REVIEW ON APPLICATION OF ACOUSTIC EMISSION TECHNIQUE IN VARIOUS FIELD

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ABSTRACT

One of the salient features of acoustic emission technique (AET) is the dynamic non-destructive detection of defects in structures. The reviews applications of acoustic emission sensing techniques in machining. Originally applied to non-destructive testing of structures but now Acoustic Emission Signals are proving to be an effective tool for monitoring of the machining process due to its sensitivity to process parameters. The source of AE is attributed to the release of stored elastic energy that manifests itself in the form of elastic waves that propagate in all directions on the surface of a material. These detectable AE waves can provide useful information about the health condition of a machine and the process. The Acoustic Emission (AE) technique combined with scanning electron microscopy observations was used to identify the typical damage mechanisms and to follow their evolution. This identification was made with a statistical multivariable analysis in which the number of parameters and classes was optimised. Finally, the participation of each damage mechanism to the global failure was evaluated from the hits number and AE energy.

Keywords: Non-destructive testing, sensitivity, scanning electron microscopy.

1.INTRODUCTION

Acoustic emission (AE) technique is a widely used non-destructive technique for structure integrity assessment. AE is the class of phenomenon whereby transient elastic waves are generated by the rapid release of energy from localized sources in a material like places of transient relaxation of stress and strain fields. The source of these emissions in metals is closely associated with the dislocation movement accompanying plastic deformation and the initiation and extension of cracks in a structure under stress. Other sources of Acoustic Emission are: melting, phase transformation, thermal stresses cool down cracking and stress build up acoustic emission phenomena in non-distractive testing and tool monitoring. Acoustic emissions have become an important tool for instrumentation and monitoring due to the great advances in signal classification, instrumentation, and sensors. The acoustic emissions do not generate during the reloading of a material until the stress level exceeded the previous high load. This irreversibility has become known as "Kaiser's Effect.

Acoustic emissions occur over a wide frequency range, but most often from 100 kHz to 1 MHz. The main benefit of using acoustic emission sensors in monitoring manufacturing processes is that the vibrations of the machine and ambient noises have a much narrower frequency range than does the acoustic emission signal. Thus, the received signal is mostly free of noise unrelated to the cutting process.

The increase in environmental consciousness and community interest, the new environmental regulations and unsustainable consumption of petroleum, led to thinking of the use of environmentally friendly materials. Natural fiber is considered one of the environmentally friendly materials which have good properties compared to synthetic fiber.

2. DATA ACQUISITION SYSTEM

The block diagram of data acquisition (DAQ) system is shown in fig. 2 and the details are discussed below.

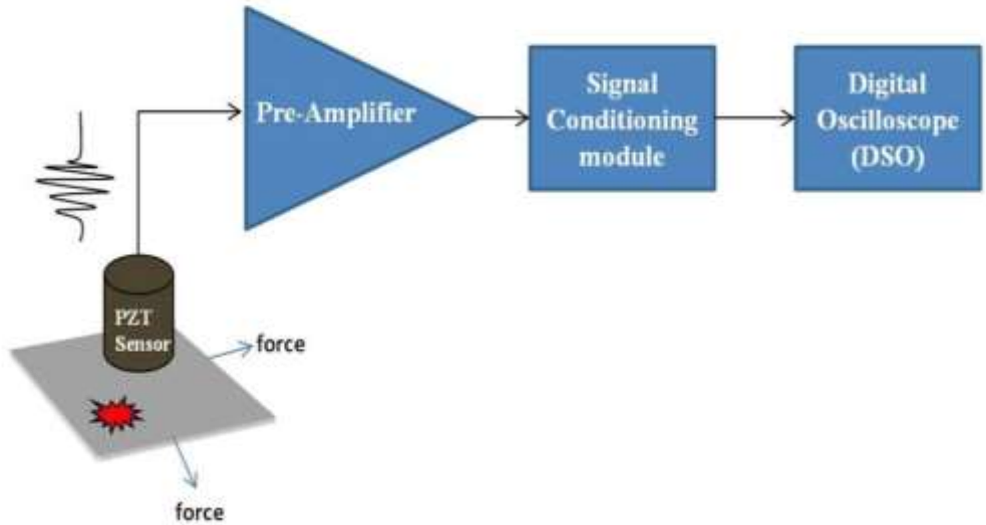

Figure 1 Block diagram of data acquisition system

2.1 Piezoelectric transducer

A piezoelectric transducer is used to detect the acoustic emissions generated from the surface of the object under test. Commonly used transducers are the resonant type and the AE signal is in the range of μVolts. Hence, a pre-amplifier with a fixed gain of 26 dB is used to increase the signal level to the range of millivolt. This pre-amplifier is a charge coupled amplifier having moderate gain, high bandwidth, high CMRR and excellent signal to noise ratio capability. Another unique feature of the preamplifier is to match high impedance of sensors to low impedance of the signal cable.

