Experimental Investigation Of Tensile Parameters With Online Acoustic Emission Testing On Al6061 Matrix Composites Using Stir Casting

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ABSTRACT

Metal matrix composites are used in ships, aerospace, nuclear, biotechnology and sporting goods fields. In this present work an attempt has been made to investigate the metal matrix composite using Al6061 T6 as matrix reinforced with TiB_2 particles and graphite particles using stir casting method. In these reinforced particles is varied by (0, 3, 6 and 12) weight percentage of TiB_2 and (0, 3, 6 and 12) weight percentage of graphite particles. The objective is to establish the damaged defects on metal matrix composites by using Acoustic Emission Technique. Fatigue test were carried out to initiation of cracks in composite materials subjected to cyclic loads. Finally the AE data were analyzed to the damage mechanism to identify the failure modes in composite material by using ANSYS software.

Keywords: *Acoustic Emission, Fatigue, Metal Matrix Composites,*

1. Introduction

Nowadays the composite materials in engineering applications have been increased gradually. The main advantage of this metal matrix is good strength, hardness and more life time. Metal matrix composites which are used in aerospace, automotive and agricultural etc. Aluminum Matrix Composites (AMCs) are light weight metals titanium and its alloy are more resistant to corrosion in reducing mineral acid solution. Acoustic Emission Technique is a relatively recent entry into the field of NDT method. In this method is used to identify the failure part of the materials. It can detect the different types of defects in metals like dislocation, movement of materials, plastic formation, yield fatigue cracking, boiling friction, mechanical impacts etc.

In this present paper is to investigate the tensile stress using online acoustic emission monitoring. These materials are made up of aluminum matrix composites with varying percentage of TiB_2 and graphite particles by stir casting process. Fatigue test were also carried out for long life of the material and good strength. Tensile tests on the prepared composites were conducted along with online AE monitoring. The sound waves were created when the material will be damaged. In this

AE signals such as HITS, Time, Amplitude, and RMS were used to analyze the tensile behavior for different combination of $AlTiB_2$ and graphite. AE signals were analyzed by the voltage, time, power and frequency in wave forms.

2. Experimental

2.1 Specimen and Materials

Metal Matrix Composites were prepared according to ASTM standard size. In this materials were prepared with Al6061 T6, varying weight percentage of TiB_2 (0%, 3%, 6%, and 12%) and Graphite particles. In this matrix material provides good combination of strength. The chemical composition of aluminum matrix is 95.8 % aluminum, 0.8% Mg, 0.4% Si, 0.04% Cr, 0.15% Mn, 0.15 %Ti, 0.15% Cu, 0.25% Zn, 0.7% Fe, and 0.05% others.

Fig: Al6061 T6

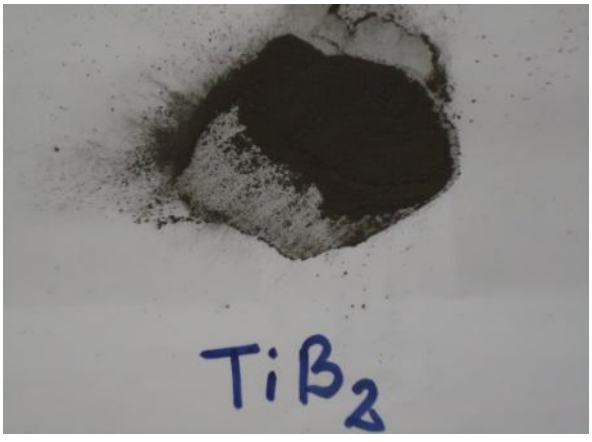


Fig: TiB_2 as Reinforcement

Fig: Graphite particles

2.2 Preparation of the composite

Stir casting method was used to prepare the composite specimens. In this process, matrix alloy Al6061 was heated its melting temperature (660°C-680°C) to keep semi mould condition and TiB_2 particles preheated at 900°C. Then the preheated particles were added to the semi mould matrix with graphite by stir cast method. The stirring was continued for 7 min at average speed of 300 rpm. Finally the mould poured into the required specimen size as 16 mm diameter and 140 mm length.

