# ACOUSTIC EMISSION FFT SPECTRA AND WAVEFORM ANALYSIS DURING TENSILE TESTING OF AA7075 AL ALLOY

M.SEEMAN

Department of Manufacturing Engineering, Annamalai University, Annamalainager 608002, Tamilnadu, India

**ABSTRACT**

In this work, The AE FFT spectra and AE waveform studied during tensile testing of AA7075 Al alloy. The AE FFT spectra pertaining to hit data and possibly related to the different regions of tensile test monitoring. The AE FFT spectra clearly indicate different regions of elastic, yield point, plastic and fracture of specimen by position peak amplitude and frequency range of AE signal. Typical AE waveforms obtained corresponding to AE FFT spectra possibly related to the different regions. From the AE waveform found that continuous with burst type AE signal in elastic and yield point, continuous type AE signal in plastic region and pure burst type AE signal in fracture during tensile testing of AA7075 Al alloy specimen.

***Keywords: Acoustic emission signal (AE signal), AA7075 Al alloy, Fast Fourier Transform (FFT), AE waveform.***

## 1. INTRODUCTION

Aluminium alloys are the second most widely used metallic materials after steels. Pure aluminum metal is ductile and malleable. It exhibits a good formability, but the mechanical strength of the metal can be largely improved by either cold working or adding alloying elements such as manganese, silicon, copper, magnesium, or zinc. Due to the addition of different amount of alloying elements variety of alloys can be formed. Aluminium alloys are used for a wide range of applications in various fields including aerospace, marine and automotive, sports and structural, because of their wide spectrum of properties, which suits for a variety of applications.

Generally 7000 series aluminium alloys are utilized in manufacturing aircraft structures and components [1-2]. In particular the upper wing structural components and tail structures, where the stabilizers and control surfaces are employed, which need high compression bending are manufactured by 7000 alloys. Apart from 2000 series which have their role in interior structural components, 7000 alloy has its own place in fuselage frames and bulkheads, where thick sections are used. 7075 aluminium alloy is commonly used by aircraft industries for its higher specific strength, machinability and low cost, but has corrosion susceptibility, that eliminates its role in manufacturing outer components, which is normally subjected to natural corrosive environments [3-4]. In-service monitoring of acoustic emission (AE) i.e., ultrasonic waves generated in materials under load, can be used for this purpose. A number of studies exist, which are aimed at finding a correlation between AE parameters and damage mechanisms [5-6]. Most studies so far have used AE signal parameters, such as rise time, counts, energy, duration, amplitude and correlated them with the occurrence of some particular damage modes. For example, low velocity impact damage on natural fiber reinforced laminates is characterized by AE parameters during tensile testing and flexural testing. "Acoustic Emission (AE) is the class of phenomena whereby transient elastic waves are generated by the rapid release of energy from a localized source or source within a material, or the transient elastic wave so generated". Acoustic emission is just one of a number of methods that can be used to monitor material quality during the tensile testing in order to provide information. 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. The objective of this research is to monitor acoustic emission signal during tensile testing of AA7075 Al alloy and study the AE FFT spectra and AE waveform correlates with tensile properties and various failure modes of AA7075 Al alloy.

## 2. EXPERIMENTAL DETAILS

### 2.1 MATERIALS AND EXPERIMENTAL PROCEDURE

The Out of various series of aluminium that we discussed in the introduction part, we decided to use the high strength aluminium series, which are applied in aerospace applications. Rolled plates of 10 mm thick aluminium alloy (AA 7075 in T651 condition) were used in this investigation. The chemical composition of base metal is presented in Table 1. The un-notched tensile specimens of AA 7075 Al alloy were prepared as per the ASTM E8M-04 standard guidelines for monitoring AE signal. Tensile testing was carried out using 100 kN Electro mechanical controlled universal testing machine (Make: FIE-blue star, India; Model: UNITEK-94100).

