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Tool Wear Detection Using Image Processing Technique

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Abstract: The most widely used output measure in the machining process for assessing the machinability of a material is tool life. The main factor influencing tool life is tool wear rate. To identify when a tool has reached the end of its design life and has to be replaced, tool wear must be measured. The primary focus of this work is the use of image processing to measure tool wear. Due to the extreme heat and cutting forces generated when machining materials with a high degree of hardness, usually over 35 HRC, serious difficulties appear. These include short tool life and rapid tool wear. The difficulties are even worse if the hardness exceeds 45 HRC because localized shearing turns the chips from continuous to serrated shapes, increasing the pressure and temperature even further. In this project, we'll utilize MATLAB to employ image processing techniques to determine tool wear. We may use MATLAB's many functions to perform image processing. For example, we are using the sober approach for edge detection to identify the wear on the edge. We'll be using another function that is comparable to this one. This imaging technology is more advantageous for calculating tool wear cheaply.

Keywords: *Tool Wear, Image Processing, MATLAB.*

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I. INTRODUCTION

Machine vision is a system that several authors have used to investigate tool wear. A machine vision system developed by Kurada et al. [1] is capable of measuring flank wear. To highlight the wear area, they were employing picture threshold.

A monochrome CCD camera was utilized by Kerr et al. [2] to take pictures from the tool nose. In order to examine the effectiveness of various methods in extracting wear information from the tool, edge operators, texture information, histogram analysis, Fourier transform, and fractal features of the image were tested. It was discovered that texture information was the most accurate and helpful in determining how much wear there was. But because the tool had to be taken out of the tool holder, the system was not designed to be used in-cycle.

T. Selvaraj et al. [3] designed an image processing tool to determine the amount of wear accumulated on single point cutting tool via a series of machining processes. By contrasting the image grayscaleS, the tool wear was calculated. [13] Here, the performance of multilayer (Al2O3+TiC+TiN+AlCrN) coated and uncoated ceramic cutting tools under dry machining of hardened AISI 4340 (46 HRC) under various cutting circumstances is investigated in terms of tool wear using image processing techniques.

The tool directly affects the goods' machining quality during the machining process. A well-maintained instrument can increase processing efficiency, yield, and quality. Furthermore, it lowers processing costs directly and boosts manufacturing enterprises' profitability and competitiveness. For this reason, monitoring tool wear is essential to maintaining product quality throughout the manufacturing process.

Generally speaking Tool wear monitoring can be broadly categorized into indirect and direct methods. Indirect monitoring involves using sensors to gather information such as power, cutting force, vibration, acoustic emission, temperature, and other process parameters. While these parameters are easily collected online, a reliable model is necessary to correlate them with tool health.

On the other hand, real-time image processing can be used in direct monitoring techniques, such as evaluating the tool's physical attributes, to deliver quick and precise assessments. Using an image processing technology, the direct detection method measures the tool's wear directly. And note any changes to the tool's look, surface features, or geometric shape.

Image-Based Approach: This method takes direct pictures of the tool while it is being machined in order to quantify wear, as opposed to depending on indirect sensor measurements such as force or power Cross-Correlation Analysis: This method looks for patterns or similarities between two images by comparing them. In this case, the tool's original (fresh) image is contrasted with the worn tool's image. Most likely, the analysis will concentrate on how the tool's look varies with wear.

Increased Sensitivity and Accuracy: According to the procedure, measuring tool wear will be more sensitive and accurate. The statistical measure of how two sets of data vary together, called cross-covariance analysis, may be responsible for this improvement.

This paper primarily focuses on the image processing procedure using MATLAB and its outcome.

