An Extensive Review of Momentous Researches on Acoustic Emission and Vibration

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ABSTRACT: *Nowadays, vibration is one of the major issues in the environment, which may cause some serious injuries to the human health. Vibration may occur due to mechanical oscillation from industrial machines, railway track nearby human reside, and many more reasons. There are two types of vibration: Free Vibration and Forced Vibration. Due to the interaction between humans and machines, vibration cause serious damage to the human health. Hence, it needs to be eradicated with proper controlling techniques. Before going to eradicate those faults we have to identify those fault localization. In this paper we have reviewed the acoustic emission and also the vibration, here author intend to find the fault localization and exploit it with acoustic emission and vibration.*

Keywords: *Acoustic emission, vibration, frequency.*

I. INTRODUCTION

Modern society is characterized by an increasing attention for the environmental impact of newly developed machinery. One of the environmental criteria that are gaining importance is the noise emission level produced by a new machine since the legal regulations more and more restrict the allowable noise levels. [1] Acoustic emission monitoring refers to the detection of transient waves during the rapid release of energy from localized sources within a material .This in-service test technique explores the damage due to corrosion. [2]

Rolling element bearing condition monitoring has received considerable attention for many years because the majority of problems in rotating machines is caused by faulty bearings. [3] The acoustic emission (AE) method has attracted attention as a monitoring method for the friction and wear processes, as well as the lubricating conditions. [4] If the lubricating grease in a rolling bearing contains contaminants, this may indicate inadequate or damaged sealing of the bearing housing, or wear of the bearing. [5] As a consequence of their importance and widespread use\ bearing failure is also one of the foremost causes of breakdown in rotating machinery. [6]

Various strategies exist that aim to reduce the response of the structure to dynamic loads, typically falling into one of the categories of structural modification, passive control, active control, semi-active control or hybrid control (a combination of active and passive control). [7]

II. ACOUSTIC EMISSION

Over the last 20 last years the Acoustic Emission (AE) proved as a powerful method for the detection of incipient defects on rotating machines. The technology offers several significant advantages over conventional vibration analysis. [8] The traditional definition of acoustic emission (AE) is an elastic wave produced as a result of the swift discharge of energy from a source within a material that is compelled by an externally applied stimulus. [9] The first comprehensive investigation into the phenomenon of AE was undertaken by Kaiser in 1950.Kaiser was the first to digitally acquire AE signals produced in the crystal structure of materials during stress tests. The AE technology is continually developing into a complementary technology for condition monitoring of machines. [9]

Acoustic Emission (AE) is the phenomenon of transient elastic wave generation in materials under stress. When the material is subjected to stress at a certain level, a rapid release of strain energy takes place in the form of elastic waves that can be detected by transducers. Typical AE signal frequency range is between 20 kHz and 1 MHz. When surface traction occurs at asperity contacts, materials can exhibit two basic responses: elastic and plastic deformation of the surface and subsurface and fracture, which are potential AE sources. In metal to metal sliding contacts, the possible AE sources due to friction and wear include: (i) contact surface damage, (ii) subsurface cracking, nucleation and propagation, (iii) phase changes, (iv) chemical reactions , (v) impulsive shocks due to asperity collision and debris and (vi) micro-vibration excited by the stick-slip at the interface. [10]

The three most significant applications of AE techniques are as follows

- Source location - determine the locations where an event source occurred
- Material mechanical performance - estimate and characterizes materials/structures
- Health monitoring - monitor the safety operation of a structure

The detection of AE can be an effective non-destructive technique for investigating the conditions of gas pipes, welds and storage tanks, or for real-time monitoring of machining processes and the performance of structures under cyclic loading such as aircrafts. [11] Today's cars represent a complex compromise between contradictory requirement with regard to safety, exhaust emissions, noise, performance and price. However, since it's widely recognized that the quality of the life, particularly in the urban environment, is heavily influenced by air and noise pollution resulting from road traffic, one of the top priorities of car manufacturers is the reduction of noise and emissions from vehicles. [12]

III. RELATED WORK

In 2008, Tzu-Shien Chuang *et al.* [13] has described a stator flux oriented current vector control of a Sensorless three-phase 6/4 switched reluctance motor without position sensors was presented. Space current vector control technology based on torque angle estimation was used to reduce the acoustic noise and vibration of the motor drive system. The power converter for the 6/4 switched reluctance motor was a three-phase full bridge inverter. The experimental results show that the maximum level of acoustic noises and vibration are 73 dB and 8 dB; m/s/s, respectively, and the steady speed error of the drive system was less than 0.1% operated at the rated load when the drive system was operated below 1500 RPM. In addition, the transient speed performance was also satisfactory.

