FEA And Experimental Investigation of Deep Draw Component Using Design of Experiment (DOE)

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Abstract- *In the 21st century, technology is omnipresent in day to day life of growing industrial sector .Forming problems of Sheet metal is typical in nature since they involve geometry, boundary and material non-linearity. Drawings part includes many parameters like punch and dies radius, clearance, lubrication, blank holding force and its trajectories etc. Lot of trial s and error procedure are involved in tool designing for part drawing. To reduce number of costly trial error steps, the process can be simulated by using finite element packages. Even the finite element package gives an approximation towards the solution. The dissertation work is relevant in the context of developing a cost effective component with a lower lead time through the phase of Design, Development, Trials and Testing, Pilot lot production & Regular supply. In this dissertation work, the significance of three important deep drawing process parameters namely blank Holding force, die arc radius and punch nose radius on the deep drawing characteristics was determined. Existence of thickness variation in the formed part may cause stress concentration and may lead to acceleration of damage. The finite element method is a powerful tool to predict material thinning deformations before prototypes are made. In this dissertation work, the combination of finite element method and Taguchi design of experiments and analysis of variance has been applied to analyze the influencing process parameters on Thinning in automotive deep draw component.*

Keywords- Deep drawing; FEM; Taguchi technique; ANOVA

I. INTRODUCTION

Sheet metal forming is one of the most widely used manufacturing processes in industry that is used to change the geometry of sheet metal of typically about 6mm thickness without loss of material. This wide use can be attributed to the ease with which a wide range of products can be produced using the method, coupled with itsadaptability to new manufacturing technologies such as hydro forming.

Deep drawing is also a process of forming sheet metal through a forming die with a punch. Metal in the area of the die shoulder undergoes a lot of stress, and will result in wrinkles if a blank holder is not used to control the flow of material into the die. Material is usually thickest in the area where the metal loses contact with the punch - the punch radius - and thinnest in the areas where stresses are greatest. Deep drawing is often used to produce metal objects that are more than half their diameters in height. The metal is stretched around a plug, and then moved into the die [10].

1.1 Problem statement

It is evident that extensive theoretical and practical research work has been done on blanking, bending and deep drawing of different sheet materials. Generally, the research has been centered on analysing the stress and strain distribution of a formed product and evaluating the forces and the factors affecting the forming processes. The work hardening of the material during sheet metal forming, in particular multiple deep drawing, has been done to predict material fracture at the last draw station.

II. LITERATURE REVIEW

S.Raju et al. [1], suggested Deep drawing experiments were carried out according to the central composite design. The optimum parameter setting for most even wall thickness was found out using TAGUCHI's signal-to-noise ratio. The parameter settings are punch nose radius of 3 mm, die shoulder radius of 8 mm, and blank holder force of 4 KN.The degrees of influence of the selected parameters on the deep drawing behaviour of circular cup in order to improve the quality of the formed part were determined.

Ganesh M. Kakandikar et al. [2], he suggested that the finite element method is widely applied worldwide to simulate the deep drawing process. For real-life simulations of deep drawing process an accurate numerical model ,as well as an accurate description of material behaviour and contact conditions ,is necessary .The finite element method is a powerful tool to predict material thinning deformations before prototypes are made. The proposed innovative methodology combines two techniques for prediction and optimization of thinning in automotive sealing cover. Taguchi design of experiments and analysis of variance has been applied to analyze the influencing process parameters on Thinning.

V. Naranje, S. Kumar.[3],In the present research work, a KBS developed for auto-matic selection of major components of deep drawing die has been presented. The system has been built using production rule based approach of AI. Considerations for selection of die components and procedure used for development of the proposed system have been discussed at some length.

Sandeep Patil, Priyadarshinipuranum[4], Study suggested a finite element analysis based simulation has been done using Altair Hyper Form for the single stage drawing processes. The effect of parameters on the wrinkles, thinning and formability quality characteristics of Single stage drawing process has been done.The virtual and actual experiment shows that, the wrinkles and thinning can be controlled by optimizingthe die radius and blank holding force.

III. DESIGN OF EXPERIMENT

Deep drawing process is characterized by a large number of process parameters and their interdependence. These are material properties, machine parameters such as tool and die geometry, workpiece geometry and working conditions.The main tools used in deep drawing process are blank, punch, die and blank holder. The geometry parameters used in deep drawing process are [4] Punch Radius (Rp), Punch Edge Radius (rp), Blank Thickness (t), Blank Radius (Rb), Die Radius (Rd) , Die Edge Radius (rd).

