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DETERMINE OPTIMIZED PROCESS PARAMETERS THROUGH DEPLOYMENT OF STATISTICAL TOOLS FOR FORMING OPERATION IN SHEET-METAL INDUSTRY: A REVIEW

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ABSTRACT

The sheet metal industry is posed with numerous challenges pertaining to the productivity and/or the quality of the parts produced. The magnitude of the defect as also the number of defects at a location would determine if the part can be considered as 'acceptable' to the given function. A good technique for process control can go a long way in reducing the occurrence of defects. This work aims to undertake research over the processing parameters of importance and the effect of change in its value or level on the overall quality of the part in terms of wrinkles, tearing, thinning or spring-back. The process parameters like blank-holding pressure as also the type of material and its thickness shall be evaluated for checking performance at alternative levels of setting. The data collected during these phases of study shall be offered a suitable statistical treatment using ANOVA and Taguchi methods for conducting Design of Experiments and for arriving at a feasible optimized solution. Altair Hyperworks shall be deployed for evaluating the performance using Hyperform over the Numerical Phase of problem solving. This methodology shall be validated through physical experimentation with any one variant applicable to any one setting for the die. Then solution shall be in the form of recommended values of the significant parameters that is likely to render a defect free part over the production line.

***KEYWORDS**: Forming analysis, DOE, form die design, Taguchi, Regression equation*

I. INTRODUCTION

It has been found that most of the researchers over the years, have dealt with various process parameters such as blank holding pressure, thickness of sheet, thickness of lubricant applied over the sheet etc., for optimization of the objectives such as minimizing the percentage thinning, wrinkles, tearing, etc. Analyze different parameters of sheet metal forming to minimize the forming defects such as wrinkles. It was reported that uniform thickness with required tolerances and dimensional accuracy can be achieved by optimization of controllable process parameters such as blank holding pressure, velocity of draw, thickness of sheet. Moreover, by selection of optimum process parameters the sheet metal forming defects such as tearing, wrinkles, thinning, spring-back etc., were also minimized.
The forming processes of sheet metal parts generally include drawing, trimming, stamping, shaping, flanging, and other processes, of which the stamping process is the most important step of all, and the results of the stamping are directly related to the product quality and subsequent process. In order to get qualified forming parts to meet customer requirements, multiple modifying and repeated debugging are required for stamping die, stamping process, technological parameters, and so forth,

while "trial and error" method is used in the traditional way for repeated testing, which not only require a longer production cycle, but also require high production costs.