Fig: Stir Cast Setup

2.3 Experimental Procedure

Metal Matrix Composites were prepared according to ASTM standard size. In this present work, tensile tests on specimen with varying weight percentage of TiB2 and Graphite of 80 mm gauge length have been prepared. The mechanical properties of matrix material have been studied in a tension test on 16 mm diameter and 140 mm length by prepared specimen. Tensile test have been conducted on the different combinations of specimens. These test were conducted using servo controlled Universal Testing Machine. This test was performed on ductile materials to determine tensile properties.

Fig: Tensile Test Setup

2.4 Acoustic Emission

In this AE test was conducted by Auto Sensor Testing (weight 5 gm), resonance frequency at 250 KHz. It was tested in the prepared composite materials at 65°C to 175°C. The Acoustic Emission sensor type is Piezoelectric –Micro80 model. A 4 channel online Acoustic Emission setup was used for detect the failures in materials. In this test, AE sensor is fixed on the middle point of the specimen to analyze the failure modes in materials.

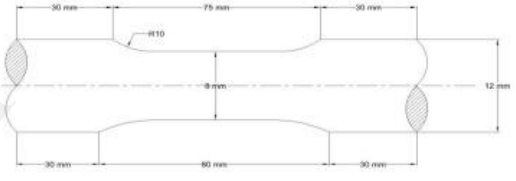


Fig: Acoustic Emission Test specimen

Fig: Acoustic Emission Test Setup

AE sound waves were produced on the prepared tensile test specimen. The AE test threshold was set to 40 dB for all combination of AE specimen from the noise on breaking material. Then the acoustic data's were monitored by online AE setup.

2.5 Fatigue Test Setup

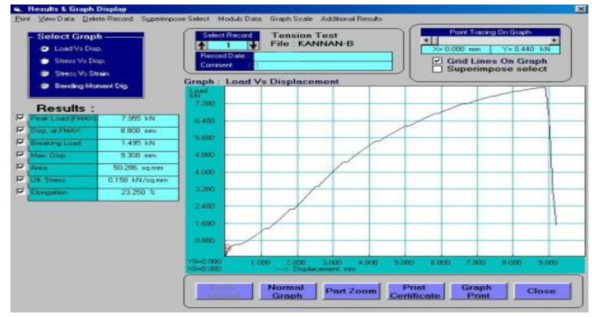
In this Fatigue test was done by INSTRON Servo Hydraulic machine for testing specimen subjected to cyclic loadings. If a material is repeatedly loaded and unloaded at say 85% of its yield strength, it will ultimately fail in fatigue if it is loaded through enough cycles. In this test 125 MPa stress was applied to all combination of specimen. Then the test was done by fluctuating loads.

