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Machine Vision for Performance Status Monitoring in Turning Nickel Base Super Alloy Using Image Processing

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Abstract

Performance monitoring is the exploitation of sensor measurements to determine the state of processes. Single or multiple sensors are used to sense signals during machining to collect information about the state of tool and work piece. The turning trails on Nimonic75 have been carried out in a precision lathe using coated carbide inserts in dry machining conditions. Tool and machined surface images were captured using machine vision. Image features of tool and surface were extracted using image processing. Features such as Wear-area and Perimeter can be used to characterize tool wear status; subsequently machined surface status can be characterized using histogram frequency feature. Further, trends have been established using extracted image features. Experimental results specify that performance monitoring of turning can be successfully accomplished by established trends.

Keywords: Machine Vision, Image Processing, Super alloy

1. INTRODUCTION

The constant aim towards higher production in modern industrial sector by manufacturing engineers has drastically changed the manufacturing system, viewing towards an automatic factory concept. Performance status monitoring is essential for improving the productivity of an automated manufacturing system. Hence, monitoring and diagnostic system are becoming necessary to monitor performance status. Tool wear studies have been carried out by many researchers and based on surplus information provided the best method of monitoring tool status is the Machine Vision systems that are being tried mainly due to their high resolution, reliability and ease of automatic processing of data. By focusing on quantifying cutting tool condition, few attempts have been made by previous researchers to incorporate machine vision system for monitoring the status of the process. Tool wear estimation has been done by extracting parameters from machined surface images and different image-processing algorithms, in estimating tool condition such as analysis of intensity histogram; image frequency domain content; and spatial domain surface texture have been presented[1]. Chen Zhang et.al, have presented an algorithm for machine vision system for assessing degree of wear. Ball end cutter images are captured using CCD camera and tool tip points are considered and wear areas are optimized within acquired images. Tool wear area images are captured before and in machining process to compare the subsequent image column. An algorithm for exact detection of wear edge points with sub- pixel accuracy is proposed to increase precision of detected wear edge points. Based on detected wear edge points tool wear can be computed [2].

An investigation was conducted by T.Y. Lim, M.M. Ratnam [3] to determine the feasible lighting condition for scanning of cutting tool images and measurement of nose radius. Open and controlled scanning with black internal opaque condition has been found to be feasible.

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Though, open scanning is not preferred, since the effect of ambient lighting which may cause unpredictable image contrast, the proposed edge detection algorithm works well for all images scanned. Due to particular adjustment and complicated experimental set up using CCD camera, the research shows that an ultimate low-cost image acquisition system for assessment of tool images and nose radius measurement. Machined surface images have been captured by S. Dutta et.al, [4] and then analyzed these images using Grey Level Co-Occurrence Matrix (GLCM) technique with appropriate Pixel Pair Spacing (PPS). Power spectral density has been used for choosing appropriate PPS for intermittent texture images. The texture descriptors deviation i.e., contrast and homogeneity, obtained from GLCM of machined surface images have been studied with respect to machining time along with roughness and tool status. P.Priya and B. Ramamoorthy [5] have made an attempt to capture images of surfaces with varying inclinations covering both sides. They found that ideal orientation of surface (flat and horizontal) by observing variation in optical roughness parameters estimated from grey level co-occurrence matrix as angle of inclination changes. It is observed that variation of roughness parameters with respect to angle of inclination also depends on surface roughness of component. The roughness values obtained by machine vision method are then consequently compared with Ra obtained by stylus method.

Performance monitoring is the exploitation of sensor measurements (e.g., Acoustic Emission, Machine vision, Force and temperature) to determine the state of processes. Use of sensors to collect information about the state of tool and work piece: Either single or multiple sensors are used to sense signals during machining. Machine Vision incorporates computer science, optics, mechanical engineering, and industrial automation and this is favored by manufacturers for visual inspections that conventionally require high-speed, high-magnification, repeatability of measurements. Inspection, traditionally executed by human beings varies in terms of accuracy, courtesy of distraction, illness and other circumstance. But finer discernment over short duration and

