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A Review on Factors Affecting the Sheet Metal Blanking Process

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ABSTRACT: *Metal blanking is a widely used process in high volume production of sheet metal components. The main objective of this paper is to present the study model to predict the shape of the cut side. The study investigates the effect of potential parameters influencing the blanking process and their interactions. Different methodology like use of simulation software's (e.g. abacus,ansys),FEM,DOE tech are applied. Finally, the factors affecting blanking process observed are Clearance ,tool wear, Sheet Thickness, Material properties .*

Keyword: *Clearance, tool wear, Sheet Thickness, .*

I. Introduction

Metal blanking is a widely used process in high volume production of metal components. General guidelines for this process exist but they are not sufficient to overcome the difficulties in designing blanking processes, where requirements for less cycle time and accurate product dimensions become more demanding. The design of blanking processes in industrial practice is still based largely on experimentations and it is often governed by time-consuming and expensive trial and-error iterations caused by limited, mostly empirical, knowledge of these processes.

1.1 Characteristics of the blanking process include

- Its ability to produce economical metal work pieces in both strip and sheet metal during medium or high production processes,
- The removal of the work piece from the primary metal stock as a punch enters a die.
- The production of a burnished and sheared section on the cut edge.
- The production of burred edges.
- The control of the quality by the punch and die clearance.
- The ability to produce holes of varying shapes – quickly.

1.2The blanking process has some downside effects., these include:

- Generating residual cracks along the blanked edges,
- Hardening along the edge of the blanked part or work piece, and
- Creating excess roll-over and burr if the clearance is excessive.

The most common materials used for blanking include aluminium, brass, bronze, mild steel, and stainless steel. Due to its softness, aluminium is an excellent material to be used in the blanking processes . Blanking process can be considered to include series of phases in which sheet metal undergoes deformation and separation... Therefore, appropriate modellingand understanding of the blanking process could be beneficialto reduce the lead-time and to control the product specifications, especially the shape of a blanked (sheared)edge.The behaviour of the blank material during the blanking process can be divided into five stages. During the start ofthe process, the sheet is pushed into the die and the blank material is deformed, first elastically. The processcontinues and the yield strength of the blank material is reached, first at the outer fibbers and later at all the fibbers in the zone between the punch and the die. Normally, the material underneath the punch is subjected to thinning.The plastic deformation causes rounding of the edge of the blank. During this stage, or possibly as early as during the plastic deformation stage, damage initiation followed byte nucleation and growth of cracks takes places. In most of the conventional blanking situations, ductile fracture occurs after shear deformation. This causes rough, dimpled rupture morphology on the fractured surface of the product. Finally, the work due to friction is dissipatedwhen forcing (pushing) the slug through the die hole.

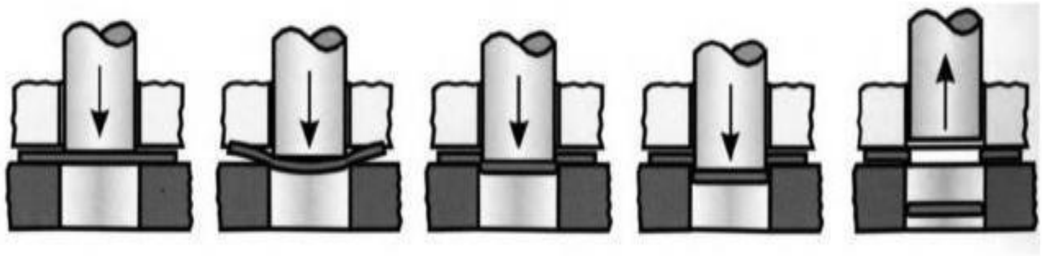

Figure 2 Steps in blanking process

II. Literature Review

Emad Al-Momani, Ibrahim Rawabdeh,[1], The main objective of this paper is to present the development of a model to predict the shape of the cut side. The model investigates the effect of potential parameters influencing the blanking process and their interactions. This helped in choosing the process leading parameters for two identical products manufactured from two different materials blanked with a reasonable quality on the same meld. Finite Element Method (FEM) and Design of Experiments (DOE) approach are used in order to achieve the intended model objectives. It can be stated that the Finite Element Method coupled with Design of Experiments approach provide a good contribution towards the optimization of sheet metal blanking process

Prof. T. Z. Quazi, R.S.Shaikh,[2],This document prescribes a model investigation the effect of potential parameters influencing the blanking process and their interaction. The blanking process optimization carried out by using Design of Experiment (DOE), Finite Element Method (FEM) with ANSYS Package, Simulation with ABAQUS-Explicit software, Blank soft Software and Neural Network Simulation in order to achieve the intended model objectives.

