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Original Research Article

CUTTING TOOL WEAR MEASUREMENT USING IMAGE PROCESSING TECHNIQUES

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Abstract:- Wear plays an important role in the life span of the product and machine elements. It is one of the main causes of service, maintenance or finally replacement in their every aspect of life. The goal of this project is tool wear measurement system for detection of micro- and macro-wear of the materials in tools without removing the tool from the process, using imaging methods. This imaging-based technique involve image acquisition, image processing by using different image processing techniques , associated measurement principles and display of wear measurement. First the wear measurement process was performed on the standard images and now on captured images via Dino-Lite camera.

Keywords- flank wear (Vb),tool life, morphological operations, scaling, reference line, base line

Introduction

Wear is a type of surface damage that arises from the relative motion between interacting solid surfaces. Tool wear during machining operation is known to change the geometry of the cutting tool, thus increasing cutting force, affecting surface finish and decreasing dimensional accuracy of the work piece.

For tool wear measurement we also have to know the parameters that affect the rate of tool wear and they are:

1. Cutting conditions (cutting speed V, feed f, depth of cut d)
2. Cutting tool geometry (tool orthogonal rake angle)
3. Properties of work material.

Thus , monitoring of tool wear during machining is important to detect problems in the cutting process, assess stability of machining, control surface finish of product and avoid damage to the machine tool itself.[6] Attempts to resolve this problem have been met with varying levels of success, but all those methods requires immense manual

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involvement and hence the accuracy cannot be guaranteed. Repositioning is a big issue .

Tool wear measurement is basically done by two methods, direct and indirect method. Examples of indirect methods include acoustic emission, tool tip temperature monitoring, vibration signatures(acceleration signals), cutting force monitoring, stress/strain analysis and spindle motor current monitoring. The implementation of indirect methods is however not easy due to inadequate knowledge on the effect of tool wear on the signals produced.Directly measuring the tool wear can be done by using machine vision because different forms and geometries can be readily observed.

Another method for tool wear measurement is online and offline tool wear measurement. Thus, a computer-based imaging system is a good strategy for noncontact, online, and high speed inspection. It should be useful for online wear monitoring and also suitable for industrial applications in an automated environment, where high speed, high accuracy and low cost are required.

In online method we don't need to separate the cutting tool from the machining process whereas in offline method we have to remove the cutting tool from the ongoing process and then perform the wear measurement techniques on it.

There are different types of wear that get introduced in the tool while processing. They are:

1. flank wear
2. crater wear

The dominant wear is the flank wear(Vb).So, it is the prime parameter for wear measurement. Therefore, in this project, we will be measuring this flank wear.

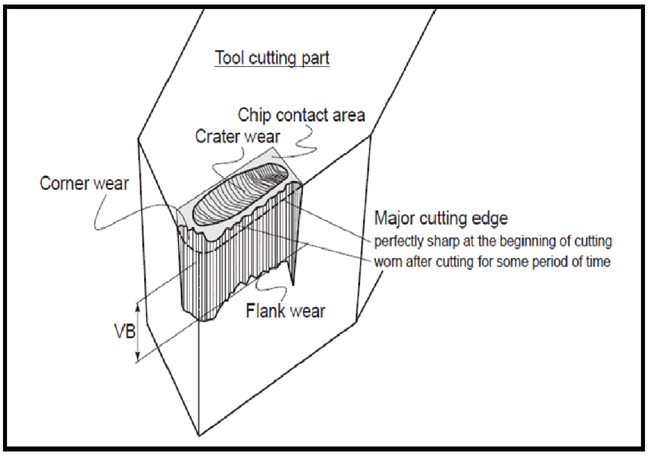

Fig. 1. Various types of wear observed in a tool lifespan

Cutting tool wear condition	Flank wear (mm)
New	$0 \leq VB < 0.08$
Half-new	$0.08 \leq VB < 0.1$
Half-worn	$0.1 \leq VB < 0.3$
Worn	$0.3 \leq VB < 0.5$

Fig. 2. Flank wear limits

BLOCK DIAGRAM

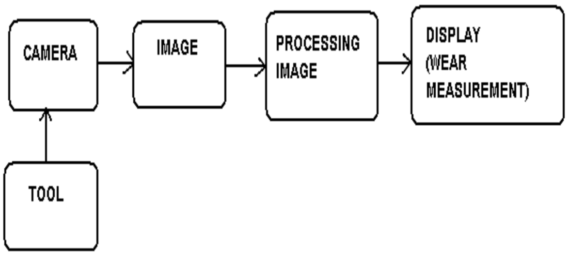

Fig. 3. Block diagram

Read the image: Working and acquiring the standard images which are taken from and were available with mechanical department, with the help of MATLAB programs using image processing.

Preprocessing of image: If the quality of the image is not good and clear, maybe because of poor illumination , the image needs preprocessing .It involves making background uniform and adjusting contrast. In short performing the image enhancement. Image enhancement method of improving the definition of a video picture by using various functions which reduces the lowest grey values to black and the highest to white. Image enhancement techniques are used for pictures from microscopes, surveillance cameras, and scanners.

Wear detection: We are using edge detection technique for wear measurement. There are various methods for edge detection like sobel, prewitt, robert and canny. Out of these methods we are using Canny as it gives the best performance, along with detecting the edges it also removes the noise present in the image. After this to make detection of edges more accurate and to find out exact worn out region morphological operations such as dilation , erosion are applied. Dilation is used to add pixels to the boundaries of objects in an image

Wear measurement: Wear measurement is done in terms of flank wear by using flank wear conditions.

