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July - December 2017

Image

The Technical Bulletin of
Indian Society for Non - Destructive Testing
Thiruvananthapuram Chapter

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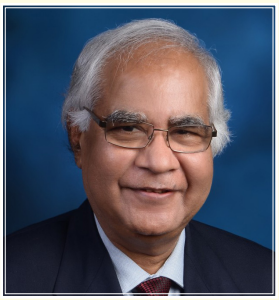
Remembering a Stalwart



Dr. Baldev Raj, Director of National Institute of Advanced Studies (NIAS), Bengaluru and former Director of Indira Gandhi Center for Atomic Research (IGCAR), Kalpakkam, sadly passed away in Pune in the morning of January 6, 2018, where he had gone to attend a meeting at the Centre for Materials for Electronics Technology (C-MET), Pune. ISNT Thiruvananthapuram Chapter expresses heartfelt condolences to the family and friends and colleagues of Dr. Baldev Raj.

Dr. Baldev Raj was always encouraging the activities of the Chapter and had been instrumental in making National Seminar NDE-2003 happen at Thiruvananthapuram. He enthused young engineers with his lucid lectures on materials and Non-destructive testing. His book "Practical Non-destructive Testing" is used in level certification courses in NDT. He was very friendly and had a down to earth approach to one and all in the Chapter. We pray for his soul to rest in peace and vow to carry on the activities in the field of NDT along his vision.

KR Mohan Ananthanarayanan
Editor

From Chairman's Desk...

Dear Friends,

At the outset, let me wish all our beloved members and family a very happy and prosperous new year, 2018.

Significance of NDE is ever increasing as more complex and critical subsystems are being demanded by Aerospace, nuclear, petroleum industries etc. Several novel technologies and automation are also being brought out by various equipment developers so as to enable fast tracking of the inspection as well as on site and in service inspection.NDT professionals need to be abreast with the latest developments in the field and should work as catalyst in the development of new technologies by giving constant feedback to the system developers. NDT professionals need to be well versed with the new developments and sufficiently qualified to improve the reliability of inspection itself. Our chapter has been contributing immensely towards this objective. Our experts are continuously engaging with the student community and sharing their knowledge. I am extremely happy to inform you that the two student chapters of ISNT Thiruvananthapuram formed at College of Engineering, Thiruvananthapuram and Government Engineering College, Barton Hill, Thiruvananthapuram are functioning very well. Two more student chapters at Sree Chitra Thirunal College of Engineering and Mohandas College of Engineering and Technology are to be inaugurated this month. I solicit your valuable suggestions and active support in making these student chapters function in an excellent way.

I am extremely happy to inform you that our proposal towards setting up of Skill development Centre on NDT is being pursued by the concerned government agencies and our experts are extending the necessary support.

Our chapter had good participation in NDE 2017 and it is very heartening to note that Shri S Harikrishna, CNDTD/ CMSE/ VSSC is honoured with the prestigious ISNT-NDTS award for system development. On behalf of ISNT Trivandrum chapter, I congratulate him for this achievement.

Our website is being updated regularly and I request all of you to regularly visit the site to be aware of the chapter programs and other related information. Your suggestions on improvement of the website are also solicited.

As a concluding remark, I would like to record my gratitude and congratulations to all the chapter members and Executive committee members for their active involvement to keep the chapter one of the most vibrant professional bodies.

I also thank the editorial team for bringing out this current issue of IMAGE and request all our members to contribute for the future issues.

Wishing you all the best,
G.Levin
Chairman, Trivandrum Chapter

Secretary's Report
July - December 2017

Inside Executive Committee

During this period, three EC meetings were arranged. Various programs like NDT courses in colleges, skill development program, technical lectures etc. were discussed. EC decided to conduct a mini seminar on NDE during June-July 2018. Two day workshop on NDT has been planned in March 2018. Student chapter inauguration was also discussed. An award proposal by our chapter was discussed.

Annual General Body Meeting (AGM- 2017)

Annual general body meeting and family get together- 2017 was conducted at Hotel Residency towers, Thiruvananthapuram on 22.07.2017. Shri. PA Suresh Babu, Chief Engineer (QA) delivered the MR Kurup memorial lecture on "Nuclear energy – An inevitable source of energy for future". The welcome address was delivered by Chairman, ISNT Thiruvananthapuram Chapter. This was followed by family entertainment programme and dinner.