➢ *Tool Wear Measurement Method*

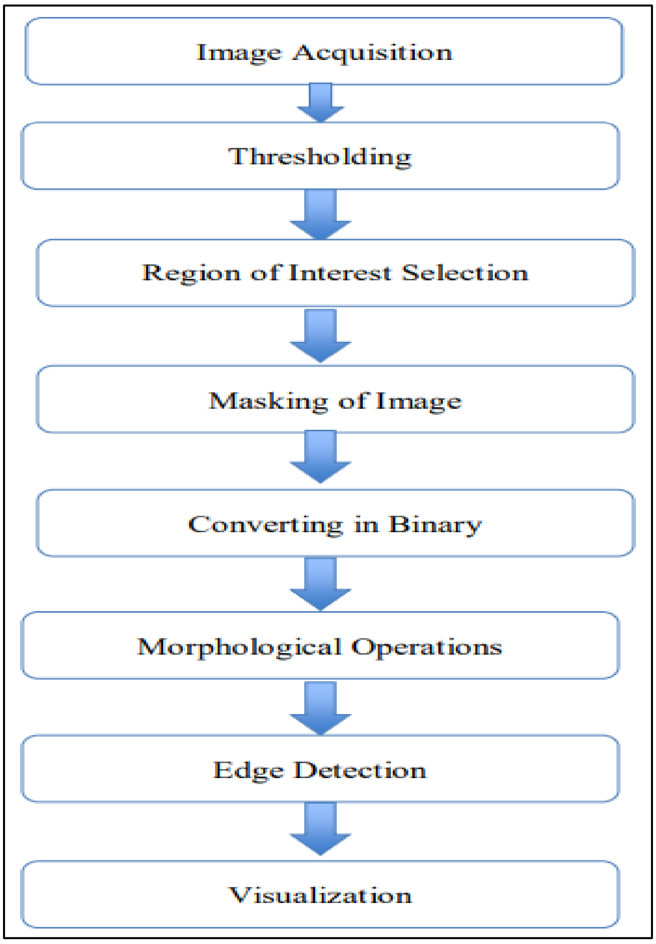

Fig 1 Tool Wear Measurement Method

II. IMAGE PROCESSING

The procedure for converting a picture to digital form and manipulating it to get valuable data. It includes a range of methods for improving, analysing, and interpreting images in order to change them for improved visualisation or to extract meaningful information.

- Image Acquisition: Using cameras, sensors, or other imaging devices, images are first captured or obtained to start the process. Depending on the tools and circumstances, the collected photos may differ in quality and features.
- Pre-processing: In this stage, raw photos are cleaned up and given a better quality. It could involve adjustments like sharpening the image, enhancing the contrast, and reducing noise.
- Image Segmentation: is the process of breaking apart a picture into sections that can be understood or interpreted semantically. This might be helpful for highlighting specific elements or items in a picture.

➢ *Flank Wear*

When a tool cuts through a work piece, the flank face that comes into touch with the substance wears down. At low cutting speeds, abrasive wear is the most important mechanism. Because it is easy to measure, this type of wear is usually utilised as the traditional wear limit. The flank wear on the tool's flank face is measured by abrasive wear. This wear is more noticeable at lower cutting speeds.

