A REVIEW ON OPTIMIZATION METHODOLOGIES AND INFLUENCING FACTORS FOR CLEARANCE OPTIMIZATION IN BLANKING PROCESS

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Abstract: This review has been performed to investigate different methodologies used for understanding the impact of optimum clearance on sheet metal blanking process and optimization of these parameters. The different methodologies are used to identify the effect of such factors which are effectively responsible for controlling the output quality of product. This overview is helpful to understand the effectiveness of all such methods while experimenting on sheet metal process.

***Index Terms* – Optimization, burr, blanking process, design of experiment.**

I. INTRODUCTION

Blanking is one of the most widely used metal fabricating mechanical process, during which a metal work piece is removed by cutting of the sheet into appropriate shapes by physical process of shearing. The removed material is refereed as Product. The blanking process forces a metal punch into a die that shears the blank from the larger primary metal strip. Recent market demands are that parts manufactured should be high quality with good surface finishing and high accuracy.

In actual practice, operators in sheet metal industries are faced with the problems of predicting proper punch-die clearance which can make process faster by eliminating surface irregularities like burr [1]. This review has been performed to investigate different methodologies used for understanding the impact of optimum clearance on sheet metal blanking process and optimization of these parameters.

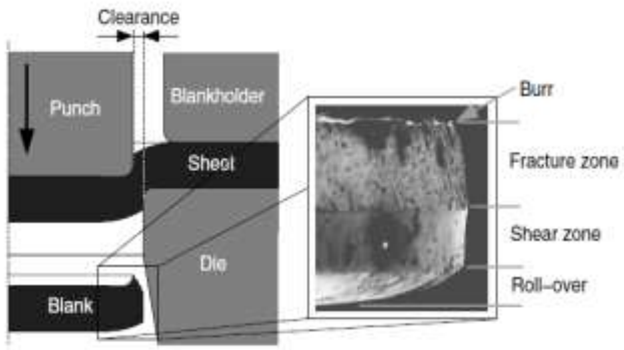

Figure 1: A schematic representation of the blanking process with an indication of the different zones [1, 2, 3]

Aluminum, Brass, Bronze, Mild Steel, and Soft Steel are the most common materials used for blanking.

1.1 Fundamentals of the sheared part

The errors on blank product are depending upon the material properties, tool shape, tool wear and noise factors [4]. In Fig. 2 represents the sheared part such as the fracture depth, the smooth-sheared depth, the burr formation, the fracture angle and roll-over depth.

Rollover Depth: It happens because of plastic deformation of material.
Shear Depth: It happens because of shearing of material smooth and shiny area is created.
Fracture/Rupture Depth: It is rough surface, result after the material cracks.
Burr height: It is a caused of plastic deformation
Depth of crack penetration: It is an angle of fracture zone depends mainly on clearance [2]

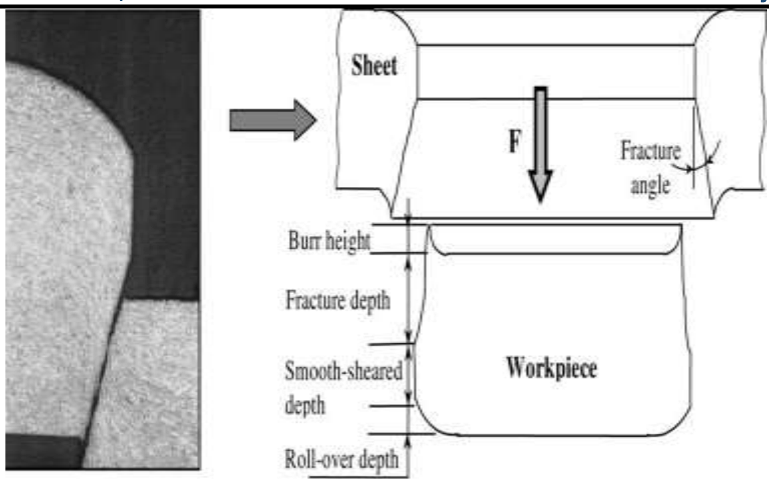

Figure 2: Geometry of the sheared work piece [5, 6]

