CHAPTER 2

REVIEW OF LITERATURE

2.1 GENERAL

In today’s world the leading industries are very much concerned about reducing down time and to increase the productivity as well as the quality. To increase the product quality the tool should have good performance. Turning process is widely used in the manufacturing operations in all the manufacturing industries.

Tool wear monitoring in manufacturing operations is the combined effect of crater wear and flank wear. Principally tool wear monitoring systems are classified into two groups, namely direct measurement techniques and indirect measurement techniques. In direct measurement technique, the tool wear is measured directly at the cutting edge of the worn tool using a tool maker’s microscope or tactile sensors. Whereas, in the indirect measurement technique the tool wear parameters are observed in the form of signals during the machining process which helps to determine the degree of tool wear. Contrary to direct measurement techniques, indirect measurement techniques allow to monitor the cutting process on-line, which is one of the biggest advantages in this method (Shiraishi 1998). Kandasami (1988) stated that the safe cutting parameters can be determined using acoustic emission Techniques (AET). Acoustic emission signals can be captured using acoustic emission analyzer or using an oscilloscope.

The method, called sensor fusion, where a number of sensory systems are used simultaneously, seemed to provide the desired information
reliably in some areas. Sensory systems essentially require fast computation of the signals using suitable statistical tools like time series modeling, regression analysis, self organization methods like group methods of data handling etc. Artificial Neural Network (ANN) has recently been found to have remarkable potential in this respect. Neural networks have been used with some success for detection of milling tool breakage, drill wear monitoring, evaluation of turning tool wear and tool wear breakage detection through multisensory systems (Das et al 1996).

Geethanjali and Mary Raja Slochanal (2008) described about optimal design of parameters using the Adaptive Neuro Fuzzy Inference System (ANFIS). The ANFIS simulated results are quite encouraging than the fuzzy models and it will be useful as an effective tool for modeling. Charles Elkan (1993) described the Fuzzy sets began as a generalisation of conventional set theory. They stated a crisp set has a unique membership function, whereas a fuzzy set can have an infinite number of membership functions to represent it. Jang (1993) described the architecture of adaptive network based fuzzy inference systems with reasoning mechanisms. By employing a hybrid learning procedure, the proposed architecture can refine fuzzy if-then rules obtained from human experts to describe the input-output behaviour of a complex system.

2.2 TOOL WEAR

In the machining process, the cutting tools wear out due to the operation of different mechanisms; namely abrasion, adhesion and diffusion. Crater wear occurs on the rack surface of the tool due to diffusion, whereas flank wear occurs on the flank surface which rubs against the machined surface after the initial break-in wear. Due to the increase in the width of the nose wear, the dimensions of the work piece vary. The tool flank wear increases the area of contact with the work piece which results in increase in
cutting forces, cutting temperature and machine tool chatter, ultimately resulting in tool failure. It is necessary, therefore to monitor the tool wear and control the work piece dimensions within the tolerance limit. To control tool wear a feedback contour can be used comprising of 1) Sensing, 2) Decision making and 3) Adjusting the inputs.

Emel Erdal et al (1989) found that the tool wear arises due to adhesive and abrasive wear mechanisms from the intense rubbing action of the two surfaces in contact, i.e. the clearance face of the cutting tool and the newly formed surface of the workpiece. Wear leads to a deterioration of surface quality, increased contact area and consequently to increased heat generation. Its rate of increase at the beginning of the tool life is rapid, settling down to a steady state and then accelerating rapidly again at the end of a tool life.