Pawan Kumar Rai, Dr. Aas Mohammad, Hasan Zakir Jafri,[3],Burr formation is common sheet metal defect and Burr control is an important issue for industrialist and engineers. It is produced in all shearing & cutting operations eg. Blanking process.As all the sheet metal industries are heavily affected by burr problem, indicating the study of all the possible causes and remedies. This paper also clears that what practices can increase the tool life & how long we produce “burr free” parts. It includes the selection of the best materials and methods for „press tools , „tool design review , “machine selection” etc.

AmolTotre, Rahul Nishad , SagarBodke,[4], During the past decade, two clear trends have been observed in the production of metal components. Firstly, time-to-market needs to be shortened in order to introduce new products competitively. Secondly, ongoing miniaturization forces product dimensions to decrease. Of all forming processes employed in high volume production, blanking is one of the most widely used separation techniques. Still, analysis of blanking is mainly based on phenomenological knowledge. Since, also in blanking processes, requirements concerning product dimensions are becoming more severe so we focus on what are the factors that will affect in blanking process.

Sudharshan H.K, Hemanth.R,[5], Sheet metal parts are widely used in products of high complexity and precision such as vehicles, aircraft and other automobile related products. Therefore, the press process has been identified as one of the most important manufacturing processes. During Blanking Process the force acting is more between the punch and die, failure or damage may occurs as reaches some production, so need to replace the punch and die as damages occurs. For small components punch and die can easily replaceable, easy maintenance, easy handling, less time consuming and low cost. As we consider lengthy components punch and die the manufacturing, heat treatment, maintenance, handlings need more time and cost is also very high. By integrating the split method of punch and die will be highly beneficial also helps to reduce the cost and time for heat treatment, easy replaceable of damaged parts, easy maintenance, easy handling, good life and durability can be achieved.

III. Methodology

Finite Element Method (FEM) is used to achieve the study objectives. The techniques isproposed to result in a reduction of the necessaryexperimental cost and effort in addition to receiving ahigher level of verification.The methodology that isfollowed to attain the research objectives is divided intothe following work phases:

• Classify the blanking parameters into controllable anduncountable. A summary of the blanking parameters with their classification is presented in Figure 1. Theidentified controllable parameters are clearance, blank holder force, sheet metal thickness, and material type.While, the uncountable parameters are material prosperities inconsistency and conditions (shape,defects and internal stresses), friction and wear state of the tool, stroke rate or blanking speed, and punch-diealignment.Figure 1. Summary of the blanking parameters situation in thisresearch.
• Choose the controllable factors that influence theblanking process as the interest domain.
• Select an appropriate working range for each potentialfactor. It is found that the working range of clearance fall within the range (0-25)% of the sheet metalthickness, the working range of the blank holder forcefall within the range (0-30)% of the shearing force andthe working range of the thickness of their usedMaterialfall within the range (0.5-0.8) mm.

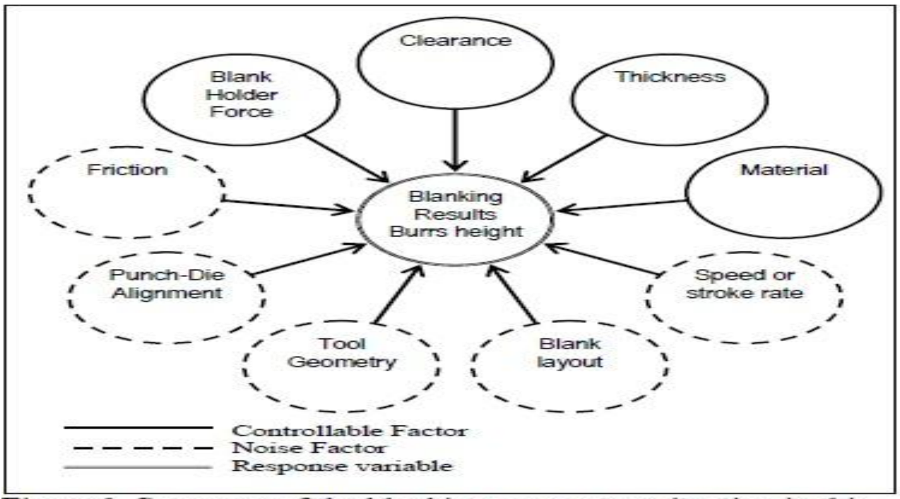

Figure 1. Summary of the blanking parameters situation in this research

- Develop a Finite Element Model (FEM) that represents the existing process in order to evaluate the quality ofthe inputs.

Simulation of Blanking Process

In this paper Lemaitre model is used for crack initiation and propagation. InLemaitre model the isotropic damage variable is the ratio between the total area of themicro cracks and cavities and cross sectional area of the material.