1.2 Problems in blanking process.

- Blanking process design: - In industry blanking operations are still performed based upon experimentations and process is governed by time-consuming and expensive trial and-error iterations due to lack of knowledge about optimum punch-die clearance.
- Due to more trial and error methods, more cycle time is required which result into inaccurate product dimensions and specification (especially formation of burr height) [7].
- Quality of component is not at satisfactory level due to formation of burr height.
- When there is a manual Quality control by operators without setting of optimum punch die clearance, it results into high quantity of rejection.

II. OPTIMIZATION

The processes can be optimized to determine the following outputs:

- Total manufacturing cost of the product
- Quality improvement of the product.
- In-process time can be optimized etc.

In this process the operator may be desired to minimize or maximize the objective function after considering the effect of following factors on the process.

2.1 Influence of clearance between punch and die

The clearance between punch and die is specified as,

$$C = \left(\frac{Dm - Dp}{2t} \right) 100\ (\%)$$

As shown in above expression, Clearance is expressed as percentage of sheet thickness. t ,Dp, Dm are the sheet thickness ,diameter of punch, diameter of die [5, 6, 8, 9].

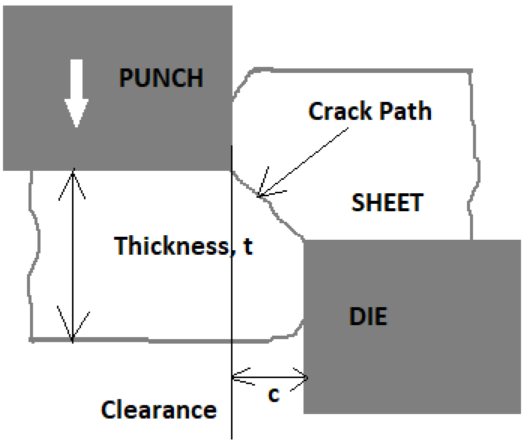

Figure 3: Representation of the clearance between die and punch [6]

To find out optimum clearance three setups are manufactured equivalent to three altered clearances as 5%, 10% and 15%. These values are commonly used clearances in sheet metal industry.

2.2 Influence of tool wear

It is important to design the punch tool for industrial fabrication process. The quality of the product cut is depending upon the wear condition of tool [6].

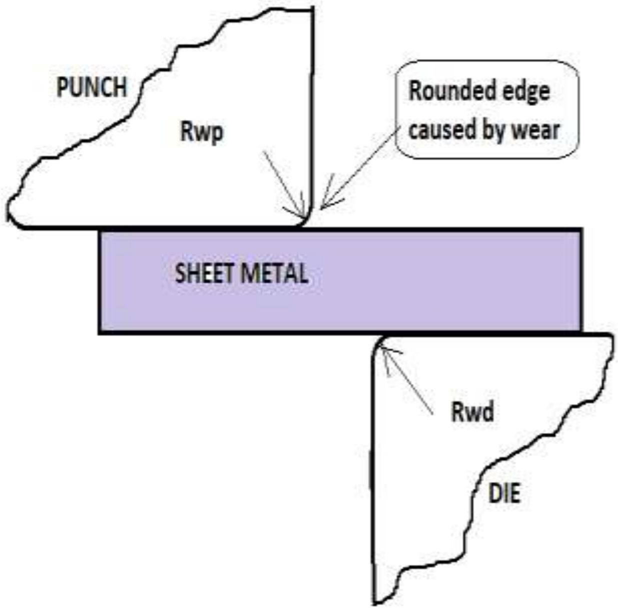

Figure 4: Cutting edges of the tool [8]

Wear is formed on tool because of the friction between punch tool and material sheet. Parameters affecting the rate of wear are punch velocity, material of punch, blanked work piece material, clearance between die and punch, lubrication and sheet thickness. Due to wear on outer edges of tool, the cutting edges become rounded (Fig.4). By varying the values of the radius of edge i.e. R_{wp} and R_{wd} (Fig.4), the effect of wear can be observed. So, the study of the tool wear effect on profile variations is important.