Choudhury and Ramesh (1995) studied the on-line monitoring and compensation of tool wear using the following steps. 1) The design of a sensing device to sense the tool nose wear during the turning of long workpieces, 2) The design of a tool actuator for constantly positioning the tool, 3) The design of a feed back system to control the variations in the tool wear and workpiece dimensions, and 4) Experimental investigation of the proposed control system on a centre lathe under different cutting conditions. They found that while a tool wears out, a tapering effect is caused on the work piece, thus the measurement of a continuous increase in the work piece diameter along its length (in case of turning) would essentially be proportional to the amount of nose wear occurring on the tool; the signal can be obtained using a sensor mounted rigidly on the cutting tool. They used a control system to compare the monitored signal with the reference signal to produce an error signal and sent it to the actuator to move the tool forward and, hence, compensate for the tool wear.
To achieve this, a microprocessor was used since its CPU reads the data, does the arithmetic calculations and makes the decision almost instantaneously. The role of the actuator in providing an exciting force to move the tool forward was performed by mechanical, electro dynamic, electro hydraulic or electro magnetic exciters. The movement of the tool post of the centre lathe was performed by coupling the cross feed shaft with a stepper motor, the whole assembly serving as a tool actuator. Therefore, an on-line control system to sense and compensate for tool wear was designed and tested experimentally. Their main aim is to reduce the effect of tool wear on the work piece dimension by repositioning of the tool. Their designed feed back control system was sufficiently accurate to monitor the tool wear during machining and compensate automatically for it.

The tool wear monitoring using time series modeling and pattern recognition based on stress analysis of three-dimensional loading was studied by Kumar et al (1997). They combined finite element analysis (FEA) and detailed stress analysis of the cutting edges and tips of sharp and worn tools from which they found that it was possible to predict the mode and location of tool failure.

A method for tool wear monitoring based on the measurement of workpiece deviation was studied by Gomayel et al (1986). Two electromagnetic probes on opposite sides of the workpiece were employed so that the electromagnetic waves could flow from the probe to the metal allowing accurate measurements of the workpiece diameter. Increasing in the workpiece diameter was used as a tool wear criterion to elaborate the calibration procedure. An experimental verification of the method suggested a relationship between the accumulated flank wear length (manually measured) and accumulative voltage differences from the two differential probes. They found that though their model could measure minute tool wear, it could not
distinguish nose wear from flank wear. The results however were affected by several factors such as vibrations, deflections and misalignment.

Palanikuamr and Paulo Davim (2009) used the design of experiments technique to find the parameters, which are having significant influence on tool flank wear on the machining of Glass Fiber Reinforced Plastics (GFRP) composite. They found that 1) The experimental technique is more easy and convenient to study the main and interaction effects of different influential combinations of machining parameters affecting tool wear, 2) Cutting speed is the factor, which has greater influence on tool flank wear, followed by feed rate, 3) The interactions also play some role in deciding the tool wear on the machining of GFRP composites. The interaction between cutting speed and depth of cut has more influence comparing with other interactions on tool flank wear on the machining of GFRP composites, 4) The parameters considered in the experiments are optimized to attain minimum tool flank wear using response Table, effect graph, normal probability plot, interaction graphs and ANOVA technique, and 5) The optimization procedure can be used to predict the tool flank wear for turning of GFRP composites within the ranges of variable studied. However, the validity of the procedure is limited to the range of factors considered for the experimentation. In this procedure does not give exact optimal solutions, which was the limitation of their study.

The shaft power, cutting forces, torque and motor current are all related to each other, originating from, and depending entirely on one another. This study was carried out by Rangawala et al (1991). They suggested that it is sufficient to measure just one of these parameters using the electric current taken by the motor during the cutting process.

Dimla (2002) has developed an experimental set-up for on-line tool condition monitoring system. The properties of the work and tool materials,
tool geometry and the cutting regime determine the contact phenomena of the tool and work piece interface. They found that the cutting speed has the strongest influence. Regardless of the differences in the values and trends of the normal and shear stresses at the contact interfaces, minimum tool wear occurs and apparent friction coefficient reaches its lowest value at the optimum cutting speed.

Luo et al (2005) investigated the intrinsic relationship between tool flank wear and operational conditions in metal cutting process using carbide cutting inserts. A new flank wear rate model, which combines cutting mechanics simulation and an empirical model, is developed to predict tool flank wear land width. The set of tool wear cutting test using hard metal coated carbide cutting inserts are performed under different operational conditions. The wear of the cutting insert was evaluated and recorded using a microscope. Their results of the tool wear cutting test indicate that cutting speed has more dramatic effect on tool life than feed rate. They mentioned that further work is required to investigate if an optimal cutting speed exists. The comparison of predicted and measured flank wear land width showed that the developed flank wear rate model can accurately predict tool flank wear land width to some extent.

