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EVALUATION OF ACOUSTIC EMISSION BEHAVIOR UNDER HYDROSTATIC TEST IN API 5L X70 STEEL PIPE

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ABSTRACT

Acoustic emission is a very important test among non-destructive tests, and it has been applied for the detection of failures in various types of equipment in the petroleum industry, such as pressure vessels, tanks and pipelines. This paper presents the investigation of AE behaviour during tensile deformation and hydrostatic test of API 5L X70 steel which was widely used as oil and gas pipe material. Results indicated that AE phenomena was very active during elastic region. Detail analysis been done in elastic region, it was found that AE amplitude and energy gave small value during initial portion of elastic region and reach the peak value in the second stage just before yielding occurs. Load tensile test and pressurize in pipe were performed and measurements were made over the entire stress range in order to determine the stress-dependence of acoustic activity.

Keywords: Hydrostatic, API 5L X70, Tensile Deformation, Acoustic Emission

INTRODUCTION

The acoustic emission (AE) method detects elastic waves generated by micro-scale internal destruction in materials and can monitor damage of materials. Conventionally, many pressure parts were inspected by visual inspection technique during hydrotest or pneumatic test. But, this technique only provides information about blowing up, leakage and noticeable deformation without any indication of whether defect had been initiated or expanded during test, which later may cause failure of such pressure parts (Vallen, 2006). The acoustic emission (AE) technique seems to be a very appropriate tool to detect in situ information about the damage occurring during mechanical testing. Acoustic Emission is the phenomena where transient elastic waves are generated by rapid release of energy from localized source within a material. Sources of acoustic emission from micro activities in materials include dislocation motion, plastic deformation and yielding, deformation twinning, fracture of inclusion, and micro-crack initiation (Kalyanasundaram et al., 2007).

AE technique becomes the most appropriate inspection technique because of its capability to detect macro and micro activity in such components. Thus, it is important to understand the AE behavior starting from elastic until yield point also is also crucial because in engineering design, no components are allowed to reach this point when operating. The main objective is to investigate the acoustic emission behavior during tensile deformation and hydrostatic test of API 5L X70 steel which was widely used as oil and gas pipeline material. Correlation between Acoustic emission parameter, such as amplitude and energy during overall deformation will be discussed briefly before detail analysis in elastic region will be done.

METHODS AND MATERIALS

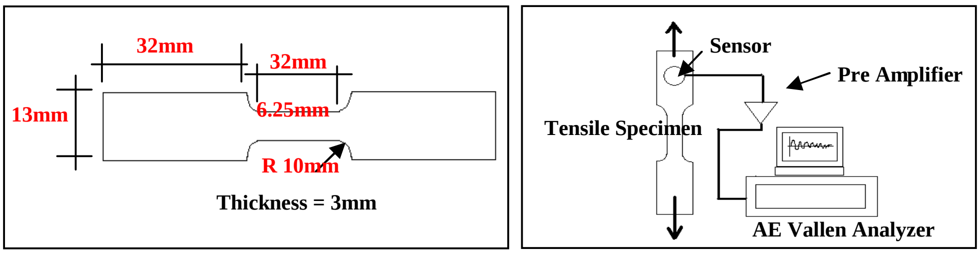
The object of study was specimens of steel API 5L X70, which were machined from real pipeline with diameter 914mm and wall thickness 12mm. API 5L X70 steel test coupon with chemical composition as shown in Table 1 were taken at the end of pipe portion in longitudinal direction.

Table 1: The chemical composition of API5LX70 steel. (all in wt.%)

C	Si	Mn	Cr	Mo	P	Ni	S	V	Ti	Cu
0.14 2	0.40 0	1.57 6	0.02 5	0.6	0.01 7	0.0187	0.003	0.007	0.0475	0.0142

Tensile Test

The test coupon was machined by milling process into a plate and wire cutted to dimension referred from ASTM E8M standard. Figure 1(a) shows the dimension of tensile specimens and Figure 1(b) shows the experimental setup. Tensile testing was operated using Zwick/Roell Universal Testing Machine with strain rate of 1.25mm/min. During tensile test, acoustic emission signals were collected using wide band piezoelectric sensor with frequency range from 350 kHz to 2 MHz and sampling rate of 5MHz, was mounted on the specimen. Before each test, the calibration of the acquisition parameter was achieved by performing a pencil lead break (Beattie et al., 1983) procedure. Threshold level of 30.2 dB was selected after load is applied to dummy specimen in pre testing. Signals was amplified by preamplifier with 34dB gain and analyzed by AMSY-5 from Vallen System.



