INCLINATION PROJECTION SETUP FOR WEAR AND TEAR DRILL BIT MONITORING SYSTEM

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ABSTRACT: This research presents a monitoring system for composite drilling that inspect the condition of the drill bit using a digital microscope camera with a computer system that implies image processing method for flank wear detection. The aims is to provide a new system by introducing a new camera view angle that can detect wear or changes in the drill bit geometry specifically, flank region in order to determine the tool life span. The camera view angle is determined based on the principle of illumination and decided to be at 45 degree view angle. Then, the images taken undergo image pre-processing and further analyse to detect wear by image fusion method. During the image pre-processing, the true colour image is converted into binary images and canny edge detector is applied to detect the flank boundary. Morphological operators such as dilation, flood fill, closing, and erosion is then applied to reconstruct the flank region to make sure it is approximately the same shape as the actual flank region. Finally, the reference image and the wear drill bit image are fuse together using Principle Component Analysis (PCA) method and the wear percentage is calculated.
KEYWORDS: *Flank region, Morphological Operation, Drill bit Image, Wear and Principle Component Analysis.*

1.0 INTR ODUCTION

The importance of composite materials has been growing widely over the last decade, which can be confirmed by their intensive use in the aviation industries. It can also be observed that nowadays composite material not only can be found in the aeronautical field, but also in other industries such as automotive, railways and marine. So, it is no doubt that the reliability and the confidence level that had already achieved in metallic materials can also be reached for composites in a matter of time.

In the later stage of parts production, machining operations like drilling are frequently needed in composite structures as the use of bolts, rivets or screws are required to join the parts. In general, the machined parts have poor surface appearance and tool wear is higher. One of the major problems that is related to composite machining is that the nature of the fibre reinforcement is usually very abrasive and can cause rapid tool wear and deterioration of the machined surfaces. Many research and experiments had been done to examine the area near the tool tip. Most of the study mentioned that the machining of CFRP consist a series of fractures, each creating a chip and damage increase as feed rate increases. There are two methods for measuring tool wear which are Direct method and Indirect method. In Direct method, the cutting edge of the tool wear is measured using a vision system such as digital microscope and the image captured is processed. By using direct method, the tool needs to be detached from the machine during the measuring process. As for indirect method, it measures the tool wear by processing the signal during the drilling process. Tool wear affect the condition and quality of the material, as a result, leads to cost increments such as time and money. Hence, it is very important to develop a proper inspection system so that tool wear can be minimized or prevented.

2.0 METHODOLOGY

This project consists of two parts which are the hardware setup and the software development. For the hardware part, a setup is developed to satisfy the objective of this project. Throughout the process, a setup was improvised based on the shape, dimension and requirement including the illumination requirement so that a clear and quality images can be obtained. As for the software development, a MATLAB coding is developed to process the images obtain so that further analysis can be done and the desired result can be obtained

2.1Cad Design

After developing ideas, the setup is drawn using Catia software to portray the design modification idea based on the previous research setup. The main setup frames were maintained and several improvisations were made to the camera holder so that it can satisfy the project's objectives. The setup was first de-assembled and re-assembled after improvisation are made accordingly.

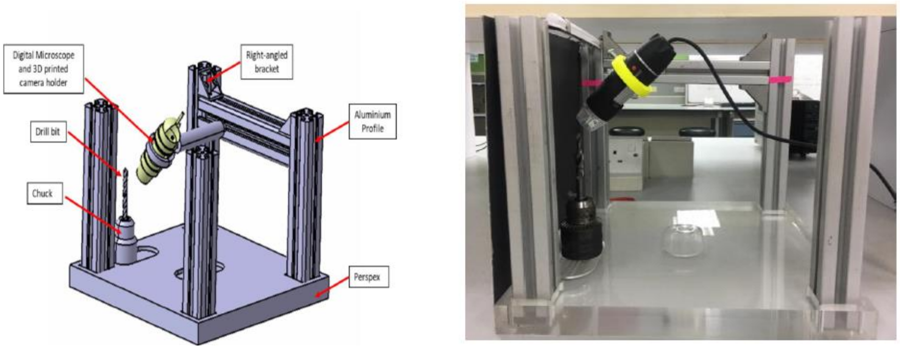


Figure 1 : (a) Catia Drawing (b) Completed Design Assembly

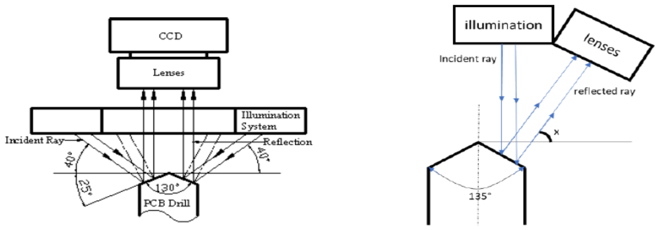
2.2 Illumination Condition

To observed the drill bit flank region, an excellent lighting system is required so that a high-quality image can be obtained and thus ease the image processing method to be done afterward. It is very important to create a clear contrast between the subject to be monitored and the background image. Initially, a white background was chosen to separate the drill bit image and the background. However, based on Figure 2, it can be seen that the contrast created by the white background causing the unnecessary part of the drill bit to be included in the camera observation and make it difficult for wear detection to be done successfully. To solve this problem, a black background is chosen instead and as a result only the surface of the drill bit can be viewed clearly.

