An Approach for Twist Drill Wear Study Using Image Processing

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Abstract- **In this project is made to study the twist drill wear. A twist drill image is take as a reference subsequently the images of the worn out tool are taken and matched to find out the deviations using image processing technique. The images of the twist drill starting from the operation until the tool is blunt or worn out are collected at various intervals of time like after 300holes, 600holes, 900 holes in the work piece and later fed as input data. The algorithm is developed using MAT Lab software, C with graphics. A data base is prepared to compare the results with obtained results. By incorporating this facility the drill diameter wear, lip angle wear, chisel edge angle wear, point angle wear, web thickness wear can be efficiently monitored in drilling machines. The conditions of the tool exerts a strong influence on the surface finish, dimensional integrity of the work piece, and control the geometrical variations of ovality, perpendicularity of the work piece. This image processing technique will analyse the image and groups it into the category of either mew or worn out tools. By incorporating this facility the tools wear can be efficiently monitored in CNC drilling machine by feeding the images art regular intervals of time for many batch size.**

Index Terms- **CNC, Image Processing, MATLAB and Twist Drill.**

1. INTRODUCTION

A computer is a device that can be instructed to carry out sequences of arithmetic or logical operations automatically via computer programming. Modern computers have the ability to follow generalized sets of operations, called programs. These programs enable computers to perform an extremely wide range of tasks.

This project, present a new approach for on-line monitoring the twist drill wear has been described. The twist drill wear measurement is based on image processing techniques. 6mm diameter parallel shank twist drill for the experiment was used.

1.1 Image Processing

Image is first acquired using the vision system. Them the acquired image is improved in pictorial information so that human beings can interpret them. The second step is processing the scene data for autonomous machine perception. One of the first applications in image processing techniques in the first category was in improving the digitized newspaper picture sent by submarine cable between London and New York.

1.1.1 Machine Perception

Machine perception is the capability of a computer system to interpret data in a manner that is similar to the way humans use their senses to relate to the world around them. The basic method that the computers take in and respond to their environment is through the attached hardware. Until recently input was limited to a keyboard, or a mouse, but advances in technology, both in hardware and software, have allowed computers to take in sensory input in a way similar to humans.

Machine perception allows the computer to use this sensory input, as well as conventional computational means of gathering information, to gather information with greater accuracy and to present it in a way that is more comfortable for the user. These include computer vision, machine hearing, and machine touch.

The end goal of machine perception is to give machines the ability to see, feel and perceive the world as humans do and therefore for them to be able to explain in a human way why they are making their decisions, to warn us when it is failing and more importantly, the reason why it is failing.

1.1.2 Machine Vision

Computer vision is a field that includes methods for acquiring, processing, analyzing, and understanding images and, in general, high-dimensional data from the real world in order to produce numerical or symbolic information, e.g., in the forms of decisions. Computer vision has many applications already in use today such as facial recognition, geographical modeling, and even aesthetic judgment.

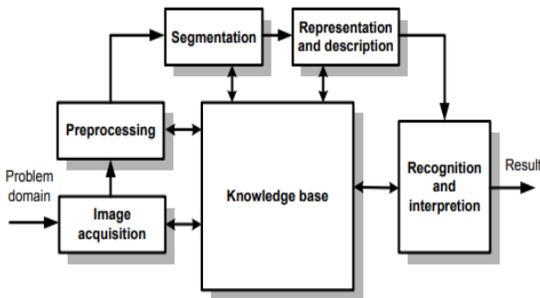## 1.2 System Design Methodology Machine Vision System Control

Figure 1: Fundamental Steps in Digital Image Processing

The model of machine vision can be defined and illustrated in above. This method identifies the seven elements or subsystems, which may be identified with a typical machine vision system.

1.2.1 Scene Constraints

The first, and arguably the most important, element identified is scene constraints. The scene refers to the industrial environment in which the manufacturing task is to take place and into which the machine vision equipment is placed.
The aim of the scene constraints subsystem is to reduce the complexity of all the subsequent to manageable levels.

1.2.2 Control of Object Position

Control is needed to position a piece part in order to provide better camera vision and hence better image acquisition. If the tolerance in the object is known fairly accurately, effective use of resolution can be maximized since the optical magnification can be adjusted so that the field of view just encompasses the necessary area and no more.it will be highly beneficial to introduce orientation and or alignment equipment specifically to ease vision problem.