Executive Committee of ISNT Thiruvananthapuram Chapter for 2017-2019:

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Dr. A Mujeeb, CUSAT

Dr. Biju Das, IIST

Dr. Bindhu KR, CET

Young Engineer's Forum

Young engineer's forum organized a Technical lecture at Trivandrum Hotel, Statue, Thiruvananthapuram on 26.10.2017. Dr. M. Nallaperumal, DGM, NDTF, VSSC and Shri Sambamurthy E, Engineer, NDTF, VSSC delivered a talk on the topic "PYRO DEVICES FOR SPACE: APPLICATIONS & NDT". 40 members attended the program.

Dr. M. Nallaperumal,DGM, NDTF, VSSC delivering a talk on "Pyro devices for space applications"

ISNT Team At NPCIL, Koodankulam

Industrial visit to Nuclear Power Corporation of India Ltd, Koodankulam, Tamil Nadu

A one day industrial visit to NPCIL, Koodankulam was arranged on 29.07.2017 for the members of ISNT Thiruvananthapuram Chapter. This was a second trip arranged by the chapter and 43 members from the chapter attended the visit. Presentations on plant activities were arranged at the venue.

Report on NDE 2017

- NDE 2017 was held from 14-16, December, 2017 at Chennai Convention centre and organized by ISNT Chennai Chapter. Three of our Chapter members, Shri G Levin, Shri Ravibabu Mulaveesala and Shri S. Harikrishna have been nominated to the National Governing Council of ISNT for the years 2018 and 2019. Shri Harikrishna attended the NGC meeting on 13/12/17 on behalf of ISNT Thiruvananthapuram Chapter.
- Shri S. Harikrishna of our Chapter from Composites Non Destructive Testing and analysis Division of Composites Entity, VSSC has been awarded the "ISNT National NDT Award" under the category of NDT Systems Innovation & Development jointly sponsored by ISNT & M/s. NDTS India (P) Limited, Navi Mumbai for the year 2017. The award was given away by the Honorable Governor of Tamil Nadu, Shri. Banwarilal Purohit at the inaugural function of NDE 2017 on 14.12.2017 at "The Chennai Trade Centre", Chennai. The award carries a citation and Rs. 20,000/-.
- The award was conferred to him for the realisation and establishment of Integrated Pulsed Thermography test facility at Composites Entity. This facility has an integration of technologies from France, USA, Germany and India. This enables testing of large composite structures in a non-contact mode. This facility is able to provide automation coupled with entire product visualisation and better defect detectability.
- A total of 10 delegates participated from ISNT Thiruvananthapuram chapter and many of them presented papers and posters. Our team also visited the exhibition stalls.

Shri. S Harikrishna receiving the award from Shri. Banwarilal Purohit, Honorable Governor of Tamil Nadu

ISNT Team at NDE 2017 Conference

ISNT Student Chapter Inaugural function at College of Engineering, Trivandrum

Student Chapter Activities

Two student chapters were inaugurated by Shri G Levin, Chairman, ISNT Thiruvananthapuram Chapter at College of Engineering, Thiruvananthapuram and Govt. College of Engineering Barton Hill. About 200 students joined the chapter. Shri Rajesh L, Joint secretary ISNT, Thiruvananthapuram is the focal point for the student chapter activities.

ISNT Student Chapter Inaugural function at Government Engineering College, Barton Hill, Trivandrum

CET Student Chapter Industrial Visit to Water Treatment Plant, Kerala Water Authority, Aruvikkara

One day workshop on NDE was conducted for the members of student chapter on 16.09.2017 at, College of Engineering, Thiruvananthapuram. About 100 members of student chapter from CET and GECBH, Thiruvananthapuram attended the workshop. Shri S. Saratchandran and Shri K. R. Mohanananthanarayanan delivered lectures in the workshop.

One day workshop on NDE conducted at College of Engineering, Trivandrum

Acoustic Emission Signal Characterization during Failure of Honeycomb Sandwich Panels

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Structural Engineering Entity, Vikram Sarabhai Space Center, Thiruvananthapuram

