CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION

Based on the continuous research pursued more than a decade in the area of analyzing the rotating machinery vibration, evolving new methods for studying unbalance, misalignments, looseness of rotors, soft computing based vibration analysis and control, the following literature survey has been made on the results of previous researchers.

2.2 MATHEMATICAL MODELLING

An article by Horst Irretier (2002) helped a lot in getting a survey over different vibration analysis methods with relevant mathematical foundations. Methods such as phase resonance and phase separation were classified with SDOF and MDOF. The indicated mathematical foundations related to these methods such as Free response and Forced response have been much useful in the analytical study.

Kameswara Rao and Desai (2003) described a higher order mixed theory for the free vibration analysis of isotropic, orthotropic and sandwich plates. This paper illustrated the comparison results of isotropic and orthotropic plates and showed very good agreement with exact solutions of three-dimensional elasticity theory and their results were tabulated.
Rik Pintelon et al (2005) studied a method for variance analysis to detect and quantify the nonlinear distortions and disturbing noise. Non-stationary signal disturbances were analysed with relevant frequency response functions at different frequency conditions. Mathematical and graphical illustration in frequency domain were also shown.

Carlos Luna et al (2006) proposed a method to measure rotation angles and illustrated with mathematical modelling to enhance the vibration segments with varying rotating angles. This paper further explained the optimised rotary angles for certain applications.

Statistical analysis and regression analysis of monitoring parameters with laboratory test and mathematical equations were found by the experimental methods of Erkki Jantunen (2006). Based on the statistical readings, a fuzzy classification was explained between lower and upper limits of classes. Readings of fuzzy classification were tabulated; further an industrial installation model was mentioned with microcontroller based hardware box as Universal Local Intelligent Module (ULIM) using Controller Area Network (CAN) bus.

Bin Xu et al (2011) described the integral equation method for the dynamic response of pile groups embedded in a layered poroelastic half-space to a harmonic axial load. Numerical solution of the integral equation yields the axial force as well as response of layered poroelastic half-space. The results were compared with the known results and different parameter responses were graphically displayed.
Tsuyoshi Inoue et al (2011) mooted a technique to reduce forward rub of a rotating machinery with a support between elements. A non-linear theoretical analysis for the rotating system with asymmetric support is mathematically proposed with functional equations and description. Vibration analysis history for different results of experimentation is presented.

Sharma et al (2011) designed a mathematical model of three dimensional vibration analysis of a spherically isotropic, generalized thermoelastic sphere subjected to stress free, thermally insulated boundary conditions. Graphical responses among different parameters showed vibration study.

Khameneifar et al (2011) presented a mathematical model and carried out the analysis for studying rotary motions. It illustrated energy patterns for specified application and their vibration study.

2.3 VIBRATION MEASUREMENT AND ANALYSIS TECHNIQUES

Djurovic et al (1999) defined a virtual instrument for time–frequency analysis. Its realization was based on an order recursive approach to the time–frequency signal analysis. Starting from the short time fourier transform and using the S-method, a distribution having the auto-terms concentrated as high as in the Wigner distribution, without cross-terms, may be obtained. The same relation is used in a recursive manner to produce higher order time–frequency representations without cross-terms. Thus, the introduction of this new virtual instrument for time–frequency analysis may be of help to the scientists and practitioners in signal analysis. The application
of the instrument is demonstrated on several simulated and real data examples.

Lee and Lee et al (1999) put forth a dynamic model for misaligned rotor ball bearing system and experimentally conducted the vibration analysis with sensitivity analysis. Directional angular misalignments were compared for experimentation and simulation with respect to natural frequencies. A tolerance of -10% to +10% was fixed for effect and an analysis was being carried for the study of misalignment using vibration analysis.

Chanting Wang and Robert Gao (2000) emphasized a LabVIEW based bearing condition monitoring system as user and engineer friendly integrated system. This paper illustrated a bearing health monitoring design, a relevant instrumentation flowchart and a virtual instrument system configuration. It also showed Virtual Instrument design optimization with DFT and comparison of reading with low pass filter and graphical results. It explained the block diagram of virtual instrument system clearly and partwise with comparative results.