1.3 Control Lighting Condition

In its simplest form, control of the lighting condition implies the elimination of problems such as random fluctuations, inadequate intensity. There are two types,

- Front Lighting
- Back Lighting

1.4 Industrial Machine Vision Applications

Industrial machine vision applications are classed as automated visual inspection (AVI). In manufacturing system process faults should be well be understood, so that even qualitative inspection offering good coverage of a broad fault spectrum can be developed relatively easily. Once the parameters that must be inspected have been elucidated it is only necessary to devise a way of measuring them by non-contact visual means.
Applications:

- Quality Control
- Assembly Control
- Surface Control
- Measurement of Tool Wear

1.5 MATLAB SOFTWARE

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include:

- Math and computation
- Algorithm development
- Modeling, simulation, and prototyping
- Data analysis, exploration, and visualization
- Scientific and engineering graphics
- Application development, including Graphical User Interface building

MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar no interactive language such as C or FORTRAN.
The name MATLAB stands for matrix laboratory. MATLAB was originally written to provide easy access to matrix software developed by the

LINPACK and EISPACK projects, which together represent the state-of-the-art in software for matrix computation.

MATLAB has evolved over a period of years with input from many users. In university environments, it is the standard instructional tool for introductory and advanced courses in mathematics, engineering, and science. In industry, MATLAB is the tool of choice for high-productivity research, development, and analysis.

MATLAB features a family of application-specific solutions called toolboxes. Very important to most users of MATLAB, toolboxes allow you to learn and apply specialized technology. Toolboxes are comprehensive collections of MATLAB functions (M-files) that extend the MATLAB environment to solve particular classes of problems. Areas in which toolboxes are available include signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation, and many others.

With the help of MATLAB interactive two dimensional and three dimensional visualization tools we can freely analyse transform and visualize data in a signal integrated process. The functions in this package are written in its own high level language. So we can examine any function and ad our own with MATLABs powered GUI tools we can create interactive displays, prototype modules and built in applications. Some of the MATLAB toolboxes are:

- Signal processing tool box
- Image processing tool box
- Control system toolbox
- Fuzzy logic toolbox
- Neural network toolbox

Image Processing Tool Box

The image processing toolbox is a collection of functions that extend the capability of the MATLAB numeric computing environment. The tool box supports a wide range of image processing operations including:

- Spatial image transformations
- Morphological operations
- Neighborhood and block operations
- Linear filtering and filter design
- Transforms
- Image analysis and enhancement
- Image registration

- De-blurring
- Region of interest operation

Many of the tool box functions are MATLAB M-files, a series of MATLAB statements that implement specialized image processing algorithms.

II. TWIST DRILL WEAR STUDIES

Drill can be defined as a rotary end cutting tool having one or more cutting lips, and having one or more helical or straight flutes for the passage of chips and the admission of a cutting fluid.
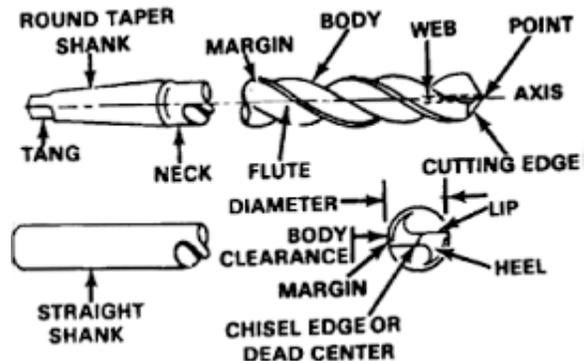
2.1 Twist Drill Nomenclature

Figure 2: Twist Drill Nomenclature

1. Axis: The imaginary straight line which forms the longitudinal center line of the drill
2. Back Taper: A slight decrease in diameter from front to back in the body of the drill
3. Body: The portion of the drill extending from the shank or neck to the outer corners of the cutting lips
4. Body Diameter Clearance: That portion of the land that has been cut away so it will not rub against the walls of the hole
5. Built-Up Edge: An adhering deposit of nascent material on the cutting lip or the point of the drill
6. Cam Relief: The relief from the cutting edge to the back of the land, produced by a cam actuated cutting tool or grinding wheel on a relieving machine
7. Hip Breaker: Nicks or Grooves designed to reduce the size of chips; they may be steps or grooves in the cutting lip or in the leading face of the land at or adjacent to the cutting lips
8. Chip Packing: The failure of chips to pass through the flute during cutting action

9. Chipping: The breakdown of a cutting lip or margin by loss of fragments broken away during the cutting action
10. Chisel Edge: The edge at the end of the web that connects the cutting lips
11. Chisel Edge Angle: The angle included between the chisel edge and the cutting lip, as viewed from the end of the drill
12. Clearance: The space provided to eliminate undesirable contact between the drill and the work piece.
13. Clearance Diameter: The diameter over the cut away portion of the drill lands.
14. Helix Angle: The angle made by the leading edge of the land with a plane containing the axis of the drill
15. Drill Diameter: The diameter over the margins of the drill measured at the point.
16. Lips: The cutting edges of a two flute drill extending from the chisel edge to the periphery.
17. Web: The central portion of the body that joins the lands; the extreme end of the web forms the chisel edge on a two-flute drill
18. Web Thickness: The thickness of the web at the point, unless another specific location is indicated
19. Web Thinning: The operation of reducing the web thickness at the point to reduce drilling thrust