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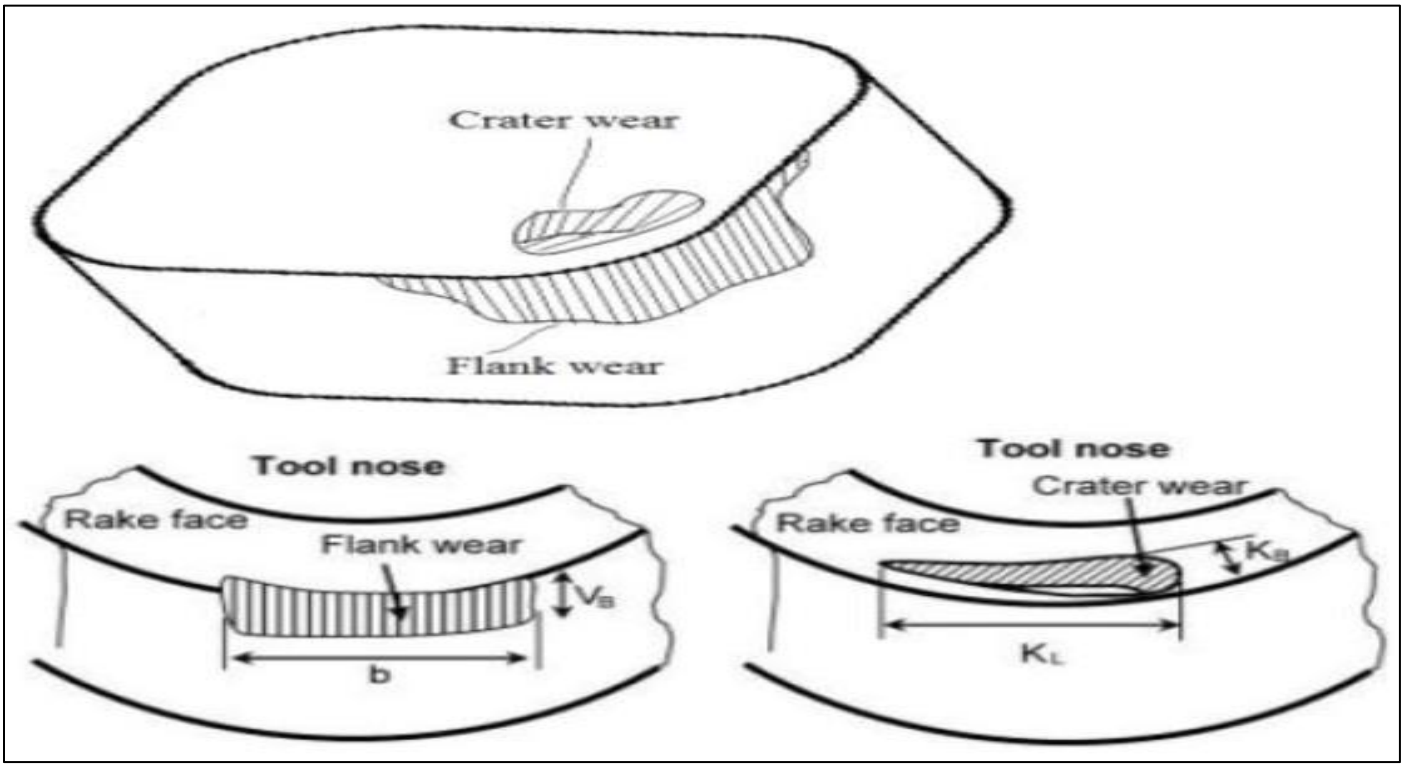

Fig 2 Flank Wear

➢ *Crater Wear*

Crater wear appears on the rake face when a cutting tool comes into contact with chips while being cut. Rapid cutting speeds highlights this. Because higher temperatures encourage chemical interaction between the cutting tool material and the work piece, diffusion wear is the most prevalent process. Crater wear can cause the cutting edge to erode to the point of failure. Crater wear appears on the rake face of the cutting tool due to diffusion wear, which is primarily caused by chemical interactions between the tool and the work piece. Crater wear can cause the cutting edge to erode to the point of failure.

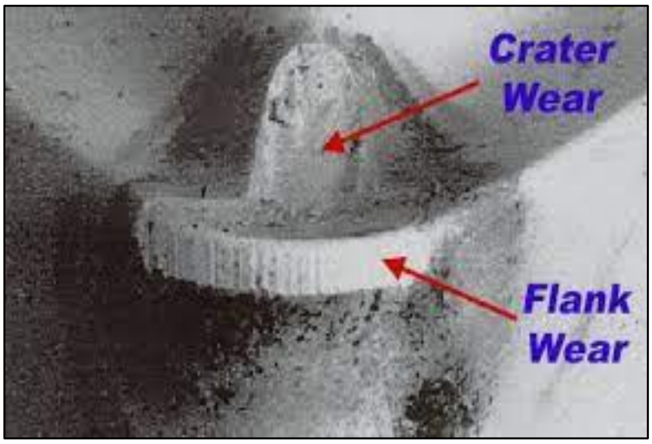

Fig 3 Crater Wear

➢ *Matlab*

The incredibly complex computer environment and programming language known as MATLAB are frequently used in science and engineering. Users could produce simulations and visualisations, work with and evaluate data, and carry out complex mathematical calculations. One of MATLAB's main advantages is its ability to analyse large amounts of data and perform computations quickly and accurately. Because of this, it is an excellent instrument for assessing tool wear, which is essential for machining. Using the MATLAB software, we can build models that replicate the cutting process while taking factors like tool shape, feed, and cutting speed into account. To extend tool life and improve machining efficiency, we can forecast tool wear rates and change the cutting parameters by analysing simulated data. Strong programming language for complex data processing, analysis, visualisation, and mathematical operations

