FLANK WEAR MEASUREMENT: A PROCEDURE PROPOSAL USING COMPUTER VISION TECHNIQUES

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ABSTRACT

This study presents a developed methodology for evaluating wearing helical drills using a computer vision system. The work takes part in a project for the production of ecofriendly cutting fluids. One of the form taken to analyze the fluid efficiency was determining the tool's wear during the machining. For the tests, high speed steel drills with 3 mm and 7 mm diameter were used. The drills were photographed before and after the drilling of 50 holes in a 1020 steel plate using the ecofriendly and the normal cutting fluids. The images were processed and analyzed to measure the flank wear. In this paper the methodology for acquisition, process and image analyze for flank wearing measurement will be shown. Besides, it will also present a different parameter based on the wearing area for low wear values.

Index Terms - Computer Vision, Drill Wear, Cutting Fluids.

1. INTRODUCTION

Drills are the main element in drilling process, the yield of these tools has a direct impact on the manufacturing costs and surface finish of the machined parts [1-2].
There are several types of drills, but each type of tool has different characteristics. One of the most used type of drill in drilling machining processes is helical drills of high speed steel, which will be the object of study in this work.
In order to get better results in machine process is highly used in tooling area cutting fluids. These are materials capable of: lubricating; cooling; Controlling surface roughness; Reduce machining efforts; Protect against corrosion; Remove chips from the cutting surface; And extend the life of cutting tools [3]. With focus in develop cutting fluid with these cited properties using ecofriendly substances, were proposed in Silva, et al [4], different types of cutting fluids to be tested its efficiency in tooling process.
The Computer Vision aims to perform, through machines, decision-making tasks, based on image analysis. The use of Computer Vision in a given process generally follows the steps: Acquisition; Segmentation; Extraction of characteristics; Classification or recognition, and Decision. With this context it is expected to extract the wear values from helical drills using computer vision techniques after machining.
The aim of this paper is develop a procedure to measure drills wear to be used in efficiency analysis of ecofriendly cutting fluids.

2. MATERIALS E METHODS

This work focuses on the definition of a methodology for measuring the wear of helical drills through images captured before and after the drills are submitted to drilling tests. For this study the flank wear parameter was used.

2.1 Acquisition system

For image acquisition was used a CCD camera, with 752x480 resolution. The camera has been adapted to the Z axis, in an universal measuring machine.
The drills were fixed on machine table by a magnetic prism, in order to keep always in the same position for all measurements. Figure 1 shows the assembly on the machine table.

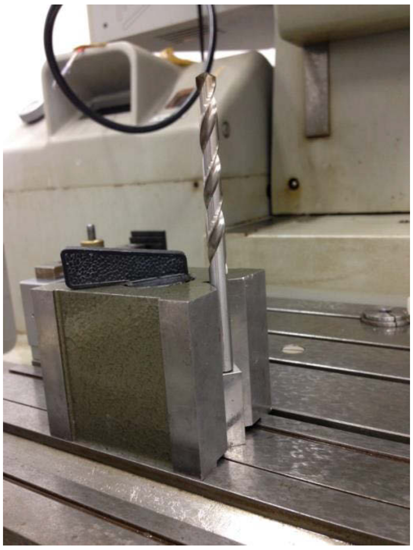

Figure 1 – Assembly of drill on machine table.

For the analysis of flank wear, images were captured at the top of the drills to visualize the cutting area. The images were captured before and after performing drilling tests.

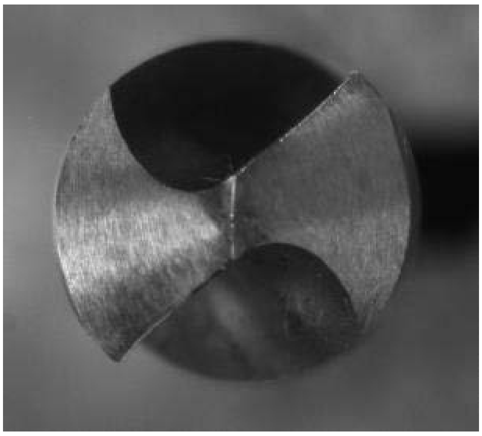

Figure 2 – Image from the cutting plane

2.2 Image segmentation

Segmentation is the process where the object of interest is highlighted on the image, that is, the rest of the image is separated from a particular region or object to be analyzed.
The image segmentation was carriedy out using Canny edge detection algorithm [5]. In order to reduce noises and decreasing calculation were made a cropping in the image selecting only the interest part, the cutting edge. This new image is called region of interest, ROI (Figure 3).

