A REVIEW ON FORCE ANALYSIS ON TURNING BY USING WAVELET PACKET TRANSFORM TECHNIQUE

Swapnil K. Patil[1], Dr. K. H. Inamdar[2]

[1]PG Student, Department of Mechanical Engineering,
Walchand College of Engineering, Sangli, India,
[2]Associate Professor, Department of Mechanical Engineering,
Walchand College of Engineering, Sangli, (India)

ABSTRACT

Effective monitoring and prediction of cutting performance degradation is a critical issue in realizing automatic high-yield manufacturing systems. This topic reported a wavelet-based cutting force analysis approach to monitor and predict cutting performance degradation in high speed machining processes. Experiments on high-speed machining process were conducted and the cutting force signals were analyzed using wavelet transform techniques.

The proposed approach is able to discover the correlations between the cutting force features and cutting performance variations, which will enable the establishment of an intelligent monitoring and prediction system for automatic high-speed machining processes.

Key Words: Cutting Forces, Tool Wear, Wavelet Analysis

I INTRODUCTION

High speed machining is one of the most important means for metal removal machining in modern manufacturing industry. Due to the complexity of the machining process, evaluation of cutting performance in high speed machining operations takes place by examine the characteristics of various signals acquired during the cutting process [1]. The advance multi sensor technologies have encouraged many studies on the correlation between the cutting performance degradation and the corresponding characteristics of various signals such as the cutting force signals [2-5].

Cutting force has been regarded as one of the most useful responses to monitor and predict cutting performance degradations due to its easy to measure and easy-to-manipulate features, as well as its strong correlation with tool wear propagation, which is the most critical factor determining the work piece surface quality [3].

The main objective is to correlate the cutting performance to the easy-to-measure force signals using wavelet transforms techniques. In the proposed approach, cutting forces are decomposed into detailed levels under different scales, taking advantage of wavelet transforms in multi-resolution analysis. Based on the features of decomposed force signals, relationships between the cutting performance and the detailed level cutting force components are discovered, which can be used to detect and predict cutting performance degradation in high-speed processes.

High speed machining is one of the modern technologies, which in comparison with conventional cutting enables to increase efficiency, accuracy, quality of workpiece and at the same time to decrease costs and machining time. The first definition of high speed machining was proposed by Carl Saleman in 1931. He has assumed that at a certain cutting speed which is 5-10 time higher than in conventional machining. Machining of metals at high cutting speeds produces high temperatures in the primary shear zone, which induces plasticity in the workpiece and hence decreases the cutting forces. High speed turning can produce as good or better surface finish at significantly higher material removal rates. Hard turning is a high speed machining phenomenon with surface speeds going normally as high as 250 m/min, some-times even more than this. For Inconel 718 high speed machining range is 60-100 /min. So the machine tool capabilities should include high machine tool rigidity, high surface speed, and constant surface speed for profile to be finished [6].

It is important to consider the cutting speed effect in order to better understand the cutting force measurement and accurately predict machining performances such as tool wear, heat generation, surface integrity, chip formation etc. the methods commonly employed include experimental, analytical and numerical methods. The cutting speed effects on high speed machining performance parameters are mentioned in Figure1.2. It is demonstrated that the cutting speed significantly influences many fundamental aspects such as cutting forces, chip formation, cutting temperature, tool wear, tool life and characteristics like surface roughness [7].

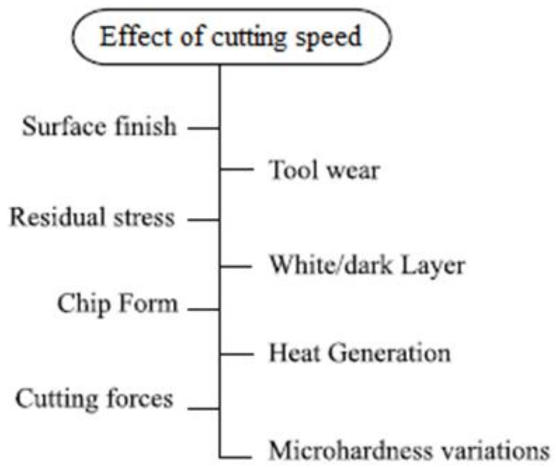

Figure 1.1 Effect of Cutting Speed on Performance Parameter in High Speed Machining.

