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► **To cite this version:**

Hamid Makich, Luc Carpentier, Guy Monteil, Xavier Roizard, Jérôme Chambert, et al.. Metrology of the burr and the punch wear in blanking process of copper alloy thin sheet. *Journal of Iron and Steel Research International*, 2008, 79, pp.7-11. hal-00373475

**HAL Id: hal-00373475**

**<https://hal.science/hal-00373475v1>**

Submitted on 4 Nov 2024

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# METROLOGY OF THE BURR AND THE PUNCH WEAR IN BLANKING PROCESS OF COPPER ALLOY THIN SHEET

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## ABSTRACT

Blanking burr and punch wear are two phenomena closely linked. This leads to consider burr as the best criterion for regrinding or renewing blanking tools. Thus, in order to control the quality and cost in blanking process, it is necessary to measure with the best accuracy the amount of burr and punch wear. In order to reach this goal, a method for measuring the volume of burr has been developed. This method is based on the use of 3D topographical images. On the other hand, punch wear was calculated by combination of mathematical models describing the evolution of the geometric shape of the punch. This model links the variations of the geometry of the punch, depending on the number of press strokes. The final aim of this study is to identify a relationship between burr and punch wear.

**Keywords:** Blanking, Burr amount, Punch wear.

## 1. INTRODUCTION

In the blanking industry, the punch wear has a significant impact on production. In particular, important wear creates geometrical defects of the cut pieces, which can lead to a rejection of products. Among other defects, the apparition of burr is the most incapacitating in the use of a blanking piece. In order to overcome this problem, industrials regrind their tools after a number of press strokes. But this operation has a negative consequence on costs. In fact, the production stopping for regrinding punches creates substantial losses for the industry. Thus, it is important to identify the parameters of the blanking operation leading to the appearance of burr. For this purpose, first of all, it is necessary to have a reliable tool to

measure the quantity of burr. In this paper, we present an original method for the quantification of the volume of burr. Moreover, a first correlation of the burr amount with the level of wear and the blanked material is also presented.

## 2. BLANKING BURR

The burr appears on the edge of the blanked pieces (Figure 1). This presence is one of the most serious limitations of the blanking process. Indeed, beyond a certain burr amount, the blanking pieces cannot be considered as acceptable.

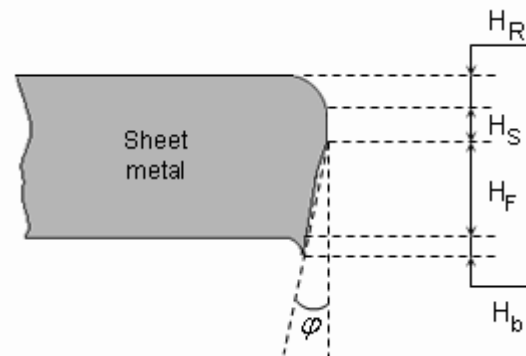


Figure 1. Geometry of the blanking edge.

- $H_R$  : Roll-over depth.
- $H_S$  : Sheared edge.
- $H_F$  : Fracture depth.
- $H_b$  : Burr height.
- $\varphi$  : Fracture angle.

Given the important issues related to the appearance of blanking burr, a lot of work has been undertaken to explain its appearance. Most of this work has been dedicated to the study of the influence of blanking conditions (clearance, radius, etc...) (Figure 2), on the appearance of burr.

The main conclusions of these studies show that the size of burr depends mainly on the

blanking clearance, the wear condition of the tool edge, the properties of the blanked materials and the tool material. According to the studies carried out in [1] and [2], it appears that the tool wear promotes the appearance of burr and that the increase in the blanking clearance results in an increase in the fracture angle of the shear zone and the height of the burr.

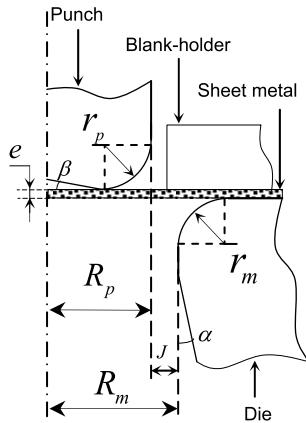


Figure 2. Geometrical parameters characteristic of blanking.

