Acousto-ultrasonic method for defect detection in epoxy adhesive joints

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ABSTRACT

An Acousto-ultrasonic (A-U) method was developed for defect detection in epoxy adhesive joint. The test method as well as test results showing the defect detectability are presented.

KEYWORDS: Adhesive joint, bonding defect, LNG Carrier

1. INTRODUCTION

The maritime transport of the liquefied natural gas (L.N.G.) is realized by specially designed vessels containing adiabatic tanks equipped with a thermal insulation system called Cargo Containment System (C.C.S.).

Mark III is membrane type C.C.S., manufactured by Samsung Heavy Industries (S.H.I.), where the heat insulation is ensured by two spaces, separated by a composite membrane called secondary barrier.

The secondary barrier is composed of two main components rigid and supple triplex assembled using epoxy glue.

Figure 1 presents a cross section showing the different elements of M III C.C.S.

In order to fulfill its role of barrier the secondary membrane must be liquid tight and ensure the containment of the liquefied gas in case of failure of the primary barrier..

The tightness of the secondary barrier is evaluated by a pressure tests performed after the first thermal cycle and regularly during the ship operations. In case of secondary barrier failure the ship is stopped and repaired in order to guarantee the safety of the ship

This paper presents an Acousto-ultrasonic method developed in order to detect bounding defect during construction with the aim to enhance the second barrier bonding properties and to reduce the costly and time consuming repair operations.

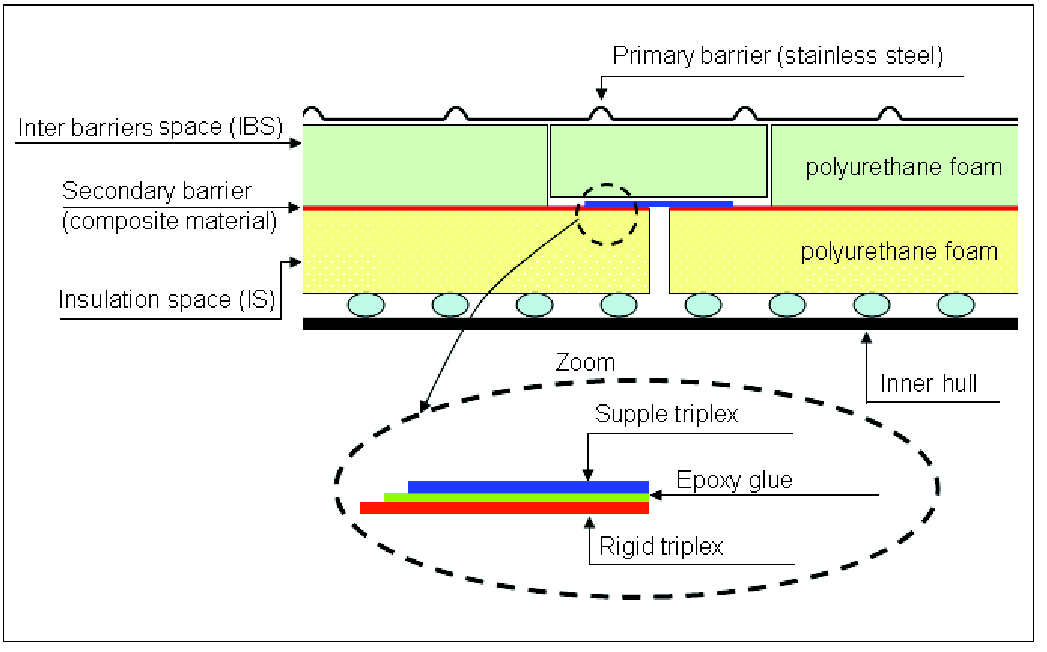

Figure 1: Cross section of MIII C.C.S

2. PRINCIPLE

Acousto-ultrasonic (A-U) technique utilizes two ultrasonic transducers to evaluate the mechanical condition of a specimen.

An ultrasonic wave is produced at a point of the inspected specimen using a sending transducer; this wave propagates and reaches a receiving transducer placed on another point of the test specimen surface. The analysis of the received wave can provide information on the presence of defects between the two transducers [1,2,3].

In this study A-U was used to detect air bubble included in the epoxy adhesive joint.

2. EXPERIMENTS

The used test specimen are presented on figure 2: A commercially available supple triplex film manufactured by Hutchinson is glued using epoxy glue on a 200x300x200mm sample of polyurethane foam covered with a rigid triplex plate cut from a typical insulation panel used by S.H.I. ship yard for the Mark III C.C.S. manufacturing .