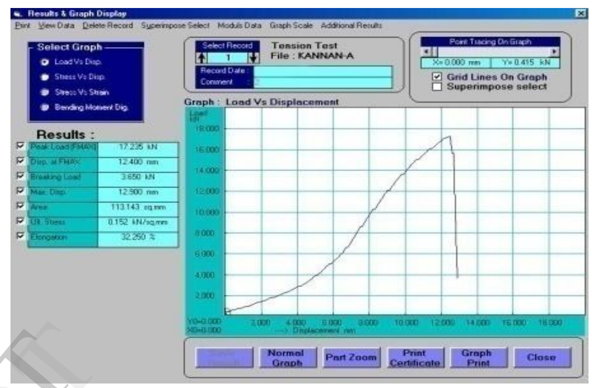
Fig: INSTRON Servo Hydraulic setup

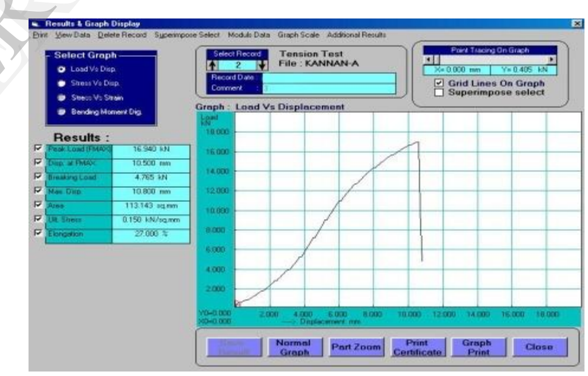
3. Results and Discussion

3.1 Effect of Tensile test

The tension test was conducted to determine the tensile properties by the prepared specimen. The results of tensile test are shown below.







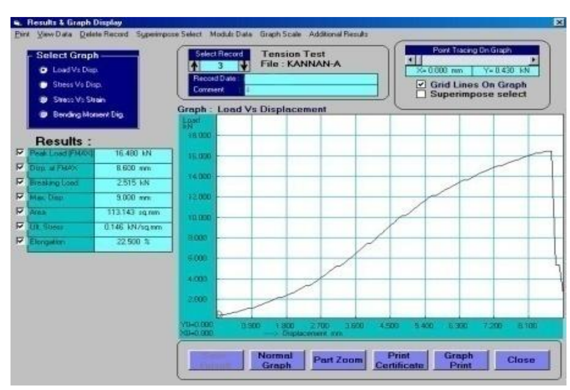


Table 1: Tensile Test Result (Al-TIB2)

SINO	DESCRIPTION	Al-0% TiB_2	Al-3% TiB_2	Al-6% TiB_2	AL-12% TiB_2
1	Peak load (KN)	7.955	17.235	16.940	16.310
2	Ultimate stress (KN/sq. mm)	0.158	0.152	0.150	0.144
3	Elongation (%)	23.25	32.25	27	26.5
4	Breaking load (KN)	1.495	3.650	4.765	3.945

In this graph represents that the displacement is plotted in x-axis and load is plotted in y-axis. In this graph is explained the detail stresses and the properties of tension test. From this result, the yield point, maximum tensile strength, breaking strength and % of elongation were measured.

SNO	DESCRIPTION	Al-3%TiB_2 + 3% Graphite	Al-6% TiB_2+ 6% Graphite	Al-12% TiB_2+ 12% Graphite
1	Peak load(KN)	8.590	8.605	17.305
2	Ultimate stress (KN/sq.mm)	0.171	0.171	0.153
3	Elongation (%)	17.50	19.0	24.0
4	Breaking load(KN)	1.151	2.480	3.075

Table 2: Tensile Test Result (Al-TIB2 - Graphite)

3.2 Effect of Fatigue Test

Fatigue test was done on the prepared specimen by INSTRON servo hydraulic machine. In this test the cracks as a result of repeated stresses applied below the ultimate strength of the material. The result of Fatigue test is shown below.

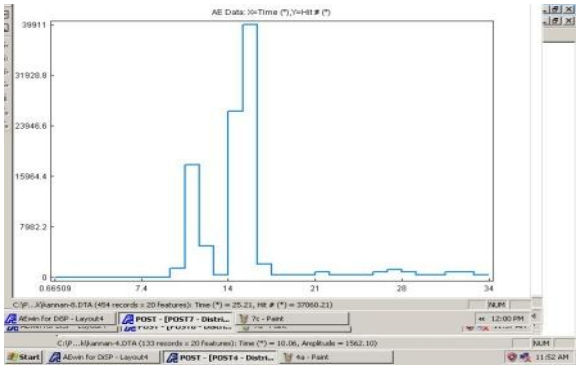
SINO	COMPOSITION	PRESSURE (MPa)	NUMBER OF CYCLES
1	Al-0% TiB_2	125	13920
2	Al-3%TiB_2	125	48037
3	Al-6% TiB_2	125	72132
5	Al-12% TiB_2	125	36420
6	Al-3% TiB_2 + 3%Graphite	125	100594
7	Al-6% TiB_2+ 6%Graphite	125	100495
8	Al-12%TiB_2+ 12%Graphite	125	45445

Table: Fatigue Test Result

As one would expect, the result clearly shows that a low number of cycles are needed to cause fatigue failures at high stress levels while low stress levels can result in sudden, unexpected failures after a large number of cycles.

