Prediction of Tool Wear and Tool Life with Condition Monitoring System on End Milling of EN31

Vijay Arora, Gurpreet Iqbal Singh

Abstract— This paper describes the tool life prediction model with end milling EN31 tool steel using P30 Tungsten uncoated carbide tool. The data set from the Taguchi method design is taken. For discussion the effects of cutting speed, feed rate and depth of cut on tool life of P30 are considered. This paper suggests a novel technique for the tool wear measurement based on machine vision. Tool images are captured with cutting operations using a machine vision system for the analysis. The proposed scheme is shown to be effective for the tool wear prediction.

Keywords- End milling, Machine vision system , Process parameters, Taguchi Method, Tool wear classification and Tool wear measurement

1. Introduction

It is projected that the wear mechanisms of cutting tools made of **EN31** were investigated using the tool life and temperature results available in the literature it can be concluded that till today most of the work has been carried out on tool life by observing the surface roughness of workpiece made of different steel grade with single cutter material. Therefore a lot of scope is there to study to find out tool life with use of tool condition monitoring system which includes force and vibration analysis of cutting operation on CNC milling machine.

2. Material Selection

The effects of cutting speed, feed rate and depth of cut on tool life was studied using tool life prediction model when end milling AISI H13 tool steel using P10 TiN coated carbide tool. The development of the model utilized the data set from the Taguchi method design of experiment with L18 (21x37) orthogonal array[1]. The model we prefer can be used for the analysis and prediction of the complex relationship between cutting conditions and the tool life in flat end milling of hardened materials with coating of TiAlN [2]. Dynamic models were created that can be used as the basis for a tool condition monitoring (TCM) system, which would make corrections to machining parameters based on the real-time measurements of changes in the dynamics response of a given machining system. The work on Al-7075-T6 workpiece with carbide tool was done [3]. It has been investigated that the order to produce any product with desired quality by machining, proper selection of process parameters is essential. Taguchi's parameter design is an important tool for robust design, which offers a simple and systematic approach to optimize a design for performance quality and cost. The Taguchi method of off-line quality control encompasses all stages of product /process development. However, the key element for achieving high quality at low cost is Design of Experiments (DOE). Quality achieved by means of process optimization is found by many manufacturers to be cost effective in gaining and maintaining a competitive position in the world market. This paper describes use and steps of Taguchi design of experiments and orthogonal array to find a specific range and combinations of turning parameters like cutting speed ,feed rate and depth of cut to achieve optimal values of response variables like surface finish, tool wear, material removal rate in turning of Brake drum of FG 260 gray cast iron material[7]

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3. TOOL CONDITION MONITORING

Tool Condition Monitoring system is essentially an information flow and processing system in which the information source selection and acquisition (sensors and data collection), information processing and refinement (signal processing and feature extraction) and decision-making based on the refined information (condition identification) are integrated. It is critical for on-line identification of tool failure or chatter in metal cutting for enhanced productivity, better quality of parts and lower costs for unmanned, automated manufacturing. Condition Monitoring is the process of monitoring a parameter of condition in machinery (vibration, temperature etc.), in order to identify a significant change which is indicative of a developing fault. It is a major component of predictive maintenance. The use of conditional monitoring allows maintenance to be scheduled, or other actions to be taken to prevent failure and avoid its consequences. Condition monitoring has a unique benefit in that conditions that would shorten normal lifespan can be addressed before they develop into a major failure. Condition monitoring techniques are normally used on rotating equipment and other machinery.

4. RESEARCH DESIGN

Determination of optimal end milling operation parameters for tool wear rate under varying conditions will be done through the use of the Taguchi parameter design process. By adopting the methodology it will be tried to determine optimal milling operation parameters for tool wear rate and prediction of tool equation under varying conditions. The use of such optimal milling operation parameters will certainly curtail the unnecessary wastage of time for performing a large number of total experiments to improve surface roughness. By using optimal milling operation parameters the following positive outcomes are found

- Optimized parameter for tool wear tool life.
- Mathematical models for tool wear rate, tool life and forces.
- Comparison

5. DESIGN TECHNIQUES

The design of an experiment involves the following steps

- Selection of independent variables
- Selection of number of level settings for each independent variable
- Selection of orthogonal array
- Assigning the independent variables to each column
- Conducting the experiments
- Analyzing the data

6. PERFORMANCE ANALYSIS WITH PARAMETERS EFFECTS

The performance analysis are based on the basic parameter effects of speed , feed and depth of cut. The responses are check with tool life and surface finish.

