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Ecological approach for assessing drill quality. A case study

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Ecological approach for assessing drill quality. A case study

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Abstract. The quality of drills is classically appreciated by measuring the effective cutting time until the appearance of the admissible wear on the land surface. The experimental tries lead to material consumption and also to resulted chips which, in most cases, are cast as a pollution element. The proposed method for assessing quality is based on measuring the electrical current at cutting and substantially reduces the quantity of resulted chips. The case study was developed for HSS $\phi 8$ drills and shows the advantages of the method and its ecological impact. The experiments were performed using 1C45 steel workpiece material.

1. Introduction

Making clean technologies has become a necessity to keep the environment clean. It is well known that a clean technology presents the following characteristics [1]:

- not to pollute the environment of outside and inside the organization;
- a very small amount of waste resulting in the machining processes;
- to have less material and energy consumption;
- the water consumption should be as low as possible;
- not to pollute the environment by noise.

The comparative analysis of various techniques and technologies from an ecological point of view has become a necessity in terms of protecting the environment in which we live. The ecological approach must be developed in all areas of human activity. A lot of solutions in this way are provided by the surrounding nature itself. Pollution elements should not be treated with other elements of man-made pollution. The reduction of pollution in a certain area has as a first approach the reduction of the quantity of polluting material resulting from various processes.

As machining is a basic method of obtaining different parts, any element resulting from the cutting process must be analysed, reduced the amount in which it is produced, or even eliminated. At present, mankind concentrates on large quantities of polluting materials and neglects small amounts resulting from processes. An example in this direction, which represents the objective of the paper, is the polluting elements resulting from the cutting process which takes place in short time in the case of the experiments carried out for quality appreciation of a cutting tool.
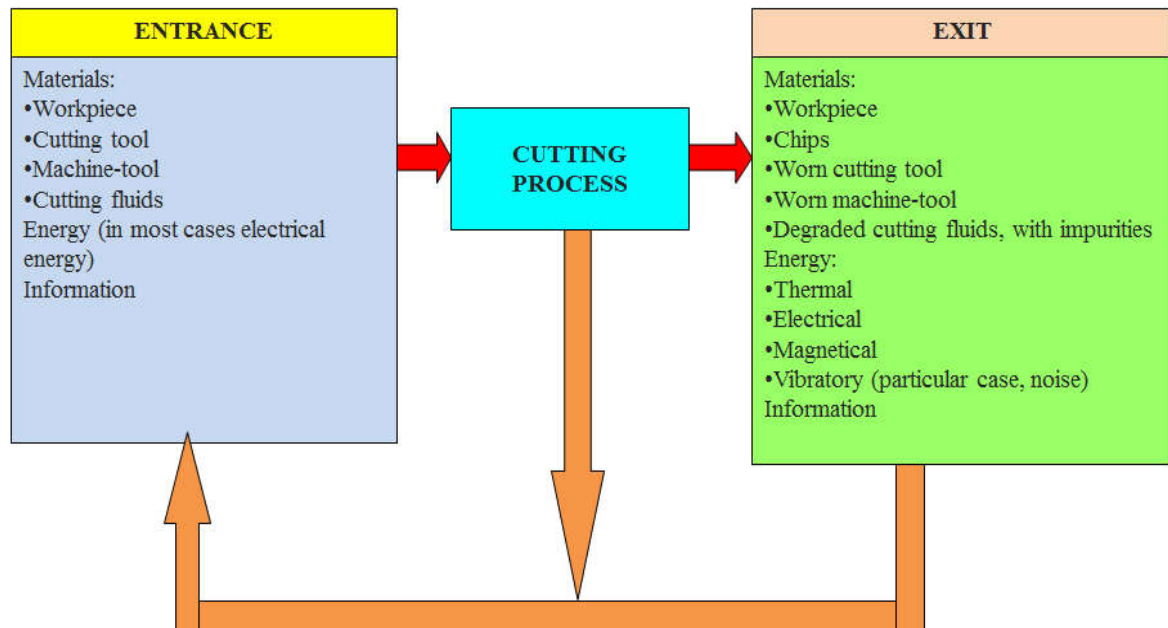
A profound analysis of pollutants in a process cannot be done without a systemic approach of the process.

The case study refers to finding a less polluting method for quality assessing of a batch of cutting tools. The classical test method consists in cutting with a batch of cutting tools until the appearance of admissible wear on the land surface, and the effective cutting time represents the tool life. From the

cutting process developed during the tests pollutants result. The systemic approach of the cutting process is presented in figure 1 [2]. Analysing this figure, the pollutants resulted from the machining process can be easily identified. Also, according to [2], the cutting process is a primary system (it cannot be decomposed into physical subsystems) with a degenerative reaction loop.

The elements that can pollute during the cutting process are found both at the entrance into the system and at the exit. Figure 2 illustrates the elements with pollution potential from the cutting process.

Figure 1. Cutting process as a system.

Figure 2. Identification of pollutants from the cutting process.

This paper proposes a method for assessing the drills quality, which, as compared to the classical method (life tests), has the advantage of a very low pollution.