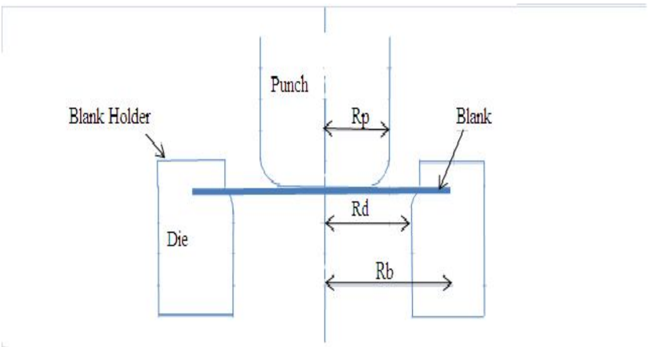

Figure 3.1: Tool geometry parameter of deep drawing process [4].

The geometry parameters must be selected carefully because the final product depends highly on above mention geometries. Clearance is the important parameters which is obtain by the difference between die radius and punch radius (c= Rd-Rp). **Clearance must be 25% larger than initial blank thickness**. The above mention physical and geometrical parameters are explained in brief below [2].

3.1Taguchi Techniques

Taguchi proposed several approaches to experimental designs called Taguchi method. This method utilizes an orthogonal array, which is a form of fractional factorial design containing a representative set of all possible combination of experimental conditions. Using Taguchi method, a balanced comparison of levels of the process parameters and significant reduction in the total number of required simulations can both be achieved. Two levels (low, high) were used for each parameter. The results indicate that the punch/die radii have the greatest effect on the thickness of the deformed mild steel cups compared to other process parameters [1].In the present study, Taguchi method of experimental design was used to plan the numerical simulations.

IV. FEA AND SIMULATION

The Finite element (FE) simulation and analysis gives a fertile environment for improvement and optimization in deep drawing. To overcome the unconvinced in the mathematical models of the deep drawing process, some researchers worked on developing empirical formulas that are based on the FE simulation results. Such empirical formulas are simple to deal with using a suitable optimization algorithm.

4.1 Simulation of component

As we selected the L9 orthogonal array, we did 9 experiments in Fastform software & took the thickness of the various region of the component showing in figures. Thickness distributions of nine experiments showing below:

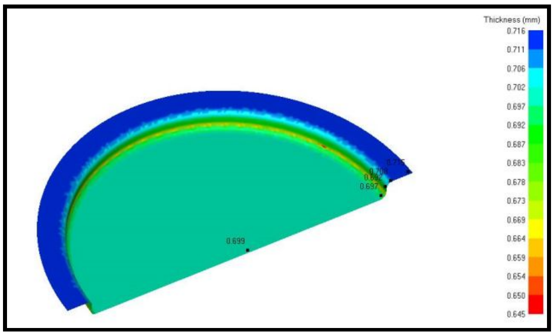

Figure 4.1-Thickness distributions of Expt. No. 1

V. OPTIMIZATION

The optimisation procedures developed in this study is based on the knowledge of underlying sheet-metal forming mechanics and validated by experimental results.

5.1 Deep Drawing Optimization Procedure

The optimization scheme for optimizing the geometry of the cup was developed with the aim of optimizing the minimum drawing force required.

The optimization scheme for optimizing the geometry of the component was developed with the aim of optimizing the minimum drawing force required. The optimization modeling procedure was developed from Equations which shows the force needed to draw a shell and is equal to the product of the cross sectional area and the yield strength in tension of the work material.

Mathematically the forming load can be expressed as:

Minimize $F(x)$ □□0

To satisfy the following constraints

$$l \le x \le u \quad i = 1,.....n.$$

Where $F(x)$ is the objective formability function and x represents the design variables and i l and i u are the lower and upper bound on the i *th*design variables respectively.[3]

VI. EXPERIMENTATION

Its good combination between experimental and finite element result which is show that Finite element method can be used in various industrial process. Experimental deep drawing processes were done on Hydraulic Press shown in Figure 7.1. For each experiment, a trial run was carried out and data collected before the final data collection run.

Experiments are to be conducted on a mechanical press of a suitable capacity. The die would be mounted on the bolster plate of the press and the speed of the ram would be set based on the historical data as well as the input received from the Flower Pollination Algorithm. Forming problems can be predicted before tool fabrication through the use of software that can be integrated into production routes which rely increasingly on computer technology.

Figure 6.1-Safety final (defect free) component

VII. RESULTS AND DISCUSSION

The experimental results were used to verify the accuracy of the process models used in the simulations.Forming process of DD CRCA steel sheet in deep drawing setup is a very promising technique for getting defect free components required for various industrial applications. The present work involving the selection of design data parameters for system confidence and proved very successful. It has a tremendous future.t provides challenge to researchers to improve the process and equipment for specific industrial applications.