**Table.1 Chemical Composition (Wt %) Of Aluminum Alloy AA7075-T651**

| Mg | Si | Cr | Zn | Cu | Mn | Ti | Fe | Al |
|---|---|---|---|---|---|---|---|---|
| 2.9 | 0.4 | 2.28 | 6.1 | 2.0 | 0.30 | 0.20 | 0.50 | Bal |

### 2.2 ACOUSTIC EMISSION SIGNAL MONITORING

The AE data Acquisition setup, AE sensor with preamplifier as shown in Fig.1 & 2, piezoelectric AE transducer was fixed on the tensile specimen using couplant made of Physical acoustic corporation Ltd (PAC) frequency range of 0-1000 kHz, before each test, the calibration of the acquisition parameter was achieved by performing a pencil lead break procedure [7]. Electric signal produced by the transducer was of very low amplitude and high frequency content, and was initially amplified with a low noise pre-amplifier. Most pre-amplifier had a gain of 40-60 dB. In this study 40 dB pre-amplified gain is used [8-9]. The pre- amplified signal was passed through a band pass filter with a threshold set greater than background noise; the conditioned signal was stored in the computer and analyzed using AE Win software. The acoustic emission monitored for the entire testing of all the specimens and tensile properties correlated with AE parameter.

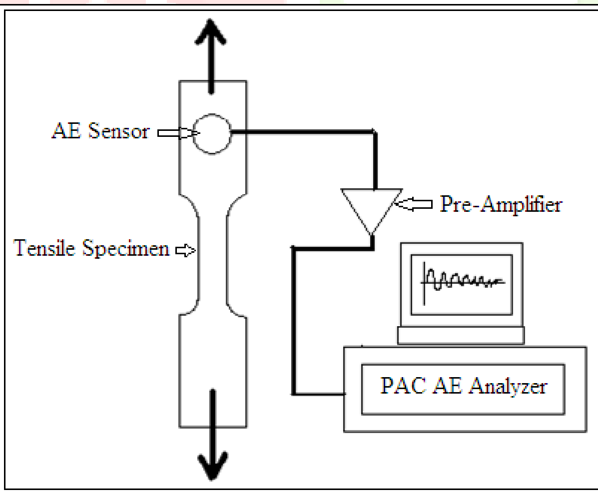


**Fig.1 AE Data Acquisition setup**

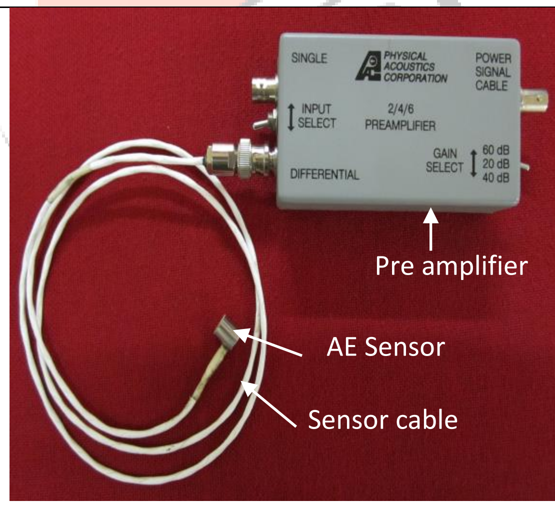


**Fig.2 PAC AE sensor with preamplifier**

## 3. RESULTS AND DISCUSSION

### 3.1 TENSILE PROPERTIES

The transverse tensile properties such as yield strength, tensile strength and percentage of elongation of AA 7075 Al alloy material were evaluated. The tensile test specimens are shown in Fig.3, three specimens were tested, and the best one selected. The same tensile specimen acoustic emission signal also captured for further analyzes. The yield strength, tensile strength and percentage of elongation of AA 7075 Al alloy material 160 Mpa, 222 MPa and 30% respectively.

**Fig.3 Un-notched tensile specimens of AA7075 Al alloy (Before and After test)**

### 3.2.2 AE FFT spectra Analysis

Typical AE FFT spectra pertaining to hit data and possibly related to the different regions of tensile test monitoring are identified from parametric analysis. AE FFT spectra of AA7075 Al alloy material is shown in Fig.4. From Figure observed that AE FFT spectra clearly distinguish different regions of elastic, yield point, plastic and fracture of tensile specimen. Fig.4 (a) shows elastic region of AE FFT spectra from figure observed that peak amplitude occur frequency of 30kHz in addition 100 kHz also high intensity of signal observed. The yield point peak amplitude decrease to 25 kHz also observed intensity of signal decrease at 100 kHz is shown in Fig.4.(b). The tensile specimen enter in to plastic region AE FFT spectra Amplitude increases and peak amplitude observed in the same frequency yield point but no signal observed higher frequency range its clearly indicate plastic region as shown in Fig.4.(c). Tensile specimen fracture identified by AE FFT spectra by low frequency peak amplitude of elastic, yield point and plastic region shifted in to higher frequency range of 375 kHz and also medium intensity signal observed entire frequency range. It's clearly indicating fracture of tensile specimen as shown in Fig.4.(d).