2.2 Quality Parameters
Inspection Check List of Twist Drill

PARAMETERS	MEASURED SIZE
C.E Diameter	6mm
Back Taper	0.040mm
Shank Diameter	5.960mm
Flute length	61mm
Overall Length	94mm
Web Thickness	1.3mm
Web Taber	1.6mm
Land Width	0.75mm
Run out	0.01mm
Helix Angle	27^0
Lip Relief	118^0

Chisel Edge Angle	15^0
Lip Out	130^0
Chisel Edge Angle	0.1mm
Lip Out	0.41mm
Flute Spacing	0.45mm
Hardness- CE DIA	813 HV

2.3 Work Involved in Drill Performance Test
- Laser Marking
- Quality parameter
- Scope
- Work Materials or Test Billet : C 45
- Dimensions of Work Material:
sq.42mm ×300mm steel
- Preparation of Work Piece
  a. Surface should be machine away
  b. Visual inspection and hard ness test should be carried out on each test piece and details recorded before commencing the cutting test.
- Machine tool
  a. FANUC –CNC Machining Centre
  b. M1TR – Vertical Milling Machine
- Cutting Fluid- soluble oil for steel without coolant for cast iron
- Tool size to be tested: 3mm to 16mm
- Mounting of the tool
- Cutting speed : 20m/min
- Cutting conditions for 6 mm diameter drill:
  a. RPM = 1420
  b. No of holes to be drilled = 20
  c. Depth of holes to be drilled= 19mm
  d. Feed = 0.16mm/ revolution
  e. Penetration/min = 227.2 mm/min

III. EXPERIMENTAL SETUP

The objective of experimental setup is mainly to capture radial images of the drill and axial images of the drill face using CNC machine Centre, with proper tool holding, work holding device and controller unit. The matching/ measurement system uses digital camera which is rested on tripod to capture the images. To obtain good quality images we have to ensure proper lighting conditions. Mainly two techniques were employed.
1. Back lighting (to get radial images)
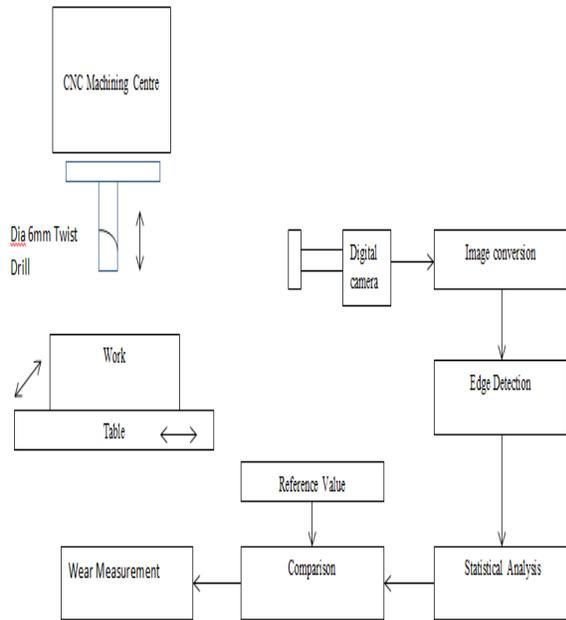2. Front lighting (for grabbing axial images)

Figure 3: Experimental Setup for Monitoring a Drill Wear

Figure 4: Drill Wear Measurement Approach

IV. RESULTS AND DISCUSSIONS

Details of Hardware and Software
Following hardware and software was used for image processing

Type   - CASIO QV5000SX
Recording System   - Digital
Imaging Element   - 1/3 inch CCD
Total Pixels   - 1,310,000
Effective Pixels   - 1,250,000
Computer O/P Image   - 1280 × 960/640 × 480 pixels
Lens   - f= 5.47mm
Focus range   - normal-03 to infinity
Macro   - 10cm
Data transfer Software   - QVLINK
Image Processing Software – MATLAB

Experimental Procedure
• Prepare setup for taking images
• Grab the images in radial directions and in axial direction.
• Eliminate the noise by using filtering techniques
• Fid the edges by applying edge detection technique
• Developing algorithm for finding the parameters
• Matching the results with data