2.3 WORK MATERIAL

Tool wear is one of the most important aspects in metal cutting, especially when machining hardened steel. Wear minimization has been pursued by different means, beginning with tools steel and heat treatments, going later to new work and tool materials. Gerard Poulachon (2003) studied the influence of the micro structure of hard end tool steel work piece on the wear of polycrystalline cubic boron nitride (PCBN) cutting tools. He suggested that the micro structure of hardened steel has an influence on tool wear in PCBN tools. The major influencing factor on the tool wear is the
presence of various carbides in the steel microstructure. The hardness of these carbides varies significantly, causing different wear rates while turning these various steels. The flank wear on the tool has resulted in grooves caused by the abrasive action of these carbides. The microstructure study of chips reveals the presence of different amounts of white layers in machining these steels.

Brinksmeier and Glabe (2001) found that the tool wear in diamond turning of Ck45N (AISI1045) steel was excessive flank wear as well as crater wear rounding of the cutting edge do occur even after a very short cutting distance of 12 m. The acoustic emission (AE) signal generation in the machining of hardened steels was studied by Barry and Byrne (2001). They found that, in ‘hard machining’, the energy of the acoustic emission (AE) signal may be up to two orders of magnitude greater than the machining of softer pearlitic steels, depending on work material hardness and cutting parameters.

Sreerama Reddy et al (2009) found that the flank wear of deep cryogenic treated carbide tool is lower than that of untreated carbide tool on machining of C45 steel. The surface finish produced on machining the C45 steel work piece is better with the deep cryogenic treated carbide tool when compared with the untreated carbide tool. The cutting force during machining of C45 steel is lower with the deep cryogenic treated carbide tool when compared with the untreated carbide tool.

Ezugwu (2007) found major improvements in the rate at which workpieces are machined usually result from the development and application of new tool materials. There have been great advancements in the development of cutting tools, including coated carbides, ceramics, and cubic boron nitride and polycrystalline diamond. These tool materials have found useful applications in the machining of cast irons, steels and high temperature
alloys such as nickel based alloys. However, none of these newer developments in cutting tool materials have been successful in improving the machinability of C45 steel.

The C45 work piece using untreated and cryogenic treated tungsten carbide cutting tool inserts in a high precision CNC lathe was investigated by Reddy et al (2008). The machining performance was evaluated in terms of flank wear of the cutting tool inserts, main cutting force and surface finish of the machined work pieces. The cutting force during machining of C45 steel was lower with the cryogenic treated carbide tool when compared with the untreated carbide tool. The flank wear of cryogenic treated carbide tool was lower than that of untreated carbide tool on machining of C45 steel. The surface finish produced on machining the C45 steel workpiece was better with the cryogenic treated carbide tool when compared with the untreated carbide tool.

2.4 CUTTING TOOL MATERIAL

Tool wear has been one of the most studied subjects in metal cutting. Wear minimization has been pursued by different means, beginning with tool steels and heat treatments, going later to new tool materials and, more recently, to coatings. Reginaldo et al (2007) studied the tool wear when turning hardened AISI 4340 with carbide polycrystalline cubic boron nitride (PCBN) tools using finishing cutting conditions. From their experimental results, combined with Finite Element Method (FEM) simulations, they found that cutting force was the highest when using the uncoated edge, due to accelerated flank wear, immediately after the beginning of the test. Amongst the coated edges, a clear distinction was only possible after about 14 km of the cutting, when the pattern followed flank wear.
Koning et al (1992) found that steel cutting grades of cemented carbides are not suitable for machining steel alloys because of their crater wear rate of the mixed carbide grains than that of the WC grains due to its thermal properties. All coated carbide tools tested show crater wear rates than those of straight grade cemented carbides. They suggested that to carry out the machining of carbon steel alloys with uncoated tools.

### 2.5 ACOUSTIC EMISSION TECHNIQUES

Acoustic Emission (AE) is the class of phenomena where by transient elastic waves are generated by the release of energy from a localized source or source within a material or the transient elastic wave so generated. Acoustic emission is one of the methods that can be used to monitor machining operations in order to provide process information to the operator. An advantage of using AE as a process monitor is that the frequency range of acoustic emission is much higher than that of machine vibrations and ambient acoustic noise.

