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Analysis of the influence of the blanking clearance size to the burr development on the sheet of mild steel, brass and aluminium in blanking process

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ABSTRACT

Purpose: This research aims to analyse the influence of blanking clearance size on the burr development for mild steel sheet, brass and aluminium. The main reason for this research is estimating the burr size on blank parts. It is still significant since the quality of the products is determined by evaluating the amount of allowable burr in the parts.

Design/methodology/approach: For the blanking process on the 3.00 mm thick sheets, various sizes of blanking clearance for a 20 mm diameter of the die opening are employed, as is the technique for obtaining the parts. Then the height of the burr on each product was measured using a micrometre and toolmaker microscope. The height of burr for each size of blanking clearance have been recorded and compared using a graph. Comparison made to identify which measure of blanking clearance and which type of material will produce a small size of burr.

Findings: For mild steel, brass, and aluminium, blanking clearance 0.15 mm produced burr heights of 0.088 mm, 0.015 mm, and 0.024 mm, and blanking clearance 0.13 mm produced bur heights of 0.192 mm, 0.055 mm, and 0.046 mm, respectively. The brass had a lower burr height than mild steel and aluminium, according to the results. More significant blanking clearance (0.15 mm) produced a smaller size of burr compared to a smaller blanking clearance (0.13 mm).

Practical implications: This study focuses on burr height rather than the wear of the punch and die cutting edge; burr height can affect punch and die sharpness. It also can guide practitioners in estimating blanking clearance and the burr height of mild steel, brass and aluminium.

Originality/value: This paper demonstrates that the gap between the punch and die influences the burr height. The material strength also affects the burr height, with a high tensile strength resulting in a larger burr.

Keywords: Blanking clearance, Burr height, Mild steel, Brass, Aluminium

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MANUFACTURING AND PROCESSING

1. Introduction

The blanking of sheet metal parts is a widely used process in the industry for mass production. The blanking process is created by feeding sheet metal between punch and die opening. In this process, the blank is punched out from the metal sheet until the pressure on the blanking edge of the punch and the die achieved the complex stress distribution [1]. Several works [2-7] present the blanking of elements with a punch of flat surface very well. The edge pressure on the sheet is uniform when punching with a flat face. The sheet material gradually blanks out when punched with a sloping face [8]. The punching force moves around the sheet as a result. The material separation occurs along the blanking edges as the punch enters the sheet. Plasticizing of material depending on process's method, different geometry of the intersection surface, and burr size.

Figure 1 shows the blanking clearance and shearing process with cutting the gap between the punch and the die opening resulted in the amount of clearance per side. Blanking clearance can be determined by the thickness and the type of material's sheet. Ductile material needs less blanking clearance, and hard material needs more blanking clearance. The recommended blanking clearance is 2.5% to 5.0% of the sheet thickness [9].

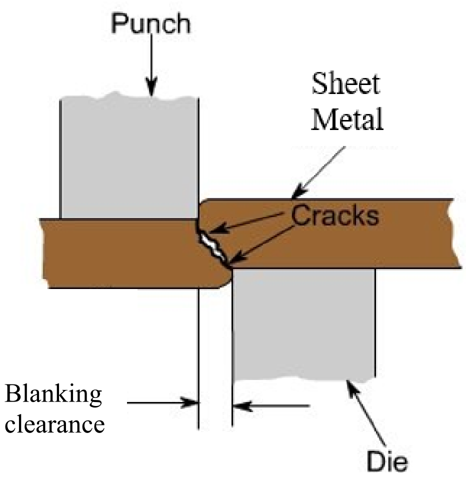

Fig. 1. Blanking clearance and shearing process

One of the most significant factors to consider throughout the blanking process is the size of the blanking clearance. The blanking clearance size will influence shearing or cutting performance and burr development. The correct size of blanking clearance is necessary to aid the life of the die punch and the quality of the piece part. There are three situations of blanking clearance that will be categorized as optimum, excessive, and insufficient [1].