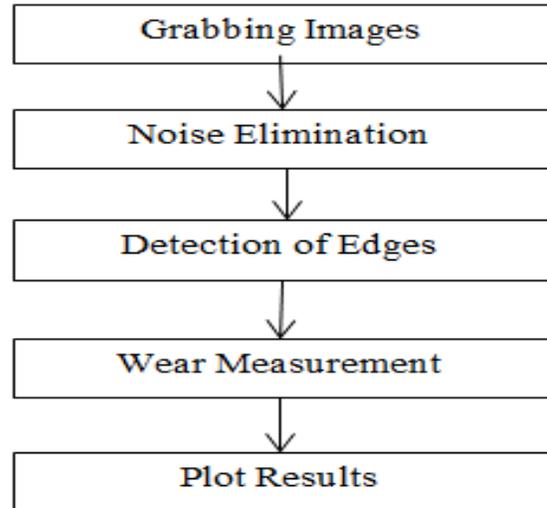Flow Chart – Drill Wear Measurement Approach

The first step of the algorithm is the reading of an image into MATLAB. All images were saved as type joint photographic experts group, a file that is compatible with the MATLAB software. These files are in small size due to a compression technique that eliminates details in the image that are undetectable to the human eye. Using smaller size benefits this procedure by reducing processing time. The algorithm was equipped to process images of grey-scale type.

These images allow for direct comparison between neighboring pixels. The grey scale image is subjected to inversion procedure where light pixels are set to darker shades and dark pixels are set to lighter shades. A threshold technique is implemented in order to eliminate pixels are so lighter shades. A threshold technique is implemented in order to eliminate pixels of lesser importance and focus pixels to be used in measurement process. The technique involves computing the total range of pixel intensities that the image contains, and then setting all pixels with an intensity value below a certain percentage of this range to the shade black (gray value= 0).

Edge Detection
Edge detection is performed to get the contour of the tool. There are basically five edge detectors are there out of which canny is preferred since it covers all the details into consideration.

Measurement algorithm

Actually five parameter of drill bit were taken in consideration because they influence the performance of drill bit. They are drill diameter, chisel edge angle, point angle, Lip, and web thickness. 6mm diameter parallel shank twist drill for experiment was used.

Measuring Radius of Drill

Step 1: Read image; get the image in MATLAB environment.

Step 2: Threshold the image: convert the image to black and white for subsequent extraction of the edge coordinates using the "bwtraceboundary"

Step 3: Extract initial boundary point: the "bwtraceboundary" routine requires that we have to specify a single point on a boundary. This point is used as the starting location for the boundary tracing process. To find the edge of the tool, pick a column in the image and inspect it until a transition from background pixel to the object pixel occurs.

Step 4: Trace the Boundaries: the "bwtraceboundary" routine is used to find (X, Y) locations of the boundary points. In order to maximize the accuracy of the radius calculation, it is important to find as many as points belonging to drill boundary as possible. We should determine number of points experimentally.

Step5: Fit a circle to the boundary: write basic equation of circle, any find the parameters a, b, c, of eq: $X2+Y2+a×X+b×Y+ c = 0$, where $a = -2×Xc$, $b= -2×Yc$, $c= Xc^2 + Yc^2 - radius^2$

Solve for parameters a, b, c and use them to calculate the radius. Finally plot (X_{FIT}, Y_{FIT}) and print the radius of tool.

Measuring Angle of Intersection

Step 1: Load image; Read image into MATLAB environment.

Step 2: Extract the region of interest.

Step 3: Threshold the image; in this step convert the image to black and white for subsequent extraction of the edge coordinated using "bwtraceboundary" routine.

Step 4: Find initial point on each boundary.

Step 5: Trace boundaries.

Step 6: Fit lines to the boundaries.

Step 7: Find the angle of intersection.

Step 8: Find the point of intersection.

Step 9: Plot results.

Table 2: Geometrical Variation in the Work Piece

Drill Size	No.of Holes Drilled in work Piece	Drilled Hole Size(mm)	Ovality (mm)	Perpendicularity (mm)
⌀ 6 mm	100	6.04	-	-
	200	6.06	-	-
	300	6.08	-	0.01
	400	6.08	0.02	0.02
	500	6.1	0.03	0.04
	600	6.12	0.04	0.08
	700	6.14	0.04	0.08
	800	6.16	0.06	0.1
	900	6.18	0.08	0.12

Drilled hole up to 200 absence of ovality and perfect perpendicularity with reference to base.

V. CONCLUSION

This work one can estimate the important geometrical features of twist drill and its related wear in a single setup accurately in less time. This method can be successively applied for the drill bit where frequent failure is occurring in order to find wear and reason for it. Thus one can evaluate the life of tool and by that control the geometrical variations like ovality, perpendicularity of the work piece. Drilling more number of holes, the wear will takes place. If geometrical variations are more in work piece one can replace the twist drill is an added advantage of using machine vision system monitoring. Twist drill required for drilling which are capable of coping with cutting parameters that achieve an economic use of the tool, demonstrate high process reliability and thereby reduce the total amount of scrap or costly work.

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