2.2 Signal conditioning module

The signal conditioning module manipulates the analog AE signal in such a way that it meets the requirements of the next stage for further processing of the AE signal. Signal conditioning circuit performs impedance matching, amplification, and filtering to the sensor signal received from the sensor which is suitable for the analog to digital conversion. It includes a buffer, digitally control gain amplifier and a band pass filter. The gain of the amplifier is varied digitally up to 45 dB in a 3 dB step. The upper and lower cutoff frequency for the band-pass filter as 100 kHz and 20 kHz respectively has been selected. The amplified output signal level is in the range of 1 to 3 volts.

2.3 AE signal

Based on the analysis of AE signal sources, AE derived from metal turning consists of continuous and transient signals, which have distinctly different characteristics. Continuous signals are associated with shearing in the primary zone and wear on the tool face and flank, while burst or transient signals result from either tool fracture or chip breakage.

2.4 AE signal processing

An AE signal is non-stationary and often comprises overlapping transients, whose waveforms and arrival times are unknown. A common problem in AE signal processing is to extract physical parameters of interest, such as tool wear, when these involve variations in both time and frequency. Many quantifiable characteristics of AE can be displayed as follows. Ring down count: the number of times the signal amplitude exceeds the present reference threshold; AE event: a micro-structural displacement that produces elastic waves in a material under load or stress; Rise time: the time taken to reach peak amplitude from the first present threshold voltage crossing of the signal; Peak amplitude: this can be related to the intensity of the source in the material producing an AE signal; RMS voltage: a measure of signal intensity

3. APPLCATION REVIEW

Acoustic Emission Applications in Automobile Industries. In Uses AE signal analysis to identify faulty combustion of an automobile engine regardless of the type of automobile. Suitability of wavelet based features as well as CFS algorithm for feature selection is proved. In [12] The FFT technique and the high order statistic of RMS averages reflect in the Sound Pressure Level (SPL) responses of the gearbox. This can be an effective way to carry out the predictive maintenance regime and consequently to save money and look promising. The identification of gearbox noise in terms of SPL is introduced. When applied to the gearbox, the method resulted in an accurate account of the state of the gear, even, when applied to real data taken from the gear test. The results look promising. Moreover, the proposed noise in terms of sound pressure level (SPL) signature methodology has to be tested on the other test rig also. RMS average value could be a good indicator for early detection and characterization of faults.

Figure 2 AE in Automobile

3.1 Acoustic Emission Applications in Civil Engineering

Non-destructive testing methods and applications have become of increasing interest due to the worldwide aging and deteriorating infrastructure network. The field of Civil Engineering, bridges and bridge components as well as non-structural elements such as roadway pavements for example, are affected. In particular, the Acoustic Emission (AE) technique offers the unique opportunity to monitor infrastructure components in real-time and detect sudden changes in the integrity of the monitored element. The principle is that dynamic input sources cause a stress wave to form, travel through the body, and create a transient surface displacement that can be recorded by piezo-electric sensors located on the surface.

Commonly, analysis methods of purely qualitative nature are used to estimate the current condition or make predictions on the future state of a monitored component. Using quantitative analysis methods, source locations and characteristics can be deduced, similarly to the case for earthquake sources. If properly configured, crack formation and propagation can hence be quantified with this technique.

If properly configured, crack formation and propagation can hence be quantified with this technique. AE sensors were employed to identify vehicles equipped with studded tires passing over bridges. It was found that this analysis method may assist in estimating the operating load conditions of in-service bridges. AE techniques draw a great attention to diagnostic applications and in material testing.

It can be applied to real large-scale structures as well as the observation of the cracking process in laboratory specimen to study fracture processes. The AE method is able to detect seismic waves from damage inside and on the surface of the structure long before a failure occurs. Acoustic emission techniques are an additional monitoring method to investigate the status of a bridge or some of its components. It has the potential to detect defects in terms

of cracks propagating during the routine use of structures. Acoustic emission method uniquely fits to the concept of SHM due to its capabilities to examine, monitor structures and assess structural integrity during their normal operation. An acoustic emission (AE) technique has been applied as a diagnostic method for grouted rock anchors subjected to uplift loads, in order to characterize their major failure mechanisms.