Development of burr at the edge of blank part commonly occurs when producing sheet metal using a punch and die. Burrs usually are the undesired formation of material beyond the edge(s) of the product or blank., which are generally due to plastic deformation during machining and or metal forming. During the cutting operation, the sheet can be residual microscope deformed, and the height of the burr is "the difference between the highest burr point and the surface of the sheet metal next adjacent to the burr." This definition seems acceptable and is the foundation for the development of our work. The rate at which the blanking tool edges wear affects the intensity of the burr height increase [3-5]. It's essential to select the right clearance so that the hardened material's surface area is kept to a minimum while blanking thin magnetic sheets [3].

In the manufacturing industry, the possibility of estimating the burr size on blank parts remains of significant relevance since the quality of the products is defined by evaluating the amount of allowable burr in the parts. The burr occurs on the cutting edge of pieces in Figure 2; this presence is one of the most severe limitations of the blanking process.

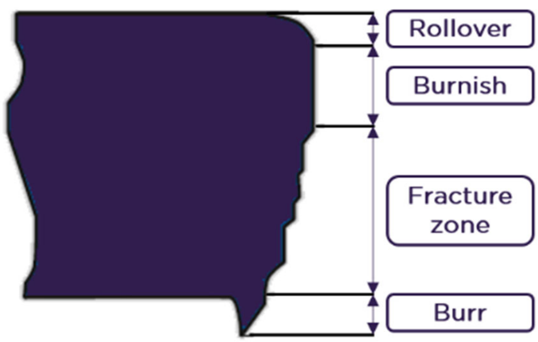

Fig. 2. Geometry of the sheared edge

Typically, the blanking clearance size of the die hole has been designed to suit the material being produced and will result in a minimum burr height. Still, this is impossible to estimate the burr size if the die is used to produce different materials. Die manufacture is costly and can be decreased if a single die can be used for various materials while maintaining an acceptable burr height.

This study will investigate burr sizes on the three various material types and sizes of blanking clearances. Tests were carried at TATI University College to examine the effect of the blanking clearance on the blanking process burr development.

2. Experimental set up

The main purpose of this study is to determine the burr height when the various size of blanking clearance used for different material likes mild steel (760 ASSAB Steel), brass (free cutting brass) and aluminium (6000 series). Table 1 shows the mechanical properties of three types of material that have been used for this experiment.

Table 1.
Mechanical properties of materials

No	Material	Shear strength, MPa	Tensile strength, MPa	Young modulus, GPa
1.	Mild Steel	345	440	210
2.	Brass	270	338	102
3.	Aluminium	83	90	69

The thickness of 3.00 mm sheet metal was used for the blanking process. Five (5) blanking punches with diameters ⌀19.70 mm, ⌀19.71 mm, ⌀19.72 mm, ⌀19.73 mm and ⌀19.74 mm have been fabricated and used to run the experiment. These punch diameters will give blanking clearance with 0.150 mm, 0.145 mm, 0.140 mm, 0.135 mm and 0.130 mm per side shows in Table 2.

Table 2.
Punch Diameter and Cutting Clearance.

Die opening, mm	Punch diameter, mm	Cutting clearance/side, mm
Ø20.0	Ø19.70	0.150
	Ø19.71	0.145
	Ø19.72	0.140
	Ø19.73	0.135
	Ø19.74	0.130

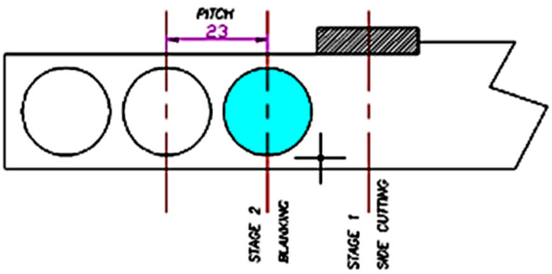

Fig. 3. Strip layout

To produce a complete blanking die or pressing tool, design work utilizing CAD is used. Strip layout (Fig. 3) is required, and every component with detailed dimensions is to be prepared, and all drawings are to be used for the fabrication process. Complete blanking die displayed in Figure 4. This blanking die is a simple die featuring a top platform, punch platform, stripper plate, die platform and top plate.

