ACOUSTIC EMISSION PARAMETRIC ANALYSIS DURING TENSILE TESTING OF AA7075 Al ALLOY

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ABSTRACT

Material health monitoring (MHM) refers to the procedure used to assess the condition of component so that their performance can be monitored and any damage can be detected early. Early detection of damage and appropriate retrofitting will aid in preventing failure of the material and save money spent on maintenance or replacement and ensure the component operates safely and efficiently during its whole intended life. The main objective of this research is to monitor acoustic emission signal during tensile of AA7075 Al alloy. The AE parameter of Counts, AE RMS, Amplitude and AE Hits clearly in indicate different regions of initial loading, elastic, plastic and fracture tensile testing AA7075 Al alloy.

Keywords: Material health monitoring (MHM), Tensile testing, Acoustic emission signal, AE RMS, AE Hits

1. INTRODUCTION

The engineering tensile test is widely used to proved basic design information on the strength of materials and as an acceptance test for the specification of materials. In the tension test a specimen is subjected to a continually increasing uniaxial tensile force while simultaneously observations are made of the elongation of the specimen. An engineering stress-strain curve constructed from the load-elongation measurements. The results from the test are commonly used to select a material for an application, for quality control and to predict how a material will react under other types of forces [1]. Properties that are directly measured via a tensile test are ultimate tensile strength, maximum elongation and reduction in area. Generally 7000 series aluminium alloys are utilized in manufacturing aircraft structures and components.

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 [2-3]. 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 [4-5]. 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 [6]. For example, low velocity impact damage on natural fiber reinforced laminates is characterized by AE parameters during tensile testing and flexural testing [7]. "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 [8]. The objective of this research is to monitor acoustic emission signal during tensile testing of AA7075 Al alloy and study the AE parameters like the counts, AE Rms, Amplitude, AE hits, 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 [9]. 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 [10-11]. 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.

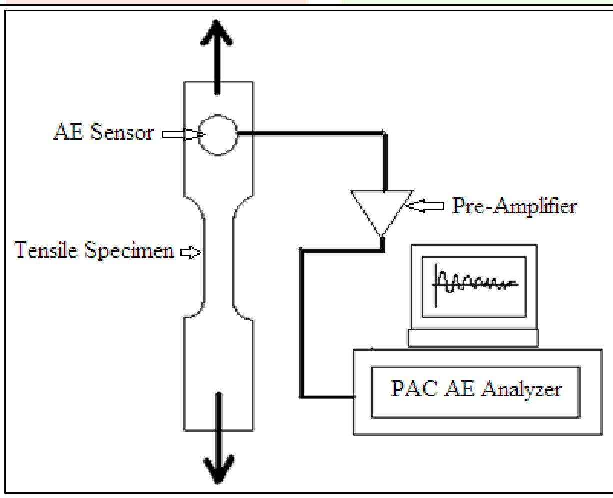

Fig.1 AE Data Acquisition setup

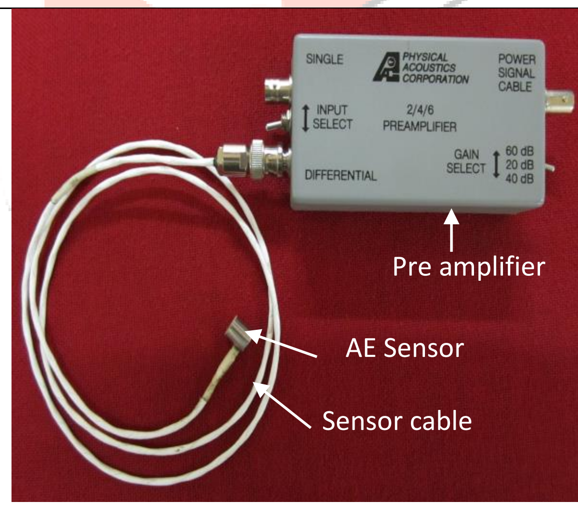

Fig.2 PAC AE sensor with preamplifier

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 of specimens are shown in Fig 3, three specimens were tested, and the best one selected and load vs. displacement curve as shown in Fig.4. 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)

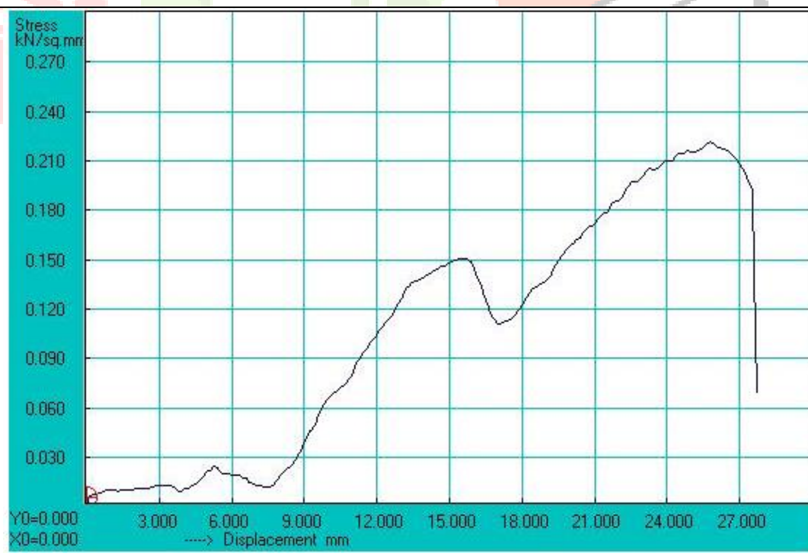

Fig.4 Load vs Displacement curve of AA7075 alloy specimen

3.2 ACOUSTIC EMISSION SIGNAL MONITORING

3.2.1 AE Parametric Analysis

Acoustic emission parameters like AE count, AE RMS, Amplitude and AE hits are monitored during tensile testing of AA7075 Al alloy and shown in Fig.5. From figure acoustic emission parameters clearly indicate different regions of initial loading, elastic region, plastic region and final fracture of tensile specimen. In Fig.5 the AE responses is represented in terms of AE counts, AE Rms, Amplitude and AE hits with respect to testing time for AA7075 Al alloy material. Four stages until failure are visible.