ABSTRACT

Honeycomb sandwich panels are widely used in the manufacturing of Aerospace components because of their high stiffness, good fatigue resistance and low weight. In launch vehicles, the sandwich structures are mainly used for the fabrication of Interstages, Equipment bay deck plates and heat shield applications. These sandwich structures undergo NDT checks mostly based on Ultrasonic testing (UT). Defects within the sandwich, such as skin/core interface debond, inclusions, core damages and voids are common deviations, which can be expected in the structure. Acoustic Emission monitoring, which is a global non-destructive testing method, is one of the most useful NDE technique used in metals and sandwich-composite structures. It's a powerful tool for detecting active defects and defect propagation in the structures in a loaded condition. This paper discusses the effectiveness of acoustic emission technique for distinguishing the initiation of defect or failure growth in honeycomb sandwich structures. AE monitoring was carried out during a four-point bending test of honeycomb sandwich specimens which are fabricated using a new indigenously developed adhesive system. The test was carried out to check whether the adhesive used sustained the loads till the skin or the core failed. The panels, which showed consistent behaviour in AE parameters viz. amplitude, duration, energy and counts during the initiation of degradation and subsequent failure. The threshold amplitude factor (THA) which is the ratio of threshold amplitude to peak amplitude of the AE event, is also found to be a better parameter that can be utilized for the health monitoring of sandwich structure. The results will help for the real time evaluation of sandwich structures using AE during load tests.

Keywords: Acoustic Emission (AE) technique, Honeycomb Sandwich Structures, Defect growth, Amplitude, Counts.

INTRODUCTION

The main advantage of using the sandwich panels for fabricating the structural components in launch vehicle are the high stiffness, good fatigue resistance and low weight. Recent advances in materials and manufacturing techniques have resulted in further improvements and the increased uniformity of the properties of sandwich composites [1]. Sandwich structures need very strict process adherence while fabrication or else may lead to defects like skin/core interface debond, foreign elements inclusions, core damages and voids and hence the NDT checks are mandatory for stage wise clearance. Mostly Ultrasonic testing (UT) or Shearography testing are using to detect the defects in Sandwich structures. The launch vehicle structures made with sandwich panels normally have to transfer axial load and to resist bending moment during flight. The real time NDT technique Acoustic Emission (AE) testing is one of the best-suited solution for detecting the initiation of debonds/failures and the growth of existing defects occurring in sandwich structures during load application and has a significant advantage over other NDT methods.

Acoustic Emission is the transient elastic energy that is spontaneously released when materials undergo deformation, fracture or both. In this technique, elastic waves generated from the material due to micro-processes will be captured using piezoelectric transducers mounted on the surface and by analyzing the data using a computer based system . Normally AE system uses piezoelectric resonant transducers which are highly sensitive in a limited range of frequencies but often with high sensitivity. AE provides the capability to monitor the entire structure by providing a global coverage by fixing sensors in an array. Since the velocity of AE waves are material dependant, the placement of AE sensors has to be decided based on the attenuation calibration studies. AE is being used in a large scale during the routine acceptance testing of metallic and composite launch vehicle structures and the real time evaluation is carried out based on an evolved acceptance criteria. AE principles of “Kaiser effect” and “Roll over” phenomena are commonly using for general AE evaluation. The AE energy corresponding to various failure modes of the material are distinct. To predict the nature of defect more precisely, the characterization of the various failure modes of the material needs to be carried out and thereby an acceptance criteria can be generated.

The characterization of various types of defect growth in the material is primarily carried out through the specimen level studies. AE behaviour of various AE parameters corresponding to yielding and crack growth in metallic materials and debonds, delaminations and the fibre breakage in composites can be studied through the specimen tests. In the case of sandwich structures no standard criteria is available for the real-time AE evaluation. There are two possibilities of failure in sandwich structures. In certain sandwich structures the core, the weakest member fails first and other possibility is the failure in the adhesive system which may detach and lead to de-bond and initiates between the skin and core. Subsequently buckling will occur in the de-bonded face-sheet resulting in an unsteady de-bond growth through the entire specimen width, causing gross loss of stiffness and the failure . This study is a preliminary step aimed for the generation of real-time criteria for the evaluation of sandwich structures. The study carried out on honeycomb sandwich panels during the four-point bend test with AE monitoring to capture the AE signals during the failure. Two specimens were tested, each with four numbers of AE sensors two each on either side of the specimen. The analysis of AE parameters is carried out in time domain and a good AE response has been observed from both the specimens during the course of failure. Literature reports that the threshold amplitude factor (THA) which is the ratio of threshold amplitude to peak amplitude of the duration of the event less than 0.7 indicate the failure in the sandwich structure. Correlation study carried out based on THA on both specimens indicated good correlation with failure and the THA for metallic honeycomb sandwich panels are generated and the details of the study carried out are presented in this paper.

