

Review of Blanking Process Using FEM and DOE Techniques to Analyze the Influence of Process Parameters on Burr Height

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Abstract

With the current situation of the global sheet metal industry, meeting market demand for low-cost, high-quality sheet metal products is a major problem. Sheet metal blanking is a metal production method that is widely used in automobiles, aircraft, electrical and electronics equipment, heavy machinery, and other industrial equipment. Burrs are undesirable material and ragged edges raised on the surface of the blank during the blanking process. The creation of a burr on a piece of metal reduces its quality, accuracy, and utility. As a result, it must be separated by further processing such as machining or deburring, which raises the cost per item in manufacturing. Burr can be reduced by selecting the right collection of process variables. This paper provides a review of finite element simulations of the blanking process using the Ansys/Explicit Dynamics software package with various sets of process parameters. It also examines the author's design of experiments (DOE) methodology and the effects of process parameters on burr formation and equivalent stress.

Keywords: *Sheet metal, blanking, process parameters, optimization, finite element method, design of experiments, burr height, stress.*

INTRODUCTION

Metal blanking is a popular process for the high-volume manufacture of metallic

components. There are common techniques for this process, but they are insufficient to address the challenges in

constructing blanking systems, where requirements for shorter cycle time and accurate part sizes become increasingly difficult.

In engineering practise, the design of blanking processes is still based mostly on experiments, and it is typically governed by time-consuming and costly trial-and-error iterations influenced by an inadequate, mostly empirical knowledge of these processes. There is a need for a unique approach that eliminates the need for trial and error decision making while constructing a blanking procedure. As a result, appropriate blanking process modelling and concentration may be useful in reducing lead-time and regulating product standards, particularly the profile of a blanked (sheared) edge burr height.

The goal of this paper is to study and analyse various authors' blanking process research for qualitative optimization of blanking process parameters using Response surface methodology and Finite Element modelling to determine the effects of various process parameters on burr formation and equivalent stress.

Punch-Die Clearance, Punch Velocity, and Sheet Thickness on performance indicators such as surface quality (Burr Height) of

blanked component and equivalent stress caused during blanking process.

LITERATURE REVIEW

Lukasz Bohdal and Leon Kukielka conducted a 3D finite element study of ductile fracture, strain distribution, and stress in the blanking technique based on geometrical and physical nonlinearities. The procedure's physical, mathematical, and computer models are described. The author investigates the effect of the leading process parameter blanking clearance on the deformation of 1018 steel and the quality of the blank's sheared edge profile. The results of ANSYS computer simulations may be used to estimate the quality of final component optimization [1].

Burr formation and shear strain field progression investigations using sheet metal blanking were proposed by Jyotiranjana Barik, Vijayalaxmi Sonkamble, and others. The ABAQUS-CAE software package performed finite element modelling of the blanking process for AA6082-T6 with multiple process and geometric parameters. The design of experiments (DOE) method was used to determine the impact of the procedure and geometric restrictions on burr development during metal sheet blanking. This effort

will not only benefit the blanking process, but will also increase product quality and lower manufacturing costs. The typical shear strain field pattern formed at different punch diffusions of sheet metal blanking is being investigated [2].

Didin Zakariya Lubis and Muslim Mahardika investigated the effects of clearance and punch velocity on the quality of blanked components made from pure thin copper sheets. The effect of clearance and punch velocity on the quality of the punched edge was demonstrated. Through the clearance variation, the study employs pure copper sheet material. Punch velocity is based on the capability of an approximately micro-punch CNC machine. At maximum speed, the punch velocity has a favourable effect on the sheared zone in copper. Fundamentally, the optimum sheared edge of a punching result is rollover and a little burr [3].

Dheeraj Dilip Kulkarni and Rakesh Adhikrao Shinde present the blanking clearing optimization process. The research has aided in estimating the impact of tool clearance, sheet thickness, and sheet material, resulting in improved clearance, which influences further process factors. The Taguchi method's designs of

experiments (DOE) technique is used to achieve the model's stated objectives. The study identifies the challenge of reliable prediction of blanked edges with an emphasis on clearance optimization. It uses Design of Experiment to offer a strategy for optimal clearance prediction of sheet metal blanking processes [4].