II LITERATURE REVIEW

Machining parameter such as cutting speed, feed rate and depth of cut do affect the production costs and product quality. Thus it is important to use Optimization technique to determine optimal levels of these parameters so as to reduce the production costs and to achieve the desired product quality simultaneously. One of the main objectives in the optimization of a high speed machining process is minimization of the cost of production and maximization of the production rate while keeping the quality of machined parts as per design specifications. Therefore, if an increase in productivity is desired then an increase in these three cutting parameters is required. But, there are limits to these cutting parameters since they also have an effect on the tool life, tool wear, surface quality, surface integrity, cutting force, tool temperature and heat generation etc. keeping this in view, many researchers have investigated effect of these parameters pertaining to the high speed machining. The following sections present the findings of some of the research studies involving these parameters with reference to high speed machining.

The force acting on the tool is important aspect of machining. Knowledge of the cutting forces is needed for the estimation of power requirements, the adequately rigid design of machine tool elements, tool-holders and fixtures for vibration free operations. Many force measurement devices like dynamometers have been developed are capable of measuring tool forces with increasing accuracy. By measuring the cutting forces, one is able to understand the cutting mechanism such as the effects of cutting force, the machinability of the workpiece, the process of chip formation, chatter, tool wear. The findings of some of the research studies pertaining to the effect of cutting parameters on cutting forces are presented below.

Scientist L. Y. Zhai etal. worked on monitor and prediction of force signal using wavelet technique.in this topic they able to discover the correlations between the cutting force, tool wear, cutting degradation. Model has been discovered for high speed milling on hardened stavex steel with 6mm micro grain tungsten carbide 2 flute ball nose end mill. they took the process parameter such as cutting speed-42000rpm,max power-14 kw, feed rate-50m/min. work piece is a block of solid Ti6Al14V,workpiece dimension is 78 mm in both hight and width. they uses kistler quartz 3 component dynamometer for force measurement, tool wear can be measured by using leisa microscope with resolution of 0.001 mm, mitutoyo portale surface roughness tester is used for surface roughness[8].

In experiment they divide the facing operation in no of part by taking depth of cut same, after each faces they measure tool wear on leisa microscope, using wavelet transform technique they found that with increase in forces the tool wear increases, and they monitor and predict the tool life and also concluded that Fy force component that is cutting force in feed direction was more sensitive to the changes in tool wear and surface roughness compared to the two axes.

Scientist Karam and R. Teti worked in area of Wavelet transform feature extraction for chip form recognition during carbon steel turning, in this area they use Cutting force sensor monitoring and wavelet decomposition signal processing were implemented for feature extraction and pattern recognition of chip form typology during turning of 1045 carbon steel. The wavelet packet transform was applied for the analysis of the detected cutting force signals by representing them in a time-frequency domain and providing for the extraction of wavelet packet statistical features. The latter were used to construct wavelet packet feature vectors, ranked according to the number of overlapping elements related to favourable chip forms that cause noise in the pattern recognition procedure (lower number, lower noise, higher rank). The eight highest ranked wavelet packet feature vectors were selected as inputs to a neural network decision-making system on chip form acceptability. Subsequently, a data refinement procedure was employed to improve the neural network performance in the chip form identification process [9].

In this research paper W. Grzesik and S. Brol worked on Wavelet and fractal approach to surface roughness characterization after finish turning of different work piece materials .In this paper, the surface profiles generated in longitudinal turning operations were characterized using continuous wavelet transform (CWT) and normalized fractal dimension Dn. In the comparative analysis, some characteristic roughness profiles after the turning of different work piece materials, such as C45 medium carbon steel, nodular cast iron and hardened (55 HRC) high-strength alloy steel were selected. For wavelet characterization, both Morlet and 'Mexican hat'analyzing wavelets, which allow the assessment of extreme and frequency distribution, were utilized. The results of the CWT as a function of profile and momentary wavelet length are presented. It is concluded that CWT can be useful for the analysis of the roughness profiles generated by cutting processes. Moreover, the wavelet transform together with fractal dimension can be capable of the detection of local self-similarity in the surface profile [10]