2.1 Model Geometry

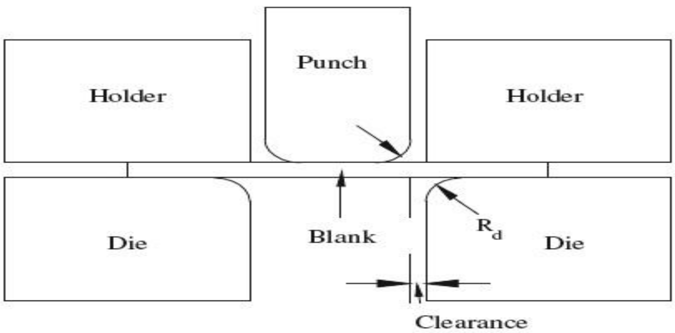

Fig. 1: Geometry of punch, die, blank holder, sheet and clearance.

Figure 1 shows the schematic diagram of the blanking process components which arepunch, die, blank and the blank holder. The punch diameter is 30 mm. The punch-dieclearance is 1 % of the blank thickness. The

blanks are of mild steel sheet of 2 mm, 3 mmand 4 mm thickness. The tool wear is simulated by rounding off the cutting edge of thepunch and die. The punch had edge radii of 0.01 mm, 0.06 mm, 0.12 mm, 0.2 mm,whereas die and blank holder edge radii were of 0.01 mm. Following assumptions aremade in the analysis:
1. The process is simplified to a two two-dimensional situation, under plane-strainconditions.
2. The process is considered quasistatic, and hence the effects of strain rate areneglected.
3. The sheet material is considered as elastoplastic while the punch and die aredefined as rigid.
4. The friction between sheet and tool follows Coulomb's law.

2.2 Input Data for Modelling

The blanking of mild steels as blank of thickness of 2 mm, 3 mm and 4 mm wassimulated with punches with different edge radii R=0.01 mm, 0.06 mm, 0.12 mm and0.2 mm; the blank holder and the die with edge radius R=0.01 mm.that contacts theblank.

The tools are modelled as hard surfaces with Rockwell hardness of C60-62 and modulusof elasticity of 210 GPa. Because they are stiffer than the blank A two-dimensional plainstrain model is used. Only half of the blanking is modelled because the blanking process issymmetric about a plane along the centre of the blank. The blank is of mild steel havingModulus of elasticity, E= 207.0 × 10^9 Pa and Poisson's ratio = 0.29. The material undergoes considerable work hardening as it deforms plastically .

2.3 Part Definition

For ABAQUS/CAE part module four parts are created. They are: one deformable part named the blank and other three are rigid parts named punch, holder and the die. The edgeradius of the punch, Rp is created with required values. A rigid body reference point needto be created. The point at the centre of the arc in view port is selected as the rigid bodyreference point. In the property module, a material named mild steel 2 mm is created. Ahomogeneous solid section named Blank Section is also created that refers to material steel.

2.4 Mesh Creation

In the Mesh module , the blank is meshed using CPE4R elements that is, four nodeelement with thickness in plane strain . It is two dimensional consideration. Forty elementsalong the horizontal edges of the blank and sixteen elements along each region on thevertical edges of the blank are specified. The total numbers of nodes were 1143 andelements1006. Figure 2 shows the mesh in shear zone.

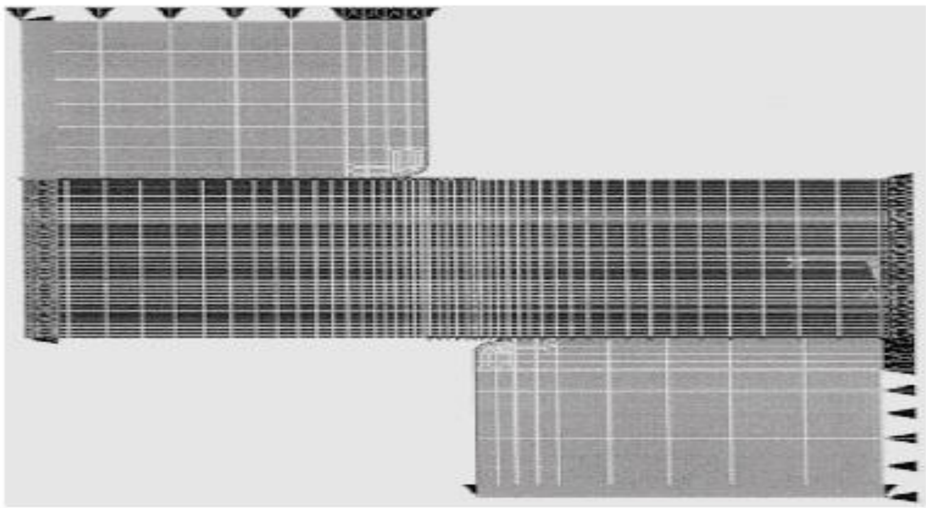

Fig. 2: Mesh in the shearing zone.