3.3 Effect of Acoustic Emission Test

From this test, Acoustic Emission is the sound waves produced when a material undergoes stress, as a result of external force. The result of Acoustic analysis was shown in below. In this data, Time is plotted in X-axis and Hits is plotted in Y-axis. When a load is applied to the test specimen beyond its elastic limit it tends to degrade.


AE Data: X=Time (*),Y=Hit # (*)
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7982.2
0
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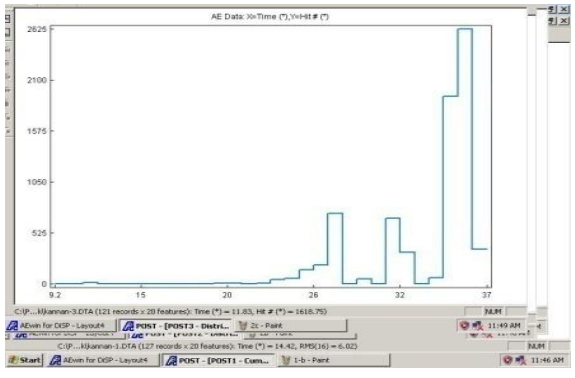
7.4
14
21
28
34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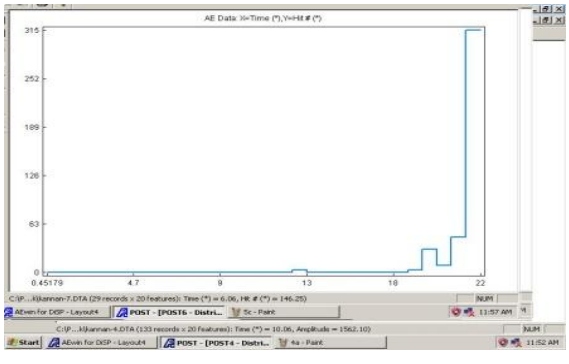
1050
525
0
9.2
15
20
26
32
37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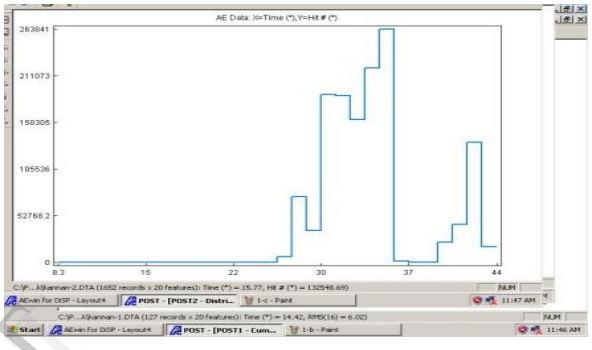
126
63
0
0.45179
4.7
9
13
18
22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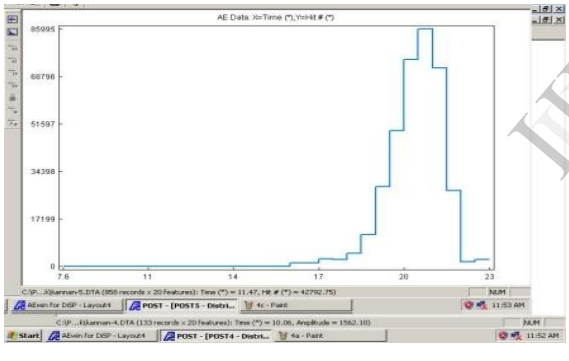
211073
158305
105536
52768.2
0
8.3
15
22
30
37
44


