Process Parameter Optimization in Sheet Metal Blanking Process A Review

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Abstract- *Metal blanking is a widely used process in high volume production of sheet metal components. In blanking operation, the quality of the product and the tool life is mainly depends upon the punch and die clearance. The main objective of present study is to improve the quality of product and also tool life optimizing the punch geometry, die clearance and sheet thickness. Excessive clearance in between punch and die results in large quantity of burrs and poor quality. On the other hand if the clearance is to small results in part with poor edge quality reduce the tool life and leads to more frequent tool component replacement. The present critical review has been carried for investigating the effect of potential parameters, influencing the blanking process and their interactions. This will be beneficial in selecting the process parameters for two identical products manufactured from two different materials blanked with a reasonable quality on the same mold. The study will also be help to evaluating the influence of tool clearance, sheet thickness and sheet material thus optimizing sheet metal blanking process.*

Keywords- Blanking, Punch and Die clearance, Optimization, sheet thickness.

I. INTRODUCTION

Blanking is a widely used process in sheet metal components. It is a cutting operation in which material is cut in between punch and dies interface. In this process a piece of sheet metal is removed from a larger piece of stock by applying a enough shearing force. The piece removed, called the blank, is not scrap but rather the desired part. Among the shearing processes blanking is one of the most frequently used due to its reliability and capability of mass production. Sheet metal forming processes like blanking, stamping and bending are very commonly used in the manufacture of sheet metal parts and it takes a combination of different processes to manufacture sheet metal parts. Blanking is a common sheet metal manufacturing process used in the production from the range of small components to high strength materials. The sheet range from the 0.2-20mm thickness can be used for the applications. [1]

In blanking, punch and die clearance is the important factor to give the better quality of the product and improve the tool life. The Fig.1 shows the effect of excessive and insufficient clearance that affects the quality of the product. If the punch and die clearance is too large leads to large burrs and poor quality, otherwise the clearance is too small results in part with poor edge quality, reduce the tool life and leads to more frequent tool component replacement.[2]

Blanking is metal shearing processes in which the incoming sheet material is sheared to a desired shape. In blanking process in which the sheet undergoes severe deformation since the sheet metal is sheared or separated to have the slug and part. The sheet material in between the punch and die undergoes very high deformation and is sheared as the punch penetrates the sheet material with velocity. Blanking process consists in a metal sheet positioned over a die in which a punch passes through to plastically deform the metal until a crack propagates and leads to complete separation of blanked part. The sheared/blanked edge is made of different zones based on material deformation that has occurred. The ratio of the different zones is influenced by parameters like the punch-die clearance, punch stroke, sheet thickness of the material and sheet material properties to name a few. A large shear zone and small rollover and burr are generally preferred in the blanked part.[3]

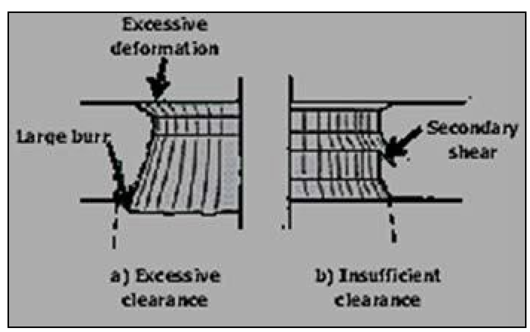

Fig.1. Effect of clearance on output product

II. LITERATURE REVIEW

The process of identifying process influencing parameters of blanking process includes an exhaustive literature review of the factors that have been suggested by various authors. Literature review was performed by collecting articles from various journals, and various popular research related sites viz. Science Direct, IEEE, Emerald, Springer Link and various free articles from internet. Literature from journal papers and conference studied for various press tool works parameters optimization are reviewed.

S. K. Maiti, A. A. Ambekar, U. P. Singh, P.P. Date, K. Narasimhan, [1], they evaluate the influence of tool clearance, friction, sheet thickness, punch/die size and blanking layout on the sheet deformation for thin M. S. sheet. The punch load variation with tool travel and stress distribution in the sheet has been obtained. The results indicate that a reduction in the tool clearance increases the blanking load. The blanking load increases with an increase in the coefficient of friction. These observations are very similar to the case of blanking of component of large size. Further, these effects are very similar in the case of both single and double blanking. An inter blanking site distance of about twice the sheet thickness is good to reduce the thinning of sheet at the intermediate regions between the two blanking sites.

Ridha Hambli [3], presents industrial software called BLANKSOFT dedicated to sheet metal blanking processes optimization. The code allows for the prediction of the geometry of the sheared profile, the mechanical state of the sheared zone, the burr height, the force–penetration curve, and the wear evolution of the punch versus the number of the blanking cycles. The approach is based on an original theoretical investigation formulated from plasticity theories. This program is designed by considering several factors, such as material and geometry of product as well as the wear state of the tool. The numerical results obtained by the proposed programs were compared with experimental ones to verify the validity of the proposed software.