Zbigniew Kozanecki and Dorota Kozanecka (2002) illustrated the dynamic characteristics of bearings and problems identified in the joints. As a rotating component, the structural stress due to joints and the dimensions of other components were analysed and presented with a test bearing analysis for its spectral frequency during vibration.

Karuppaiah et al (2003) described vibration measurement for partial load conditions and tabulated the different vibration levels for various tracks and speeds. This paper illustrated the random vibration concept and
parametric study. The results, ranging from 0.26 to 2.15 at axle and 0.03 to 0.34 at chassis, were experimentally compared with theoretical model.

Sharma et al (2005) tried to determine the dynamic response of steam turbine rotor using modal time history analysis technique. The results from frequency analysis were tabulated for different modes and all mode shapes of rotor and blade could be visualized clearly from 3-D approach. Solid FE modal was developed using modern 3D CAD for this purpose.

Surial and Kaushal (2005) conducted an described about engine vibration test with validation of analytical model to provide a method of assessing critical speeds for the reliable operation of rotating machinery at higher speeds. It studied structural integrity of engine dynamics with forced response analysis with the required sensor accelerometers at the front, center and rear. The results from frequency analysis were tabulated for different modes and frequencies were observed ranging from 9.42 Hz to 52.58 Hz.

Sheng Zhang et al (2006) recommended a feature selection and pattern recognition procedure for rotating machinery fault diagnosis. This method indicated Bayesian neural network for classification and the wavelet packet transform was used for feature extraction. The hidden layer weights and training dataset were tabulated for fault diagnosis as case study using WPT tree.

Haider and Koronios (2006) traced the different technological advances including vibration analysis for the condition monitoring so as to improve the performance of manufacturing industries. The proposed e-intelligent integrated condition monitoring was studied with CC1010 interface with sensors. The authors mentioned about the need for
communicating the result with MIS to provide indications and exact location where failure condition developed.

Haider and Koronios (2006) perused different technological advances including vibration analysis for the condition monitoring so as to improve the performance of manufacturing industries. This work studied e-intelligent integrated condition monitoring with CC1010 interface with sensors and also discussed the need for communicating the result with Machine Interface System to provide indications and exact location where failure condition developed.

Portillo et al (2007) dealt with the virtual instrumentation system (VIS) for the analysis and development of machining solutions in the WEDM process.

Luigi Fortuna et al (2007) evaluated the design procedure and performance of a virtual instrument based on stacked neural networks, designed to monitor product quality in a refinery. The performance of different modelling strategies was compared and the results among various parameters were graphically plotted. VIS employs a commercial data acquisition board with sampling rates that range from 20 k Samples/s to 10 M Samples/s per channel.

Carbone et al (2008) probed the basic issues related to measurements performed in the domains of software engineering and metrology. They highlighted the similarities and differences with the aim of analyzing the level of knowledge in both domains. A theoretical approach was followed, allowing the proposal of a measurement process model, which was used as a guiding scheme throughout the paper to illustrate the peculiarities
arising when taking software measurements. Describing a common ground between metrologists and software engineers the authors discussed the foundations of measurement in the software context.

Ruqiang Yan and Robert Gao (2009) developed integrated detect feature extraction technique for the diagnosis of rotary machines and machine components using wavelet transforms. The authors investigations included the selection of base wavelet and related them to detect the extracted energy from defect induced vibrations. Tabulating the energy – bandwidth ratio for different wavelets such as Morlet, mexn, Gaus2, Meyer, Haar etc. ranging from 22.91 to 0.56 they plotted the response for centre frequency interval with computational time. It helped to prove the defect diagnosis and signal noise reduction. With the extracted energy percentage and noise reduction, the authors suggested the necessity of noise reduction for correctly selecting the best suited wavelet scale for signal feature extraction. This technique has been observed to new trend in vibration analysis and rotating machine diagnosis.