METHODOLOGY

A. Working with the standard images

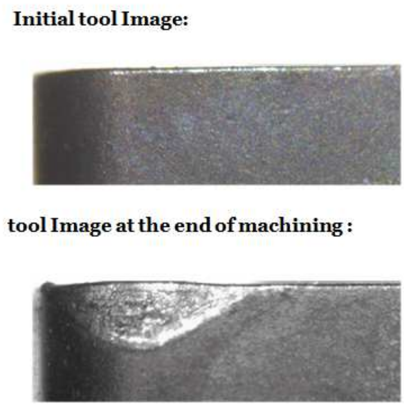

Fig. 4. Standard images taken from mechanical department to carry out the preprocessing

B. Preprocessed image

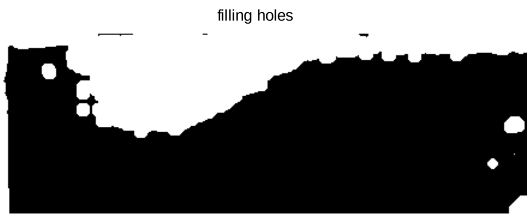

Fig. 5. Uniform background, adjusting the contrast and applying morphological operators to cover the worn out region by white pixels

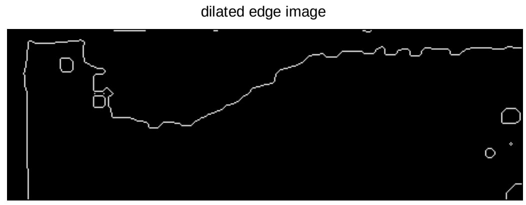

Fig. 6. Canny edge operator output

C. Working with the captured image

Fig. 7. Image captured in mechanical department

D. Scaling

As limits of flank wear are in mm scale while the processed image will give the flank wear in terms of pixel. Hence, we need to go for mm-to-pixel scaling. For that purpose, the images of the tool and scale are captured at same height and same resolution . The relation between the pixel corresponding to 1 mm and the height at which the images are captured is plotted and it is found to be linear.

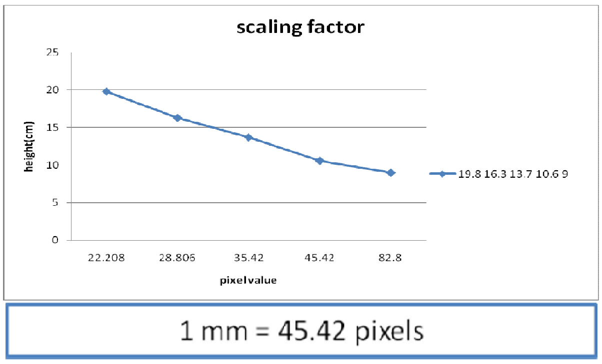

Fig. 8. Linear relation observed for the scaling factor at different heights at which image is captured

E. Algorithm

1. Preprocessing :
- Uniform background
- Contrast adjustment
- Morphological operations
- Wear detection

2. Wear measurement :
- Determine the reference line (rl)
- Find the base line (bl)
- Height in pixels Vb = bl-rl

3. Scaling :
- Scaling factor X = 45.42
- Height in mm Vbf = Vb/X

4. Based on standard limits , display the esult

F. Processing on the captured image

1. Wear detection

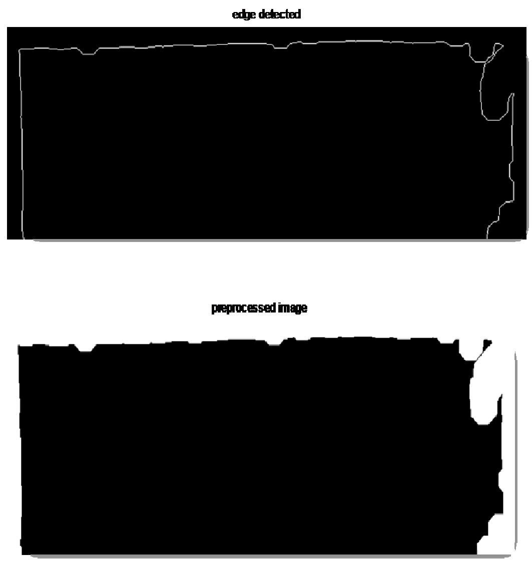

Fig 9. Wear detection on captured images using morphological operations and edge detection technique

2. Wear measurement

Initially, the flank wear is measured by using MATLAB in-built function "imtool". But, it requires manual aid. Obviously, it involves error.

Fig. 10. Wear measurement using imtool function in MATLAB

With imtool :

Vb = 90 pixels = 1.9815mm

Thus, we carried out the logic to find the base line and the reference line. Reference line is the row with maximum white pixels and closest to the detected worn out region while the base line is the row with maximum black pixels and again closest to the worn out region. This means if we get two rows with maximum white pixels w.r.t. reference line then , we will take the maximum row number whereas for base line , it will be the minimum row number.The difference between the row positions of these lines gives us the required result in the form of wear; but in pixels which we need to convert to mm scale with the help of scaling factor (X). Comparing with the prescribed limits for flank wear measurement, we displayed the result.

Without imtool function (by program) :

Height in pixel : Vb = 93 pixels

Scaling factor : X=45.42

Height in mm : Vbf = 2.0476 mm

G. Results

Automated results (MATLAB) :

base line: 111

reference line: 18

height in pixel:

Vb = 93

X = 45.4200

Vbf = 2.0476

RESULT:

Completely damage

H. Conclusion

Our result matches with the actual tool state. But, again our project has the drawback that it varies with the atmospheric conditions, illumination of light, presence of chipping particles and dust, may vary from tool-to-tool. Accordingly, our code needs to be generalized.

Acknowledgment

With immense pleasure we are presenting "Cutting Tool Wear Measurement Using Image Processing" project report as part of the curriculum of B.E. Electronics and Tele Communication course. We wish to thank all people who gave us their unending support so far.

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