(a) (b)

Figure 1: (a) Dimension of tensile specimen (b) Data Acquisition setup.

Hydrostatic Test

The specimens used were built from pipe sections steel 8 inches in diameter and 8.12 mm thick. These sections were blind flange at their ends to form a closed volume that could be pressurized. The hydrostatic test medium for pipe systems shall be water.

Water injection by pressure pump can use to pressurize at a rate 7.5 psi/sec. The hydrostatic procedure as below;

i. Pressurize up to 500psi and hold pipe for 5min to visual leak check.
ii. Continue pressurize up to 1000psi and hold pipe for 5min to visual leak check, and
iii. Continue pressurize up to 1500psi and hold pipe for 2 hour to stabilization and holding period.

During hydrostatic test of steel pipe, acoustic emission signal were collected using wide band piezoelectric sensor with frequency range from 10 kHz to 1 MHz and sampling rate of 5MHz. It was mounted using vacuum grease and calibrated by pencil lead break test and shows the experimental setup in Figure 2. Threshold level of 25.7 dB was selected after load applied to dummy specimen in pre-testing. Signals was amplified by preamplifier with 34 dB gain and analyzed by AMSY-5 from Vallen System.

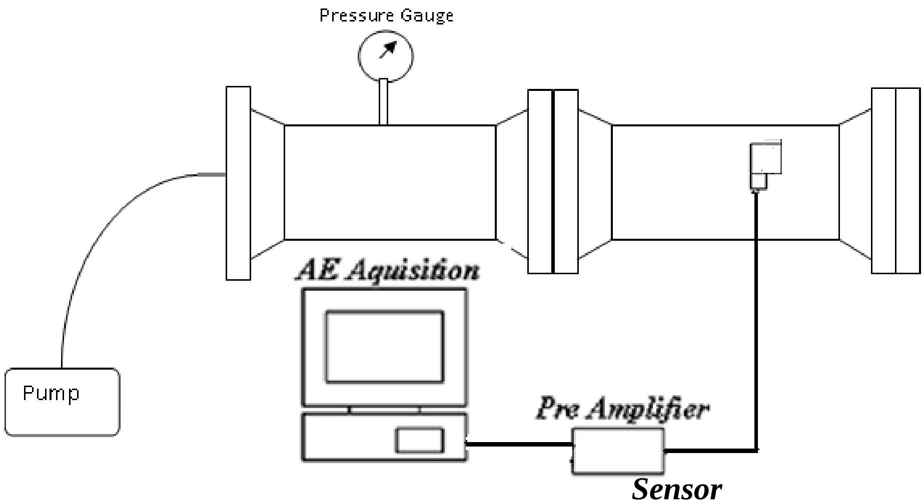


Figure 2: The experimental setups of hydrostatic test with AE Vallen system.