The adhesive joint was realized by qualified personnel using the standard procedure applied in S.H.I. ship yard: at the appropriate temperature, curing time and pressure.

The bonding defect was manufactured by placing a vinyl disc in the adhesive joint. This defect manufacturing method was chosen among other tested methods because it allows acceptable defect repeatability.

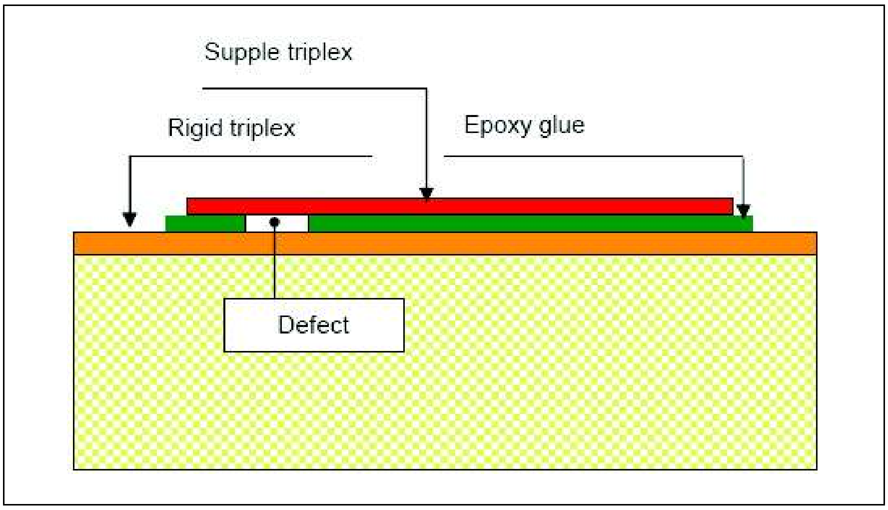

Figure 2: tested specimen

3. RESULTS

3.1. TEST ON SOUND SPECIMEN

In this first step wave attenuation in a non defected specimen was characterized. The wave amplitude was measured at 9 different positions on the surface of the supple triplex (figure 3) using P.A.C. Micros Samos acoustic emission system.

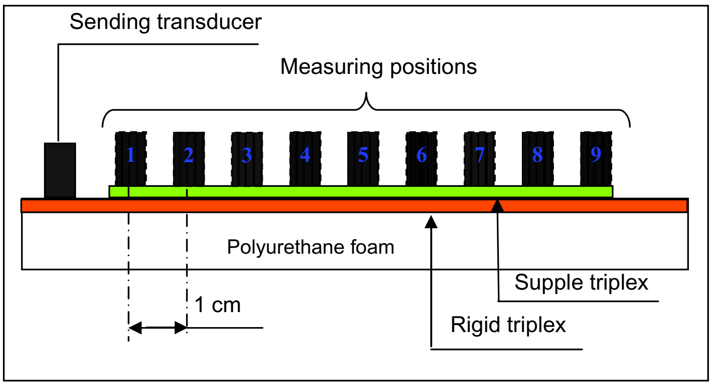

Figure 3: Wave amplitude measurement

The wave attenuation in the non defected adhesive joint was then calculated as following:

$$AS_i = A_1 - A_i$$

Where:
AS_i: Attenuation in sound specimen at the position i (i: from 2 to 9)
A_1: Wave amplitude at position 1[dB]
A_i: Wave amplitude at position I [dB]

