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Description of an *in situ* method to measure the punch wear during blanking

G. Monteil, X. Roizard,* F. Gréban and H. Makich

The purpose of this study is to develop a new method in order to measure the punch wear on a real stamping press during blanking. This *in situ* measuring method has been used for measuring the wear of tungsten carbide punches during blanking of thin copper alloy sheet steels (approximately 1/10 mm). As the quality of the final parts is largely influenced by the dimensions of the punch, the wear of the punch as low as a few micrometers must be avoided and consequently measured. So the difficulties to measure such a small wear amount on a high speed real industrial process (800 p/min) associated with the small overall dimensions of the punch is a great challenge. None of the existing measuring techniques (mainly geometrical) can ensure a continuous wear measurement without dismantling the blanking punch. The wear measurement technique developed for this study is the thin layer activation technique. The working area of the punch has been activated by means of a particles beam. The decay of the activity of the punch allows the punch wear to be monitored. Care has been taken to obtain a precise measurement of the punch wear during blanking. The results of the measurements of punch wear on an industrial stamping press are presented for various working conditions. For example, the influence of the punched material and the amount of lubrication upon the wear kinetics are described.

Keywords: wear; punch; blanking; thin layer activation

Introduction

In the blanking process, the main problems are linked to the final appearance and the functionality of the blanked parts. In the field of electronic industry, the quality of the blanking process is closely linked to the presence of the burrs, which can be responsible for electric failures. In order to avoid such problems, it is necessary to predict the growth of the burrs during the blanking process.

As this growth has been proved to be related to the wear of the blanking tools and mainly to the punch wear,^[1,2] it is therefore needed to monitor the punch wear all along the blanking process. The various methods available for this purpose, like the measurement of the blanked profile^[3,4] or of the worn contour of the punch,^[5-10] suffer major limitations.

In order to obtain a quantitative wear indicator, one must either wait until the end of the process or dismantle the blanking tool during the blanking process at regular intervals.

The first method requires a long time to be done and additionally, can be very expensive. The second one is questionable because when dismantling and remounting the tool, the punch-die clearance must be set at the same value because it influences dramatically the blanking conditions.^[3] Consequently, efforts have been undertaken to overcome these limitations by setting up a technique which allows the punch wear to be measured directly on the punch without dismantling the blanking tool. The only available and sufficiently accurate method is the thin layer activation.

This article presents the application of the thin layer activation to the *in situ* wear measurement of a punch during blanking.

Thin Layer Activation Technique

The thin layer activation technique has been used in a wide range of wear measurements.^[11-18] In most of the cases encountered in

literature, it has been applied in large systems.^[19,20] Its advantage is the ability to measure the wear continuously^[20] or quasi-continuously.^[21] In this last method, as the measured activity is proportional to the square root of the distance care has to be taken to precisely reposition the counting detector.

The principle of this method is to realize a selective activation by means of a particle beam on a precise area of the part to be monitored. This activated volume of material then emits radiations, which can be measured by means of a photo detector. The intensity of these emitted radiations is proportional to the remaining activity of the source, i.e. the activated part. As the residual activity is coming from the only remaining activated material, the difference between the original activity and the measured one is an indication of the removed quantity of the material. Consequently, if one is able to transmute the material of the punch on a selected area and ensure a proper set of measuring conditions, it will be possible to monitor the punch wear.

Thin Layer Activation of the Punch

The practical case under study is the blanking of electronic lead frames. The particular conditions of this process are linked to the dimensions of the blanked parts and the very limited amount of wear even after a million produced parts. For these reasons, the

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measurement of the wear of the tools proves to be very difficult and traditional dimensional measurements are not suitable. These conditions are also a great challenge for the thin layer activation technique because as the parts are small, the punch is also very small and the small amount of worn material requires a high precision in the final wear measurement.

The punch to be activated is made of tungsten carbide-cobalt alloy. For a set of reasons, the tungsten element has been chosen. The punch has been exposed to a beam of deuterons. Tungsten is then transmuted into various species according to their isotopic abundance.

Only two created species are available for measuring the wear of the punch because of their half-lives, ^{183}Re and ^{184}Re . The decay of the activity of small species with half-lives allows the measurement to be made during the blanking of a million parts (three weeks) without interference. In order to limit the detrimental consequences of the activation of the punch, precautions have been taken to minimize the level of activity generated on the punch to limit the toxicological risks associated with the handling of the parts. Thus with the help of previous measurements of the maximum wear depth expected after a million blanked parts the activation volume has been set to a height of $50\ \mu\text{m}$ and a depth of $100\ \mu\text{m}$ on the cylindrical punch used for this study as shown in Fig. 1.