Ravindra et al (1998) and Byrne et al (1995) studied the acoustic emission for tool condition monitoring in metal cutting. The detection and analysis of acoustic emission (AE) signals generated during machining of C60 steel with a multilayer coated carbide tool was carried out in order to monitor tool wear. The possibility of applying AE methods as an on-line tool wear monitoring technique was studied. Many quantifiable characteristics of the AE signal, viz. rise time, energy, ring down counts, events, peak amplitude, RMS voltage etc., were studied and an attempt was made to correlate the above parameters with tool wear and cutting conditions. The parameters rise time, energy, RMS voltage and to an extent ring down count seem to respond to the wear rate and cutting conditions. Chipping of the cutting tool causes a substantial change in the RMS value, but a steep decrease in the rise time. The digitized signals of the acoustic emission collected were pre-processed. Power
of the AE signal and power of the residual signal were also considered as features. Tool failure detection using a pattern recognition technique was investigated. The results of their study suggests that AE signals are sensitive tool for tool failure prediction and can be used for on-line monitoring of the failure of a cutting tool.

Xiaoli Li (2002) studied on acoustic emission (AE) sensing on tool wear in turning. Their study includes, 1. AE generation in metal cutting process, AE signal classification, and AE signal correction. 2. AE signal processing with various methodologies, including time series analysis, wavelet transform, etc., 3. The estimation of tool wear condition includes FUZZY classifier, neural network, sensor and data fusion. They noted that, AE based sensing technology is the area of most intense research activity for developing intelligent tool condition systems. The reason is that the sensitivity of AE to tool wear and fracture is coupled with a high response rate of the signal. However, AE signals are heavily dependent on process parameters. Thus, a key issue is how to reduce these effects in intelligent tool wear and fracture monitoring using AE signals. They reviewed that the careful signal processing or feature extraction and integration with other sensors will be an effective approach for AE based tool condition monitoring.

Bernhard Sick (2002) stated that the tool wear is the most difficult task in the context of tool condition monitoring for metal-cutting processes. Based on a continuous acquisition of signals with multi-sensor systems it is possible to estimate or to classify certain wear parameters. Hotton and Qinghuan (1990) studied the effects of built up edge on acoustic emission (AE) in metal cutting. Li Dan and Mathew (1990) have explained the tool wear and failure monitoring techniques in the turning operation. The tool flank wear was caused by the friction between the flank face of the tool and the machined surfaces. Its wear mechanism was very complex. At the tool
flank-work piece surface contact area, tool particles adhered to the work piece surface and were periodically sheared off. Adhesion of the tool and work piece increases at higher temperatures. Adhesive wear occurs when hard inclusions of work material or escaped tool particles scratch the flank and work piece as they move across the contact area as well.

Choi et al (1999) studied the acoustic emission (AE) and cutting force parameters for tool condition monitoring (TCM) in turning operation. Two sets of experiments were conducted using tungsten carbide insert tips with one set slotted by wire EDM to accelerate fracture while the second was brazed to the workpiece to induce tool breakage. The recorded data was analyzed using a fast block-averaging algorithm for features and patterns indicative of tool fracture, and it showed the occurrence of a large burst of AE during tool breakage.

A statistical signal-processing algorithm to identify the root mean square (RMS), skew and kurtosis of the acoustic emission (AE) signal in the detection of catastrophic tool failure was developed by Jemielniak et al (1998). Cutting force measurements recorded simultaneously were used as reference signals to indicate when the failure actually occurred. Their results indicated that the skew and kurtosis to be better indicators of catastrophic tool failure than the RMS values.

Xiaoli Li (2002) has explained the tool wear monitoring process by acoustic emission technique (AET) which refers to stress waves generated by the sudden release of energy in deforming materials, and it has been successfully used in laboratory tests to detect tool wear and fracture in single-point cutting tool operations.

Arul et al (2006) have found that the trend of acoustic emission is the class of phenomenon where transient elastic waves are generated by the rapid
release of stored energy from localized sources within a material. This rapid release of energy is generally induced by applied stress. As the thickness resisting stiffness reduces the ply layers flex elastically under the influence of applied thrust force. If the thrust force is larger than the inter laminar bond strength, then the crack is initiated which propagates to result in a finite damage around the hole. This leads to small spikes in the acoustic emission (AE) signal. This is associated with plastic deformation and sliding at high stress and strain rates and provides many sources for acoustic emission.