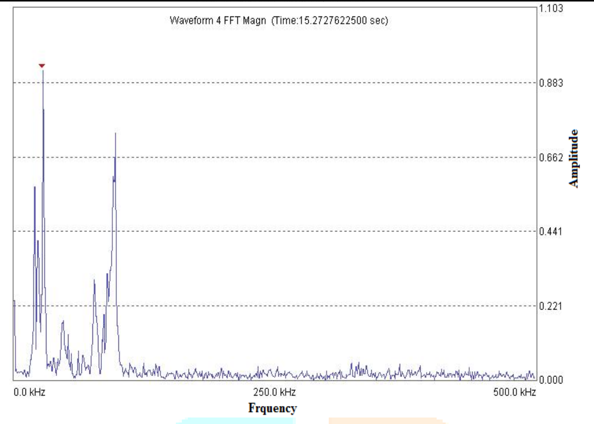


**Fig.4. (a)** AE FFT at Elastic region

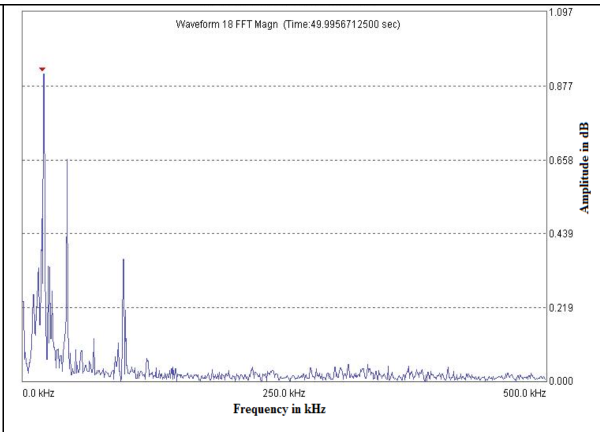


**Fig.4. (b)** AE FFT at Yield point

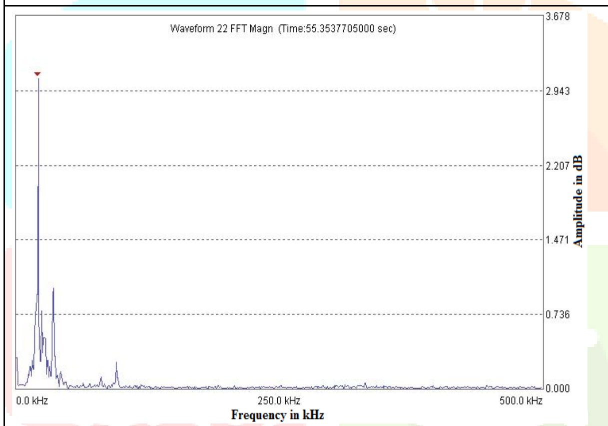


**Fig.4. (c)** AE FFT at Plastic region

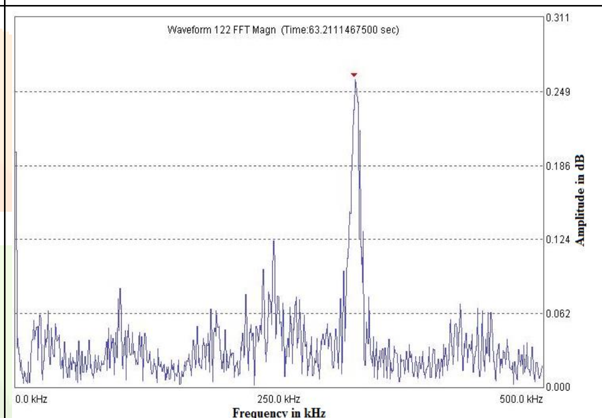


**Fig.4. (d)** AE FFT at Fracture

**Fig.4. AE FFT Spectra during tensile testing of AA7075 Al alloy**

### 3.2.3 AE Waveform Analysis

Typical AE waveforms obtained corresponding to AE FFT spectra as shown in Fig.5 possibly related to the different regions of elastic, yield point, plastic and fracture of AA7075 Al alloy tensile testing. It's clearly indicated different regions of elastic, yield point, plastic and fracture. From figure elastic region and yield point observed continuous with burst type AE signal as shown in Fig.5.(a)&(b). The Fig.5(c) shows plastic region of AE waveform from figure observed that continuous type AE signal it's different from elastic and yield point AE signal of continuous with burst type. The continuous with burst type of elastic, yield point and continuous type plastic region signal shifted to pure burst type AE signal during fracture of AA7075 Al alloy tensile specimen as shown in Fig.5(c).