In this paper scientist Ning Fang and P Srinivasa Pai works on Tool-Edge Wear and Wavelet Packet Transform Analysis in High-Speed Machining of Inconel 718,in this case consider the tool edge wear parameter out of different wear such as adhesive wear, abrasive wear, diffusion wear, delamination wear, attrition wear. work material nickel based super alloy Inconel 718 was selected, tool material cemented carbide is choosen,speed-125 to275 m/min, feed rate is 0.01 to .10 mm/rev, tool edge radius .04 to.07mm,depth of cut 0.8mm same as tool nose radius. experiment carried for 1 second repeated nine times with same working condition, tool edge profile measured offline cutting forces and vibrations were measured online, they were observed that Fc (cutting force)> Ff >Fp and in vibration Vz >Vx >Vy and vibration are very sensitive than forces with tool wear [11].

Pawade R. S. and Joshi S. S., [12] analysed multi-objective optimization of cutting force and surface roughness. Workpiece used was Inconel 718. A commercially available low Cubic Boride Nitride (CBN) content inserts were used as tool. Results showed that depth of cut had statistical significance on overall turning performance. It concluded that an increase in the value of predicted weighted GRG from 0.1160 to 0.2071 confirms the improvements in the performance of high speed turning process using optimal values of process parameters.

Fang et al. [13] investigated a comparative experimental study of high speed machining of two materials-titanium alloy Ti-6Al-4V and Inconel 718 have been performed. The results show that for both materials: as the cutting speed increases, the cutting force, the thrust force and the result force all decrease; however, the force ratio increases.

Ekanayake, R. A., et al. [14] carried out experimental investigation on high speed end milling. The experimental results the cutting force increases with increasing feed and depth of cut does not show a specific trend with increasing speed. This could be due to the complex effect of temperature, strain and strain rate on the flow stress of the material. From the observations, the chamfered insert is the best insert to use for lower force generation. These experimental results will be used to develop a theoretical model to understand the process and predict forces in high speed end milling.

III WAVELET TECHNIQUE

The traditional time domain analysis based on the root mean square (RMS) vibration amplitude is not helpful in explaining and showing the dynamic development of tool-edge wear. No distinct features from the time domain vibration signals can be extracted to effectively correlate the cutting vibrations with dynamic tool-edge wear. Wavelet packet transform (WPT), a modern advanced signal-processing technique, was thus employed and is described as follows. Compared to other signal processing techniques (such as fast Fourier transform, FFT) that relate tool wear (primarily crater and flank wear) and the cutting vibrations not only helps in identifying the changes in the vibration signals in different frequency bands that are associated with dynamic tool-edge wear, but also helps in identifying the most important features of vibration signals that are most sensitive to dynamic tool-edge wear. A brief introduction to wavelet packet transform is first provided to better understand the wavelet packet algorithm employed in the present study.

IV WAVELET PACKET TRANSFORM

Wavelet transform (WT) is a mathematical function that multiplies the signal during all its length, with elongated and compressed versions of a wavelet. A signal is decomposed into a low frequency component (called approximation) and a high-frequency component (called detail). The approximation in is then decomposed into a second level of approximation and detail, and this process is repeated. WT can extract signal information in the time domain at different frequency bands and provides flexible time-frequency resolution properties. However, WT has one drawback that the frequency resolution is rather poor in the High frequency region. Thus, it faces difficulties indiscriminating between signals having close high frequency components. To overcome the drawback of Wavelet transform, wavelet packet transform is used as one of the most generalized signal decomposition methods. Wavelet packets are alternative wavelet bases formed by taking linear combination of the usual wavelet functions.

V CONCLUSIONS

Wavelet transforms are a powerful tool to analyze time-varying non-stationary signals. It provides a multi-resolution analysis which can supply localised detail features of the signal in both time and frequency domain. In this study, cutting force signals were analysed using wavelets and the features of force signals are extracted to monitor and predict cutting performance degradations in a high-speed process. The results have shown that the magnitude and STD of the high frequency components of cutting force signals have a strong correlation to the propagation of tool wear. As a result, the relationships between cutting force signals and cutting performance degradation discovered in this study will enable the establishment of a force-based monitoring and prediction system to detect the status of tool wear and surface degradation in high-speed processes.

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