Blanking Process Optimization by Finite Element Analysis and Taguchi Technique Study Work has been conducted by Aniket N. Patil and V. L. Kadlaghas to explore the influence of quality parameters that affect the blanking process and their relationships. This aids in the selection of process principle parameters for identical work members made from two distinct materials blanked with appropriate quality. The combination of the finite element approach with the taguchi method yields good results for the optimization of the sheet metal blanking process.

The study evaluates the influence of tool clearance, sheet material thickness, and sheet material on clearance, which affects other blanking process parameters. It was also discovered that before designing a blanking die, it is beneficial to do a finite element analysis to determine how parameters affect the design and to choose a feasible and result-oriented design. The

Taguchi technique and finite element method results are then validated using a physically designed blanking die [5].

Yarnagula Rawali¹, K.S.L. Soujanya, and others used ansys explicit dynamics to examine the influence of process restrictions in blanking. CATIA V5R20, explicit dynamics, and the ANSYS suite are used to create the blanking process model, simulation, and optimization. The blanking process for various sheet materials is investigated, as well as the percentage of punch-die clearances, sheet thickness, and punch fillets. Computer simulation results can be utilised to anticipate the quality of finishing component optimization [6].

J. A. Soares, M. L. Gipiela, and others have all been characterised. The effect of punch-die clearance on the sheared edge quality of thick sheets gives the possibility of employing FE-simulations to reduce the number of tests required, resulting in a better knowledge of the effect of specific punching process factors. Clearances of 0.2% to 15% between the punch and die were investigated. The effect of punch-die clearance on fracture propagation was also investigated [7]. Antonello, Annibale, and others all suggested Process factors influencing the blanking of AISI 1006 low

carbon steel, A bench shears was built to test the effects of blanking settings on the damage of a sheet of low carbon steel, with special attention paid to the punch-die gap. An FE model was constructed to understand the final work piece behaviour and anticipate breakage using the damage Brozzo's criteria.

Following a preliminary set of FE simulations, it was feasible to assess the force-stroke trends obtained from tests and determine the appropriate critical value for Brozzo's damage rule. Once the necessary knowledge to identify the damage was obtained, a second set of simulations utilising three alternative gap values was directed to appropriately analyse the influence of the punch die gap on the work piece finish. In terms of work piece final shape and side surface polish, a good agreement was discovered between experimental and simulation findings [8].

C. Labergerea and K. Saanouni presented modelling and adaptive numerical simulation of the fine blanking process using entirely coupled advanced constitutive equations with ductile damage, thermodynamically-consistent constitutive equations, intensely coupled with ductile damage, and specific boundary conditions (specific command of

forces on the blank holder and counterpunch). The Vumat user subroutine imported this model into ABAQUS/EXPLICIT and linked it to an adaptive 2D remeshing technique. The different material characteristics for the steel S600MC are identified via experimental tensile testing that is accompanied by the ultimate fracture. A parametric study was conducted to investigate the sensitivity of process parameters (die radius, clearance die/punch) to punch force and rupture surface topology (convex zone, sheared zone, fracture zone, and burr) [9].

Kaan Emre Engin and Omer Eyercioglu report a finite element technique investigation of process parameters on the blanking of AISI 304 stainless steel. For simulation and investigative investigations of the blanking process, five different clearances and three different thicknesses were employed in this study. The simulations were carried out with the help of the FEM software Deform 2-D. Fracture advancement characteristics such as crack initiation, indentation angle, rollover angle, crack propagation angles, depth, and the corresponding blanking energy values were investigated. The current study's findings agree with the findings of previous research [10].

Piemaan Specifically, Jeahyeong Yu offers a Finite element study of the blanking process of a magnesium alloy (AZ31) sheet using ductile fracture criteria, as well as experimental confirmation at various temperatures. Using a finite element approach, modelling and assessing the sheet blanking process of magnesium alloy sheet (AZ31) at various temperatures is possible. Previously, the computational analysis was compared to the experimental setup findings. The value of the critical damage criterion influences the fracture initiation and form of the blanked edge in the finite element model (c). By altering various process parameters and temperature, the critical criterion is established and matched using the ductile fracture criteria presented by various researchers. The influence of temperature and process factors on blanked edge geometry, including burr, rupture zone, shear surface, and rollover, has been investigated. Furthermore, numerical predictions matched experimental results [11].