AE Data: X=Time (*),Y=Hit # (*)
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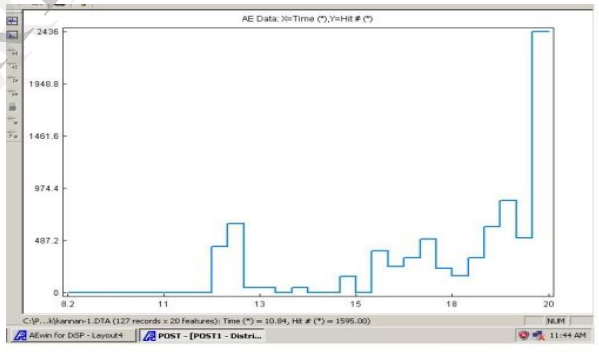
51597
34398
17199
0
7.6
11
14
17
20
23


AE Data: X=Time (*),Y=Hit # (*)
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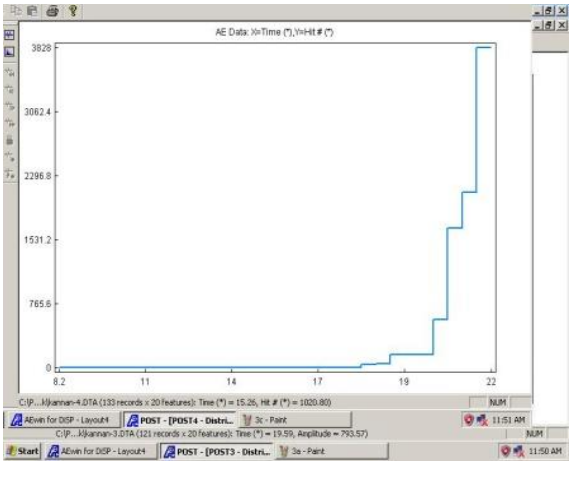
974.4
487.2
0
8.2
11
13
15
18
20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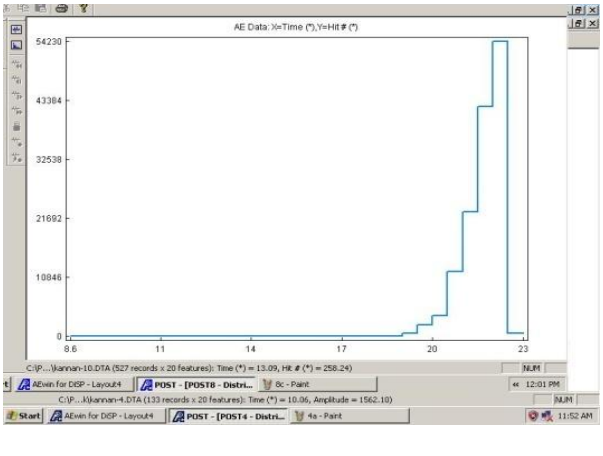
11
14
17
19
22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11
14
17
20
23