Engineering and research both use MATLAB. It is an excellent resource for figuring out tool wear and may be applied to build models that replicate cutting processes, predict tool wear rates, and increase the efficiency of machining. This article will explore the process of predicting tool wear with MATLAB, create precise models, and discuss challenges associated with tool wear estimation.

➢ *Tool Wear Monitoring by Image Processing*

Since measuring tool wear affects the surface quality, dimensional accuracy, and manufacturing costs of material components, it is an important problem. After taking a photograph of the tool wear, flank wear is estimated using a grayscale analysis of the picture. Optimisation has important practical implications, especially for machining operations. Several techniques were explored, including edge operators, texture data, histogram analysis, the Fourier transform, and fractal characteristics, to compare the results with the wear data collected from the instrument. The purpose of this study's image-processing tool is to determine how much

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wear a single-point cutting tool has sustained after several cycles of continuous machining.

III. LITERATURE REVIEW

The authors present a real-time system for detecting tool wear in turning operations utilizing acoustic emission (AE) and image processing techniques in this work. They employ AE sensors to detect changes in the sound generated by the cutting tool as it ages, as well as a CCD camera, to record pictures of the cutting tool. MATLAB then processes the data to derive characteristics relating to tool wear. The extracted characteristics are utilized to forecast tool wear. The authors conduct tests to determine the efficacy of the suggested strategy. They capture AE signals and photos of the cutting tool at various levels of wear using a series of turning tests. These data are used to train the algorithm and assess the accuracy of the predictions. The findings demonstrate that the suggested technique can forecast tool wear correctly with a maximum error of 3%. The authors conclude that the suggested technique can increase tool wear monitoring accuracy and efficiency in turning operations.[1] The authors suggest a method for analysing tool wear in turning operations using image processing techniques in this research. They collect photos of the cutting tool with a CCD camera, which are subsequently analysed by MATLAB to extract information relating to tool wear. The extracted characteristics are utilized to investigate the cutting tool's wear process. The authors conduct tests to determine the efficacy of the suggested strategy. They gather photos of the cutting tool at various levels of wear using a series of turning tests. They utilize these photos to extract tool wear characteristics and analyse the wear process. The results reveal that the suggested technique properly analyses the cutting tool's wear mechanism, offering insights into wear behaviour and boosting understanding of the wear process.[2]

In this research, the authors offer a method for monitoring tool wear in milling operations using image processing and neural network techniques. They collect photos of the cutting tool with a CCD camera, which are subsequently analysed by MATLAB to extract information relating to tool wear. The retrieved characteristics are sent into the neural network, which is then trained to estimate the level of tool wear. The authors conduct tests to determine the efficacy of the suggested strategy. They gather photos of the cutting tool at various levels of wear using a series of milling experiments. They utilize these photos to train the neural network and assess prediction accuracy. The findings demonstrate that the suggested technique can forecast tool wear correctly with a maximum error of 5%. The authors conclude that the proposed strategy can increase milling operations' efficiency and productivity.[3]

IV. METHODOLOGY

➢ *Collect Images of the Tool:*

Using a camera or other specialised imaging instrument, take images of the tool. To produce a diversified dataset, take multiple photos of the instrument from different angles and in different lighting conditions. By collecting many images of the tool taken from different angles and in different lighting conditions, a more trustworthy dataset for the tool wear prediction system might be created. This is due to the fact that the system will be more adept at generalising to new, untried images of the instrument if it has been trained on a broad range of photos. Additionally, using a specialised imaging equipment to take photos may produce more consistent and high-quality images, which improves the accuracy of the system.