Figure 3 AE in SHM

3.2 Acoustic Emission Applications in Non-Destructive Testing

The application of acoustic emission to non-destructive testing of materials in the ultrasonic regime, typically takes place between 100 kHz and 1 MHz's Unlike conventional ultrasonic testing, AE tools are designed for monitoring acoustic emissions produced within the material during failure or stress, rather than actively transmitting waves, then collecting them after they have traveled through the material. Part failure can be documented during unattended monitoring. The monitoring of the level of AE activity during multiple load cycles forms the basis for many AE safety inspection methods that allow the parts undergoing inspection to remain in service.

The technique is used, for example, to study the formation of cracks during the welding process, as opposed to locating them after the weld has been formed with the more familiar ultrasonic testing technique. In a material under active stress, such as some components of an airplane during flight, transducers mounted in an area can detect the formation of a crack at the moment it begins propagating. A group of transducers can be used to record signals, then locate the precise area of their origin by measuring the time for the sound to reach different transducers. The technique is also valuable for detecting cracks forming in pressure vessels and pipelines transporting liquids under high pressures. Also, this technique is used for estimation of corrosion in reinforced concrete structures. In addition to non-destructive testing, acoustic emission monitoring has applications in process monitoring. Applications where acoustic emission monitoring has successfully been used include detecting anomalies in fluidized beds, and end points in batch granulation.

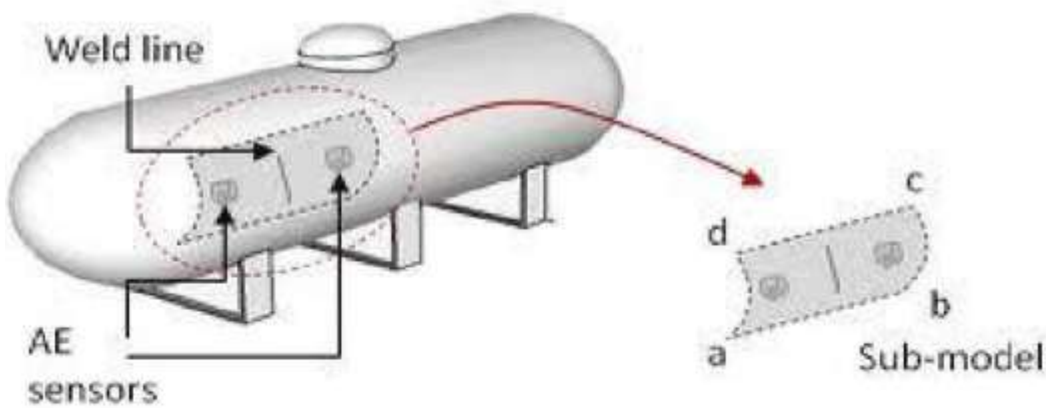

Figure 4 AE in NDT

3.3 Acoustic Emission Applications in Machining.

Application of acoustic emission technique for on-line monitoring of various manufacturing processes such as punch stretching, drawing, blanking, forging, machining and grinding has been reviewed and discussed. During the past several years has established the effectiveness of acoustic emission sensing methodologies for machine condition analysis and process monitoring. AE has been proposed and evaluated for a variety of sensing tasks as well as for use as a technique for quantitative studies of manufacturing processes. The applicability of AE to gear health diagnosis. The behavior of AE to changes in speed or process in real time has been presented. Correlate the condition of broaching tools to the output signals obtained from multiple sensors, namely, acoustic emission (AE), vibration, cutting forces and hydraulic pressure, connected to a hydraulic broaching machine.

