 (2007) 51–54
4. W.M. Chan, H.I. Chew, H.P. Lee, B.T. Cheok. Finite element analysis of spring-back of V-bending sheet metal forming processes, Journal of Materials Processing Technology 148 (2004) 15–24
5. Nayan G. Kaneriya, Gaurav Kumar Sharma. Experimental Evaluation and Optimization of Dry Drilling Parameters of AISI304 Austenitic Stainless Steel using Different Twist Drills, 5th International & 26th All India Manufacturing Technology, Design and Research Conference (AIM TDR 2014) December 12th -14th , 2014, IIT Guwahati, Assam, India
6. Guangyong Sun, Guangyao Li, Qing Li. Variable fidelity design based surrogate and artificial bee colony algorithm for sheet metal forming process, Finite Element in Analysis and Design 59 (2012) 76-90
7. Hakim S. Sultan Aljibori. Finite Element Analysis of Sheet Metal Forming Process, European Journal of Scientific Research ISSN 1450-216X Vol.33 No.1 (2009), pp. 57-69
8. Sachin S Chaudhari, Navneet K Patil. Effect of Process Parameters on Spring Back in Deep Drawing: A Review, 2015 IJEDR, Vol. 3, Issue 4, ISSN: 2321-9939
9. A. R. Joshi, K. D. Kothari, Dr. R. L. Jhala. Effect of Different Parameters on Deep Drawing Process : Review, International Journal of Engineering Research and Technology, ISSN: 2278-0181, Vol. 2 Issue 3, March 2013
10. R. Venkat Reddy, Dr. T. A. Janardhan Reddy, Dr. G. C. M. Reddy. Effect of Various Parameters on the Wrinkling in Deep Drawing Cylindrical Cups, International Journal of Engineering Trends and Technology- Vol. 3 Issue 1- 2012
11. Chandra Pal Singh, GeetaAgnihotri. Study of Deep Drawing Process Parameters: A Review, International Journal of Scientific and Research Publications, Vol. 5, Issue 2, Feb. 2015
12. Mr.MarlapalleBapurao G., Prof.Dr.Rahulkumar S. Hingole. A Review Paper on FEA Application for Sheet Metal Forming Analysis, International Journal of Scientific & Engineering Research, Vol. 6, Issue 12, Dec-2015
13. Anup S. Atal, Prof. M. T. Shete. Material Deformation and Wrinkling Failure in Deep Drawing Process by Finite Element Approach: A Review, International Journal of Engineering Research and Technology ISSN: 2278-0181, Vol. 2 Issue 12, Dec-2013