In1999, Tandon *et al*. [14] have reviewed vibration and acoustic measurement methods for the detection of defects in rolling element bearings is presented in the proposed technique. Detection of both localized and distributed categories of defect has been considered. An explanation for the vibration and noise generation in the bearings was given. Vibration measurement in both time and frequency domains along with signal processing techniques such as the high-frequency resonance technique have been covered. Other acoustic measurement techniques such as sound pressure, sound intensity and acoustic emission have been reviewed. Recent trends in research on the detection of defects in bearings, such as the wavelet transform method and automated data processing, have also been included.

In 2011,T.H. Loutas *et al*.[15] The monitoring of progressive wear in gear using various non-destructive technologies as well as the use of advanced signal processing techniques upon the acquired recordings in the direction of more effective diagnostic schemes was the scope of the present work. For the proposed reason multi-hour tests were performed in healthy gears in a single-stage lab scale gearbox until they were seriously damaged. Three on-line monitoring techniques are implemented in the tests. Vibration and acoustic emission recordings in combination with data coming from oil debris monitoring (ODM) of the lubricating oil were utilized in order to assess the condition of the gears. A plethora of parameters/features were extracted from the acquired waveforms via conventional (in time and frequency domain) and non-conventional (wavelet-based) signal processing techniques. Final heuristic rules based on characteristic values of the resulted independent components were set, realizing thus a health monitoring scheme for gearboxes. The integration of vibration, AE and ODM data increases the diagnostic capacity and reliability of the condition monitoring scheme concluding to very interesting results. The present work summarizes the joint efforts of two research groups towards a more reliable condition monitoring of rotating machinery and gearboxes specifically.

In 2009, T.H. Loutas et al. [16] have discussed the condition monitoring of a lab-scale, single stage, gearbox using different non-destructive inspection methodologies and the processing of the acquired waveforms with advanced signal processing techniques is the aim of the present work. Acoustic emission (AE) and vibration measurements were utilized for this purpose. The experimental setup and the instrumentation of each monitoring methodology are presented in detail. Emphasis was given to the signal processing of the acquired vibration and acoustic emission signals in order to extract conventional as well as novel parameters–features of potential diagnostic value from the monitored waveforms. Innovative wavelet-based parameters–features are pro-posed utilizing the discrete wavelet transform. The evolution of selected parameters/features versus test time was provided, evaluated and the parameters with the most interesting diagnostic behavior are highlighted. The differences in the parameters evolution of each NDT technique are discussed and the superiority of AE over vibration recordings for the early diagnosis of natural wear in gear systems was concluded.

In 2009, Ziaur Rahman *et al*.[17] has described the acoustic emission (AE) technique was applied to rolling contact fatigue tests using a test-rig running under constant load and speed for detecting the incipient damage and damage location. The proposed technique incipiently-damaged roller was investigated in detail and monitored by further running to determine the damage severity and to understand the surface damage propagation process by applying the AE techniques. The conventional AE parameters and AE signal features were studied, and their relation to the AE source locator hit count rate were correlated. The results demonstrated the successful use of the AE measurement unit, which was principally, consists of the AE data analyzer and the AE source locator as a new system for detecting incipient damage produced by fatigue. Moreover, the system is able to forecast the position of the damage in the roller, capable of providing an indication of the severity of damage i.e. damage size, and thus it could allow the user to monitor the rate of further degradation of the rolling elements.

In 2009, Kean Chen *et al.* [18] have described the rolling element bearings are the most common cause of rotating machinery failure. Over the past 20 years, Acoustic Emission (AE) technology has evolved as a significant opportunity to monitor and diagnose the mechanical integrity of rolling element bearings. The proposed technique presents results of an investigation to assess the potential of the Acoustic Emission (AE) technology for detecting and locating natural defects in rolling element bearings. To undertake the proposed task a special purpose test-rig was built that allowed for accelerated natural degradation of a bearing race. It was concluded that the sub - surface initiation and subsequent crack propagation can be detected using a range of data analysis techniques on AE's generated from natural degrading bearings. The proposed technique also investigates the source characterization of AE signals associated with a defective bearing whilst in operation. The proposed also attempted to identify the size of a natural defect on bearings using AE technology.

In 2012, Zhang Zhi-qiang *et al*. [19] have proposed that the objective of the present study was investigating rolling contact fatigue (RCF) damage process of the sprayed coating by acoustic emission (AE) and vibration signals. Fe-based alloy coating was prepared on 1045 steel using the plasma spraying technology. The result shows that RCF damage process was composed of four stages. The AE with higher sensitivity can detect fatigue damage details, such as the material deformation, crack initiation and growth. The vibration could reflect the final failure, such as extensive and deeper pitting. The analysis of AE waveform and frequency are effective methods for studying RCF damage process.