R. Hambli [5] , presents an experimental investigation into the blanking process was carried out using tools with four different wear states (wear radius 0.01, 0.06, 0.012, 0.2 mm) and four different clearances (5%, 10%, 15%, 20%). The aim was to study the effects of the interaction between the clearance, the wear state of the tool and the sheet metal thickness on the evolution of the blanking force and the geometry of the sheared profile. He used designed of experiment method for model and analysis the relationships that describe process variations. This investigation shows that, in order to minimize the blanking force, the clearance should be set at 10%, however, to minimize the fracture angle and the fracture depth, it is preferable to set the clearance at 5%. When the clearance is set at 10%, the process is slightly more robust to tool wear, as far as the blanking force response is concerned. Whether clearance should be set at 5% or 10% ultimately depends on the priorities of the practitioners.

F. Faura, A. Garcia, M. Estrems [6], they proposed a methodology to obtain optimum punch-die clearance values for a given sheet material and thickness to be blanked, using the finite-element technique. To determine the optimum clearance, the diagonal angle and the angle of the direction of crack propagation for different clearances were calculated. The influence of clearance on diagonal angle and angle of the direction of crack propagation, from which it is seen that as the clearance increases, diagonal angle increases proportionally while angle of the direction of crack propagation remains nearly constant. At the point of intersection, the direction of crack propagation coincides with the diagonal line, and so the cracks emanating from the punch and die meet, resulting in a cleanly blanked surface. Hence, this value of clearance is taken as the optimum clearance. The optimum clearance for the values of the parameters used in this work is between 11 and 12%. It is observed that punch penetration increases as the c/t ratio increases.

R. Hambli, S. Richir, P. Crubleau, B. Taravel [7] elaborates blanking process and structures of the blanked surfaces are influenced by both the tooling (clearance and tool geometry) and properties of the work piece material (blank thickness, mechanical properties, microstructure, etc.). Therefore, for a given material, the clearance and tool geometry are the most important parameters. They use simulation of an ax symmetric blanking operation with ABAQUS- explicit software for a given sheet material. A damage model of the Lemaitre type is used in order to describe crack initiation and propagation into the sheet. They use four materials for testing with four different elongation (30%, 47%, 58%, and 65%).They show that the optimum clearance decreases as the material elongation increases. The results of the proposed experimental investigation show that there is no universal optimal clearance value. Whether clearance should be set at 5% or 10% ultimately depends on the priorities of the practitioners.

Emad Al-Momani, Ibrahim Rawabdeh [8], Represents a model investigates the effect of potential parameters influencing the blanking process and their interactions. Finite Element Method (FEM) and Design of Experiments (DOE) approach are used in order to achieve the intended model objectives. They use Design of Experiments (DOE) technique by selecting the experimental levels for each selected factor, i.e. the clearance to be in five levels (5, 10, 15, 20, 25) % of the sheet metal thickness, blank holder force to be in two levels (0, 3000N) and sheet metal thickness to be in four levels (0.5, 0.6, 0.7, 0.8)mm. Perform a factorial experimental design in order to take high-level interactions.

Develop a Finite Element Model (FEM) that represents the existing process in order to evaluate the quality of the inputs. Compare the two techniques (FEM and DOE) and analyze the results to get the proposed optimal set of parameters. Simulations are conducted on commercial FEM software package ABAQUS/Explicit. in their article , they show that, in order to minimize the burrs height, the clearance should be set at about 5 % with almost no blank holder force.

Ridha Hambli [9], describes a methodology using the finite element method and neural network simulation in order to predict the optimum punch–die clearance during sheet metal blanking processes. A damage model is used in order to describe crack initiation and propagation into the sheet. The proposed approach combines predictive finite element and neural network modeling of the leading blanking parameters.

Gang Fang*, Pan Zeng, Lulian Lou [10], in this paper, the punch–die clearance values for a given sheet material and thickness are optimized, using the finite element technique and Cockcroft and Latham fracture criterion. In the study, the shearing mechanism was studied by simulating the blanking operation of an aluminum alloy 2024. The results of the present paper agree with the previous experimental results.

III. FACTORS INFLUENCING BLANKING PROCESS

a) Influence of Blanking Clearance

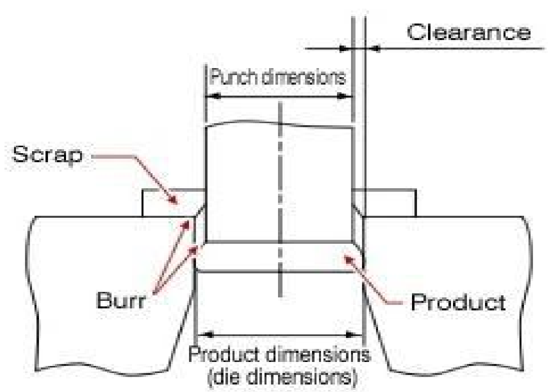

Fig.2.Clearance between Die and Punch

In blanking processes, the clearance (Fig.2.) expressed as a percentage of the sheet thickness, is defined by:
$C=100\ (D_m - D_p/2t)$ (%)