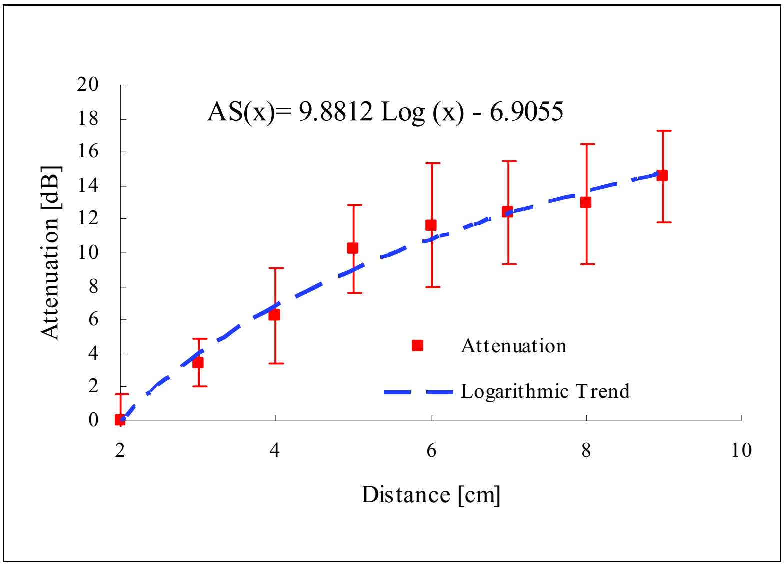

Figure 4: Attenuation curve

The attenuation curve resulting from twenty tests is presented on figure 4. It shows a logarithmic trend presented by the dashed curve: AS(x) = 9.8812 Log (x) - 6.9055.

As the standard deviation observed in all measurement positions was lower than 4 dB, an attenuation 4 dB higher than the AS(x) can be considered as a possible bonding defect indication.

3.2. TEST ON SPECIMEN WITH ARTIFICIAL DEFECTS

A specimen containing intentionally introduced artificial defects was tested.

The wave attenuation in the defected adhesive joint was calculated as following:

$$AT_i = A_1 - A_i$$

Where ATi is the wave attenuation in the test specimen at the position i (i: from 2 to 9)

And the evaluation criterion (Ev) was calculated as following

$$Ev = AT_i - AS_i$$

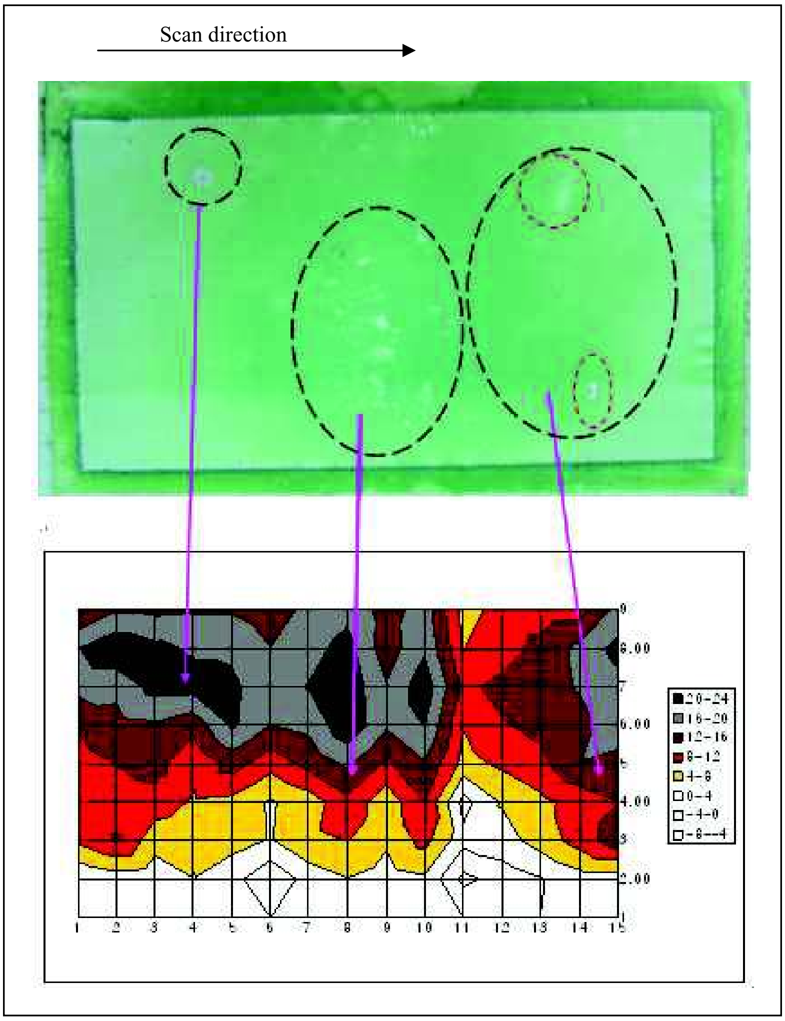

Figure 5: Comparison defect map tested sample.

Based on the standard deviation observed in non defected specimen's test an evaluation value (Ev) higher than 4 dB is considered as an indication of defect.

Figure 5 presents a picture of the specimen, after supple triplex removal, as well as a defect map presenting the obtained Ev in each position.

The comparison of the calculated defect map and the sample picture shows good defect detectability using the developed method.

4. CONCLUSION

The defect detectability on reduced size specimen was demonstrated. The design of an automated system and testes on full scale specimens are currently in progress.

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