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Application of Acoustic Emission Technique in Various Field

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Abstract:- This paper 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. This paper gives some background of acoustic emission and its application in various field .Special emphases on its application in monitoring of machining Process.

Keywords:- Acoustic Emission, AErms, Ringdown count, Rise time, Kaiser's Effect

I. INTRODUCTION

Acoustic Emission, according to ASTM, refers to the generation of transient elastic waves during the rapid release of energy from localized sources within a material. 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. Kaiser was the first to use electronic instrumentation to detect audible sounds produced by metals during deformation [2].

He observed that acoustic emission activity was irreversible. In other words, 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," and it has proved to be very useful in acoustic emission studies. Kaiser also proposed a distinction between burst and continuous emission, where the acoustic emissions are attributed to friction between grains. In recent years, acoustic emission sensors designed for the automated manufacturing environment have been very successful.

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. However, interpretation of the acoustic emission data requires considerable testing experience and background knowledge.

1.1 AE signal source

Research has shown that AE, which refers to stress waves generated by the sudden release of energy in deforming materials, has been successfully used in laboratory tests to detect tool wear and fracture in single point turning operations. Dornfeld (1989) [3] pointed out the following possible sources of AE during metal cutting processes (see Fig. 1)

Plastic deformation during the cutting process in the work piece;
Plastic deformation in the chip;
Frictional contact between the tool flank face and the work piece resulting in flank wear;
Frictional contact between the tool rank face and the chip resulting in crater wear;
Collisions between chip and tool;
Chip breakage;
Tool fracture.

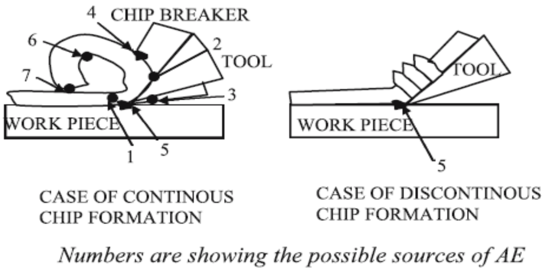

Fig.1: Sources of AE

1.2 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. Therefore, from (a) to (d) sources generate continuous AE signals, while from (e) to (g) generate transient AE signals (see Fig. 2). The AE signal types in cutting process show in Fig.2

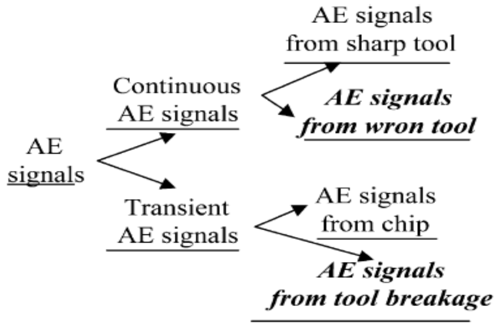

Fig.2: AE signal

1.3 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 [4]:

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.

II. LITERATURE REVIEW

2.1 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. In 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. In [5] 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. In [6] 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. In [7] the AE method is able to detect seismic waves from damage inside and on the surface of the structure long before a failure occurs. In [8] 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. In [9] 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. In [10] 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.

Fig 3 AE in SHM

2.2 Acoustic Emission Applications in Automobile Industries:

In [11] 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

Fig. 4 AE in automobile

2.3 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.

In [13] 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 [14][15] and pipelines transporting liquids under high pressures. Also, this technique is used for estimation of corrosion in reinforced concrete structures.[13][16] 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.

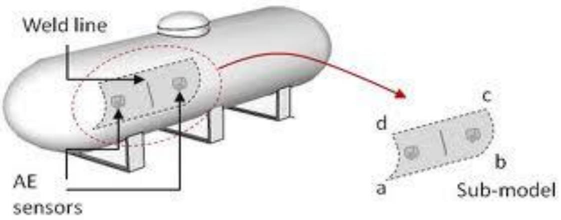

Fig.5 AE in NDT

2.4 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. In [17] authors demonstrated the applicability of AE to gear health diagnosis. The behavior of AE to changes in speed or process in real time has been presented. In [18] 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.

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. In [19] 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.

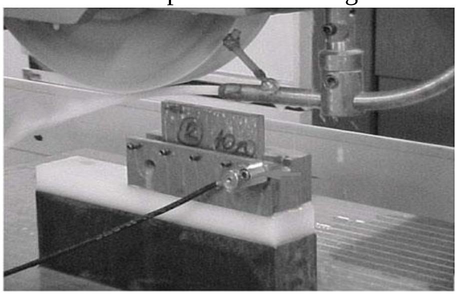

Fig.6 AE in grinding

In [20] the author describes 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. In [21] 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. In [22] work highlights 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.

Furthermore, it is aimed at implementing an online monitoring system for machine tools, using a sensor fusion approach to adequately determine process parameters necessary for creating an adequate tool change timing schedule for machining operations. In [23] Crater wear stages can be monitored by observing cumulative mean values of AE parameters like Area, RMS value and average value. The limiting values of AE parameters obtained to monitor tool condition for a given cutting conditions is found to be applicable to monitor tool condition, even when the cutting speed is varied within ± 12% by keeping all other cutting conditions constant. In [1] It is possible to observe tool wear level related features both in AE time series and their RMS values. Particularly interesting are the statistical properties of the AE time series, in which power law characteristics have been identified. This behaviour has already been observed in the properties of acoustic emission signals in numerous other fields. The frequency distributions of the RMS values have also been studied as a function of wear, showing that even in this case it is possible to identify discriminating features.

III. 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.

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