This is confirmed also in [3] and [4]. With regards to the properties of blanked materials, Gréban [5] concludes that the composition of the blanked alloys has a strong influence on the quantity of burr created during the blanking operation. However, the works are more focussed on the theoretical study of the conditions of burr appearance, than on an experimental metrology on the burr amount.

### 3. METROLOGY OF THE BURR

The possibility to estimate the burr size on the blank pieces remains of great importance in the blanking industry, because the quality of the products is determined by the evaluation of the level of acceptable burr on the parts. It is possible to study, in theory, the emergence of blanking burrs. However, in order to verify the theoretical predictions, it is necessary to be able to accurately and reliably measure the quantity of burr. To summarize, we can return to what might be a definition of the burr height, the main criterion mentioned here. According to [6], because the sheet can have a residual mac-

roscopic deformation during the blanking operation, the height of burr is defined as "the difference between the highest point of burr and the surface of the sheet metal immediately adjacent to the burr". This definition seems satisfactory and will be the basis for development of our work.

#### 3.1 Metrology

Many different ways of measuring the burr can be found in the literature, but fundamentally based on a destructive test of blanked pieces. Therefore the metrology is done only on some particular positions of the blanked edge.

#### 3.2 Crushed burr

In the particular case of progressive blanking, the parts with a complex geometry are produced by several press strokes, which has the effect of crushing the burrs created by the first step of the process.

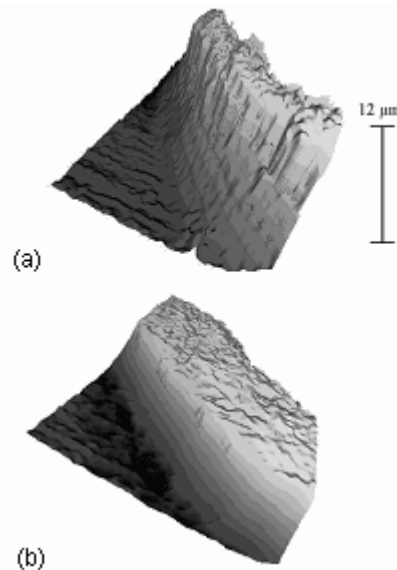


Figure 3. Crushed burr.

Consequently the height of the burr is more difficult to measure by means of the traditional methods (Figure 3).

This has prompted us to seek, in this work, a new method more able to give us a precise quantification of the crushed burr. In order to achieve this goal, we sought to define a reference plan around the blanking form, because the adjacent sheet is distorted.

### 3.3 Setup of the measurement process

As the aim of this work is the quantification of the burr amount even if the burr is crushed, the work was focused on the method to obtain this proper value.

From the above mentioned limitations of the existing methods it has been chosen to focus our work on a new approach. This has been done using a topomicroscope generating optical images of the burr all around the blanked contour.

#### 3.3.1 Images Acquisition

The device used in the present work is a microscope Infinitefocus<sup>®</sup> Alicona (Figure 4). It is based on an optical microscope coupled to a camera. Unlike a confocal microscope, which uses a monochromatic sensor, the device uses a contrast color sensor. On the whole height, the microscope collects images which are then analysed by the software. The latter analyses each pixel and compares it to its neighbours to see if it is focused or not.



Figure 4. The optical device measurement: InfiniteFocus<sup>®</sup>

Then, it reconstructs a three-dimensional image from these focussed points. From this image, surface, volume, surface state and topographic dimensional measurements are possible.

In accordance with the selected lens, the image size ranges from 2.1x1.6 mm<sup>2</sup> to 103x83 μm<sup>2</sup> and the vertical resolution from 444 nm to 20 nm.

If the sample or areas of interest are larger than the size of capture of the selected lens, it is possible to achieve a multi-field acquisition through motorized tables.

This multi fields images is built up by the interconnection of a series of elementary images preselected to cover the entire area to be analysed.