2.3 Influence of the thickness of the material

It is detected that the sheet thickness affects energy required for blanking. The conclusion is given as: When ratio of clearance with thickness of sheet increases blanking energy decreases and blanking is directly proportional with thickness of sheet. The magnitudes of the depth features are influenced by the thickness of sheet [6].

III. METHODOLOGIES

3.1 Design of Experiments

Design of experiment can be defined as a branch of applied statistics which deals with planning, conducting controlled tests, interpreting the result and analysing to estimate the factors which have control over the quality parameter or group responses. An experiment which is intentionally planned and executed may provide a great deal of information about the effect of one or more factors on a response variable. In many experiments keeping some factors constant and changing the levels of another variable. This approach is known as One–Factor–at–a–Time (or OFAT), however to process knowledge it is inefficient when compared with changing factor levels simultaneously.

In start of the 20th century from the work of R. A. Fisher (Fisher, 1974), Many of the current statistical methods to designed experiments originates. Fisher built up how setting aside the opportunity to truly consider the outline and execution of a trial before attempting it maintained a strategic distance from every now and again experienced issues in analysis. The key concepts in creating a designed experiment are blocking, randomization and replication. In product realization the use of experimental design can produce work-pieces those result in products that are easy to manufacture and that have improved reliability and field performance, shorter product design, reduced development time, and lower product cost.

The Taguchi approach to quality enhancement, which employs DoE is most effective when the experiments are scheduled and carried out as a team project [13]. For experiment conduction rather than an individual effort a group effort is required. It supports an approach where accord is come to before propelling a trial as opposed to spending time persuading others about the outcomes after the investigation is finished. This logic is especially proper in mechanical settings, where ventures include an extensive number of individuals in the achievement and execution of result. The new restraint requests that that all choices with respect to the test studies are come to by accord in a formality converted of meeting of project team members.

DoE can create maximum profits when applied in product development, research, and concept design. Scientific personnel and Engineers should learn to apply DoE just as they do basic principles of mechanics, physics, and chemistry. Manufacturing and process specialties are the next areas to benefit from DoE. Each and every process including brazing, machining, blanking, piercing, casting, heat treating, painting, molding, soldering, bonding, welding, gluing and coating is controlled by a several factors. They can all be fine-tuned by approximately designed experiments. To improve production processes Engineers at manufacturing plant should regularly routine DoE techniques.

3.2 Finite Element Method

FEM is suitable to design the process as it helps to reduce the number of trails. Sheet metal forming problems can be solved with numerical simulation using FEM. In industry, Fem simulation is already in use but FEM codes are not commercially available for simulating. . The FEM model is able to guesses burr height, height of smooth sheared zone and fracture zone and shape of roll over portion [2, 13]

A model using FEM and DOE can investigate the best value of clearance to minimize burr height. This analysis shows that clearance should be agreed at approximately 5 % without any blank holder force on sheet [7].

FEM program ANSYS is used for studying shearing mechanism of AISI 304 sheets. The results of the FEM simulation are compared with the results of experimental studies. Clean blanked surfaces are obtained when the path of direction of crack coincides with the line connecting crack initiating points [8].

The FEM analysis can also be used to predict influence of parameters. The blanking load is inversely proportional with tool clearance. So when tool clearance decreases, blanking load increases. Also it states that plastic zone of blanked part is not affected when clearance is varied from 0 to 20 % of sheet thickness [10].

3.3 Neural Network Analysis

This method is suitable when we don’t have any known relationship between data of factors of input and output. In this method input data is supplied to with target output data. The error between neural network output and target output is minimized by using the system and by adjusting the internal connections. Then it is stored in processors. Neurons are inter connected processing elements. They are organized in layers. ANN consists of large number of neurons as a parallel architecture.ANN is then trained and tested. The output signal of an individual processing element is sent to other processing elements as input signals via the interconnections [11].