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flexibility in classification and adaption to new defects and quality assurance policies are better exhibited in humans. Machine vision is consistent in processing of images but typically designed to perform single, repetitive tasks. In the present study, a new technique to monitor performance in terms of tool and work piece status in turning, through processing and extracting the machine vision based image features

2. EXPERIMENTAL CONDITIONS

Due to the extreme toughness and work hardening characteristic of the nimonic75 alloy, the problem of machining this alloy is one of growing magnitude. The experiments have been conducted for 450rpm speed, 0.2mm depth of cut and Feeds considered are 0.05, 0.06 and 0.07 mm/rev. The chemical compositions of Nimonic75 materials are mentioned in Table1. Nikon D-90 digital camera used to acquire image. Table.2 gives the specification of Nikon D-90 digital camera.

Table 1: Chemical Composition of Nimonic-75

Chemical Composition of Nimonic-75								
Weight%	Ni	Cr	Ti	C	Si	Cu	Fe	Mn
Alloy Nimonic- 75	Bal	18.9 -21.0	0.2 / 0.6	0.08 / 0.15	1.0 max	0.5 max	5.0 max	1.0 max

Table 2: Specification of NIKON D-90 Digital camera

Sensor	• 12.3 million effective pixels
Image sizes	• 4,288 x 2,848 (12 MP) • 3,216 x 2,136 • 2,144 x 1,424
Sensor cleaning	• Image Sensor Cleaning • Image Dust Off
Autofocus	• Nikon Multi-CAM1000
Lens servo	• Single-servo • Continuous-servo • Automatic Manual focus (M)
Continuous	• 4.5 fps
White balance	• Auto

3. DETAILS OF EXPERIMENTATION

Turning experiments were performed on Nickel Base Super Alloys having a 300mm length by SNMG 120408 coated carbide inserts, in dry machining conditions. In this experiment, feed rates were varied since; it has got significant effect on surface finish. From the literature it is found that little significance of speed on surface finish variation for dry turning. Therefore, in the present work, only one speed and three feeds are chosen for turning at constant depth of cut 0.2mm. A new cutting edge has been used for each subsequent experiment with different cutting conditions. Tool status has been monitored (visualized) after each stages of turning and subsequently machined surface images acquired using machine vision system; this procedure is repeated until the tool status reaches a predetermined value or threshold value. The experimental set up for acquisition of tool and machined surface images is as shown in Fig.1.

Fig. 1: The experimental set up

4. CHARACTERIZATION OF MACHINED SURFACE USING IMAGE HISTOGRAM

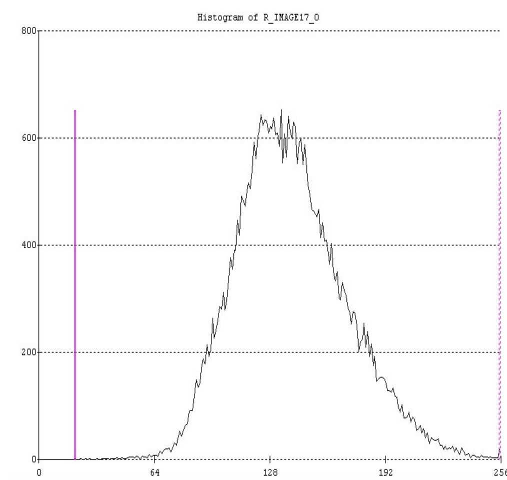


Fig. 2: Histogram of machined surface having Ra = 0.5µm

The histogram of an image tells a lot about the distribution of grey levels within the image. Histogram provides a natural bridge between images and a probabilistic description. Thus, Histogram is more significantly defined as the percentage of pixels within the image at a given gray level. Histogram of an image represents the relative frequency of occurrence of the various gray levels in the image. Histogram is the graphical representation of grey level intensity variations as per the surface roughness of the machined surface. Histogram left side represents smaller intensities and right side represents large value of intensities. Since the metal surface possesses high reflectivity, right side of histogram monitoring is preferable. Hence gray level 125 has been considered as reference point to quantify the histogram frequencies. In Fig.2, smooth machined surface having surface roughness Ra = 0.5 µm, gray level 125 approximately having frequency 600.