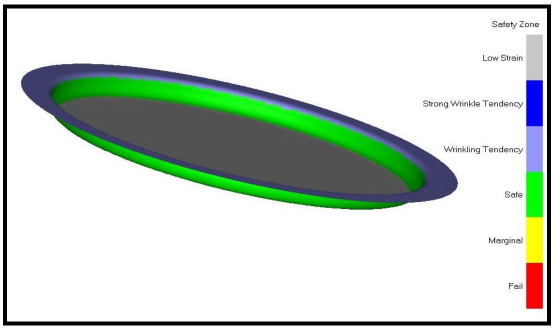

Figure 7.1-FEA Result

Table 7.1-Comparison between simulation and experimental thickness value

Position of thickness measured	Thickness from FEA(mm)	Thickness from EXPT.(mm)
1	0.645	0.64
2	0.685	0.67
3	0.692	0.69
4	0.709	0.7
5	0.712	0.71

VIII. CONCLUSION

It is a finite element analysis based simulation has been done using Hyper Form for the single stage drawing processes. The effect of parameters on the wrinkles, thinning and formability quality characteristics of Single stage drawing process has been done. The accuracy of sheet metal formation depends on many factors like yield stress, temperature and die rigidity etc. Also nature of load effects the accuracy of the deep drawn objects. In the present work, a comparison has done between experimentally available punch loads with finite element solution.

By controlling all these parameters minimization of thinning occurs. Here, in this project, Taguchi method with fastform is used to optimize the thinning in deep drawing. Simulation technique used effectively to optimize the die design and process parameters. So it is concluded that the proposed optimization approach is successful and it is validated with experiments which reduce the cycle time and material cost

REFERENCES

Reference Books

Advances in Metal Forming: Expert System for Metal Forming
https://books.google.co.in/books?isbn=3662444976
Rahulkumar Shivajirao Hingole - 2014 -Technology & Engineering

Reference Journals

[1] R. Padmanabhan, M.C. Oliveira, J.L. Alves, L.F. Menezes, Influence of process parameters on the deep drawing of stainless steel, Science Direct ,Finite Elements in Analysis and Design 43 (2007) 1062 – 1067

[2] D. Risch, G. Gersteyn, W. Dudzinski, C. Beerwald, A.Brosius,M. Schaper, A. E. Tekkaya1, F.-W. Bach "Design and Analysis of a Deep Drawing and Inprocess Electromagnetic Sheet Metal Forming Process" 3rd International Conference on High Speed Forming – 2008

[3] SandeepPatil ,Priyadarshinipuranum , Praveenkumar Moon "Formability Analysis of Single Stage Drawing of Cylindrical Cup Using Altair HyperWorks"2015 India Altair Technology conference.

[4] R. Chandramouli Associate Dean-Research Sastra University, Thanjavur-613401,NPTEL - Mechanical Engineering – Forming

[5] R.S.Hingole&V.M.Nadedkar, "A study of spring back effect in bending component", International Conference International Deep Drawing Research Group IIT Bombay, pp 25-30(IDDRG 2012).

[6] SachinRamdasJadhav,SunilHiraman More, Swapnil S. Kulkarni, " Die design for formed component using inputs from FEA for determining the most suited values for the design/ process parameter" International Journal of Advanced Engineering Research and Studies E-ISSN2249–8974

[7] Amir Atrian an. el.; "Deep drawing process of steel/brass laminated sheets"; international journal of Composites: Part B; 47 (2013) 75–81

[8] J. Jeswietan.el.: "Metal forming progress since 2000"; CIRP Journal of Manufacturing Science and Technology; 1 (2008) 2–17.

[9] C. Nikhare, P. V. Marcondes, "Experimental And Numerical Evaluation Of Forming And Fracture Behaviour Of High Strength Steel", 1School of Engineering and Technology, Faculty of Science and Technology,Deakin University, Waurn Ponds 3217, Australia.

[10] Michael P.Pereira, MatthiasWeiss, BernardF.Rolfe, TimB.Hilditch, "Investigation Of The Deep Drawability Of Steel And Aluminum Sheets By Finite Element Simulation ", Metallurgical And Materials Engineering, 2005

[11] H. Zein, M. El-Sherbiny, M. Abd-Rabou, M. El Shazly, Effect of Die Design Parameters on Thinning of Sheet Metal in the Deep Drawing Process, American Journal of Mechanical Engineering, 2013, Vol. 1, No. 2,pp. 20-29

[12] 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- Volume3Issue1-2012,pp.53-58

[13] Y. N. Dhulugade, P. N. Gore, Design and Development of Sheet Metal Draw Component Using CAE Technology, International Journal of Emerging Technology and Advanced Engineering ,Volume 3, Issue 3, March 2013,pp.30-39

[14] GyadariRsamesh, Analysis of Optimization of Blank Holding Force In Deep Drawing By Using LS DYNA, International Journal Of Engineering Research and Applications (IJERA) ISSN: 2248-9622 Vol. 3, Issue 4, Jul-Aug 2013, pp.1975-1995.

[15] Mr. Amit D. Madake1, Dr. Vinayak R. Naik2 Development of a Sheet-Metal Component with a Forming Die Using CAE Software Tools (Hyper form) For Design Validation and Improvement, International Journal of Modern Engineering Research, Vol. 3, Issue. 3,May-June. 2013 ,pp-1787-1791