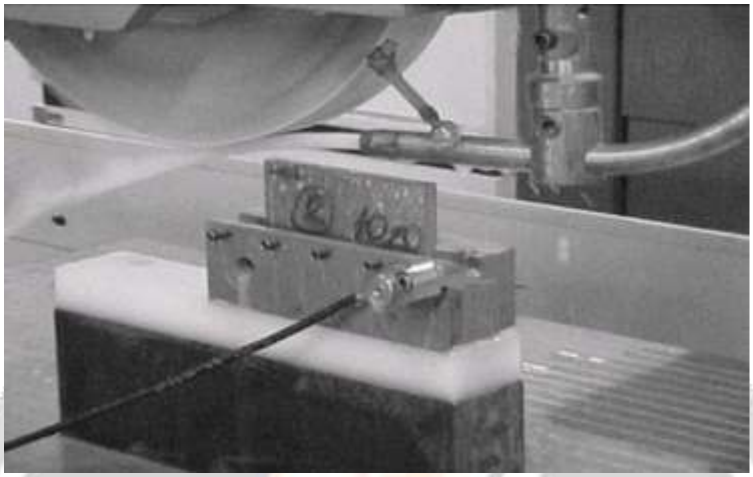

Figure 5 AE in griding

The results show that AE, vibration and cutting force signals are all sensitive to tool condition and a correlation can be made between the broaching tool condition and sensory signals using a variety of signal analysis techniques. Time and frequency domain analysis of the output signals showed that there is a wide choice of sensors and signal processing techniques that can be utilized for tool condition monitoring in broaching. Wavelet packet transform is used as a tool, to characterize the acoustic emission signals released from glass/phenolic polymeric composite during drilling. The results show that the selected monitoring indices from the wavelet packet coefficients are capable of detecting the drill condition effectively.

The development of a tool wear monitoring system using AE signals acquired during drilling on mild steel work-piece. AE energy of the signal has shown increasing trend with increasing drill wear. AE signal analysis was applied for sensing tool wear in face milling operations. Cutting tests were carried out on a vertical milling machine. The results of this investigation indicate that AE can be effectively used for Monitoring tool wear in face milling operations. Ring down count (RDC) and RMS voltage can be effectively used as indicators for tool wear monitoring in face milling. RMS voltage is very clear in distinguishing the normal state from the abnormal state. The effects of acoustic emission (AE) signals emitted during the milling of H13 tool steel as an important parameter in the identification of tool wear. These generated AE signals provide information on the chip formation, wear, fracture and general deformation.

3.4 Application of AE to interface studies in single fibre composite (SFC) tests

The mechanical properties of fibre reinforced polymeric composites strongly influence their final industrial application. Mechanical properties of composites depend on several factors, such as the properties of constituent reinforcement and matrix, their relative volume fraction, the shape, size and architecture of reinforcement phase, but to a great extent on the reinforcement/ matrix interfacial shear strength (IFSS). A relatively strong interfacial bond is needed for an effective transfer of the applied load, since a weak interface will probably lead to a premature failure of the composite. The IFSS is a critical factor affecting the toughness, transverse mechanical properties and interlaminar shear strength of composites, hence a detailed knowledge of the characteristics of fibre/matrix interface is necessary when tailoring performance to applications. In fact, improving IFSS results in increasing the tensile and flexural strength of the composite whilst lowering the impact strength and toughness. The quality of the interface region represents a remarkable concern for traditional man-made fibre reinforced composites and an even more worrying aspect for natural fibre reinforced composites. In fact, what has prevented a more widespread use of natural fibres is the lack of good adhesion to most polymeric matrices. The hydrophilic nature of natural fibres adversely influences adhesion to the hydrophobic matrix, resulting in low compatibility and strength. Furthermore, a strong interfacial bond represents a key aspect for the durability of composites

3.5 Acoustic emission in damage evolution and failure mechanisms detection

Several test methods and techniques have been developed to evaluate and monitor the damage mechanisms and failure modes. As a result of these techniques, AE has gained fundamental attention in recent years. Several studies were carried out in the use of AE method analyzing the damage evolution and failure mechanism detection in traditional polymer composites reinforced with glass, carbon or aramid fibres. However, there have only been few papers dealing with acoustic emission associated with damage mechanisms in composites reinforced with natural fibres e.g., flax, jute, hemp and kenaf. It is worthy to note that some of these studies have successfully demonstrated the possibility of determining the failure modes of these green composites using the acoustic emission technique.

Using the AE monitoring to characterize the failure modes mechanism as a function of the amplitude vs. time in maize hull filled (at different contents) polyethylene composites during a tensile test. The examination showed that it was possible to reveal and distinguish the presence of three main failure modes for these composites: matrix deformation (below 25 dB), maize hull pull-out (26–40 dB), and maize hull breakage (over 41 dB. From AE analysis it was noted that higher amplitude signals (55 dB) were emitted in the composites reinforced with untreated kenaf fibres compared with composites reinforced with treated ones (50 dB).