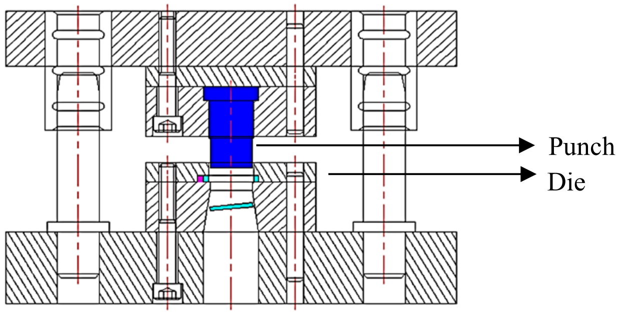

Fig. 4. Blanking die construction

The blanking die was mounted on the press machine to carry out the experiments with manual feed of the sheet metal. The study involved a blank test with five different punch diameters for three different material types with the same thickness. The blanking products were examined to determine the burr height for each product will be recorded into the table. There were around 225 samples to measure burr height. The toolmaker microscope was used to measure the burr's height (Fig. 5), followed by the average burr height recorded in another table.

Fig. 5. Toolmaker microscope

3. Result and discussion

All burr heights for the three different sheet metal materials were taken and recorded in Table 3, Table 4 and Table 5, then the average burr height was calculated and shown in Table 6.

Table 3.
Burr height of mild steel

No	Test number	Blanking 1	Average	Blanking 2	Average	Blanking 3	Average	Blanking 4	Average	Blanking 5	Average	Remarks
1.	Ø19.70	a. 0.089		a. 0.089		a. 0.087		a. 0.085		a. 0.087		
		b. 0.087	0.088	b. 0.088	0.089	b. 0.089	0.087	b. 0.084	0.085	b. 0.089	0.091	0.088
		c. 0.086		c. 0.087		c. 0.086		c. 0.086		c. 0.096		
2.	Ø19.71	a. 0.096		a. 0.098		a. 0.098		a. 0.105		a. 0.107		
		b. 0.098	0.097	b. 0.096	0.097	b. 0.096	0.098	b. 0.106	0.104	b. 0.112	0.111	0.101
		c. 0.094		c. 0.098		c. 0.099		c. 0.101		c. 0.113		
3.	Ø19.72	a. 0.132		a. 0.132		a. 0.131		a. 0.131		a. 0.132		
		b. 0.133	0.133	b. 0.132	0.132	b. 0.132	0.131	b. 0.132	0.132	b. 0.134	0.133	0.132
		c. 0.134		c. 0.134		c. 0.131		c. 0.132		c. 0.132		
4.	Ø19.73	a. 0.156		a. 0.154		a. 0.157		a. 0.154		a. 0.155		
		b. 0.155	0.156	b. 0.155	0.155	b. 0.154	0.156	b. 0.154	0.154	b. 0.155	0.155	0.155
		c. 0.155		c. 0.157		c. 0.156		c. 0.154		c. 0.156		
5.	Ø19.74	a. 0.192		a. 0.196		a. 0.192		a. 0.197		a. 0.192		
		b. 0.193	0.193	b. 0.196	0.196	b. 0.191	0.191	b. 0.192	0.194	b. 0.192	0.192	0.193
		c. 0.193		c. 0.193		c. 0.190		c. 0.192		c. 0.193		

Table 4.
Burr height of brass

No	Test number	Blanking 1	Average	Blanking 2	Average	Blanking 3	Average	Blanking 4	Average	Blanking 5	Average	Remarks
1.	Ø19.70	a. 0.016		a. 0.015		a. 0.015		a. 0.015		a. 0.012		
		b. 0.017	0.016	b. 0.015	0.015	b. 0.015	0.016	b. 0.016	0.015	b. 0.014	0.013	0.015
		c. 0.015		c. 0.016		c. 0.016		c. 0.014		c. 0.013		
2.	Ø19.71	a. 0.025		a. 0.025		a. 0.025		a. 0.025		a. 0.024		
		b. 0.026	0.025	b. 0.024	0.024	b. 0.024	0.023	b. 0.026	0.025	b. 0.025	0.025	0.024
		c. 0.025		c. 0.023		c. 0.023		c. 0.025		c. 0.025		
3.	Ø19.72	a. 0.032		a. 0.034		a. 0.034		a. 0.035		a. 0.034		
		b. 0.033	0.033	b. 0.035	0.030	b. 0.035	0.035	b. 0.035	0.035	b. 0.035	0.034	0.034
		c. 0.033		c. 0.035		c. 0.035		c. 0.034		c. 0.034		
4.	Ø19.73	a. 0.043		a. 0.044		a. 0.044		a. 0.044		a. 0.045		
		b. 0.042	0.043	b. 0.045	0.045	b. 0.045	0.046	b. 0.044	0.044	b. 0.043	0.044	0.044
		c. 0.045		c. 0.046		c. 0.046		c. 0.045		c. 0.043		
5.	Ø19.74	a. 0.056		a. 0.054		a. 0.054		a. 0.056		a. 0.056		
		b. 0.056	0.056	b. 0.054	0.054	b. 0.054	0.056	b. 0.054	0.055	b. 0.057	0.056	0.055
		c. 0.055		c. 0.055		c. 0.055		c. 0.057		c. 0.054		