Jose De Jesus Rangel-Magdaleno et al (2010) exploited an FPGA based vibration analyser as a full custom IC design machine monitoring with FFT and DWT analysis to decompose the frequency band with certain sampling frequency. The authors showcased an instrumentation system with three axes vibration sensors and FPGA based signal processing unit with storage and display units. LabVIEW based systems also have such features for configuring similar vibration analysis. The authors presented the experimentation results graphically with time domain analysis, FFT and DWT analysis and also a combination of them. Consequently, this paper leads to the PC based instrument system.
Jose De Jesus et al (2010) an FPGA based vibration analyser as a full custom IC design machine monitoring with FFT and DWT analysis to decompose the frequency band with certain sampling frequency. An instrumentation system with three axes vibration sensors and FPGA based signal processing unit with storage and display units demonstrated and presented the experimentation results graphically with time domain analysis, FFT and DWT analysis and a combination of all these put together.

Mehdi Behzard et al (2011) examined a vibration analysis and response during the defect in the rolling element. An excitation and defect model were analysed and numerical results were presented. Numerical simulation results and experimental results were being compared in both time domain and frequency domain. A comparison of experimental result with theoretical models was shown graphically.

Masoud Ansari et al (2011) suggested the model and exact frequency analysis of a rotating beam with an attached mass, undergoing coupled torsional-bending vibrations. The effects of several system parameters on the resonant conditions of the system were graphically determined.

HyunCheol Kim and Whoi-Yul Kim (2011) scheduled an automated inspection system for the train brake shoe. The image acquisition and analysis of brake shoe algorithms were used and the accuracy of various parameters was tabulated.

Ferrero et al (2011) stated an estimation method for the evaluation of the spectral components of a signal by means of discrete Fourier transform or fast Fourier transform algorithms, subject to leakage errors whenever the
sampling frequency is not coherent with the signal frequency. It used smoothing windows to mitigate these errors and applied interpolation methods in the frequency domain to reduce them further on. However, if cosine windows are employed, closed-form formulas for the evaluation of harmonic frequencies can be used only with the Rife–Vincent class I windows, while approximated formulas have to be used in other cases. In both cases, a high computation burden is required.

Park et al (2011) prescribed a method for estimating the signal frequency of sampled sinusoidal signals, which does not require any iteration for the frequency search. A noniterative method of frequency estimation was already developed by Zhang et al where an analytical expression for the signal frequency was obtained using the differences between the neighboring input data. However, this method is very susceptible to additive noise. This paper extends the algorithm of Zhang et al to maintain the same signal-to-noise ratio as with the traditional four parameter estimation method that requires iterations for the signal frequency search. Unfortunately, the proposed method is unable to estimate the accurate frequency in the case of an infinite number of data points when noises are added to the signal. From a noise analysis, it was found that the average frequency estimation error becomes zero when using a \((2/3)\pi\) phase interval to calculate the signal difference.

Numerical simulation results show that the frequency estimation error when Gaussian noise is added to the input data is about 13% higher than the square root of the Cramer–Rao bound. An additional 6% error is also added when the phase interval for frequency estimation deviates 10% from \((2/3)\pi\). Furthermore, it was found that the effect of harmonic components on the frequency estimation error could be minimized when the phase interval is
close to $(2/3)\pi$, and the total number of data sample covers several signal periods or truncated close to an integer multiple of the signal period. As a result, the frequency estimation with the proposed method is more than 40 times more accurate than that with the IEEE-1057 method when the harmonic components are added to the input signal, which is confirmed by numerical simulations.

Yadav et al (2011) proposed a novel prototype-based engine fault classification scheme employing the audio signature of engines. In this scheme, Fourier transform and correlation methods have been used. Notably, automated audio classification has immense significance in the present times, and it is used in both audio-based content retrieval and audio indexing in multimedia industry. Likewise, it is also becoming increasingly important in automobile industries. It has been observed that the real world automobile engine audio data are contaminated with substantial noise and outliers. Hence, it is challenging to categorize different fault types in different engines. Accordingly, the present paper discusses a methodology where a set of algorithms checks the state of an unknown engine as either healthy or faulty. Fault categorizing algorithm is based on its cross and autocorrelation coefficient values. Appropriately, in this study, the engine amplitude–frequency values of fast Fourier transform are calculated and subdivided into bands to calculate the correlation coefficient matrix. The correlation coefficient matrix for the unknown engine is then calculated and matched with this “prototype” engine matrix to categorize it into a single or multiple fault(s).