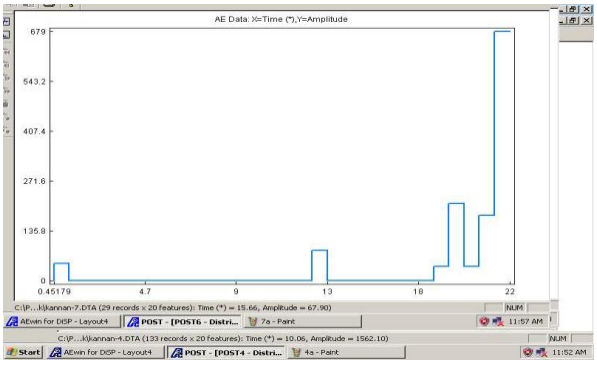
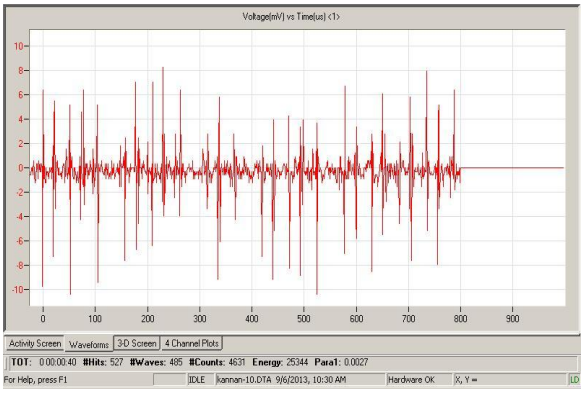
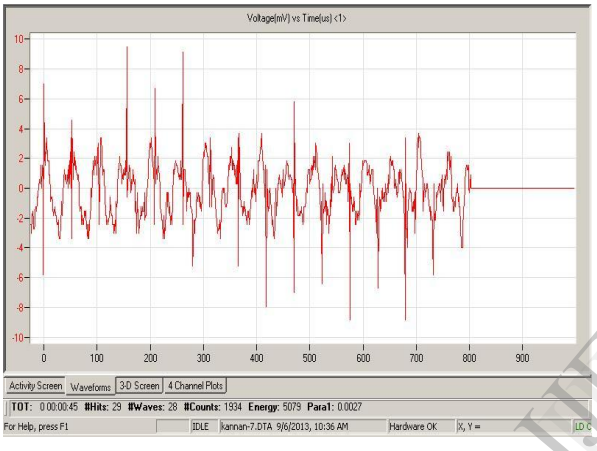
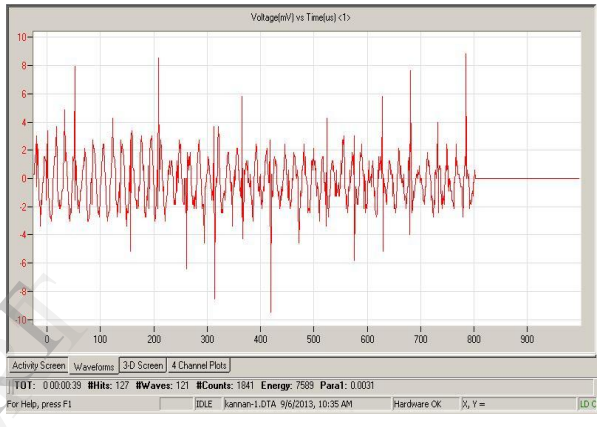
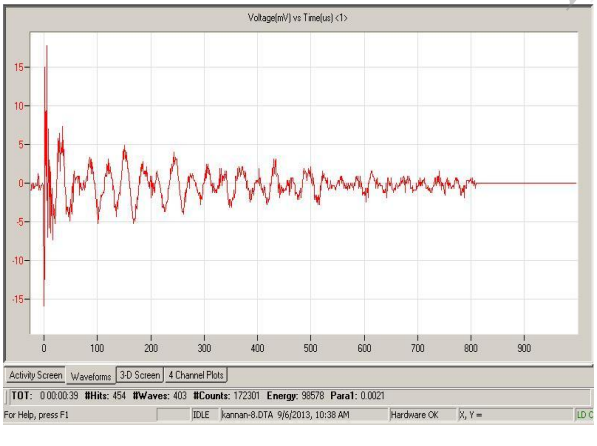