Dm, *Dp*, and *t* are, respectively, the die diameter, the punch diameter, and the sheet thickness In order to study the influence of this design parameter, four tools have been designed corresponding to four different clearances, 5%, 10%and 15%. These values correspond to the most used clearances in industry.[17]

b) Influence of the Sheet Thickness

For a given material, the energy requirement in blanking is influenced by the sheet thickness. It has been observed that:

1. The blanking energy decreases with increasing clearance-to-sheet thickness ratio *c*/*t* and increases with increasing sheet thickness.
2. The proportions of the different depth characteristics of the sheared profile are affected by the thickness.

b) The Effect of Material

The part edge quality also depends on the material being blanked. Materials with large ductility, low yield strength, and homogeneity will have better blanked edge quality, dimensional tolerances, and longer tool life[7]

IV. RESEARCH OBJECTIVE AND APPROACH

a) Objectives:

The objective of this is to

1) Minimize burr height of the parts for different types of part.
2) Optimization of blanking process to reduce burr height.
3) Selection of proper combination of process parameters at their specified levels in such a way that costly dies will not be manufactured until the finite element method shows the best set of results for process parameters.[12]

b) Following are the parameters which affect the blanking process.

1) Clearance (Controllable)
2) Material (Controllable)
3) Material thickness (Controllable)
4) Friction (Noise factor)
5) Punch die alignment (Noise factor)
6) Tool geometry (Noise factor)
7) Speed of stroke rate (Noise factor)
   Above parameters, some are the controllable parameters which can be control to get optimum results in blanking operation.[9]

c) Approach:

The Process parameter optimization in sheet metal blanking process can be achieved by the following approaches.

1) Finite element method & Taguchi method .
2) Combination of these two techniques provides good contribution for the optimization of sheet metal blanking process.
3) Understand the effect of parameters; with simulation in blanking process & get optimize value with Taguchi Method and comparing the results with practically design tool. [6]

V. OPTIMIZATION TECHNIQUES

There are various techniques used to optimize Sheet metal blanking process. Following are discussed in detail. [13]

a) Design of Experiments

It is a systematic approach for optimizing the process performance. Setting of the single factor is at a time till response is improved. It is used to get various combination of parameter.

b) Finite Element Method

Simulation problems associated with sheet metal forming using finite element analysis can help to design the process by reducing so many numbers of trial steps. Process modeling by FEM simulation is widely use in various industries of forming operation. Among the various numerical methods, Finite element analysis is has been used with success. However this requires generation of large set of data to get accurate results and consumes more investment in engineering time & computerized resources. FEM is the good choice for sheet metal processes since it helps to eliminate the need for time consuming experiment to optimize process parameters. So many of the time consuming process can be replaced by computer simulations. Therefore, more accurate results may be obtain using FEM simulation. Finite element gives approximate solution with an accuracy which depends on type of elements and fine quality of finite element mesh.

c) Taguchi Method of approach

In Taguchi method modified & standardized form of design of experiments is used. It is help to study the effect of various factors on quality characteristics. Experiments are design using specially constructed tables known as orthogonal array which makes experiments very easy and less no of trials require to study the entire parameters. Experimental results then transfer into signal to noise (S/N) ratio to measure quality characteristics. There are three categories, Lower the better, higher the better, nominal the better. Greater S/N ratio leads to better quality. After this statistical analysis of variance (ANOVA) is done to see which parameter is significant? With S/N ratio and ANOVA analysis optimum parameter can be predicted.[14]

d) Neural network analysis

Networks are used as numerical devices for substituting finite element code for optimum clearance prediction. Neural networks are used to estimate or approximate function that can depend on large number of inputs and are generally unknown.

e) Genetic Algorithm

In genetic algorithm, population of candidate solution to the optimization problem evolved towards better solution. Each of these candidate solution has set of properties which can be mutated and can be altered. The evolution usually starts from the population of randomly generated individuals and happens in generations. In each of the generation, the fitness of each and every individual in the population is evaluated, the more fit individuals are selected from the current population, and each individual’s genome is modified to form a new population. The new population is then used in the next iteration of an algorithm. Commonly, algorithm terminates when either the maximum number of generations has been produced, or a satisfactory fitness level has been reached for the population. Once the genetic representation and the fitness functions are defined, a GA proceeds to initialize the population of solutions and then to improve it through continuous application of the mutation, crossover and inversion and selection of the Operators.

VI. CONCLUSION

In blanking, the tool life is an important factor for improve the productivity and improving in quality, and also burr height is to optimal value to improve the quality of the product. Thus these two parameters play an important role in Maximization of Tool life and Minimization of Burr height. The tool life and the burr height is mainly depends upon the sheet thickness as well as the punch and die clearance, it directly relates to the improvements in productivity and tool life.

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