It is worth mentioning here that although a rank-based maximum close scheme is adopted for finding the unknown engine’s fault, the work can be extended to any other parametric and neural network-based classification
scheme. Keeping this background in mind, the present paper deals with the proposed methodology to find a prototype engine, unknown engine classification, implementation on real audio signal for single cylinder engine data and its results.

2.4 VIBRATION SENSORS AND HARDWARES

Chong-Won Lee et al (2002) with the help of an experimental set up which has magnetic exciter and Hall sensors, illustrated the modal testing analysis for asymmetric rotors. Directional frequency response functions were used for the estimation to compare one exciter/two sensor and two exciter/two sensor for the practical realisation.

Levent Eren and Michael Devaney (2004) stipulated a wavelet packet decomposition to detect rotating element defect with respect to rotational speed. A test was conducted on 3ph, 1hp, 200V, 60 HZ, 1750 rpm four pole induction motor and STFT was used to present spectrum. The results with statistical mean and standard deviation were tabulated for healthy and faulty bearings.

Mayank Tiwari et al (2005) postulated dynamic response of a rigid horizontal rotor- ball bearing model using unbalance excitation and parametric excitation. The solution of the bi-periodically excitation system, the phenomena of chaos with the routes being period doubling and intermittency and their results of theoretical simulation were graphically displayed.

Depari et al (2007) exploited an innovative calibration technique making it possible to perform simple recalibration with superior results if
compared with traditional techniques. It employs the ANFIS algorithm and it has been tested on a 2-D pyroelectric positional sensor.

Ashok Chettri et al (2007) using careful experimentation intended to tell that conventional exciters might tend to change the natural frequencies of the system under analysis. An industrial mount was presented with the application of static rated load 120 kg and results were obtained to be 23.75 Hz as natural frequency and 2724 N/mm as stiffness compared to hammer tests and forced vibration tests.

Ghassemi et al (2008) optined that accelerometer-based angle sensor is not a suitable replacement for resolvers, encoders, and other contact-type angle sensors. But as shown here, it can produce reasonable results in situations where these sensors are difficult or expensive to deploy and maintain. However, other measurements, such as linear acceleration, angular velocity and acceleration sensing can also be performed by this sensor.

Guido Perrone and Alberto Vallan (2010) conducted a vibration analysis and an evaluation of displacement and acceleration using a plastic optical fibre sensor. These authors performed the vibration analysis experimentally and sensor calibration issues with high frequency vibration test. In addition, they reckoned with the configuration.

Alberto Vallan et al (2010) deliberated on the fiber optic sensor and material characteristics for certain vibration identification. Further, they illustrated about the test conditions and electronics required for proper vibration measurement and noise isolation.
Khameneifar et al (2011) endorsed a modelling and analysis of piezo electric mount for rotating machine applications. An electro-mechanical model with numerical results was found with beam-mass system characteristics of piezo ceramic layer. Graphical responses among different parameters were shown for energy harvester study.

Carlos De Marqui et al (2011) contrived the frequency domain piezoaeroelastic modelling and analysis of cantilevered plate like wing with embedded piezoceramics. The results of piezoaeroelastic behaviour are tabulated and graphical responses among different parameters are shown for energy harvester study.

Amini Karami and Daniel Inman Et al (2011) conceived a new geometry to lower the frequency of a MEMS scale harvesting device. It helped to increase the length, making the substrate device compatible with the frequency range of ambient temperature. An analytical solution was presented and verified against Rayleigh’s method and was validated against a microscale experiment.

Changki Mo et al (2011) fabricated and tested the MEMS piezoelectric energy harvesting devices to demonstrate energy generating performance. The results indicated that the fundamental frequencies and generated power of the microbenders were about 9.1kHz, 1.4µW for trapezoidal bender and 18.48 kHz, 18.2µW for the diagonal bender.