Ichiro Inasaki et al (1998) studied the need for monitoring the metal cutting process encompasses monitoring the machine and the cutting process dynamics, cutting tools and workpiece to ensure optimum performance of the systems. A tool condition monitoring system can therefore be viewed to serve the following purposes; 1. Advanced fault detection system for cutting and machine tool, 2. Check and safeguard machining process stability, 3. Means by which machining tolerance is maintained on the workpiece to acceptable limits by providing a compensatory mechanism for tool wear offsets, and 4. Machine tool damage avoidance system.

Sampath et al (1986) studied the power spectra of the acoustic emission (AE) signal for coated carbide tools. They found some distinctive peaks at the resonant frequency of the sensor. However when a worn tool is used, the energy is more distributed into higher frequencies. After establishing they found that it is not a mistake in the measurement procedures, but it is due to the changeable content of the signal to the characteristics of the cermet tool material. With a different structure and compact composition, the cermet has higher damping characteristics than carbides. The increase in the wear of the cermet tool is reflected only in higher energy at the frequency range of 2.5 kHz to 6.0 kHz. Therefore, the higher ability of cermet material to absorb high frequency vibrations causes different frequency responses from the sensor, which are reflected in the shape of the power spectra.
Liang and Dornfeld (1989) studied the tool wear using acoustic emission technique. A new concept of resource of the cutting tool based upon the physical theory of reliability was studied. As such, this resource was defined as the limiting amount of energy that can be transmitted through the cutting edge until it fails. It was shown that the resource of the cutting edge does not depend on a particular manner of exhaustion.

Jiang et al (1996) found that when the flank wear is increased, the frequency spectrum also increased as a whole, but begins to saturate with further increase of tool wear. The rate of increase was relatively large in a frequency range from 120 to 270 kHz. Teti et al (1989) found that the magnitude of the AE signals increased in amplitudes at frequencies of about 120 kHz, 170 kHz and 220 kHz with an increase in the flank wear.

Moriwaki et al (1990) worked in the frequency range of 100 kHz and 1 MHz. Hence the suitable AE signal frequency range to monitor tool wear was experimentally studied. Blum and Inasaki (1990) studied the relationship between the acoustic emission (AE) waves and the cutting process in the frequency range of 100 kHz to 300 kHz.

Narayanan et al (1994) developed a method based on acoustic emission measurement and analysis for coated tool life estimation. The underlying principle behind their devised method for coated tool life estimation was that, during progressive tool wear, the tool material changes from one substrate layer to another and emits AE signals that could be monitored to determine tool life. An experimental test rig was set-up and tests were conducted on it. The AE and tool wear (crater) were measured together with the surface roughness. Typically, Acoustic Emission RMS values for the recorded AE signal and the wear values (initial, middle and tertiary stages of tool wear) were graphed on the same scale for comparison.
A Hall Effect sensor to measure the current supplied to the spindle motor drive of a vertical NC miller together with the cutting forces was proposed by Zhang et al (1994). The relationship between the measured motor current and the milling torque was developed by modeling the acquired motor current and torque. They found that cutter breakages were reliably diagnosed with motor current measurements than force/torque measurements. Computer algorithms were developed to track the waveforms, rate of peak change and the relative eccentricities of the modelled relation.

A study by Dalpiaz et al (1998) showed that the AE parameters did not exhibit a definite trend with tool wear but rather a general random behaviour with sudden variations related in the process of deterioration phenomena. Emel et al (1998) had shown through their pattern analysis that the reliable frequency range lies between 100 kHz and 1 MHz.

Hoessein Cheraghi and Curt Everson (1999) stated that the sensor mounting is also another item that needs to be addressed. It would be best to mount the sensor in the tool bit or tool holder. Everson et al (1999) found that the amplitude and duration of the signal sometimes provide a correlation and sometimes do not provide the correlation. This is not a problem with energy, since it is calculated from both the duration and the amplitude. Energy is, therefore, a better measure for this application.