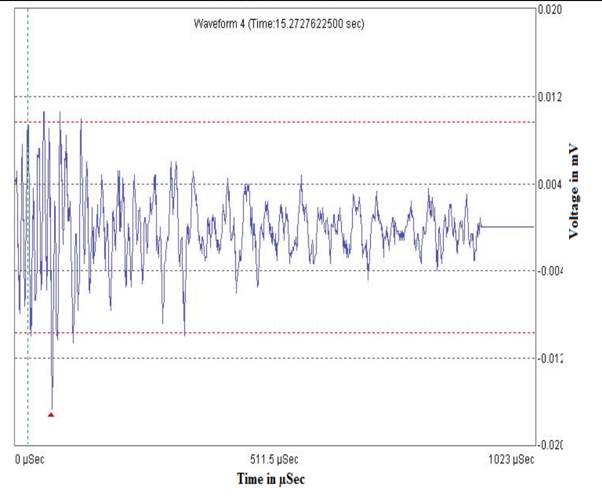


**Fig.5. (a)** AE Waveform at Elastic region

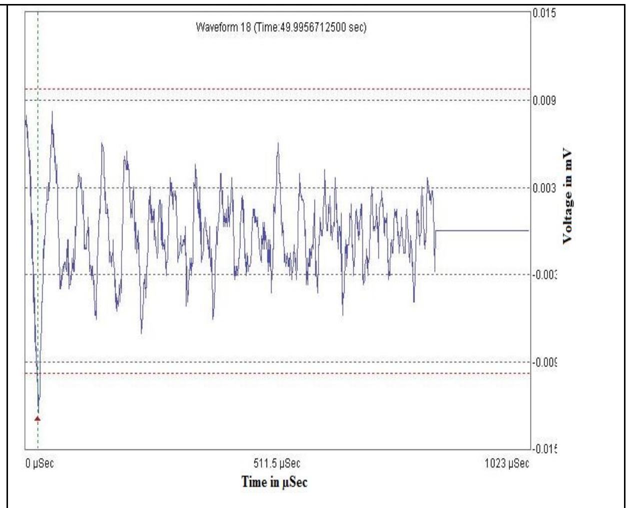


**Fig.5. (b)** AE Waveform at Yield point

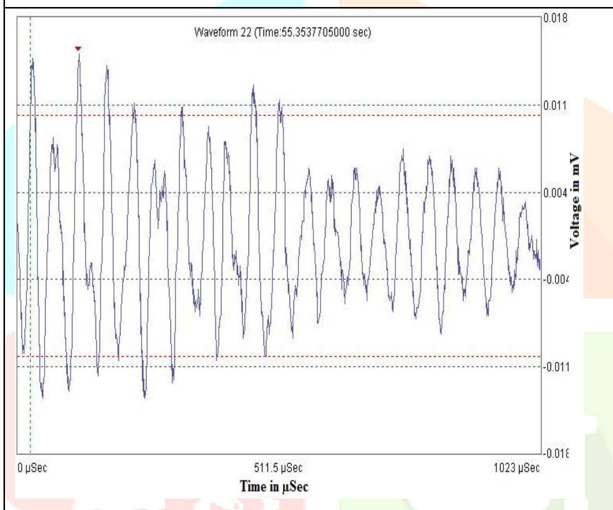


**Fig.5. (c)** AE Waveform at Plastic region

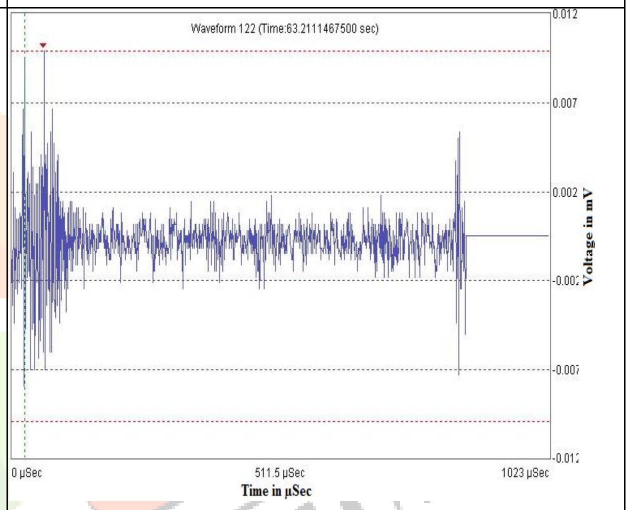


**Fig.5.** (d) AE Waveform at Fracture

**Fig.5. AE Waveform during tensile testing of AA7075 Al alloy**

## 4. CONCLUSIONS

From the Acoustic emission signal monitoring during tensile test of AA7075 Al alloy specimen the following conclusions can be drawn.

1. The AE FFT spectra clearly indicate different regions of elastic, yield point, plastic and fracture of specimen by position peak amplitude and frequency range of AE signal.
2. The fracture of AA7075 Al alloy tensile specimen identified by AE FFT spectra by low frequency peak amplitude of elastic, yield point and plastic region shifted in to higher frequency range of 375 kHz and also medium intensity signal observed entire frequency range.

3. From the AE waveform found that continuous with burst type AE signal in elastic and yield point, continuous type AE signal in plastic region and pure burst type AE signal in fracture during tensile testing of AA7075 Al alloy specimen.

**REFERENCES**


1. Jordon J, Horstemeyer Mark, Solanki K, Bernard, J.D, Berry John, Williams T N: Damage characterization and modeling of a 7075-T651 aluminum plate: Mater.Sci.Eng A, 527, (2009), 169-178.