5. CHARACTERIZATIONS OF TOOL WEAR STATUS USING IMAGE PROCESSING

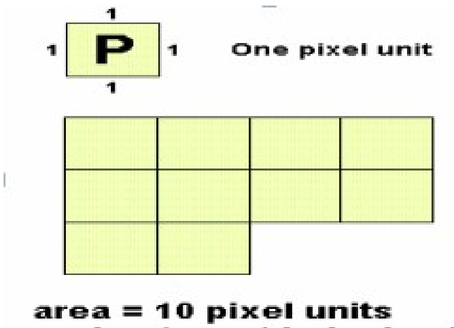


Fig. 3. Wear area image feature

Tool Images are acquired using machine vision, image processing is done using view flux software and feature extraction is done. Wear area is the image feature that characterizes the tool wear state accurately.
Wear Area =Area of the tool wear region, the number of pixels within the tool wear region as shown in Fig. 3.

6. RESULT & DISCUSSION

Progressive wear studies and their effect on surface roughness have been carried to assess their role as a factor of increasing tool wear state. Flow chart of performance monitoring using image processing is as shown in Fig.4The tool wear statuses are characterized in terms of machine vision features such as wear area. The machined surface characterization has been done in terms of image histogram frequency. Performance of machining is monitored in terms of surface finish obtained which varies with respect to the status of the tool. In order to keep track of this machining process the tool's status is as important as that of keeping track of the machined surface. Both the tool and the machined surface of the work piece carry information about the overall performance of the turning process. Hence monitoring both the tool's status and machined surface at the interaction zone; called here as performance monitoring, is a key to obtain the desired state of the machining process.
Performance monitoring could be carried out by capturing the information given by tool and the work piece. Tool images and corresponding machined surface sample, taken during performance monitoring using machine vision system as depicted in Fig.5.As is evident from Fig.5.the progressive wear of the tool leads to deterioration of machined surface.
The wear area followed the trend till the flank wear measured 0.3mm. As the flank wear measurement crossed 0.3mm, due to rapid wear of the tool, the values of the measured features increased drastically. Since the behavior of the measured features followed the established trend, the features themselves are potentially dependable information carriers of performance status during machining nimonic75 work material using coated carbide inserts. (Ref. Fig. 6 and 7). It should be noticed that the last value of Ra and histogram frequency corresponds with the worn status of cutting tool. Wear area and flank wear is higher at feed of 0.07mm/rev than 0.05 and 0.06mm/rev. the wear area of the insert grows faster at 0.07mm/rev and the generated surface if very rough. The same trends have been observed for all considered cutting conditions. Image histogram frequency of the machined surface plays a minor role with respect to tool status measured in terms of wear area as is evident from Fig.8 for different conditions of turning. Similar results in which surface roughness's being constant with increasing flank wear in various conditions have been ascertained by Ghani et al [6] is as shown in Fig.8 and 9. It is observed from the graphs that the image histogram frequency values tend to oscillate in a narrow horizontal band with little deviation. It could be seen from the plots that, the development of wear area explain the change in the machined surface clearly.