Olguta Marinescu et al (2011) deployed the model and analysis of ROM of tuned and mistuned structures with cracked blade disks. The response of various parameters on the accuracy of the ROMs was graphically displayed.
Andrea Tonoli et al (2011) prescribed a model for electrodynamic bearings with experimental validation. Probably, all the parameters were taken into account for modelling test rig and a unified procedure had been followed in this paper to conduct vibration test. The impact test results and analysis for stabilization graphically showed for stator casing interaction.

Guruswamy et al (2011) developed a novel method to obtain vibrotactile textures from real-world samples. During haptic rendering of the profiles, the user can traverse the textured surface at any speed, and the spatial frequencies of the features remain constant. But damping is fixed in time, i.e. the spatial extent of the waveform varies with velocity. The procedure extends and unifies the decaying sinusoid approach that has been previously proposed by others. The estimation method has been able to pin point IIR filters for stochastic, patterned and mixed surfaces. The method is based on the fully automatic segmentation of the acceleration signal and the use of Prony’s method for filter design. The method is also stable for repeated scans of a surface despite scanning variations that are introduced by hand-held scanning approach.

Saponara et al (2011) evolved the model and the comparison of two acquisition systems developed at the Test Centre Division, European Space and Technology Centre, of the European Space Agency in the framework of two investigations: 1) on microelectromechanical-systems-based sensors for the detection of very low-g accelerations and 2) on the feasibility of a compact and low-power multi-sensor acquisition platform for environmental tests of spacecrafts or subsystems. A simulink-based approach is proposed for fast, accurate, and reconfigurable model of both systems, taking into consideration the sensors and the acquisition chain. This paper aimed at highlighting the importance of the models as key tools to predict the
distortion and noise sources; to allow fast set up of the experiments and to manage the signal conditioning process. The validity of the proposed technique, applied to the two acquisition systems, is assessed by comparing the predicted results with tests on the real system. Finally, this paper aimed to prove, by comparing the two approaches (dedicated acquisition system and multisensor acquisition platform), the importance of the characterization of the whole acquisition system when high performances need to be achieved.

Hyun Cheol Kim et al (2011) used an automated vision system that inspects brake shoes for rolling stock is proposed. The system consists of two modules, namely, one for image acquisition and another for image analysis. The first module is placed under the railway tracks and automatically captures the images of brake shoes using digital cameras as trains pass along the module. The captured images and train information are then transferred to a database. Three specifications, namely, the thickness, any unbalanced wear on the brake shoes, and the distances between the brake shoes and the wheels are measured by the second image analysis module. The shadow regions between the brake shoes and the wheels are defined for detecting brake shoes and wheels. They are also utilized to model both the boundaries of brake shoes and wheels as part of a constrained curve-fitting problem. The measurements are made in terms of the distance between the fitted curves rather than the number of pixels in the image. Experimental results show that system that this researcher proposes can measure all specifications of the brake shoes with high accuracy values.
2.5 ENERGY LOSS CALCULATION

Moshrefi Torbati et al (2003) considered the credibility of a receptance code to successfully model the vibration behaviour of satellite boom structure over a wide frequency bandwidth. The response of a passively optimized boom structure was presented.

Mohite et al (2005) employed equivalent circuits for MEMS capacitive microphones. Critical evaluation of the equivalent parameters using two techniques are numerical and analytical. An analytical technique using Rayleigh-Ritz energy method yielded a comparison of equivalent mass and stiffness of diaphragm. This approach integrated the 2-D domain and squeeze film damping analysis, carried out in ANSYS.

Karimi et al (2006) deployed a self-tuned notch filter in detecting bearing faults to remove multiple noise components. The authors discussed extracting original vibration signal \( x[n] \), by suppressing background noise \( s[n] \) using blind deconvolution. A damaged ball bearing was tested in the test rig with relevant instrumentation between amplitude fluctuation from -75dB to -90dB. Experimental results were graphically displayed in time and frequency domain.

Ruqiang Yan and Robert Gao (2009) scrutinized the integrated feature extraction technique for the diagnosis of rotary machines and machine components using wavelet transforms. This technique investigated the selection of base wavelet and the detection of the extracted energy from defect induced vibrations were investigated. Then, the Energy – bandwidth ratio for different wavelets such as Morlet, meixh, Gaus2, Meyer, Haar etc., ranging from 22.91 to 0.56 were tabulated. It also plotted the response
for centre frequency interval with computational time to prove the defect diagnosis and signal noise reduction.