(a) (b)

Figure 2: (a) image with white background, (b) image with black background

The fundamental of this idea is based on the law of reflection where it is known that when light falls on a smooth surface, the angle of reflection is equal to angle of incident. This can be explained in Figure 2 where (a) shows the principle of illumination by Zhang et al. (2006) and Figure 2 (b) shows the propose illumination system for this project. Since the lighting position is fixed, the camera is adjusted until the best position is obtained where most reflecting lights can enter the lens. Beside the illumination position, other parameters are set to be constant such as the height of the light source and the distance between the light source and the drill bit. The relationship between these parameters will be considered in determining the camera position and camera view angle which is show as in Figure 3.



(a) (b)

Figure 3: Principle of illumination

Figure 4 shows the images obtained at different light intensities where (a) and (c) is not favourable the light intensity is too low and too bright while (b) met the requirement of inspection.

(a) (b) (c)

Figure 4: images obtained at different light intensities

3.0 RESULTS AND DISCUSSION

3.1Data Collection

The drill bit is inserted into the chuck holder and by using the setup made, a clear image of the drill bit flank region for both sides of the drill bit is obtained. Figure 5 shows both of the cutting lip that can be seen from top view angle. The images were then input into the MATLAB software developed and undergo image processing procedure. Finally, the wear percentage of the drill bit is calculated and recorded. The processed was iterated 10 times for both side of the drill bit flank region and the mean value was calculated. Then, the results were tabulated in a graph of number of maximum holes drilled versus wear percentage. To check the data consistency, equation (1) to (3) were used to calculate the mean and the standard deviation.

$$\mu = \frac{x_1+x_2+x_3+\ldots x_n}{n} \quad (1)$$

$$\sigma^2 = \frac{1}{N}\sum_{i=1}^{N}(x_i-\mu)^2 \quad (2)$$

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i-\mu)^2} \quad (3)$$

From the graphs, the results were analysed based on the data consistency and conclusions are made. The drill bit has two side of flank region that was observed individually as can be seen from the first column of the table. The top column shows the four different drill bits with different number of maximum holes drilled and the mean value is shown for both side of each drill bit respectively. The lowest row of the table shows the total wear percentage of each drill bit for both sides of the drill bit flank region. Table 1: Mean data from 10 iterations from each maximum number of drilled holes

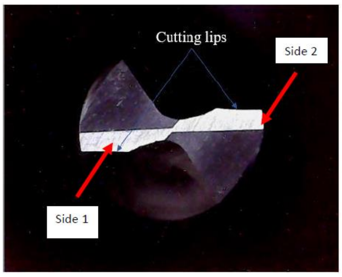


Figure 5: Flank region view from top of drill bit tip

Table 1: Mean data from 10 iterations from each maximum number of drilled holes

Drill Bit	88	153	364	613
Side 1 (%)	1.781	8.382	2.422	11.999
Side 2 (%)	1.210	7.190	1.828	10.596
Total (%)	2.992	15.571	4.250	22.596

3.2 Wear Pattern

Based on the graph in Figure 6, it can be seen that the drill bit with maximum number of drilled holes of 88 has the least wear percentage and the drill bit with maximum number of drilled holes of 613 has the highest wear percentage. However, the drill bit with maximum number of drilled holes of 153 has higher wear percentage compare to the drill bit with maximum number of drilled holes of 364. The same observation is applicable for both sides of the drill bits.

Figure

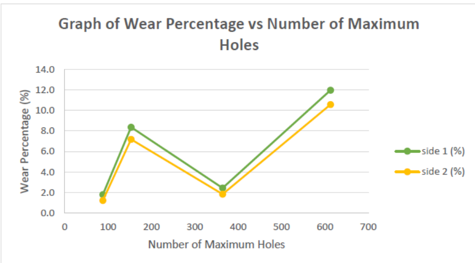


Figure 6: Graph of Wear Percentage vs Number of Maximum Holes Drilled

Generally, there are three sections of the line trend where the first section shows a gradual increment and then dropped significantly in the second section and finally gradually increased in the third section. Comparing the first two drill bits in the first section, at 88 maximum number of holes drilled, the wear percentage is 1.781 percent for side 1 and 1.210 percent for side 2 while at 153 maximum number of holes drilled, the wear percentage is 8.382 for side 1 and 7.190 for side 2. The difference in number of wear percentage between these two drill bits are 0.57 and 1.19 respectively.

3.0 CONCLUSION

In this study, a system is to be develop with the aim to introduce a new camera view angle that is able to capture image and further inspect the wear percentage of the drill bit using image processing technique. A system setup is designed and built where the camera has adjustable view angle until a fixed view angle is chosen experimentally. The camera is then fixed to be having 45 degree view angle and the distance between the drill bit and the camera is fixed at 20mm.

There are five drill bits with different maximum number of holes drilled involved in this experiment which are 80, 88, 153, 364 and 613. The drill bit with the least maximum number of holes drilled is chosen as the reference image. All the drill bits are provided by industry for research purposes. This study is conducted as a preliminary inspection of drill bit flank wear to determine the tool end life.

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