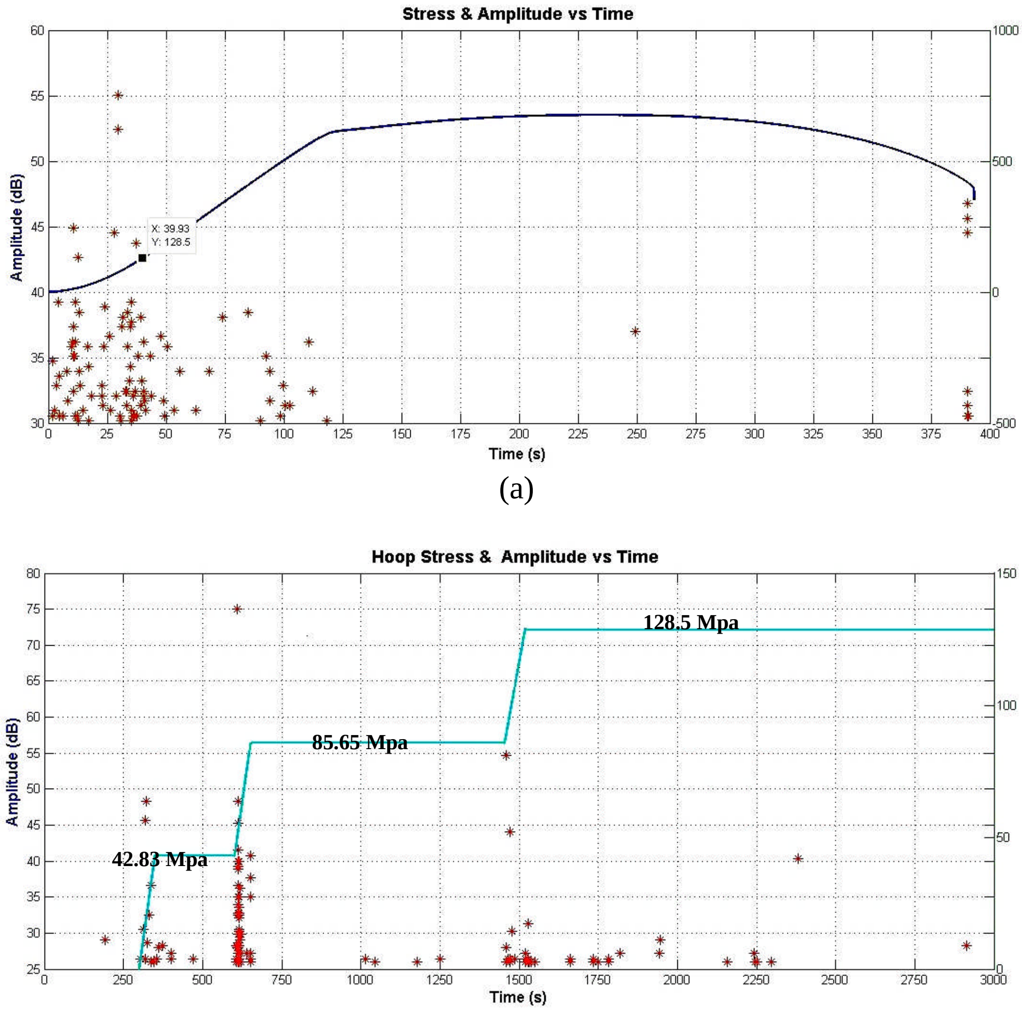
RESULTS AND DISCUSSION

Acoustic Emission Amplitude And Energy During Tensile Deformation and Hydrostatic Test

Correlation between stress/time/AE amplitude in tensile test and Hoop stress/time/AE amplitude in hydrostatic test is shown in Figure 3(a) and (b). While, stress/time/AE energy and Hoop stress/time/energy is shown in Figure 4(a) and (b), respectively. Acoustic emission shows a significant activity during elastic deformation as AE amplitude and AE energy increase. Only small activities appear when the deformation enters the plastic zone in stress-strain tensile test and holding time pressurized in hydrostatic test in pipe. AE activities increased rapidly during rupture in tensile test and continue pressurize up in hydrostatic test. Similar pattern have been shown by (Yoshida et al., 1997). The tensile results of API 5L X70 steel pipe is tabulated in Table 1.

Table 2: Tensile result of API 5L X70 steel pipe.