Dane Quinn et al (2011) held out a modelling and analysis of energy efficient approach for vibration absorption through the use of an energy harvester as the non linear sink. The performance of harvesting system was based on impulsive loading conditions. The results were graphically presented for energy harvester study.

2.6 FUZZY LOGIC AND ANN BASED APPROACHES

Nalinaksh Vyas et al (2002) recounted the identification of faults in the rotating machinery with neural networks by using database available with previous article in their research literature survey. With the help of monitoring parameters, faults like mass imbalance, misalignment, permanent bow, rotor rub and bearing damage were dealt with the help of three layered Back Propagation Network (BPN) by considering sigmoid function.

Investigations were carried out and compared with probabilistic neural network to settle with an output at 4000 epochs with respect to 5000 epochs in BPN architecture. It worked for 0.05 as learning rate in both the architectures to reach the goal at 0.05. Simulation was carried out with MATLAB and training vectors and results were tabulated for the aforesaid faults.

schematic of damage and graphical illustration for different strain time histories are very well explained. Local detection and intensity estimation are presented using fuzzy integrated neural network for predicting the location and intensity of damage.

Suresh et al (2005) inquired into a parallel algorithm of memory neuron networks for identification of rotating machinery. Network structure for identification with message passing interface library for three previous outputs and two past outputs were explained. Parallel efficiency and speed up were defined followed by the number of processor requirement for training the memory neuron.

Wang Rixin et al (2007) characterized a neural network based parameter identification for analysing nonlinear parameters of a rotating element. This work illustrated the techniques of error minimisation and faster convergence to identify the damping co-efficients. Group wise results for damping co-efficients were tabulated with respect to BPN architecture.

Erkki Jantunen et al (2006) furnished an expert system for condition monitoring of rotating machinery. It is system presented statistical analysis and regression analysis of monitoring parameters with laboratory test and mathematical equations. Based on the statistical readings, a fuzzy classification was proposed between lower and upper limits of classes. The readings of fuzzy classification were tabulate and further, an industrial installation model was mentioned with microcontroller based hardware box a Universal Local Intelligent Module using CAN bus.

Omkar and Mani (2007) illustrated neural network to improve the model accuracy using certain training methods with a database. By using the
numerous data an approach is explained to map the optimised data handling for training.

Marzi et al (2008) designed an NN diagnostic system to diagnose faults in the coolant system of a machine tool. The diagnostic system consists of two stages, each containing one or more modules of NNs. In this application, it was found that the BP NNs at each stage produced good results.

The diagnostic system was trained to identify four different trained faults, each acting alone from the healthy operation of the coolant system, and to detect if a novel fault (i.e. previously unmet) was occurring. The ability to detect novel failure cases was achieved by introducing a threshold to the classification of NNs at the test stage. The monitoring technique was able to demonstrate a hardreal-time capability in solving fault detection problems in industrial machines.

Adamo et al (2008) configured Supervisory Control And Data Acquisition (SCADA)/Human to Machine Interface (HMI) systems using LabVIEW with the associated Datalogging and Supervisory Control Toolset (DSC). It helped to develop the SCADA/HMI section (operator’s interface and datalogging) of a software simulated industrial plant. The plant consisted of a vessel with charge and discharge proportional valves, a heating/cooling element, a level sensor and two flow rate sensors.

Jie Liu et al (2010) found real time condition monitoring system for the prevention of machinery performance degradation and malfunctions. With respect to kurtosis ratio reference function an Enhanced Diagnostic scheme was proposed with Neuro Fuzzy classifier using Feed Forward NN, Recurrent NN, ANFIS and NF predictor. The vibration analysis was conducted for
comparing parameters of healthy bearing against rolling-element faults, inner and outer race defects. Upon comparing with different schemes, an adaptive NF classifier was found to be suitable for vibration analysis and classification.