Hundit et al (2003) captured AE signal in an oscilloscope and studied the grinding process using acoustic emission technique (AET). In this work a digital storage oscilloscope was used to capture AE signal and the ‘AUTO DASP’ software was used to analyze the signal.

Arul et al (2006) developed an acoustic emission (AE) sensing technique for on-line detection of work piece status and to improve the process stability and work piece quality by minimizing associated defects.
The acoustic emission can be a good way to monitor on-line growth of surface roughness in turning and therefore it can be useful for establishing the end of tool life in these operations.

Kandasami (1988) found that the acoustic emission technique (AET) is relatively a recent entry in the field of Non–Destructive Evaluation (NDE) which has particularly exhibited very high potential for material characterisation and damage assessment in conventional as well as non–conventional materials. Due to its complementary non–destructive evaluation methods, it is utilized in a wide range of applications.

Kamarthi et al (1995) found that the energy thus released travels as a spherical wave front and can be picked from the surface of a material using highly sensitive transducers. The picked energy is converted into electrical signal which on suitable processing and analysis can reveal valuable information about the source causing the energy release.

Li et al (1998) studied the behaviour of generation and propagation of the acoustic emission waves. They stated that the acoustic emission (AE), a stress wave emission, is emitted as a spherical wave from the source. Due to the applied load on the work piece by the tool, a micro crack is formed. This emits stress waves spherical in nature. This spherical wave propagates through the material and become surface wave on reaching the surface. This surface wave is picked up on the surface by the acoustic emission (AE) sensor. Thus, by keeping the sensor on the immediate surface where AE becomes surface wave, we can capture the AE signal without much distortion and attenuation. The crater wear occurred on the rake face of the tool and the flank wear occurs on the side surface of the tool. Hence, the suitable position of the sensor to capture AE due to crater wear is the top surface of the tool holder and the flank wear is the side surface of the tool holder.
2.6 ARTIFICIAL NEURAL NETWORK

Modern producers for part manufacturing impose cost reductions that can be realized in the following ways; increasing turning regime, reducing manufacturing time and number of rejects. In order to accomplish that in various processing procedures, extreme efforts of tools and machines are required. Processing tool condition is very influential on reducing rejects and standstills in manufacturing, which can directly be seen through geometry, surface and structural properties and characteristics of a processed part. The increase of cutting forces is directly linked to the wear condition of a processing tool which leads to heat increase and hence to structure change of the processed surface of the work piece and its dimensions. Timely and adequate tool replacements present a very important component in processing, and therefore in turning, to which a significant studies are going on across the world.

Antic et al (2006) developed a neural network based intelligent system for tool wear monitoring. They found that the neural network can be used for efficient wear monitoring during hard turning. After considering many possible setups for wear monitoring model using different configuration types of neural networks, and based on input and output parameters, the one selected performed with optimal results for the selected number of network layers and neurons.

Sivanandam et al (2002) described about the stability of back propagation neural network (BPN) system using various activation functions. Also improvements in BPN network using slope parameter has been analyzed which gives the basic idea to introduce the PID function with the BPN network.
Das et al (1996) developed a simple on-line tool wear monitoring process for turning carbide inserts using a three layer back propagation type ANN system taking the three component cutting force signals. The principle, process and the results of the monitoring system in C25 steel turning were investigated. Their results show that the neural network has close matching between the model output and the directly measured average flank wear. Deviation of the model output from the target flank wear value at the high speed-feed condition may be due to unstable built-up edge formation, chipping, mild vibration and random chip breaking in certain cases absorbed during machining.

Tanaka (1996) discussed stability of Artificial Neural Networks (ANN) based control systems using Lyapunov approach. The dynamics of ANN systems can be represented by a class of nonlinear systems treated as Linear Differential Inclusions (LDI). Stability conditions for the class of nonlinear systems are derived and applied to the stability analysis of single ANN systems and feedback ANN control systems.