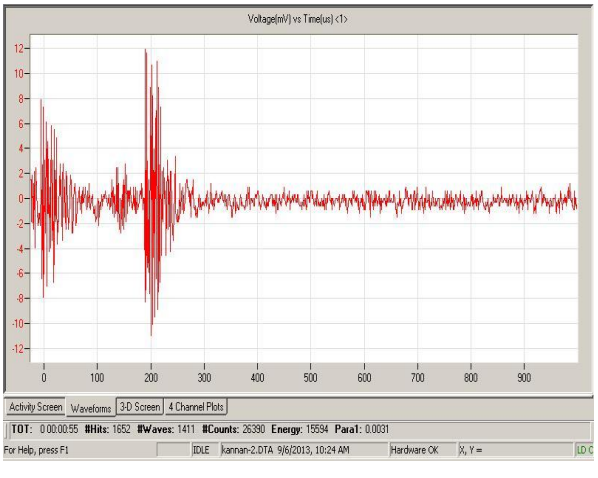
Fig: AE Result data (Time Vs Hits)











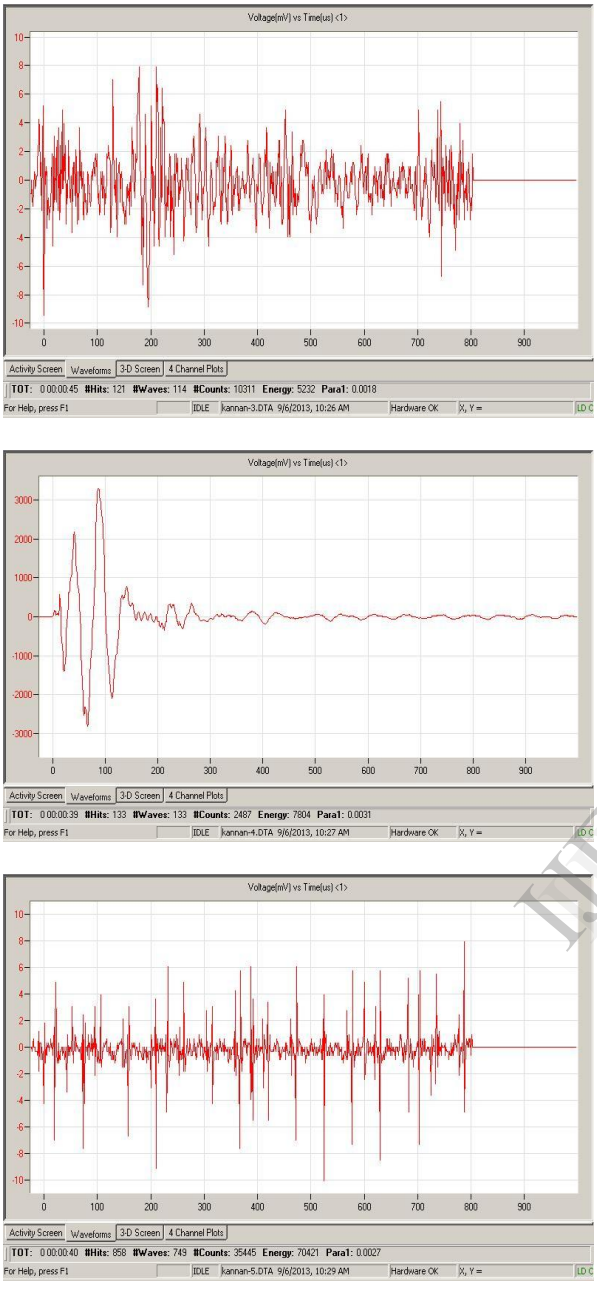


Fig: AE Result- Waveform (Voltage Vs Time)

4. Conclusions

Tensile tests on composite material were performed on different combinations of specimen and analyzed by online AE monitoring. In this resonant sensor of AE in materials was analyzed the different failure modes based on Hits, Amplitude, Time and Counts. These parameters are used to identify the failure parts using analysis software. AE data represents the real time record of progressive damage dislocation of materials and bonding materials.

In this fatigue tests, whereas in the results of test specimens aluminum with TiB_2 the fatigue life is longer than Al6061, 3% TiB_2 with 3%Graphite specimen.

Finally the graphite reinforcement added composition of specimen has the good tensile strength, hardness and long fatigue life.

5. Acknowledgements

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