As mentioned previously, a cylindrical punch has been chosen because on such a form the operating conditions at the contact are the same all along the cutting edge of the punch. So the wear distribution is uniform on the activated zone of the punch and then it is allowed to obtain a quantitative result like a

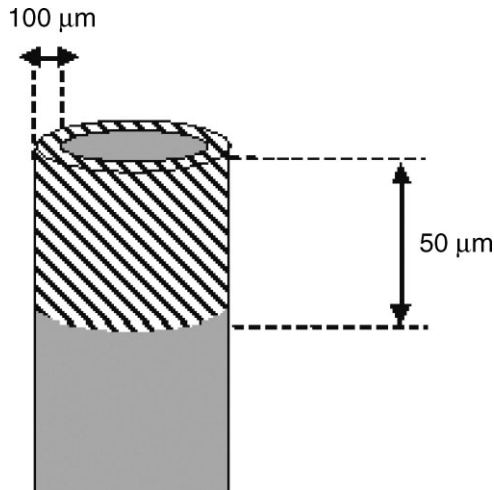


Figure 1. Schematic representation of the activated punch.

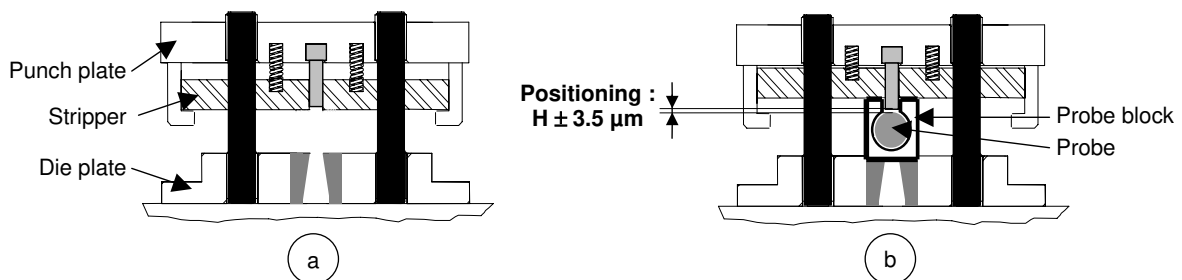


Figure 2. (a) Blanking tool in opened position (top dead center). (b) Blanking tool in measuring position.

wear volume or a wear depth. A measuring set up where the scintillation detector measuring the γ -rays is very close to the irradiated element has been designed since the measured intensity decreases with the square of the distance between the source and the detector (depending of solid angle). Precautions have been taken (Fig. 2) to ensure a constant position of the detector ($\pm 3.5\ \mu\text{m}$) when measuring at each stop of the press (every 10 000 parts).

The measured data represent the activity with respect to the number of blanked parts. In order to convert the loss of activity measured on the punch into a worn volume of material, a preliminary calibration has been done by activating a stack of tungsten sheets of $6\text{-}\mu\text{m}$ thickness under the same conditions as the punch. With this reference material, it is allowed to measure the remaining activity while pulling out the sheets one by one in order to give rise to a curve of the relative activity according to the thickness of the tungsten sheet stack (Fig. 3).

Given the linear law of the decay of the activity with respect to the thickness by means of the sheet stack it can be concluded that on the first $50\ \mu\text{m}$ the activity is constant. Consequently, after the corrections described above, the percentage of lost activity can be directly related to the percentage of worn volume. The natural decay of the activity with respect to time of the tungsten has also been subtracted from the measured loss of activity of the punch, giving rise to the value of the lost activity only coming from the wear of the punch. At least a correction has been introduced also because of the variation of the distance detector/source associated to the thermal expansion of the press.

Results

The blanking tests have been driven on a 50 tons BRUDERER press with the operating conditions listed in Table 1.

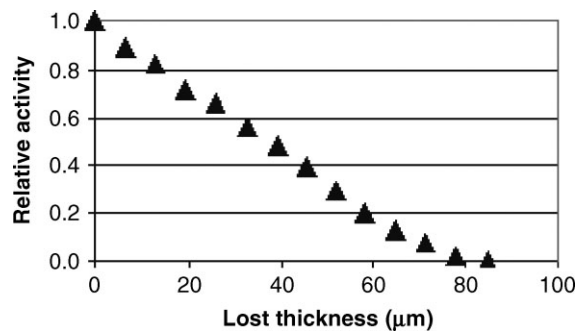


Figure 3. Relative activity with respect to the thickness decrease of the tungsten sheet stack.

