ABSTRACT

Tool life prediction and tool change strategies are now based on most conservative estimates of tool life from past tool wear data. Hence usually tools are under utilized. In an unmanned factory, this has the effect of increased frequency of the tool changes and therefore increased cost. Several monitoring methods for mass production have been developed during the last few decades by many researchers. However few reliable indirect methods have been established for industrial use. This is mainly due to the complexity of machining process and the uncertainty in the correlation between the process parameters and tool wear.

An ultrasound on-line measurement of gradual wear during the turning operation is presented. The method relies on inducing ultrasound waves in the tool, which propagates through the length of the tool and are reflected by nose, rake and flank surfaces. The amount of reflected energy is correlated with wear land height and crater depth. Here the various ultrasonic parameters like time of flight (T.O.F), amplitude, pulse width and root mean square of the signal (R M S) are considered to quantify the wear land height, crater depth and width of wear. The power spectrum analysis of received signals shows the importance of frequency components in the prediction of tool wear.
In the presented work, the normalizing of signals is carried out by an insert hole which is provided for clamping, which is not influenced by the wear but affected by other factors like vibration, improper couplant, temperature etc. The response of the wear signal is normalized to the response of hole signal by mathematical division. It eliminates the modification in tool geometry presented in earlier studies that requires an intrinsic mark cut on each tool by EDM process. A new approach for monitoring of crater in carbide insert is presented. The study of flank wear monitoring in HSS tool shows, the capability of ultrasonic system for complex tool geometry. For HSS tool the end flank surface echo is used to normalize the received ultrasonic signals.

A modelling algorithm, Adaptive Neuro Fuzzy Inference System (ANFIS) is presented for wear (Crater and Flank) monitoring in turning process. This improves the system accuracy and eliminates the limitation in statistical modelling. Finally a decision making algorithm (DMA) is proposed which takes a global decision in tool changing.

Another important parameter in machining is surface roughness of workpiece that also exposes the tool wear indirectly. With increasing demands for higher productivity and quality, there has been increased interest in monitoring all aspects of the machining process. Surface topography is of great importance in specifying the function of a surface. A significant proportion of component failure starts at the surface due to either an isolated manufacturing discontinuity or gradual deterioration of the surface quality.
Typically, these problems of lower surface integrity, lead to corrosion and fatigue failure. The most important parameter describing surface integrity is surface roughness.

The ultrasonic technique was further extended for surface roughness monitoring in grinding and end milling process, as the methodology is almost found to be similar for tool wear and surface roughness monitoring. It shows the adaptability of the same ultrasonic system for various machining process.

In the direct contact method, measurements are obtained using a stylus drawn along the surface to be measured for defined sampling length. This technique may be useful in 100% inspection of parts but not in 100% inspection of entire surface of the workpiece. But ultrasonic technique scans the entire surface of the workpiece. In the proposed system, normal incident probes are used for surface roughness monitoring.

In contact technique, the scattering on workpiece front surface is judged by the back surface echo, which has limitation in the workpiece to have a smooth back wall. The problem is eliminated by non contact technique, which uses coolant circulation as a couplant. In addition to this, the power spectrum analysis provides very strong information about the surface conditions. The ANFIS framework is used to eliminate the error which dominates in previous studies in modelling. Then the model is validated with minimum error, less than 6% which is experimentally reasonable. A decision making algorithm (DMA) is proposed which is used to take a decision on accepting/rejecting the part in mass production.