Tool Condition Monitoring in Turning Using Statistical Parameters of Vibration Signal

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In this study, the relationship between vibration and tool wear is investigated during high-speed dry turning by using statistical parameters. It is aimed to show how tool wear and the work piece surface roughness changes with tool vibration signals. For this purpose, a series of experiments were conducted in a CNC lathe. An indexable CBN tool and a 16MnCr5 tool steel that was hardened to 63 HRC were both used as material twins in the experiments. The vibration was measured only in the machining direction using an acceleration sensor assembled on a machinery analyzer since this direction has more dominant signals than the other two directions. In addition, tool wear and work piece surface roughness are measured at different cutting time intervals where the cutting speed, radial depth of cut, and feed rate are kept constant. The vibration signals are evaluated using statistical analysis. The statistical parameters in this study are the Root Mean Square (RMS), Crest Factor, and Kurtosis values. When the flank wear increases, the Kurtosis value and RMS also increase, but the Crest factor exhibited irregular variations. It is concluded that these statistical parameters can be used in order to obtain information about tool wear and work piece surface roughness.

NOMENCLATURE

RMS Root Mean Square

KV Kurtosis Value

CF Crest Factor

FFT Fast Fourier Transform

AE Acoustic Emissions

1. INTRODUCTION

Products can be manufactured by using various methods such as casting, extruding, and pressing. In the past, machining has been the most popular of the various manufacturing processes. The necessity of keeping in low level of product cost is dictated by competition among the manufacturers, so this is required to manufacture products with high quality. One very important factor that affects the product quality is tool wear. Tool wear in any machining process affects surface quality and dimensional accuracy of the product, which is why tool wear monitoring is an important issue to consider. Tool wear monitoring methods are classified as direct and indirect.[1,2] A Direct method is implemented by using optical devices to measure the geometry of the wear land. The indirect method is based on the acquisition of measured values of process variables (such as the change of size of the work piece, cutting force, temperature, vibration, spindle motor current, acoustic emission, and surface roughness) and establishes the relationship between tool wear and the process values of variables.[2] Among the process variables, vibration supplies the best information about tool condition. Some of the advantages of vibration measurement include ease of implementation and the fact that no modifications to the machine tool or the work piece fixture are required.[3] Past studies have been divided into two main groups: Acoustic Emission RMS and Vibration monitoring methods. Many researchers focused on the Acoustic Emission RMS method for machining applications for a long time. However, the studies based on vibration monitoring are relatively less than the others.

Ghani et al.[1] presented a study of tool life, surface finish, and vibration while turning a nodular cast iron using ceramic tool. They concluded that the surface finish was found to be almost constant with the progression of the flank wear under different cutting conditions. They also observed that vibration during cutting decreased as the speed increased and at a low depth of cut, the vibration remained almost constant with the increase of flank wear. Risbood et al.[4] conducted several experiments to predict surface roughness and dimensional