II. LITERATURE REVIEW

R. Padmanabhan, M.C. Oliveiraa.et al. [1] has found that the Optimization of process parameters in sheet metal forming is an important task to reduce manufacturing cost. To determine the optimum values of the process parameters, it is essential to find their influence on the deformation behavior of the sheet metal. The significance of three important process parameters namely, die radius, blank holder force and friction coefficient on the deep-drawing characteristics of a stainless steel axi-symmetric cup was determined. Finite element method combined with Taguchi technique form a refined predictive tool to determine the influence of forming process parameters. The Taguchi method was employed to identify the relative influence of each process parameter considered in this study. A reduced set of finite element simulations were carried out as per the Taguchi orthogonal array. Based on the predicted thickness distribution of the deep drawn circular cup and analysis of variance test, it is evident that die radius has the greatest influence on the deep drawing of stainless steel blank sheet followed by the blank holder force and the friction coefficient. Further, it is shown that a blank holder force application and local lubrication scheme improved the quality of the formed part.
Dong-wog Jung [2] has observed that in the interest of improved automotive fuel economy, one solution is reducing vehicle weight. Achieving significant reduction will normally require the panel thickness or using alternative materials such as aluminum alloy sheet. These changes will affect the dent resistance of the panel. In this study the correlation between panel size, curvature, thickness material properties and dent resistance is investigated. A parametric approach is adopted, utilizing a 'design software' tool incorporating empirical equations to predict denting and panel stiffness for simplified panels. The most effective time to optimize an automotive body panel is early in its development. The developed design program can be used to minimize panel thickness or different materials, while maintaining adequate panel performance.
Wang Hu, Li Guang Yao.et al. [3] has found that the previously developed adaptive response surface method (ARSM) is suggested for construction of metamodel for highly non-linear responses. In order to develop the accuracy and efficiency of metamodel, the particle swarm optimization intelligent sampling (PSOIS) scheme is developed. This kind of intelligent method can guarantee the sampling search in right direction and constraint the bounds of design variables in feasible region. For validation of developed method, the Rosenbrock function is successfully approximated by proposed method; corresponding metamodel appropriateness can be well predicted by analysis of variance (ANOVA). Metamodel by ARSM with PSOIS are employed for optimization of initial blank shape and blank hold force (BHF) in sheet forming process, with validations by finite element simulations using LSDYNA970 commercial code. The results show that developed method is able to produce remarkable metamodels for highly non-linear problems with multi-parameter.
Chirita Bogdan Alexandru [4] have observe that The final form of the parts in sheet metal forming, especially in U bending, is highly affected by the spring back occurring when the material is set free of the forming constraints. Numerous studies aiming to control this phenomenon are conducted and there is still a degree of incertitude concerning the intensity of spring back. As the analytical methods are not accurate, due to the complexity of the factors intervening, the development of the finite element methods proved to be a valuable tool. Still there are numerous differences between the results from the real physical tests and the results from simulations especially when it comes to estimation of spring back. The present paper aims to propose a method that can be effective in reducing the spring back with exemplification on U bended sheet metal parts.
Resit Unal, Edwin B. Dean [5] have observed that The quality engineering methods of Dr. Taguchi, employing design of experiments (DOE), is one of the most important statistical tools of TQM for designing high quality systems at reduced cost. Taguchi methods provide an efficient and systematic way to optimize designs for performance, quality, and cost. Taguchi methods have been used successfully in Japan and the United States in designing reliable, high quality products at low cost in such areas as automobiles and consumer electronics (Cullen and Hollingum, 1987; Logothetis and Salmon, 1988; Sullivan, 1987; Wille, 1990). However, these methods are just beginning to see application in the aerospace industry. The purpose of this paper is to present an overview of the

Taguchi methods for improving quality and reducing cost, describe the current state of applications and its role in identifying cost sensitive design parameters.

A.F.Marcon, E.Bittencourt. et al. [6] have observed that the compression test of ring customarily used to determine the friction coefficient in metal forming problems. The aim of paper to describe procedure to obtain, for metals in the large deformation range, the stress strain curve and friction coefficient is evaluated by comparing curves obtained by a finite element code with the experimental curves. The stress-strain curve is obtained by inverting an analytical soluction, calculated by a lower-upper-bound approach.

Raghu Echempati • Andrew Fox [7] have analyze that Modern software programs are routinely used by industries to study the characteristics of and to reduce the cost of sheet metal parts that are used in automotive and other applications. Virtual simulations that are based on complex math models and state-of-the-art computational tools play a very important role in reducing the high costs associated with prototypes and the time to market the product. Formability studies of a sheet metal part determine if a part is formable by changing the factors that affect its formability. Vibration (or modal) analysis is performed to determine the frequency and mode shapes of the component or the assemblies.

With the advent of high-speed computer technology and simulation tools, many industrial establishments are using virtual manufacturing processes to predict formability of sheet metal components before prototypes and testing are performed. Reduction of cost and cycle time to manufacture these parts are of paramount importance leading to lot of research in innovative production and optimization methods involving modern light weight and strong materials for the car body panels.