The clearance-dependent critical ductile fracture criteria obtained by the Cockcroft-Latham and Oyane criteria were used to moderate the time and cost of experiments to achieve the value of the critical fracture criterion, as proposed by Phyo Wai Myint

and Seiya Hagihara in their paper, Application of the Finite Element Method to Analyze the Influences of Process Parameters on the Cut Surface in Fine Blanking Processes by Using Clearance-Dependent Critical Frac

The Finite Element Method (FEM) was used to investigate the impacts of process factors such as punch and die corner radii, beginning compression, and the size and form of the V-ring indenter on the length of the sheared surface. Also discussed are the effects of stress triaxiality and punch diameters on the sheared surface created by the fine blanking process. The process settings and tool geometry that were evaluated to find a fully-fine sheared SPCC surface are detailed. The results demonstrated that the Oyane criteria may be used to forecast ductile fracture onset in an accurate and stable manner [12].

A finite element simulation of the blanking process was performed by Afzal Ahmed and Hasmira Muhamad. The blanking process is well simulated by ABAQUS v6.4 in this investigation. The elastic plastic range simulation agrees well with the exploratory data. As the fracture grows, the punch power decreases significantly and the punch penetrates depending on the punch edge radius. With

increased sheet thickness, the crack height decreases and the blank quality improves. In the elastic zone, adjusting punch wear (edge radii) has no discernible effect on force. However, in the plastic/fracture zone, different punches wear through the blanking at different forces, as observed in experiments by Hambli and Potiron. However, this significant difference is not readily apparent in simulation due to the use of a damage model that does not account for punch wear [13].

Prof. T. Z. Quazi and R. S. Shaikh provide an overview of the clearance optimization method in sheet metal blanking. This study proposes a model for investigating the influence of probable blanking process factors and their interaction.

The Design of Experiment (DOE), Finite Element Method (FEM) using ANSYS Suite, Simulation with ABAQUS-Explicit software, Blank Soft Software, and Neural Network Simulation were used to optimise the blanking process [14].

The impacts of clearance and punch speed on the sheared surface quality effects of a brass blanking on the micropunch CNC machine are described by Ichsan Ristiawan and Muslim Mahardika. An experiment to examine the influence of clearance and

punch speed on brass using a workpiece in the shape of an 800 m circular hole. This investigation was carried out using a micro punch CNC machine that was created and tested directly to the ability and requirements using simulations and trials. The study reveals the effect of clearance on punch effect surface quality; the less clearance, the higher the burnish area created than the roll over, fracture, and burr zone. The effect of punch speed utilised demonstrates minimal leverage [15].

H.Y. Chan and A.B. Abdullah examined geometrical defects in precision blanking and punching. A thorough examination of burr development. The study provides an overview of burr development and discusses the aspects that contribute to its occurrence. Based on the investigation, it was discovered that die clearance is one of the most important factors tested experimentally. The study also discussed the current issues faced by the manufacturer and investigator regarding the burr problem, as well as some of the remedies recommended to address this problem. Furthermore, the authors discussed the issue of measuring the burr since the size of the component is smaller and the degree of accuracy is higher [16].

The results of an experimental study of blanking angled hooks with a punch with a sloping face in a thin steel sheet with a hardness of 55 HRC are presented to present Jacek Mucha and Jacek Tutak's study of the influence of blanking clearance on the wear of the punch, the change of the burr size, and the geometry of the hook blanked in the hardened steel sheet. K340 cold-work tool steel was employed as the punch material for blanking. Three different clearance and sheet thickness values were tested.

The examination of the influence of the number of cuts produced by the punch on the growth of the burr at the sheet edge was presented. Furthermore, the effects of clearance on the initial values of burr (BH), deflection (HB), and bending radius (RB) of the hook have been demonstrated. The influence of the friction route on the severity of working surface degradation and the punch blanking boundaries was also illustrated. The results obtained allow for the selection of good clearance and novel tool materials for blanking blades operating in generally severe tribological situations [17].

CONCLUSION

If the Finite Element Method paired with the Design of Experiments technique gives

strong assistance for the optimization of the sheet metal blanking process. The design of trials will assist in the management of the selection of the correct combination of process parameters at their quantifiable levels, such that costly dies will not be created until the finite element technique validates the optimal set of process parameters. The combination of DOE and FEM approaches is expected to result in lower experimental costs and effort, as well as a higher degree of confirmation. clearance and novel tool materials for blanking blades operating in mostly challenging tribological circumstances [17].

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