Results showed that different heights of burr for different blanking clearance sizes and also for different materials. Figure 6 shows the average of burrs height using different blanking clearance sizes on three different sheet materials.

The figure showed that a mild steel sheet produces the largest burr size where burr size on brass is the smallest at blanking clearance 0.150 mm to 0.140 mm, then at blanking clearance 0.135 mm to 0.130 mm burr height at aluminium blank is the smallest. For these three types of materials, a smaller blanking clearance will create more burr height. The height of Burr on aluminium is not up or down. As shown on the graph, at the blanking clearance 0.150 mm to 0.140 mm, the burr height increases until blanking clearance 0.135 mm, then the burr height decreases, but it increases again when using blanking clearance 0.130 mm. For brass, the burrs are uniformly raised when blanking clearance decreases.

The result of this experiment shows that material strength is also one factor contributing to burr height for the blanking parts [10]. When it comes to prior research, a study by Tekiner et al. [11] found that as clearance increased, the blanking forces changed significantly. However, Shuqin et al. and Gang et al. [12,13] found that as clearance increases,

Table 5.
Burr height of aluminium

No	Test number	Blanking 1	Average	Blanking 2	Average	Blanking 3	Average	Blanking 4	Average	Blanking 5	Average	Remarks
1.	Ø19.70	a. 0.026		a. 0.025		a. 0.023		a. 0.021		a. 0.022		
		b. 0.024	0.025	b. 0.024	0.024	b. 0.024	0.024	b. 0.022	0.023	b. 0.022	0.022	0.024
		c. 0.026		c. 0.024		c. 0.025		c. 0.025		c. 0.021		
2.	Ø19.71	a. 0.026		a. 0.023		a. 0.025		a. 0.028		a. 0.026		
		b. 0.025	0.026	b. 0.024	0.024	b. 0.026	0.026	b. 0.027	0.028	b. 0.024	0.026	0.026
		c. 0.027		c. 0.026		c. 0.026		c. 0.029		c. 0.028		
3.	Ø19.72	a. 0.035		a. 0.035		a. 0.036		a. 0.035		a. 0.035		
		b. 0.036	0.035	b. 0.036	0.036	b. 0.034	0.035	b. 0.034	0.035	b. 0.036	0.036	0.035
		c. 0.035		c. 0.036		c. 0.035		c. 0.036		c. 0.037		
4.	Ø19.73	a. 0.035		a. 0.036		a. 0.035		a. 0.038		a. 0.036		
		b. 0.036	0.035	b. 0.036	0.035	b. 0.034	0.035	b. 0.037	0.037	b. 0.035	0.035	0.036
		c. 0.035		c. 0.034		c. 0.037		c. 0.036		c. 0.035		
5.	Ø19.74	a. 0.045		a. 0.044		a. 0.047		a. 0.048		a. 0.046		
		b. 0.04	0.044	b. 0.045	0.045	b. 0.046	0.046	b. 0.047	0.047	b. 0.048	0.048	0.046
		c. 0.046		c. 0.046		c. 0.046		c. 0.047		c. 0.049		

Table 6.
Average burr height for each sheet

No	Punch diameter (cutting clearance), mm	Average of burr height, mm		
		Mild steel	Brass	Al.
1.	Ø19.70 (0.150)	0.088	0.015	0.024
2.	Ø19.71 (0.145)	0.101	0.024	0.026
3.	Ø19.72 (0.140)	0.132	0.034	0.035
4.	Ø19.73 (0.135)	0.156	0.044	0.036
5.	Ø19.74 (0.130)	0.192	0.055	0.046