The method proposes the measurement of the electrical current at cutting [3-7] for the quality assessment of drills, instead of life tests. As compared to the classical method, due to the short cutting time (20 seconds on average) the quantity of resulted chips is very low.

In the approached case study 2 batches of drills are compared.

2. The quality analysis of two drills batches, from two different producers, using the electrical current at cutting

The paper continues the approach from another paper [8], by comparing two HSS-Co steel drills batches with the diameter of 8 mm. The batches of 10 drills each were purchased from two different producers.

For quality assessing, the electrical current at cutting was measured, by following the next steps:

- measuring the electrical current at cutting for each drill using the experimental stand presented in figure 3;
- microscopically visualisation of drill edges to obtain additional information regarding the connection between the electrical current at drilling and the state of the cutting edge.
- processing the experimental data and concluding.

The experiments were done on 1C45 material with the following chemical composition: C = 0.49%, Si = 0.19%, Mn = 0.77%, P = 0.027%, S = 0.003%. The 1C45 steel tensile strength is 806MPa (80.6 daN/mm^2) and the hardness is 224 HB.

Figure 3. Experimental stand for measuring electrical current at drilling.

The experimental stand is composed of: 1 – mandrel for fixing the drill, 2 – collector brushes, 3a- instrument for measuring the electrical current voltage with data acquisition, 3b – PC with software for data acquisition and 4 – gripping device for multiple drilling.

The obtained values for the first batch of drills, from one producer, are presented in table 1, and for the second batch, from another producer, in table 2. The same cutting parameters as in the paper [8] were used for additional comparisons.

Based on tables 1 and 2, table 3 was conceived, which presents, comparatively, the number of drills that have the same value of the electrical current at cutting and the minimum and maximum values for each batch.

Table 1. Values for electrical current at cutting "U_0" at drilling 1C45 with HSS-Co drills, for batch I.

Drill no. from batch I	Drill diameter [mm]	Spindle speed [rev/min]	Feed [mm/rev]	Voltage "U_0" of electrical current at cutting[mV]
1	8	560	0.25	1.3
2	8	560	0.25	1.4
3	8	560	0.25	1.3
4	8	560	0.25	1.1
5	8	560	0.25	1.4
6	8	560	0.25	1.1
7	8	560	0.25	1.2
8	8	560	0.25	1.6
9	8	560	0.25	1.3
10	8	560	0.25	1.1

**Table 2.** Values for electrical current at cutting "U_0" at drilling 1C45 with HSS-Co drills, for batch II.

Drill no. from batch II	Drill diameter [mm]	Spindle speed [rev/min]	Feed [mm/rev]	Voltage "U_0" of electrical current at cutting[mV]
1	8	560	0.25	1.0
2	8	560	0.25	1.2
3	8	560	0.25	1.2
4	8	560	0.25	1.0
5	8	560	0.25	1.2
6	8	560	0.25	0.9
7	8	560	0.25	1.0
8	8	560	0.25	1.0
9	8	560	0.25	1.1
10	8	560	0.25	1.1

Table 3. Number of drills with the same value for electrical current at cutting for batch I and II.

No. crt.	Cutting electrical current voltage U_0 [mV]	No. of drills from batch I	No. of drills from batch II
1	0.9	0	1
2	1.0	0	4
3	1.1	3	2
4	1.2	1	3
5	1.3	3	0
6	1.4	2	0
7	1.5	0	0
8	1.6	1	0
	Total	10	10

The results from table 3 are graphically presented in figure 4.
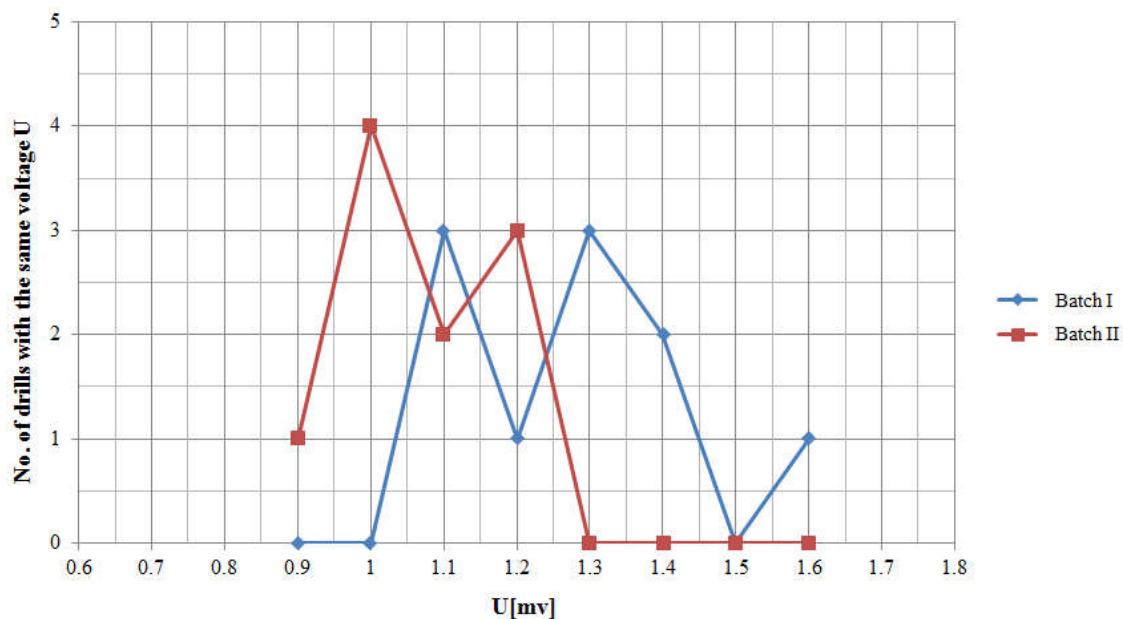
Figure 4. No. of drills with the same value for electrical current for batches I and II.