Table 1. Technical data of the blanking test

| Punch material | WC/Co | Blanked material | Copper alloy |
|--------------------|-------------|------------------|----------------------|
| Punch geometry | Cylindrical | Sheet thickness | 0.254 mm |
| Punch diameter | 3.7 mm | Lubrication | 3.3 g/m ² |
| Clearance per side | 20 μm | Cadency | 500 parts/min |

In order to evaluate the efficiency of this technique, it has been decided to check out the effect of changing various parameters of the blanking process on the wear kinetics. Two operating parameters have been studied, namely, the blanked material and the lubrication conditions. The wear kinetics is calculated from the slope of the linear regression of the punch wear volume *versus* number of stroke curve upon 50 000 blanked parts.

Figure 4 illustrates the results of the influence of the blanked material on the worn volume with respect to the number of blanked parts. Two copper alloys have been chosen because they have been previously identified as exhibiting very different behaviors on a tribometer test (material A and B). Material A is a copper alloy free of precipitates and material B is a copper alloy with a high level of precipitates. Three different phases can be identified: the first one and the last one which have the same slope and correspond to material A, and the second showing a higher level of the slope in relation to the change for material B known to be more abrasive. The wear volume is nearly 3 times higher with material B as shown by the slope value.

In addition, as the wear kinetics monitored for material A before and after the material change is the same it can be concluded that the change in wear kinetics can be attributed to the only effect of material B.

In order to study the influence of the lubrication conditions, material A has been blanked with two different oil feeding quantities: on one hand the oil flow has been reduced by 40% and on the other hand the amount of lubricant has been increased by 40%. In order to check the only effect of these lubrication conditions, the standard lubrication conditions have been monitored before and after these tests.

The results from Fig. 5 show that the thin layer activation is able to discriminate between various conditions of lubrication: it can be seen that an amount of lubrication reduced by 40% gives rise to an increase of the wear kinetics of the punch of 1.5. On

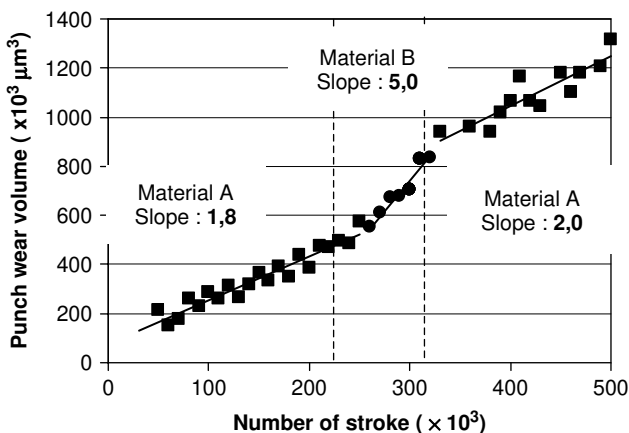


Figure 4. Influence of the blanked material on the punch worn volume (materials A and B).

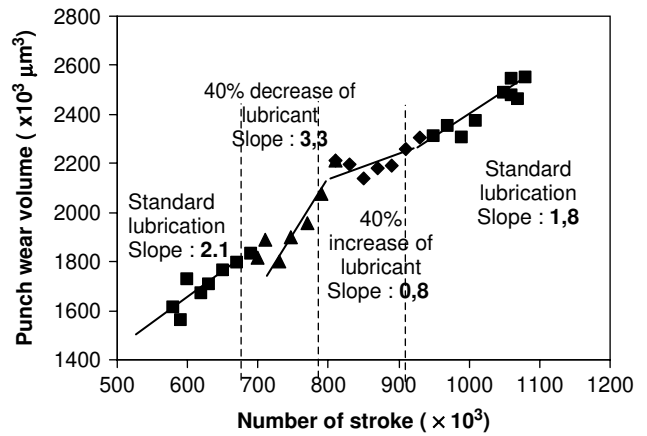


Figure 5. Influence of the lubrication conditions on the punch worn volume (material A).

the contrary, when lubrication is increased by 40%, the wear is lowered by a factor greater than two.

Conclusions

A blanking punch has been activated selectively on its cutting edge. By a calibration carried out with a stacking of tungsten sheets, it has been allowed to calculate the volume of wear of the punch corresponding to the loss of activity. From the measurements of the loss of activity of the punch, it has been shown that the influence of the parameters of the blanking process, like the nature of the blanked material or the amount of lubricant, can be quantified. This method exhibits a good precision, a high sensitivity to a change in the tribological conditions. There is no other method available which can measure the wear of the tool during blanking where there is no necessity to dismount the blanking tool and to consequently change the geometry of the blanking tool. This method has also been applied for the first time in the field of blanking of very small parts.

This method is now available for a systematic study of the influence of the blanking parameters on the wear of the tools with a reduced number of blanked parts, typically about 1–5% of the number of blanked parts between two sharpening.

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