Furthermore, they found a higher average number of AE event counts for the composites with untreated fibres and for the samples having a higher ligament length. It could be related to a stick-slip mechanism caused by the rough surface of the kenaf fibre, which opposes the pull-out mechanism. As a consequence, the pull-out showed higher amplitude signals. On the contrary, the treatment improving fibre–matrix adhesion resulted in lesser pull-out. The examination of AE signals amplitude during force elongation curves showed that it was possible to associate AE signals to three main failure modes. In particular, during the tensile test they observed only few and low amplitude signals related to matrix cracking, at the onset of the load. It has been detected that by increasing the load, the intensification of acoustic activity can be associated to fibre debonding and pull-out.

3.6 Damage mechanisms assessment of hybrid flax-glass fibre composites Tensile tests

The tensile tests were performed on the dry specimens before ageing and the wet specimens after the samples reached the saturation limit. They were conducted with an universal mechanical testing machine Instron 3382 at room temperature, following the ASTM D3039 standard. The cross-head speed used was 2 mm. min^{1}. To avoid failure in the machine clamps and ensure that breaks would occur within the gauge length, glass/epoxy composite tabs were bonded at the ends of each specimen (Fig. 6). For each composite, five tests were carried out. The average value and the standard deviation were then reported.

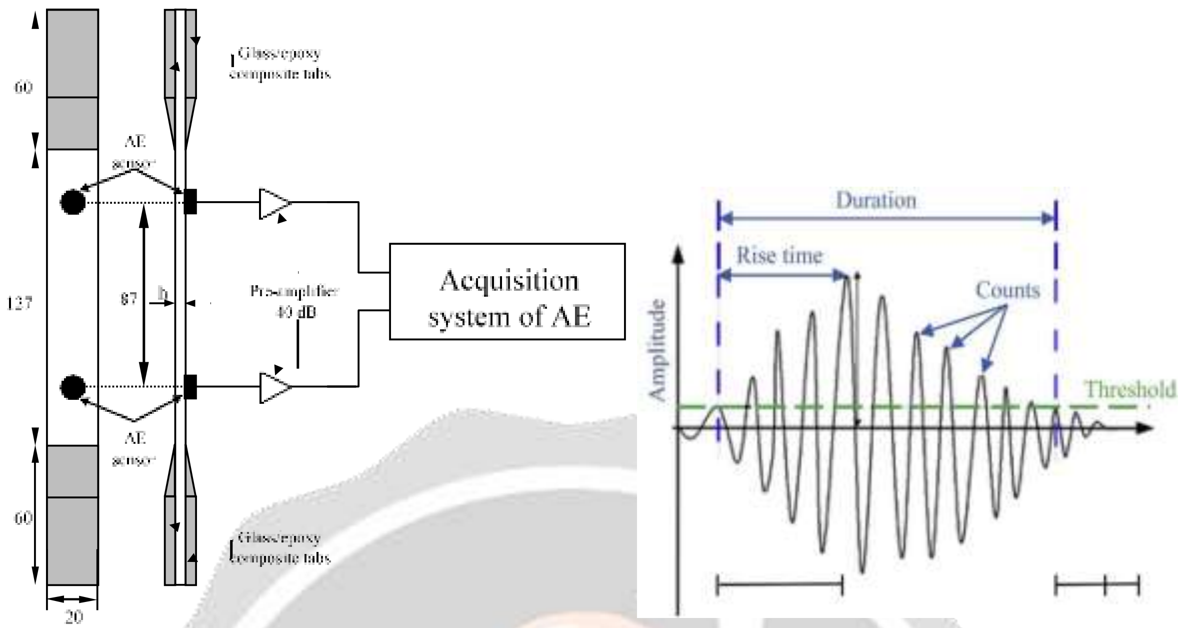

Figure 6 Tensile test and AE parameters

4. CONCLUSION

AE signal technique is use in many industries. AE is not limited to a particular field huge amount of research is going to find out its feasibility in different application. It is an easy and effective tool for health monitoring of machines, products, buildings, gears etc. more and more application of AE in different field will come up in future.

the damage mechanisms of hybrid flax-glass fibre composites, using acoustic emission technique. The composites, composed of twill flax and glass fibre laminate plies with different stacking sequences, were aged to water immersion at 55 C and subjected to tensile test.

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