S.No.	Parameter	Unit
1	Speed	m/min
2	Feed	Tooth/min
3	Depth of Cut	mm
4	Tool Life	min
5	Surface Finish	micron

7. FORMULAS USED

$$Cutting\ Speed = \frac{\pi DN}{1000}\ m/min$$

$$Cutting\ Speed = \frac{\pi DN}{12}\ ft/min$$

Where, D is taken in inches

$$Feed\ per\ revolution = feed\ per\ tooth \times T$$

$$Feed\ per\ tooth = \frac{\text{Feed per minute}}{N \times T}$$

$$Feed\ per\ Minute = feed\ per\ revolution \times N$$

8. RESULTS

The results of research on tool wear detection based on Machine vision end milling process and depicted figures are shown below

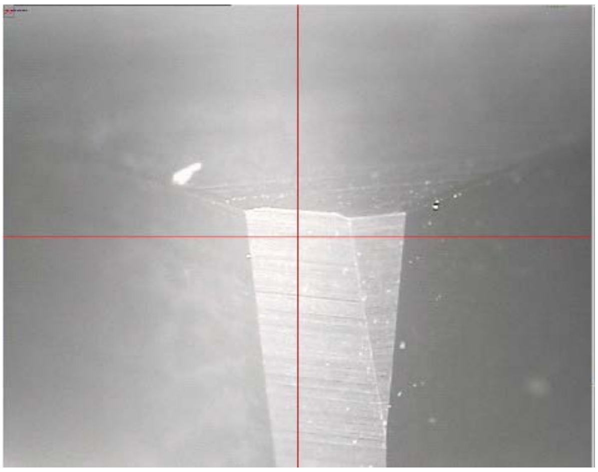

Figure1.Unwear Sample Image

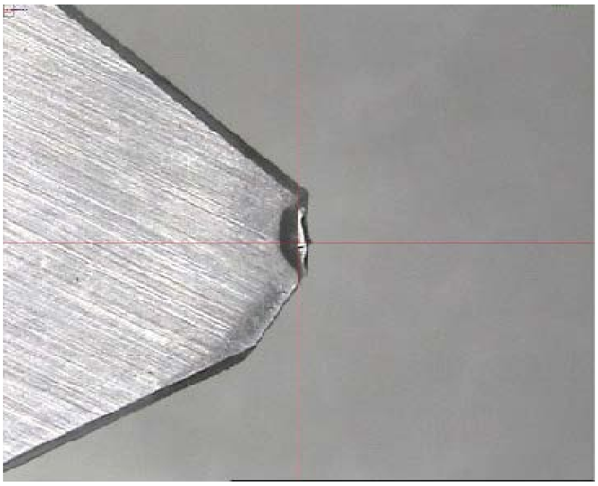

Figure2. Nose wear after 10 pass

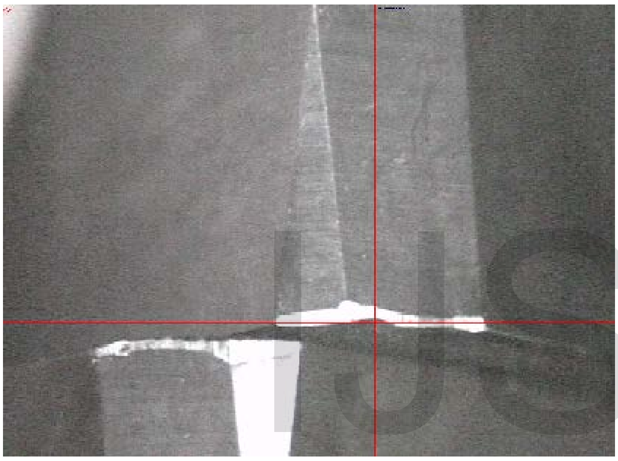

Figure3. Compared Image of Wear and Unwear Sample

The figure1 shows the unused and unwear sample of workpiece. The figure2 shows the wear sample after the 10 pass operations at the workpiece. And the figure3 shows the comparison between the used and the unused sample image.

9. Conclusion

The use of the EN31 give the different and optimum parameters. The wear mechanisms of cutting tools made of **EN31** were investigated. The EN31 is preferred because of its property of hardness . Machine on which the experiments will be carried out is HURCO VM 10. This is a vertical type CNC Milling Machine is used for the analysis process. The work follows the ISO standard for Flank's wear.

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