#### 3.3.2 Measurement

The measurement method has been developed in our laboratory specifically for quantifying the burr volume.

The originality of this method lies in the transformation of the blanked shape, (here a circular shape). The main stages of this transformation are:

- First, a straightening of the image around the blanked shape (hole) is achieved (Figure 5). This is done in order to eliminate any imperfections in the image straightness. The straightening of the image (outside the zone of burr) is made by means of the least squares plan.

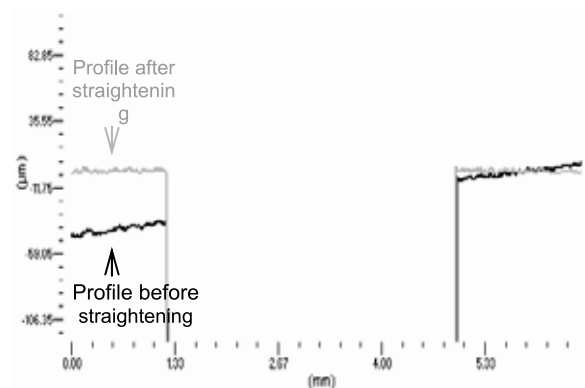


Figure 5. Profiles extracted on the surface of the sheet before and after straightening.

- Secondly, an image processing is performed in order to extract a chosen number of vertical profiles from the contour of the blanked shape (Figure 6).

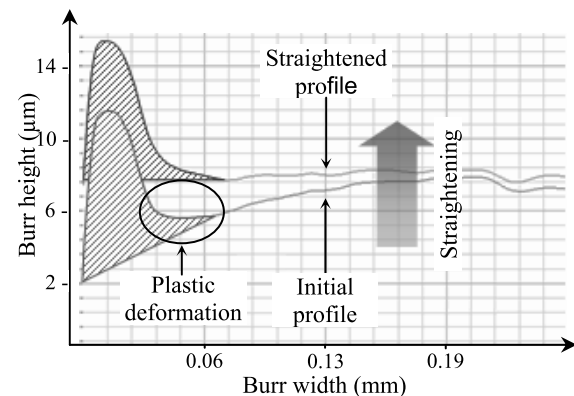


Figure 6. Example of an extracted profile.

- Thirdly, profiles are extracted so as to build a rectangular matrix; each profile being the average of 100 adjacent profiles. Thereafter, the image is adjusted, outside the zone of the blunder, with a linear polynomial of degree 2, which assembles all the profile (Figure 7).

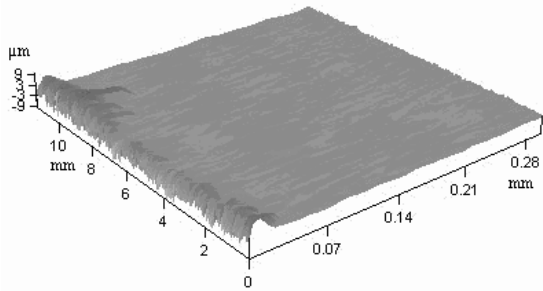


Figure 7. Representation of the profiles assembling.

- Finally, the volume is determined only in the areas where the burr is present on the image.

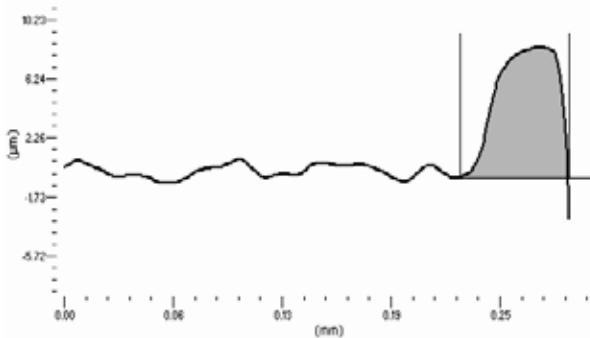


Figure 8. Limitation of the burr

#### 4. PUNCH WEAR

The purpose of this paragraph is to show how ready to wear punch as the emergence of burr.