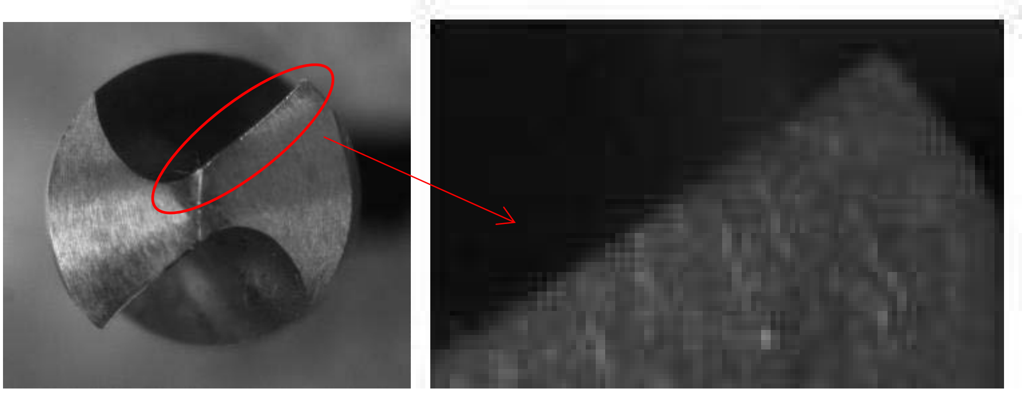

Figure 3 – Region of interest from cutting plane.

After the image was highlighted, a Canny filter was applied to detect edges of the cutting edges. This method takes the edges of the image as an output of the algorithm, the image is analyzed using two threshold points, one high and one low. When a pixel in the image is larger than the high threshold, its neighbors must be larger than the low threshold so that the edge has continuity.
With the Canny filter it was possible to obtain the edges of the cutting edges for the measurement to be carried out. Figure 4 shows the result of the image after filter application. Only the cutting edge of the bit is observed.

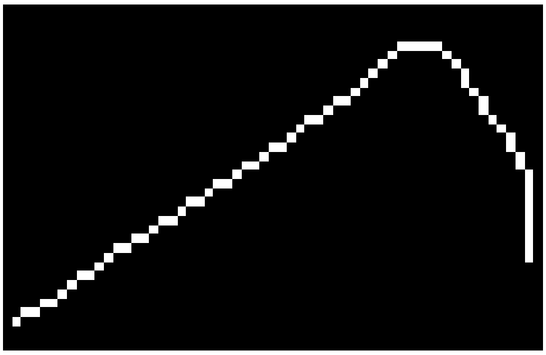

Figure 4 – Edges detected by Canny method.

2.3 Data analysis

After application of the Canny algorithm is possible to obtain the end points of the cutting edge of the drill bit (Figure 5). The coordinates of these points are considered into the following variables: $P_1(x, y)$ e $P_2(x, y)$.

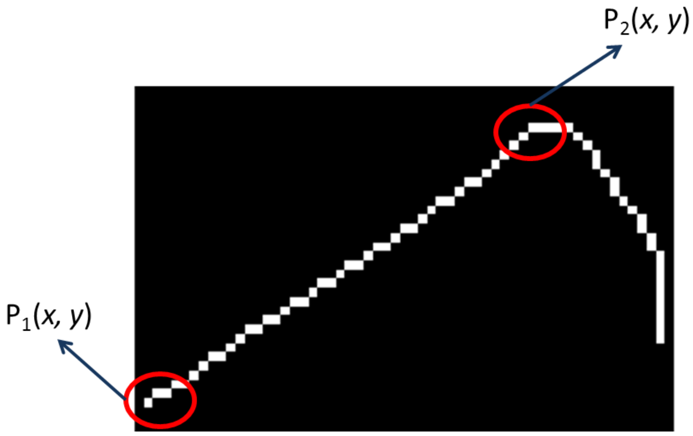

Figure 5 – Coordinates used to fit a reference line.

Using the coordinates of that points, is fitted a line to be used as reference profile of cutting edge to measure the drill wear.
With the X and Y coordinates of the cutting edge points and the line equation, the wear values are calculated as the distance between the points of the real edges (found by Canny method) and the fitted line. The distances obtained correspond to the wear of each point of the cutting edge. With these distances, the maximum value is called as maximum flank wear (VBmax).