Cyclostationarity was a relatively new technique that offers diagnostic advantages for analysis of vibrations from defective bearings. Similarly the Acoustic Emission (AE) technology has emerged as a viable tool for preventive maintenance of rotating machines. In 2011, Kilundu *et al*. [20] have presented an experimental study that characterizes the cyclo stationary aspect of Acoustic Emission signals recorded from a defective bearing. The cyclic spectral correlation, a tool dedicated to evidence the presence of cyclostationarity, was compared with a traditional technique, the envelope spectrum. The proposed technique comparison showed that the cyclic spectral correlation was most efficient for small defect identification on outer race defects though the success was not mirrored on inner race defects. An indicator, based on the proposed cyclostationary technique, has also been proposed. It was concluded that it offers better sensitivity to the continuous monitoring of defects compared to the use of traditional temporal indicators (RMS, Kurtosis, and Crest Factor).

The challenge in many production activities involving large mechanical devices like power transmissions consists in reducing the machine downtime, in managing repairs and in improving operating time. In 2010, Renaudin *et al*. [21] have proposed an alternative way of bearing condition monitoring based on the instantaneous angular speed measurement. By the help of a large experimental investigation on two different applications, they prove that localized faults like pitting in bearing generate small angular speed fluctuations which are measured with optical or magnetic encoders. They also emphasize the benefits of measuring instantaneous angular speed with the pulse timing method through an implicit angular sampling which ensures insensitivity to speed fluctuation. A wide range of operating conditions has been tested for the two applications with varying speed, load, external excitations, gear ratio, etc. The tests performed on an automotive gearbox or on actual operating vehicle wheels also establish the robustness of the proposed methodology. Sideband effects are evidently seen when the fault was located on rotating parts of the bearing due to load modulation.

In 2011, Eftekharnejad *et al*. [22] has described the application of Acoustic Emission (AE) technology for machine health monitoring is gaining ground as a powerful tool for health diagnostic of rolling element bearing. The proposed technique provides an investigation that compares the applicability of AE and vibration technologies in monitoring a naturally degraded roller bearing. The proposed research was the first known attempt investigating the comparative effectiveness of applying the Kurtogram to both vibration and AE data from a defective bearing

Condition monitoring of induction motors was a fast emerging technology in the field of electrical equipment maintenance and has attracted more and more attention worldwide as the number of unexpected failures of a critical system could be avoided. Keeping this in mind a bearing fault detection scheme of three-phase induction motor has been attempted. In 2011, Konar *et al*. [23] study, Support Vector Machine (SVM) was used along with continuous wavelet transform (CWT), an advanced signal-processing tool, to analyze the frame vibrations during start-up. CWT has not been widely applied in the field of condition monitoring although much better results can be obtained compared to the widely used DWT based techniques. The encouraging results obtained from the present analysis was hoping to set up a base for the condition monitoring technique of induction motor which will be simple, fast and overcome the limitations of traditional data-based models/techniques

IV. PROPOSED RESEARCH SCOPE

In this review paper, I have analyzed acoustic emission and vibration to predict the fault localization. There are several aspects of the fault localization. In this work my ultimate aim is to predict the fault where it occurs for that, I indent to collect various acoustic emission and vibrating parameters in frequency under various faulty condition with various speed condition and also attain result for normal working condition. The frequency attainment under normal working condition is compared with the abnormal working condition, the difference between normal and abnormal working condition frequency range is unique to one another. This unique frequency range is classified into different sorts. The technique used to classify this process frequency is a multiple support vector machine (MSVM). This technique is implemented in the working platform MATLAB. The technique which I am going to propose gives better results for the classification process. This study may facilitate the researchers to further enhance the vibration and acoustic emission process and this review paper will be the enhanced background for the research on acoustic emission and vibration. In the future, we anticipate a large number of brainwaves will rise with the aid of our review.

V. CONCLUSION

In this review paper, an extensive technique work base on acoustic emission and vibration are reviewed thoroughly. The ultimate aim of the proposed technique is to predict the fault localization, for this process author intends to go with the multiclass support vector machine. This paves the path for the classifications which categorize the fault and predict the fault localization in the effective manner. The reviewed techniques were classified under various processes of acoustic emission and vibration. Thus, this review paves the path for the budding researchers to be acquainted with various techniques existing in this field.

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