➢ *Pre-Process the Images:*

To improve and clean up the photos, use image processing techniques. It includes:

- Grayscale conversion: To do the grayscale conversion, use the rgb2gray function. As a result, processing the image and extracting pertinent information will be simpler.
- Improve the picture: Use image enhancement techniques, such as contrast stretching or histogram equalisation, to improve the image's contrast and clarity.
- Resize the image: Use the resize function to get the image to the desired size. This may mean that the sizes of the images in the dataset need to be standardised.
- Image cropping: Use the "imcrop" function to crop the image to a specific area of interest (ROI) that encompasses the tool. This could help to isolate the tool from any extraneous or background objects in the picture.
- Save the picture after processing: Use the (imwrite) function to turn the pre-processed image into a new file.

V. RESULTS

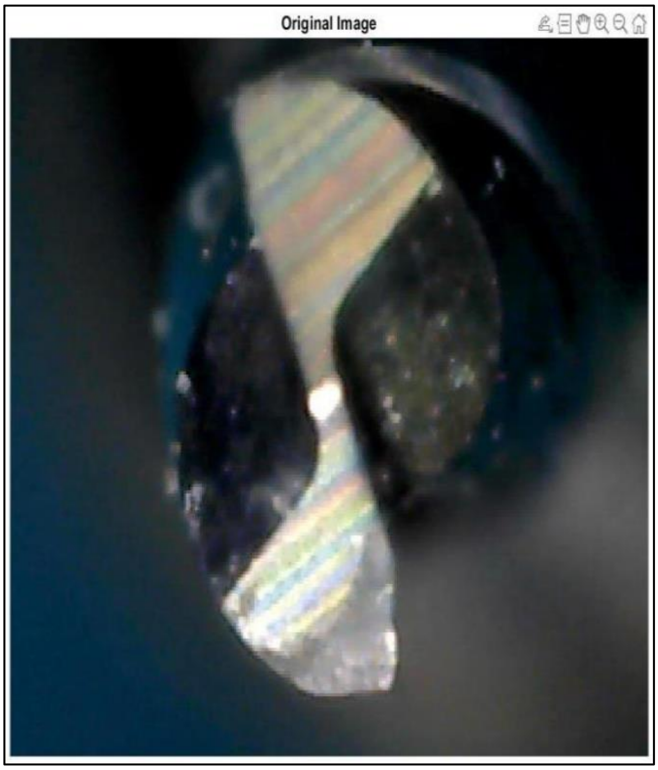

Fig 4 Original Image

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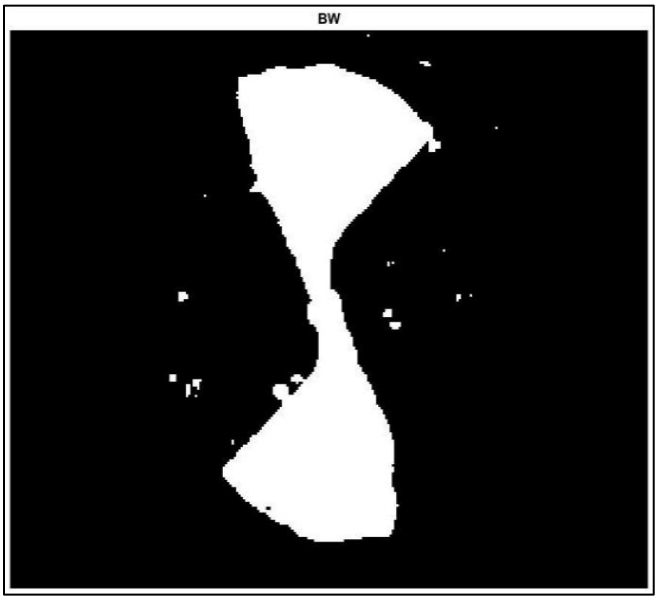