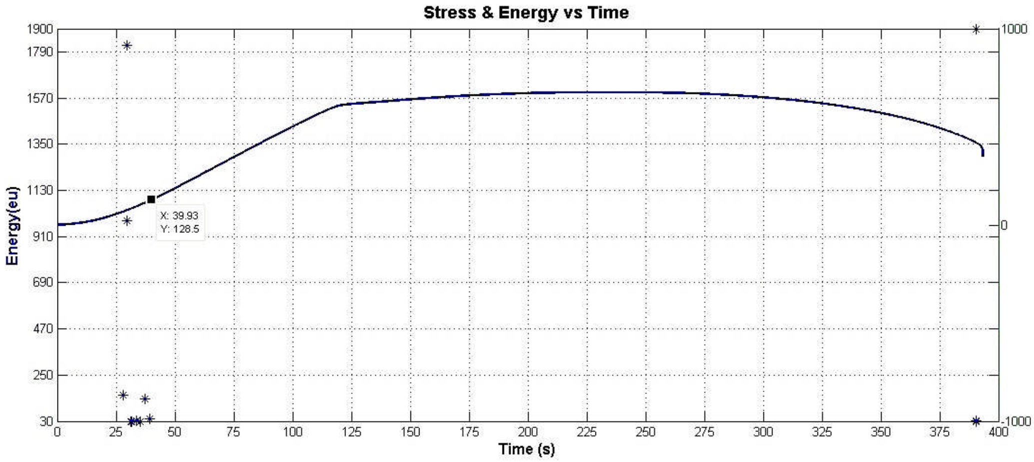
Test No.	0.02%Yield	UTS	Fracture
	Mpa		
1	657	707	377
2	657	708	365
3	638	692	368



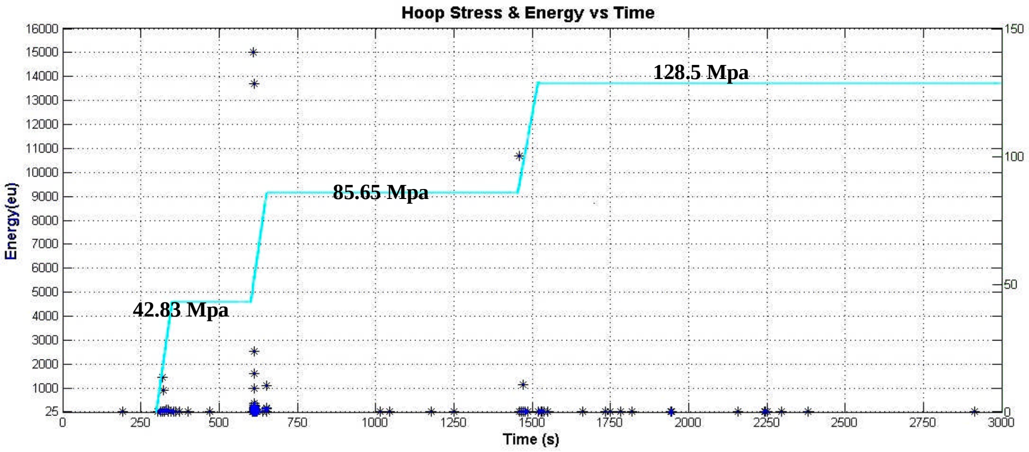
(a)

(b)

Figure 3: (a) AE Amplitude during tensile deformation (b) AE Amplitude during hydrostatic test.



(a)