The blanking process is carried out as per the procedure described by ABACUS /CAE.
Figures 3 and 4 show the shape of 2 mm MS sheet before and after the application ofpunch force.
Fig. 3: Contour of undeformed shape in blanking process of mild steel 2 mm.
Fig. 4: Contour of shape after blanking process of mild steel 2 mm.

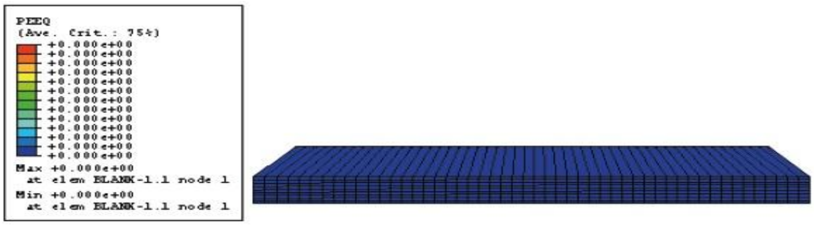

Fig. 3: Contour of undeformed shape in blanking process of mild steel 2 mm.

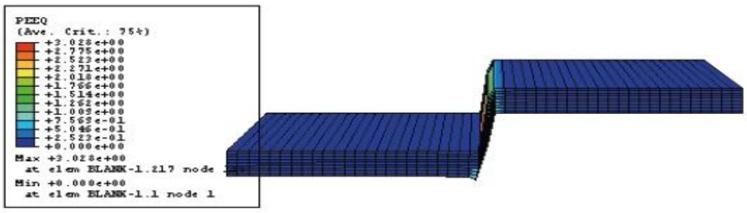

Fig. 4: Contour of shape after blanking process of mild steel 2 mm.

IV. Conclusion

Factors affecting in the blanking processare

- Clearance
- tool wear
- Sheet Thickness
- Material

A. The effect of clearance

Clearance c is the space (per side) between the punch and the die tool . The fracture will proceed towards each other until they meet and the fractured portion of the sheared edge then has a clean appearance. For optimum finish of a cut edge, correct clearance is necessary and is function of the kind, thickness, and temper of the material. This edge radius is produce by plastic deformation taking place and is more pronounce when cutting soft materials. Excessive clearance will also cause large radius at this corner as well as a bur on opposite corner.

When clearance is not sufficient, additional layers of the material must be cut before complete separation is accomplished. With correct clearance, the angle of fractures will permit clean break below the burnish zone because the upper and lower fracture will extend toward one another. Excessive clearance will result in tapered cut edge because for any cutting operation, the opposite side of the material that the punch enters after cutting, will be the same size as the die opening.

The width of the burnish zone is an indication of the hardness of the material. Provided that the die clearance and material thickness are constant, the softer the material the wider will be the burnish zone. Harder metals require large clearance and permit less penetration by the punch than ductile materials; dull tool (punch and die) create the effect of too small a clearance as well as bur on the die side of the stock. Clearance is generally expressed as a percentage of the material thickness, but some authorities recommend absolute values.

Table 1
Value of clearance as the percentage of the thickness of material

MATERIALS	MATERIAL THICKNESS T(MM)				
	<1.0	1.0 TO 2.0	2.1 TO 3.0	3.1 TO 5.0	5.1 TO 7.0
LOW CARBON STEEL	5.0	6.0	7.0	8.0	9.0
COPPER AND SOFT BRASS	5.0	6.0	7.0	8.0	9.0
MEDIUM CARBON STEEL 0.2% TO 0.25% CARBON	6.0	7.0	8.0	9.0	10.0
HARD BRASS	6.0	7.0	8.0	9.0	10.0
HARD STEEL 0.4% TO 0.6% CARBON	7.0	8.0	9.0	10.0	12.0

Table illustrate the value of the shear clearance in percentage depending on the type and the thickness of the material

B. The effect of tool wear

Tool wear leads to the Formation of burrs and increases burr length. Burr length is generally an important criterion in the industry to evaluate part quality. Burr length indicates when the tool should be reground to obtain the sharp die-and-punch radius. It has also been observed that the effect of tool wear is more pronounced at higher blanking clearances. The effect of tool wear on part edge quality is significant. Tool wear leads to the formation of buns and increases burr where the effect of tool wear was simulated by assuming different punch corner radii in simulations. It has also been observed that the effect of tool wear is more pronounced at higher blanking clearances.

C. The Effect of the Sheet Thickness

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

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

D. 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.

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