Fig 5 BW Image

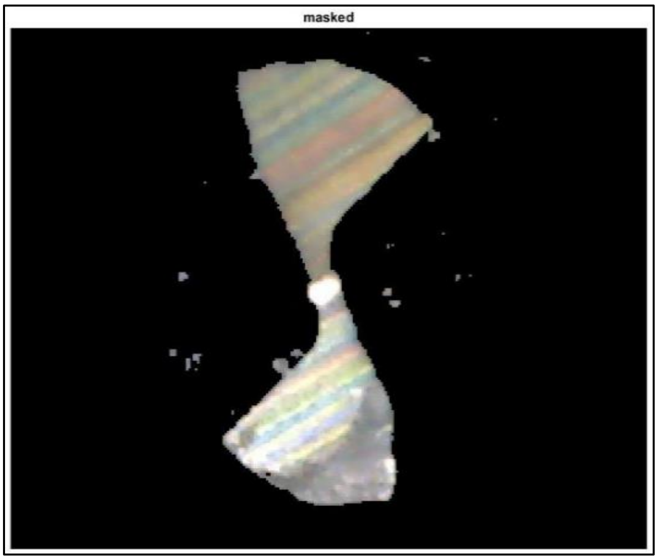

Fig 6 Masked Image

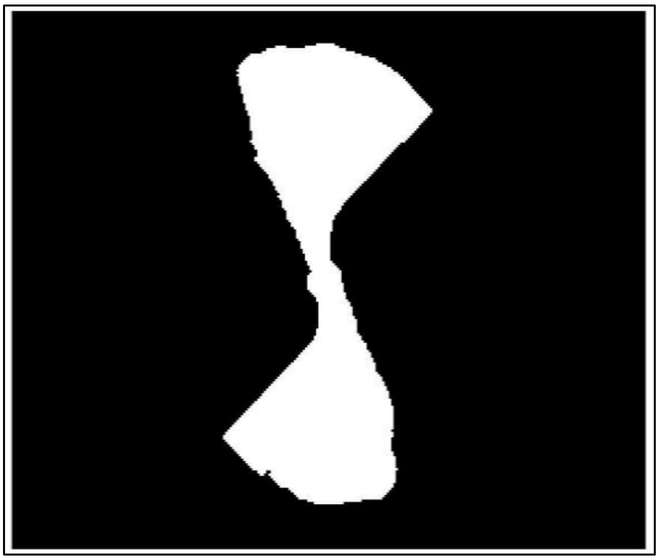
Fig 7 Result


Fig 8 Result Image

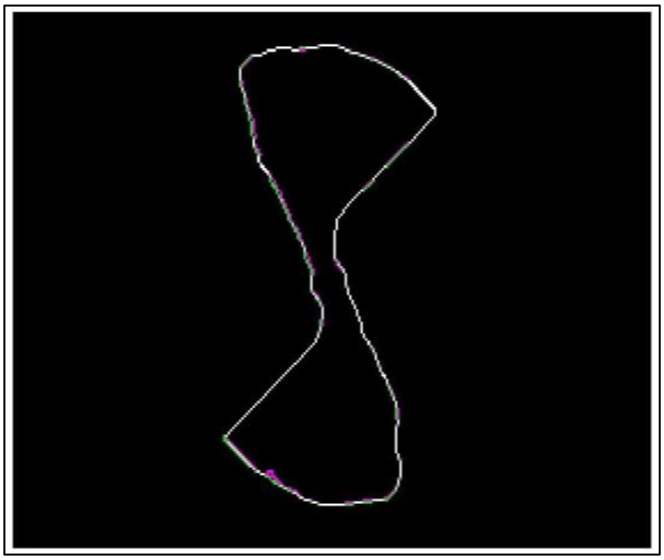
Fig 9 Result Image

VI. CONCLUSION

A strong and adaptable method for keeping an eye on the state of machining tools is to use MATLAB's image processing tools for tool wear analysis. Tool Extensive image preparation, segmentation, feature extraction, and analysis can be accomplished efficiently with the help of MATLAB's extensive collection of image processing algorithms. This method improves sensitivity and accuracy in tool health monitoring by making it easier to obtain useful quantitative information about tool wear directly from visual data.

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