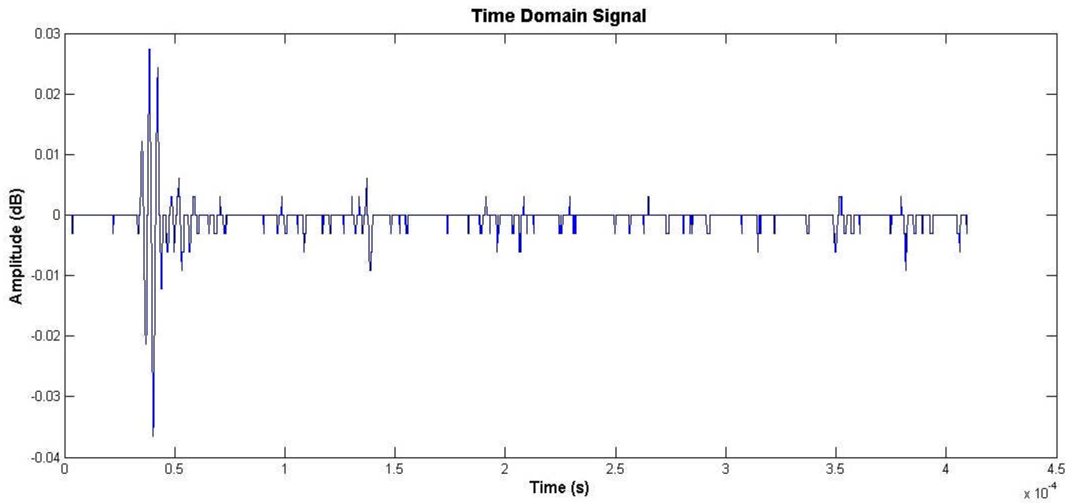


(b)

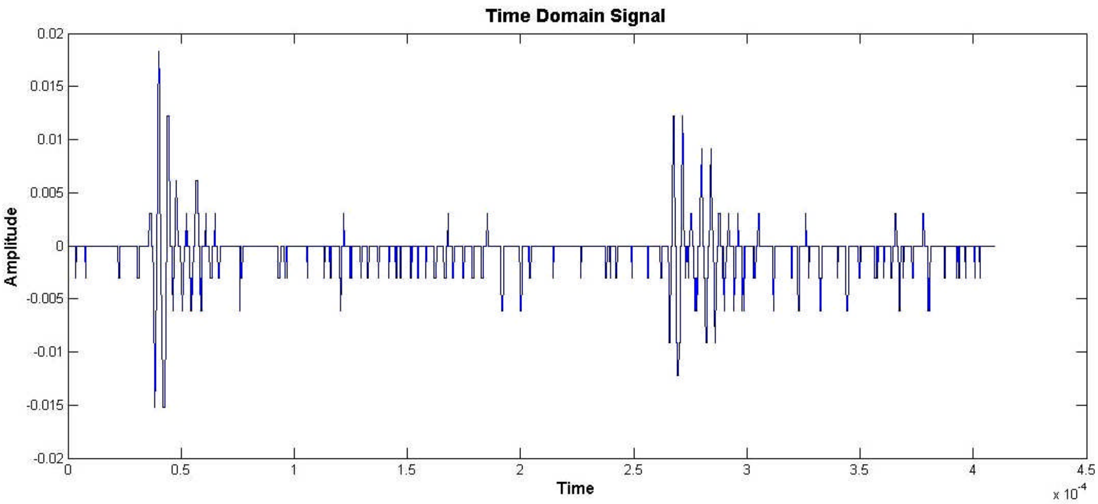
Figure 4: (a) AE Energy during tensile deformation (b) AE Energy during hydrostatic test.

Acoustic Emission Amplitude During Tensile And Hydrostatic Test

Correlation between AE amplitude (Amp: 31.32 (dB), Stress 92.7MPa) in tensile deformation and AE amplitude (Amp: 26.43 (dB), Hoop stress: 89MPa) during hydrostatic test as shown in Figure 4. The initial portion of elastic region, appearance of burst type AE signals as shown in Figure 5(a) and (b) were dominates. The burst type AE signals have a short duration and this phenomenon lead to the small values of AE amplitude. Small AE energy also obtained because those values were proportional to square of the amplitude (Baranov et al., 2007). As the result shown that, AE amplitude in both test have a same type burst test in the stress range between 89 to 93 MPa. Figure 5(b) shown that continuous waveforms builds from the combination of burst type signals and has a long duration. The plastic deformation of individual crystal occurred when total deformation is small and the metal is in elastic region from phenomenological viewpoint.



(a)



(b)

Figure 5: Two types of Acoustic Emission signals appears during elastic deformation (a) Burst signal during early elastic deformation (b) Burst signal during hydrostatic test.

CONCLUSION

Acoustic emission behavior during tensile deformation of API 5L X70 had been discussed. 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 rupture point. While, in hydrostatic test was very active in pressurize up and low active in holding time. Analysis of AE behaviors during elastic deformation of API 5L X70 also been done. During initial portion of elastic region at stress range between 89 to 93Mpa in both test, AE amplitude and energy was very small and appearance of burst type waveforms were dominates.

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