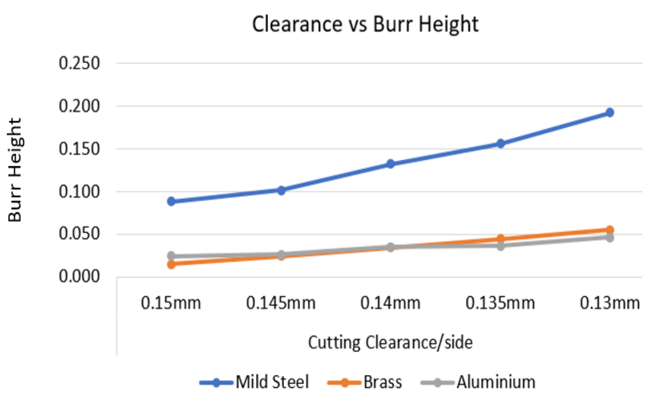

Fig. 6. Clearance vs burr height

the blanking force decreases slightly. Mild steel with tensile strength 440 MPa is the highest compared to brass with 338 MPa, and aluminium has the lowest tensile strength with 90 MPa.

In blanking process parameters, blanking clearance is the most significant parameter to be controlled, especially in the thin sheet metal part. There are three critical stages in the blanking process: plastic deformation, penetration, and fracture. The burr occurs on the fracture stage because the ductile fracture is much bigger than the fracture zone and burr [14]. Figure 7 [15] show the stages and fracture occur at material during blanking process.

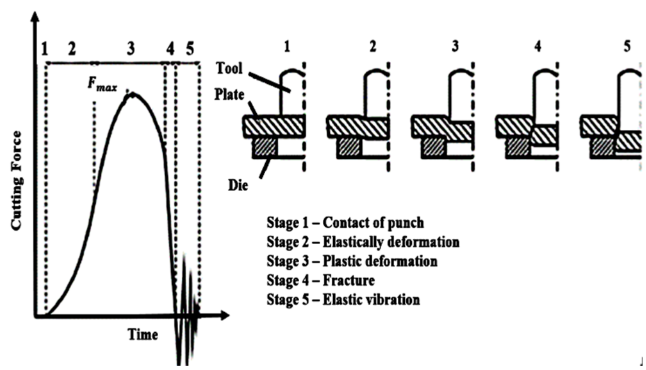

Fig. 7. Stages of blanking process [15]

The other factors contributing to burr are punch and die worn off in Figure 8 [16]. The wear of the sharp edge in a blanking tool determines the burr height and the quality of the parts. The blanking tools often show abrasive wear in the contact area [17]. When the punch and die wear out, it may lead to an increase in burr height. Like the cutting process, tool material, cutting edge preparation, rake angle and coating, will help to extend tool life [18].

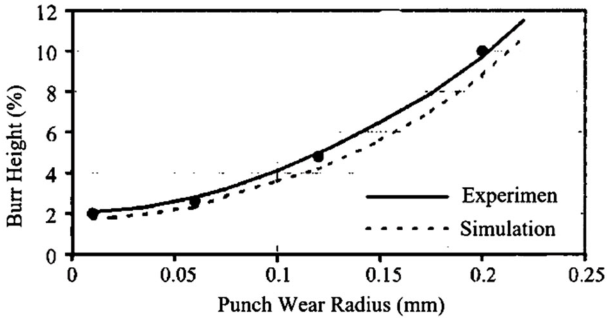

Fig. 8. Punch and die worn off [16]

4. Conclusions

The finding of this research is to determine the influence of blanking clearance on the development of burr height at the edge of part on mild steel, brass, and aluminium sheets. The models of the relationship between blanking clearance and burr height have resulted in the blanking process. The burr height among these three materials using different blanking clearances showed that brass had the lower burr height (0.015 mm) under 0.015 mm blanking clearance, and then aluminium (0.024 mm) and mild steel get the highest burr height with 0.88 mm. Burr height increase cause the gap between punch and die smaller and drive of higher burr. The material strength will also produce different burr heights, and the high tensile strength will result in a higher burr.

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