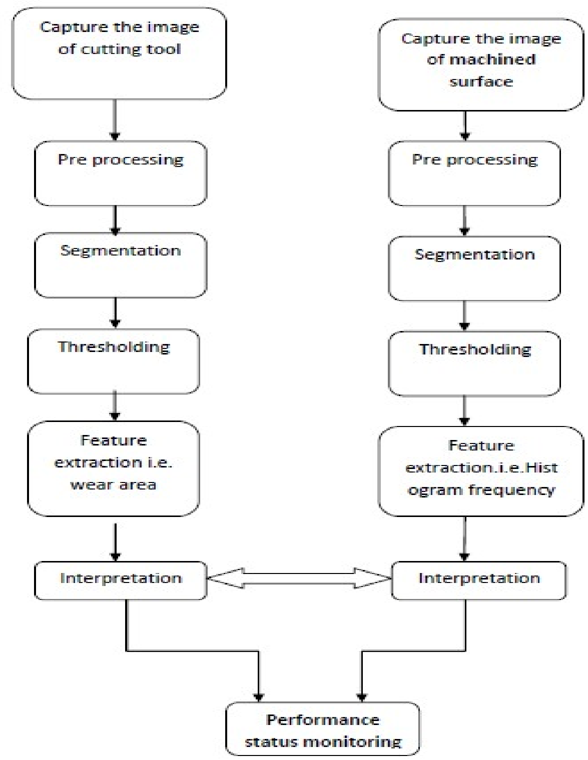
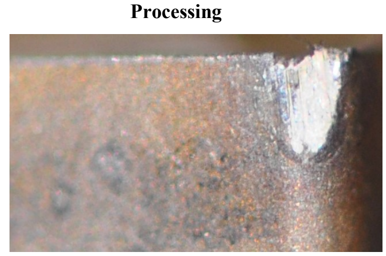
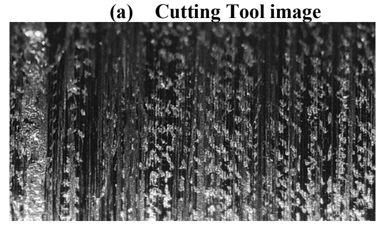


Fig.4 Flow Chart of Performance Monitoring Using Image Processing



(a) Cutting Tool image



(b) Machined surface image

Fig.5: Tool images and corresponding machined surface sample, taken during performance monitoring speed=450rpm,feed=0.07mm/rev and depth of cut 0.2mm

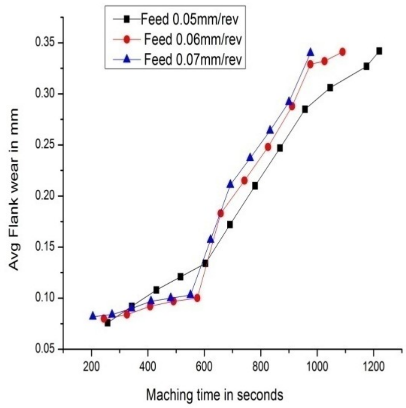


Fig.6.Tools wear v/s machining time

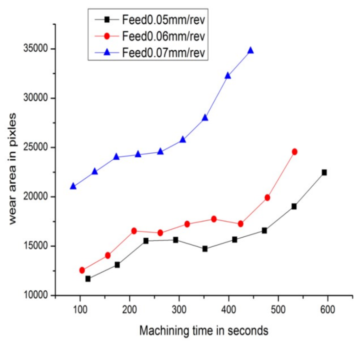


Fig.7: Wear Area v/s Machining Time

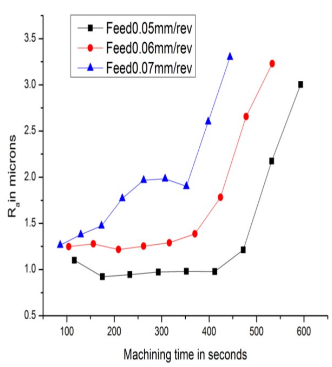


Fig. 8: Ra v/s Machining Time

7. CONCLUSION

The capturing and processing of image features of tool and machined surface during machining of nimonic75 with a titanium coated carbide tool has been carried out in order to monitor performance of the process. The possibility of applying machine vision as performance monitoring system was studied.

- Wear area and machined surface histogram frequencies were extracted by processing the images using machine vision. The variation of surface feature (histogram frequencies) and tool image feature (wear area) parameters with machining time, for which trend has been generated
- Performance assessment of turning process, the image processing method could be applied to automate the machine tool monitoring systems.
- The results show that, the procedure explained in this study, is able to monitor tool and machined surface status simultaneously.

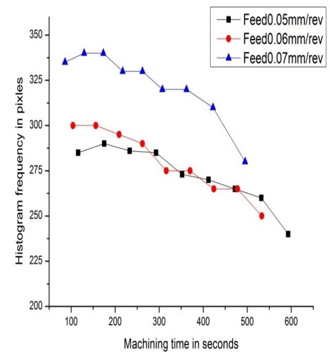


Fig.9: Histogram frequency v/s machining Time

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