2. Okafor A C, Natarajan S: Acoustic emission monitoring of tensile testing of corroded and un-corroded clad aluminum 2024-T3 and characterization of effects of corrosion on AE source events and material tensile properties: AIP Conf. Proc., 1581, (2014), 492–500.
3. De Oliveira R, Marques AT: Health monitoring of FRP using Acoustic Emission and Artificial neural network. Computers and Structures, 86, (2008), 367-373.
4. Jalaj K, Sony P, Mukhopadhyay C K, Jayakumar T, Vikas K: Acoustic emission during tensile deformation of smooth and notched specimens of near alpha titanium alloy: Res.Nondestruct. Eval, 23, (2012), 17–31.
5. Lugo Marcos and Jordon, J and Horstemeyer, Mark and Tschopp, Mark and Harris, J: Quantification of damage evolution in a 7075 aluminum alloy using an acoustic emission technique: Mater.Sci.Eng A, 528, (2011), 6708-6714.
6. Ai Yibo, Sun Chang, Que Hongbo, Zhang Weidong: Investigation of Material Performance Degradation for High-Strength Aluminum Alloy Using Acoustic Emission Method: Metals 5, (2015), 228-238.
7. Vinogradov A, Lazarev A, Linderov M, Weidner A, Biermann H: Kinetics of deformation processes in high-alloyed cast transformation-induced plasticity/twinning-induced plasticity steels determined by acoustic emission: Acta Mater. 61, (2013) 2434–2449.
8. Beattie A G: Acoustic emission principle and instrumentation. J of Acoustic Emission, 2, (1983), 95-128.
9. Cousland S M, Scala C M: Acoustic emission during the plastic deformation of aluminum alloys 2024 and 2124: Mater.Sci.Eng., 57, (1983), 23–29.