Analysing figure 4, it can be observed that the drills from batch II have a lower voltage during the cutting process, meaning that the temperature is lower and the tool life will be longer.

Also, the variation interval of the electrical current voltage is shorter, meaning that the technological process for drills manufacturing is better handled by the second producer.

The microscopically images from figure 5 show that the qualitative differences between the two batches are given by the shape of chisel edge adjustment and a better roughness on the land surface of the drill from the batch II.
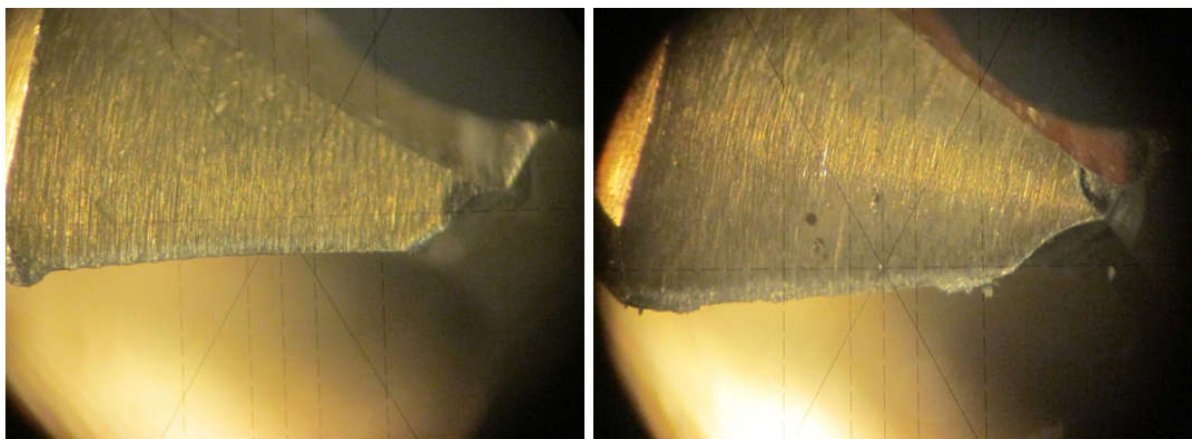
Figure 5. Images with a drill from the batch I (left) and batch II (right).

3. Determination of the amount of chips obtained from the experiments
In the classic method, the experiments would have been carried out until the admissible wear, the effective cutting time being the drill life. According to [9] the tool life for the used cutting parameters would be 25 minutes. The total length of the machined hole is:

$$L = T \cdot s \cdot f \quad [mm] = 25 \cdot 560 \cdot 0.25 = 3500 \ mm, \tag{1}$$

where:

- T [min] is the effective processing time with a drill;
- s [rev/min] is the spindle speed;
- f [mm/rev] is the cutting feed.

The volume of the removed material for a drill would be:

$$V_1 = L \cdot f \cdot d = 3500 \cdot 0.25 \cdot 4 = 3500 \ mm^3, \tag{2}$$

where d [mm] is the cutting depth.

For the two batches, the total quantity of removed material would be:

$$V_{1, total} = 3500 \cdot 20 = 70000 \ mm^3. \tag{3}$$

For the method used by the authors, the volume of removed material is:

- $L_2 = 0.33 \cdot 560 \cdot 0.25 = 46$ mm;
- $V_2 = 46 \cdot 0.25 \cdot 4 = 46 \ mm^3$;
- $V_{2, total} = 46 \cdot 20 = 920 \ mm^3$.

It can be observed that the quantity of chips is reduced by 98.7%, being in the same proportion with the removed material.

4. Conclusion

From the case study presented in this paper, the following conclusions can be drawn:

- electrical current at cutting is a simple and sensitive method for quality assessing of a cutting edge;
- the drills from batch II are better from qualitative point of view than drills from batch I produced by a different company;
- the quality difference between the two batches is given by the land surface roughness (the drills from batch II present a smaller roughness) and also by the quality of the chisel edge adjustment (the drills from batch II present a more accentuated adjustment of the chisel edge);
- using this method, reduction of chips pollution is very significant and, in the same time, is also reduced the consumption of material along with the electricity consumption.

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