Mi Wang & Zhong-Yi Cai et.al. [8] In this paper they focused on Development of flexible forming is crucial for manufacturing three-dimensional sheet metal parts. In this paper, continuous roll forming (CRF) is investigated to improve the forming results, especially for doubly curved parts. The CRF process employs an upper flexible roll and a lower flexible roll as a forming tool, and the different forming shapes are achieved by controlling and adjusting the distribution of the roll gap between two rolls. This paper is focused on analysis of the longitudinal bending deformation in CRF process, the plane assumption for longitudinal bending analysis is discussed, and the formulation to calculate the longitudinal strain distributed over the cross-section is derived.

Three-dimensional surface sheet metal parts are widely used in automobiles, ships, airplanes, as well as modern architectures. The conventional forming methods, such as stamping, stretch-bending, and hydroforming, have been applied extensively to manufacturing three-dimensional surface sheet metal parts. Yet, these forming processes associated with large initial investments and long setup times are not profitable for forming single-piece and small-batch parts. However, the requirements for products in the changing and competing markets nowadays tend to be personalized and of small volume productions.

Jakirahemed. MD, M. J. Davidson et al.[9] This paper deals with the effect of process parameters on the peak load and the energy absorption of the expansion of thin walled tubes using a die. The energy absorption and peak load during the expansion process were calculated for various punch angles (α) and with different expansion ratios (rp/ro) at different temperatures (T) by finite element analysis where rp is the punch outer radius and ro is the tube inner radius. The effect of these input parameters on the response parameters peak load, energy absorption and local buckling have been critically analyzed using Taguchi method. The ANOVA performed on the experimental results revealed that the expansion ratio (rp/ro) is the most important process parameter that minimizes the peak load followed by punch angle and tube temperature. Also it is found that the expansion ratio improves the energy absorption.

Aluminum alloy tubes with various structural shapes are used in various applications such as pneumatic, hydraulic and exhaust systems of machines and used as energy absorbing devices in transport vehicles like aircraft and automobiles to meet the demand of energy absorption for the low density and specific strength of the aluminium alloys. Tube end forming is performed by expanding the tube ends by pushing a conical punch into the tube while the bottom of the tube is fixed. However, due to poor formability at room temperature, the usage of this process to meet the required application is minimal. It is essential to improve the formability of the material to meet the industrial application needs and study of the influence of the process parameters on the expansion of thin walled tubes helps in achieving the goal in a better way.

Rohit S. Birajdar &P. D. Kamble [10] in their study they observed the defects occurring in general sheet metal forming are bound to occur in the wheel disk forming process and these defects are reduced by varying the forming process conditions (trial and error method). This causes loss terms of money and time. There are various parameters included in the forming process which affect the final products quality. The final part in its desired quality limits is obtained by selection of some critical parameters which affect more on the total process and varying their values to their optimum values. This requires expertise in the tool design and thorough knowledge of the behavior of process according to these parameters. This trial and error methods are replaced by the virtual simulations of these trials using Finite Element Method (FEM) based software and optimization is carried out by the Design of experiments (DOE) techniques. This method will replace the need of industrial expertise and also save a lot of cost and time. In this paper simulation of the multi-stage forming of wheel disk by using Altair's Hyperform. The most effective parameters are identified using Analysis of variance (ANOVA). The optimization of these process parameters is done using Design of experiments (DOE) by Taguchi's orthogonal arrays in Minitab software. The results of optimization are validated by actual formed wheel disk at industry using same optimized parameters.

Car wheel disk are formed by multi-stage forming process. Manufacturing of car wheel is done in three stages as, multistage forming of wheel disk, roll forming of wheel rim and by welding together the wheel disk and wheel rim to form complete steel wheels. In roll forming of wheel rim the occurrence of defects are very less compared to the multi-stage forming of wheel disk hence the process of multi-stage forming of wheel disk is selected for the study.