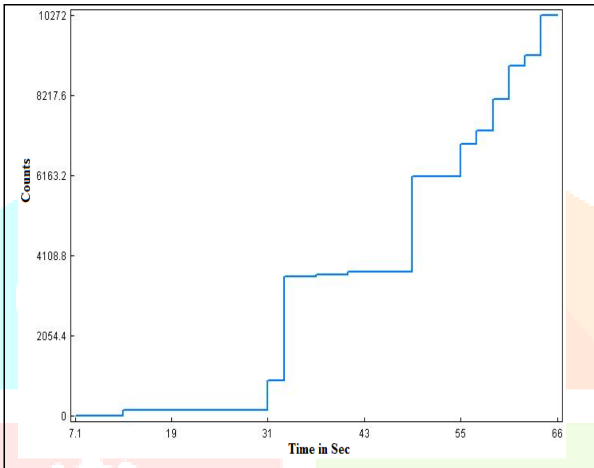

Fig.5 (a) Counts

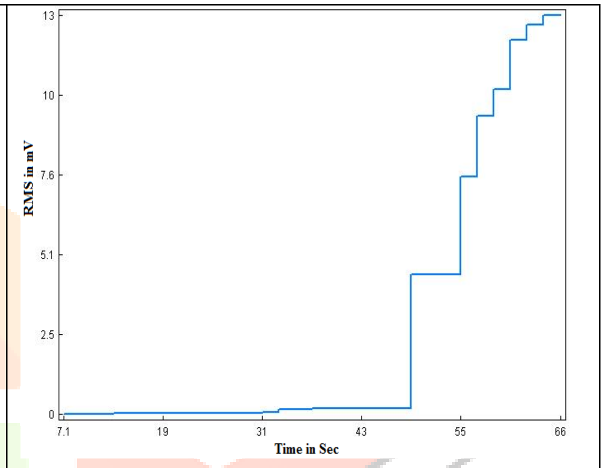

Fig.5 (b) RMS

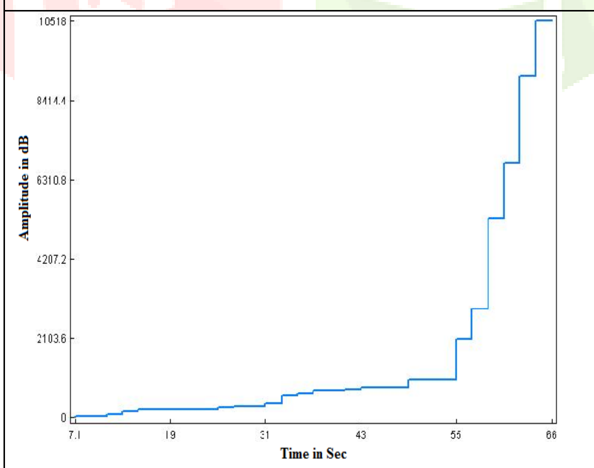

Fig.5 (c) Amplitude

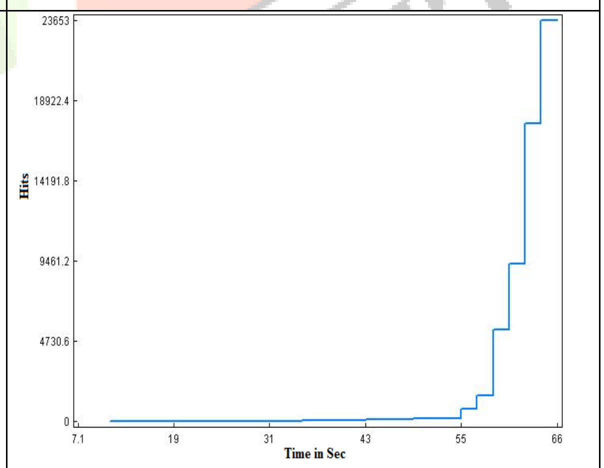

Fig.5 (d) Hits

Fig.5 AE parameters vs Time during tensile testing of AA7075 Al alloy

The first stage corresponds to the initial stage of loading, up to 13 seconds, the variation of counts, AE Rms, amplitude and hits vs. time is almost flat, which indicates initial loading

[12]. The second stage of elastic region occur due to damage accumulation in which the martial micro cracking progress: this is indicated by a sudden and abrupt increase in counts to peak, AE Rms, amplitude and hits. Third plastic region followed by elastic region and yield point where micro and macro cracking progresses AE signal drop significantly when it starts to enters plastic region (no change AE signal almost flat). The final sharp increase in the counts to peak, AE Rms, amplitude and hits is deemed representing rupture point during testing (final sharp increase of AE signal).

4. CONCLUSIONS

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

1. AE parameter of Counts, AE Rms, Amplitude and AE Hits clearly indicate different regions of initial loading, elastic, plastic and fracture of AA7075 Al alloy specimen during tensile testing.
2. It was found that the acoustic emission phenomena in tensile test was very active in elastic region, drop significantly when it starts to enters plastic region and increase rapidly at fracture during tensile testing of a AA7075 Al alloy.

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