Sood et al (1994) described the operational behaviour of the individual Neural Network controllers and by comparing the behaviours of the traditional Proportional-Integral controller and Neural Network controller. Silva et al (1998) studied the tool wear in turning operation by neural network. They developed a neural network to study the tool wear in terms of 15 features calculated from the outputs of five sensors. They used two types of neural networks, the self organizing map and adaptive resonance theory, in order to classify the statistical and frequency domain features of the sensor signals. They applied the Taylor model to identify and eliminate outlier data improved the network predictions in all cases and it appeared that repeated application of this approach might lead to a closer prediction of tool wear than would be available from the Taylor model or Neural networks alone.
2.7 ADAPTIVE NEURO-FUZZY INFERENCE SYSTEM

In machining process, a tool has a fixed life time in accordance with tool manufacturer recommendations or past experiences. This tool change policy has two drawbacks, at one end; a worn tool without being exchanged in time will produce out of specification parts or even cause tool breakage, and at the other tools being thrown away permanently over time will incur a huge waste of manufacturing resource. Zurada (1995) reviewed many fuzzy logic and neural networks. Several monitoring methods have been developed during last few decades by many researchers. These methods may be classified into two groups, direct and indirect methods. Direct methods are based upon direct measurements of the worn area of the tool using optical sensors, vision systems etc. These methods have the advantage of high measurement accuracy, but cannot be easily adopted for on-line applications. Various indirect methods have also been developed in which the state of the wear is estimated from measurable parameters such as cutting forces, vibration, acoustic emission, cutting temperature and surface roughness. However few reliable indirect methods are established for industrial use. This is mainly due to complexity of machining process and the uncertainty in the correlation between the process parameters and the tool wear. Adaptive neuro-fuzzy inference system (ANFIS) is a modeling algorithm which relates the signal parameters with the on-line tool wear prediction.

Kuo et al (1999) have analyzed on – line tool wear estimation through radial basis function networks and fuzzy neural network. The supervision of tool wear was found to be the most difficult task in the context of tool condition monitoring for metal-cutting processes. Based on a continuous acquisition of signals with multi-sensor systems they found it possible to estimate or to classify certain wear parameters by means of neural networks.
Geethanjali and Mary Raja Slochanal (2008) described about optimal design of the over current relay using the ANFIS. The ANFIS simulated results are quite encouraging than the fuzzy models and will be useful as an effective tool for modeling. Jang (1993) described the architecture of adaptive network based fuzzy inference systems with type-3 reasoning mechanisms. By employing a hybrid learning procedure, the proposed architecture can refine fuzzy if-then rules obtained from human experts to describe the input-output behaviour of a complex system.


Dinakaran et al (2010) introduced a new approach for tool wear monitoring using ANFIS. The basic inferences shows that the amplitude level of the ultrasonic signal, RMS of the received ultrasonic signal pulse width duration during cutting process is affected by the tool wear. The frequency domain of signal shows the distribution of frequency components and frequency shift in the received signal which can be related to flank wear. Correlation between the ultrasonic parameters and flank wear shows that every parameter is contributing in the of flank wear growth. The decision making algorithm presented in their work determines the tool wear status in real time.

2.8 SUMMARY

The literature review gives the following details,

1. On-line tool condition monitoring in any machining processes will improve the quality of the products.
2. Selection of work and tool material is an important matter while studying the tool wear.

3. Acoustic emission technique (AET) is a suitable method to monitor the tool wear during machining.

4. Only limited number of literature are available in the area of acoustic emission technique (AET) in turning operation.

5. Suitable Acoustic Emission (AE) sensor selection and usage is important in predicting the tool wear in different machining operations.

6. The Acoustic Emission Technique (AET) has the potential for on-line monitoring of tool wear in single point cutting tool.

7. Motor current, cutting force, acceleration due to tool vibration is not suitable to predict accurate tool wear.

8. Artificial neural network (ANN) could be used to study the pattern of the tool wear and ANN can be used to measure the on-line tool wear.

9. Adaptive Neuro Fuzzy Inference System (ANFIS) has more flexibility and accuracy in measuring the tool wear.

Therefore, research work for on-line monitoring of tool wear is an important need of the hour in different machining operations. In this research work, tool wear using acoustic emission technique has been studied experimentally. Also, an Artificial Neural Network (ANN) and Adaptive Neuro Fuzzy Inference System (ANFIS) models were trained using the experimental results, and the results are validated. The details of the experimental set-up and the intelligent techniques are discussed in the next chapter.