IV. LITERATURE SURVEY

The first book on Design of Experiments was introduced by Ronald Fisher in 1974 that states about statistical method with some new advances like Analysis of variance i.e. ANOVA. Also it explains concept of experimentation and randomization of experiments for biased use of systematic arrangement.

Another book on Design of Experiments investigated welding process using Taguchi method with ANOVA for optimization and demonstrated techniques of DOE with the help of some practical examples and case studies. Calculations in DOE are made easy with the use of software like MINITAB, Design Expert, and Qualitech4 [13]

There are two different approaches. First method includes blanking experiment with the explanation of a ductile rupture model in a blanking experiment. The other method used is more positive for manufacturing. It replaces difficult blanking test and uses tensile test [1]. According to [1] it is predicts ductile fracture initiation over a varied choice of clearances if the critical C is determined in a tensile test. (C is a material constant which is to be calculated experimentally).

According to [2] it uses a finite element model which is presented with very large distortions. The model is able to guesses burr height, height of smooth sheared zone and fracture zone and shape of roll over portion. An investigation is conducted to evaluate ductile fracture methodologies so it helps to determine shape of sheared profile in blanking technique [3]. The strategy of using fracture criterion in a blanking experiment has higher accuracy for all materials. According to[3] it concludes that a tensile test strategy with ductile fracture is simple as compared to first one. According to [4] they studies process variations which are analyzed by using DOE method to find out interactions between process factors. If clearance is kept at approximately 10% then blanking force required is less. Fracture angle and the fracture depth will be less if clearance is kept at 5% of thickness of sheet.

According to [5], Crack initiation and its path of propagation is shown by using a damage model. The FEA technique and Artificial Neural Network simulation are used. It concludes that if material ductility increases then clearance value decreases. According to [6] they have used the specially developed software BLANKSOFT. The mechanical condition of the sheared portion of blanked part and its geometry can be determined by using BLANKSOFT software. Tool wear profile shape is predicted by comparing experimental readings and software results. A model is prepared by using FEM and DOE [7] and it investigates the best value of clearance to minimize burr height. This analysis shows that clearance should be agreed at approximately 5 % without any blank holder force on sheet.

An investigation is conducted on a shearing mechanism to find out optimum punch-die clearance value [8]. FEM program ANSYS is used for studying shearing mechanism of AISI 304 sheets. The results of the FEM simulation are compared with the results of experimental studies. Clean blanked surfaces are obtained when the path of direction of crack coincides with the line connecting crack initiating points. According to [9] it summarizes the results of multi-purpose FEM code and MARC-2D simulation of the blanking process. An updated lagrangian approach is used. The influence of process parameters like clearance between die and punch tool geometry and properties of material are studied and compared with results of experimentation. The model developed is not able to detect the path of propagation of crack. But crack initiation can be predicted.

The FEM analysis is used to predict influence of parameters [10]. The blanking load is inversely proportional with tool clearance. So when tool clearance decreases, blanking load increases. Also it states that plastic zone of blanked part is not affected when clearance is varied from 0 to 20 % of sheet thickness.

V. RESULTS AND DISCUSSION

On the basis of literature survey made, it has been observed that the amount of work which is done is basically related with techniques like fracture simulation, neural network to predict the fracture conditions of metal sheet. Most of the researchers have examined effect of process parameters on the blanking process. In this work, clearance and thickness has been used to enhance the efficiency of the metal blanking process, which are the most influential parameter in blanking. An optimization technique can be selected suitably based on the output performance of the optimization technique. The finest one can be choose to increase the productivity. This is possible only by evaluating the performance of different algorithm.

Lot of investigators are concentrating only on predicting the shape of blank and fracture phenomenon of blanking process. Moreover no study has been performed in blanking process to develop mathematical model by using Taguchi Method and regression analysis. In recent years evolutionary methods like Design of experiments (Taguchi) have been used to get promising results in manufacturing applications which helps to improve quality and economy.

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