Katzourakis et al (2011) explained a driving-simulator fidelity which is usually defined by the quality of its visual and motion cueing system. However, the quality of its haptic cues is also very important and determined by both hardware and control properties. A relatively low-cost solution for hardware is deployed, consisting of a velocity-controlled three-phase brushless servomotor, of which its high-bandwidth control allows for a realistic representation of forces. A method is presented to overcome electromagnetic interference, produced by the industrial servomotor and the controller through careful amplification and filtering. In conclusion, the designed system allowed reproduction of a large range of steering-wheel dynamics and forces. As a result, the developed system constitutes an efficient haptic device for human–machine-interface automotive experiments.

Zhou et al (2011) explained the identification and online prediction of lifetime of cutting tools using cheap sensors, crucial to reduce production costs and downtime in industrial machines. A reduced feature subset, which is optimal in both estimation and clustering least squares errors, is then selected using a new dominant-feature identification algorithm to reduce the signal processing and number of sensors required. Tool wear is then predicted using an Auto-Regressive Moving Average with exogenous inputs model based on the reduced features. The experimental results on a ball nose cutter in a high-speed milling machine show the effectiveness in predicting the tool wear using only the dominant features. A reduction of 6.83% of mean relative error is observed when compared to the other methods proposed in the literature.
2.7 VIBRATION CONTROL

Rao and Sreenivas (2003) studied the dynamic behaviour of misaligned rotor system to perform harmonic analysis to detect the dominant harmonic between two critical speeds. The values obtained at maximum were analysed for their forces and moments were correlated with the derivation of Gibbon. The results were analysed to find the axial forces due to harmonics and hence to predict the presence of misalignment.

Ferri et al (2008) presented an application of second generation current-conveyor (CCII)-based active inductance simulators to mechanical vibration damping. The oscillation amplitude of a metallic beam, which is near some resonant frequencies, can be reduced by converting mechanical energy into electrical energy through a piezoelectric transducer that is bonded to the beam. The effectiveness of the traditional inductance simulators and CCII based simulators is discussed, comparing the responses of an experimental mechanical–electrical system, with different circuit implementations, through experimental results. The use of series resistance compensation, which is obtained through the use of a suitable topology based on the CCIIIs, in the implementation of the equivalent inductance, allows one to obtain the best vibration damping. This has been confirmed by measurements, for all the natural mechanical frequencies of the realized system.

David York et al (2011) devised a vibration isolator with single DOF and vibration control mount investigation. Mathematical modelling was correlated with an experimental set up which could formulate a multi degree study on components. Analysis and experimental results were compared and for parametric identification and system identification.
2.8 PROBLEM FORMULATION

Based on the literature survey the development of enhanced vibration analyser configuration is required for vibration monitoring and analysis system with the provision for reconfigurability and network based automation features.

All rotary machine experience some oscillations during start up, shut down and continuous operation. In the rotating machinery, it is necessary to classify the machine’s performance based on frequency analysis. Hence the research is intended to develop an enhanced fuzzy based inference system in order to classify different frequency domains and hence the performance of the system.

After having classified the various vibration frequencies, it is necessary to identify the faults for the predictive maintenance of the system. It helps to preserve the system from premature faults such as bent shaft, loosened joints, improper mounts, high speed operation and bearing damage.

Since the predictive maintenance techniques are prominent in rotating machine monitoring, fault identification is another problem to be studied. Hence the research is designed to develop an Artificial Neural Network based improved fault identification scheme. It uses a Back Propagation Network with comparable performance over the scheme indicated in the literature survey.

After having monitored and analysed, it is necessary to suggest a few control strategies with a suitable control scheme. This has also been considered taken as the problem to be resolved.
2.9 SUMMARY

Based on the literature survey made on different sections such as mathematical modelling of rotating machinery, vibration measurement and analysis methods, vibration sensors and hardware used for vibration rig, energy loss calculation, fuzzy and neuro based approaches and vibration control, the research problem has been identified and methods have been formulated. The design for enhanced hardware for analysis, input for fuzzy logic and ANN based system have been developed with respect to literature survey. An improved vibration control scheme has also been suggested based on the literature review.