In this paper we sought to propose a geometrical model of evolution of punch during blanking.

To build this geometric model we used the punch profile (Figure 9) at the end of the test using the topomicroscope described above.

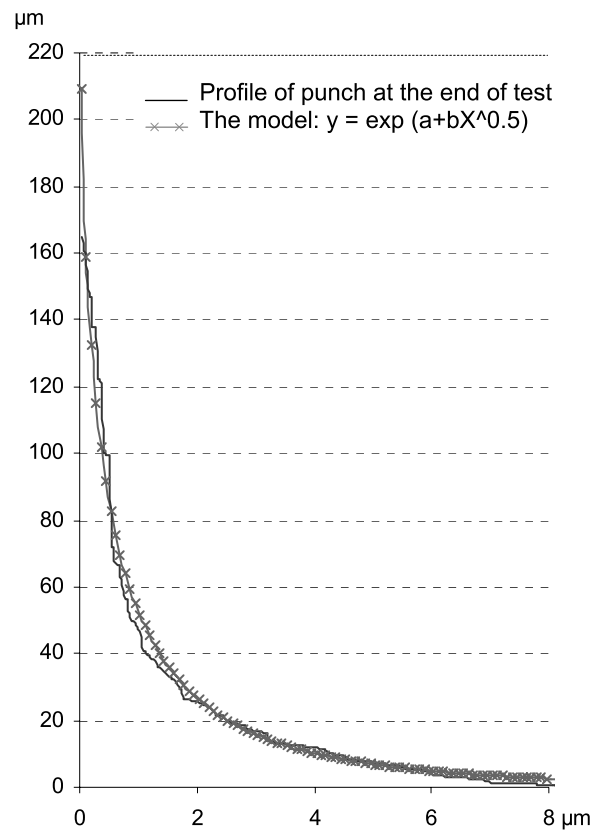


Figure 9. Punch Profile at the end of the test and the model associated.

#### 5. RESULTS AND DISCUSSION

Figure 10 shows the evolution of the burr volume according to the number of press strokes. We observe an increase of a burr volume with the increasing number of press strokes. It can be seen in addition that the kinetics of the apparition of burr is decreasing when the number of press strokes increase.

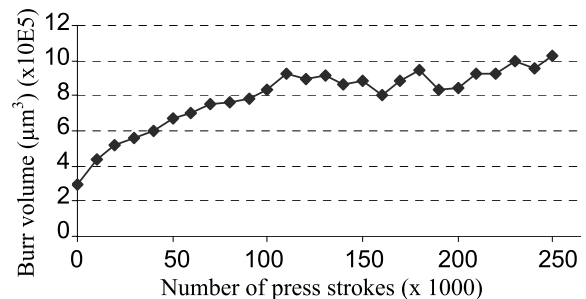


Figure 10. Burr volume with respect to press strokes.

The amount of burr is also related to the blanking material as it has been highlighted by Greban [5] (figure. 11).

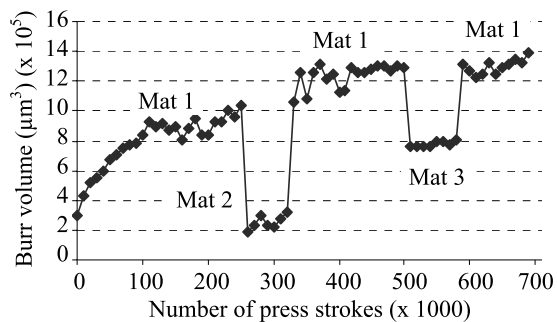


Figure 11. Burr volume for different materials.

This method seems to be enough accurate to monitor slight changes in the process of blanking and their influence on the burr creation.

As it can be applied all along a blanking process of a lot of parts a net of data of the amount of burr can be easily compared to the wear amount of the tool leading to a comparison between these two results.

## 6. CONCLUSIONS

Because of the non-homogeneity of the burrs on the blanked contour, the method described here seems the most appropriate, because it is obtained from a large number of profiles, which has the advantage of allowing a complete scan of the blanking edge.

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