2.4 Area wear measurement

In the tests carried out on samples drill the wear results for parameter of mean flank wear and maximum flank wear were too low due the reduced number of tests.
In order to get another one expressive value for wearing measurement was calculated the area wear.
For measure the area wear, besides the line equation, other important information is extracted from the image that are the real points of cutting plane. All coordinates positions on the cutting plane are used to fit a squared equation, by method of least squares (Figure 6).

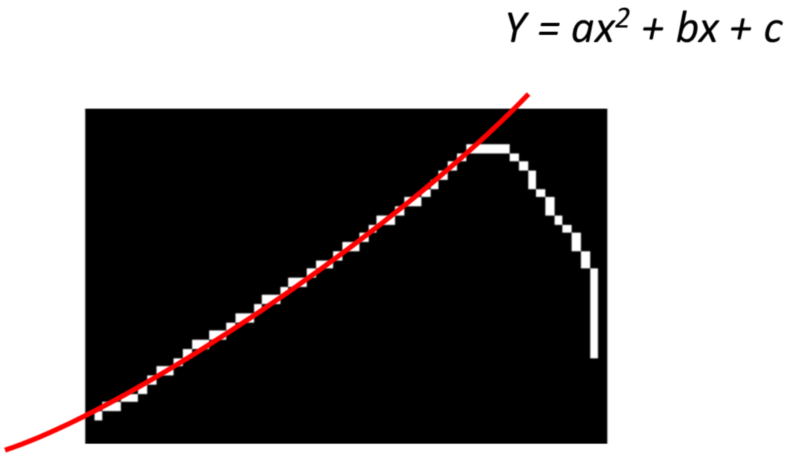

Figure 6 – Example of squared equation for area measurement.

Through the equations of the line and the parabola, the wear area can be estimated as being the area between the two curves. Obtained calculating the integral of the difference between the functions.

3. RESULTS

To perform the experiment and the measurement of the drills wear, eight drills with diameter of 7 mm and eight drills with a diameter of 3 mm were used. Images from cutting plane of each drill ware captured before and after tooling test.
Fifty holes were performed with each drill. The sample used for these test was a 1020 steel plate and was the same for all drills. The machining parameters, as cutting speed, feed rate and rotation, were kept constant during all test. The conditions were maintained the same in order to evaluate only the variations in wear values due the cutting fluids.
Different cutting fluids were evaluated in the machining process. Among the eight 7 mm drill, two were machined with the cotton oil, two with the epoxidized oil, two with the hydroxylated oil, one with a commercial cutting fluid. The same procedure was adopted with the 3 mm drill. Table 1 show all drills and cutting fluids used for the tests.

Table 1 – Fluids and drills used in the experiments.

Cutting fluid	Diameter
Cotton Oil	3 mm, 7 mm
Epoxidized Oil	3 mm, 7 mm
Hydroxylated Oil	3 mm, 7 mm
Commercial Oil	3 mm, 7 mm

Following the procedure described before, the measurements were made on the drills before they were machined and after being machined. The results presented below are the differences between the both values.
The wear measured and presented below are maximum flank wear (VBmax) and area flank wear.

Table 2 – Results for measurement using image process techniques

Cutting fluid	Diameter	Vb max (mm)	Area (mm^2)
Cotton Oil	7 mm	0,001	0,040
Epoxidized Oil	7 mm	0,004	0,020
Hydroxylated Oil	7 mm	0,009	0,082
Commercial Oil	7 mm	0,021	0,062
Cotton Oil	3 mm	0,010	0,005
Epoxidized Oil	3 mm	0,012	0,004
Hydroxylated Oil	3 mm	0,005	0,017
Commercial Oil	3 mm	0,022	0,037

4. CONCLUSIONS

According to information presented in items 2 and 3, it is possible to conclude that the research was able to establish a procedure for the automatic measurement of wear in helical drills by computer vision techniques. The use of the two parameters in the analysis was able to provide information about the efficiency of the ecofriendly fluids for wear on the cutting surface of tool, even if the wear values are too low, in the order of micrometers, with the tools exposed to a low effort.

The results obtained in this work will be analyzed together with other parameters for the conclusion about efficacy of the developed ecofriendly fluids.

A comparison with another method for the wear measurement for validation of the proposed procedure is important to continuity of the research. However, new drilling tests must be carried out with a larger number of holes causing higher tool wear values.

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