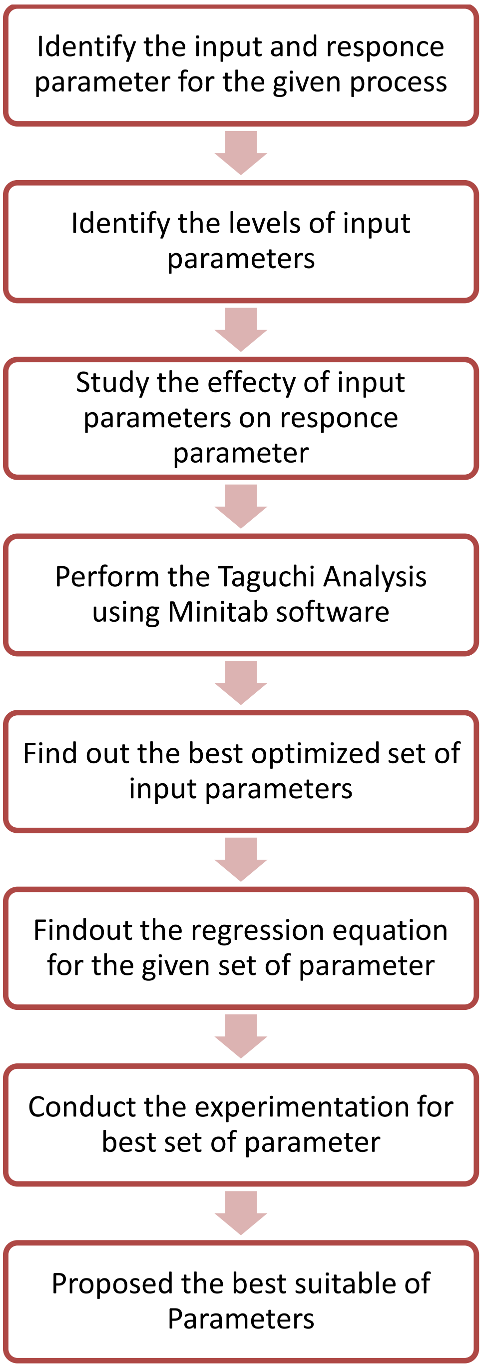
III. PROBLEM STATEMENT

A forming or draw operation performed in it's very basic or elementary method of deployment normally delivers a part which is unstable for its function. The operation or the process need to be studied and assessed in detail while arriving at possible solutions to the problem encountered. The defects like wrinkling and spring-back could be annoying to the process Engineer while at the management level of decision making it could mean financial losses in terms of rejection of the parts. The sponsoring company is looking at ways to arrive at a set of values corresponding to each significant parameter. This setting should fetch a good quality part consistently during the production run. The development time allowed is short-limited to six months-while the quality criteria for acceptance shall be the certification from the Company regarding the acceptability of the part. The company also encourages use of statistical or analytical tools for finding solutions.

IV. METHODOLOGY

- For this case study we are using two different methodology such as Statistical Method and Experimental Method:
- In statistical method, basic problem solving techniques are used. In this work, DOE (Design of Experiments) methodology was used for optimizing process parameters of sheet metal forming process. DOE includes following techniques
- Historical data analysis
- Taguchi analysis
- Regression Analysis
    - ANOVA Analysis

Stages in Design of Experiment include:



V. Probable Outcome

Using the different statistical tools, the outcome would be giving the best parameters combination for the effective sheet metal forming procedure.

VI. Conclusion

The literature review highlights some significant processing parameters as the Blank Holding Pressure and Material of the blank. Other parameters might assume significance based on the case under study. Statistical treatment offered using ANOVA and Taguchi Methods should fetch the outcome for optimized values of the concerned parameters in order realize the `response' of the system.

VII. FUTURE SCOPE

Precise identification of the significant parameters to be attempted through the deployment of ANOVA while offering the statistical treatment. Optimization to be sought using Orthogonal Array for Taguchi Methods. Validation to be done while conducting experimentation over the shop floor using the Die developed for manufacturing the part.

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