Experiment details

The panel shown in Fig. 1. is 375 mm long, 50 mm wide and 62 mm thick. The panels underwent the four-point bend test in Lyod make UTM machine. The load was applied through the rollers provided on the top and bottom of the specimen as shown in Fig. 2.

Fig.1.Honeycomb Panel

Fig.2. Test Setup

The panels were instrumented with four numbers of 150 kHz resonant AE sensors as shown in Fig.3.

Highly viscous ultrasonic couplant was used to acoustically couple the sensor to the specimen. The sensors were connected to the AE system through preamplifiers. The data was acquired using Acoustic Emission Data acquisition system supplied by Physical Acoustic Corporation USA. A threshold of 35dB was applied for testing. The sensitivity of the sensors are verified through Hsu-Neilsen pencil 2H lead break calibration.

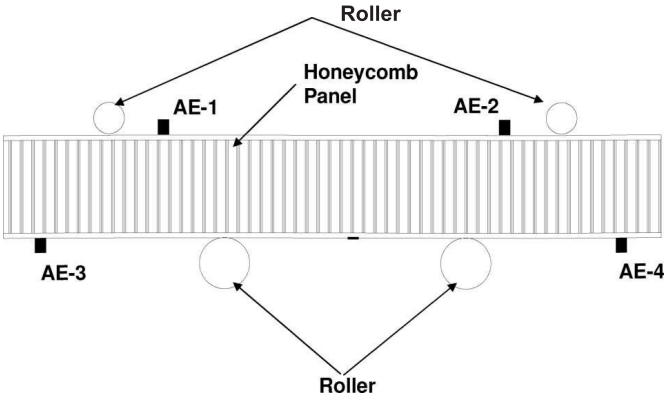
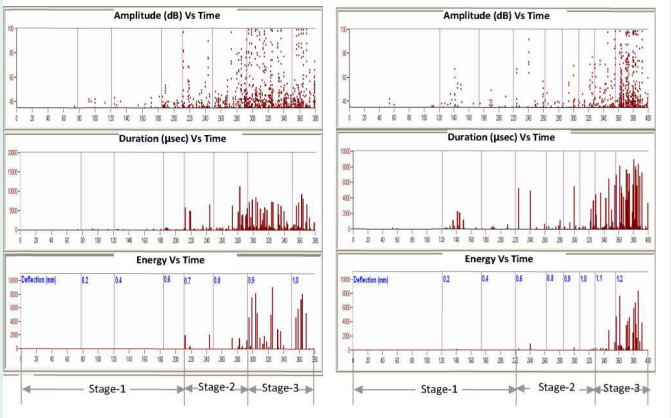


Fig. 3. AE instrumentation on HC panels during 4-point bend test

Results & Discussions

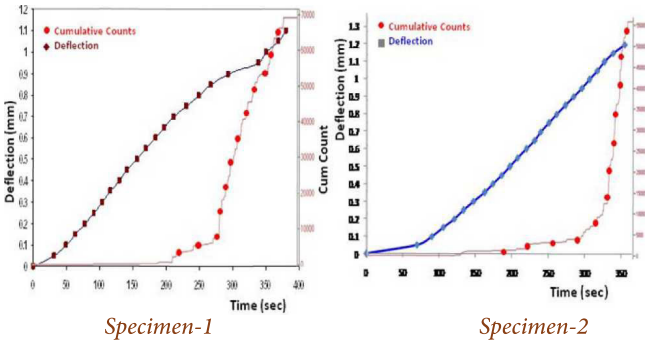
The analysis of acoustic events is carried out in time domain to understand the response of the specimen corresponding to the initiation and growth of degradation of the material. The behaviour of fundamental AE parameters like amplitude, duration, energy and counts are distinct during the course of failure of the specimens. Several methods are being used currently for correlating the AE with failure. The correlation study based on the value of THA shows a clear indication of failure initiation in both specimens. The trend in both specimens shows three stages of AE activity as shown in Fig.4. Feeble AE activity was observed upto 50% of total deflection. The specimens registered very less number of emissions upto a deflection of 0.7mm in case of first specimen while the second specimen similar behaviour was observed upto a deflection of 0.6mm and the magnitudes of the emissions are very low in nature. These emissions could be mostly due to the geometric corrections under stress and is safe zone of working.



AE data of Specimen-1 *AE data of Specimen-2*

Fig.4. Acoustic Emission data acquired during the 4-point bend test of Honeycomb panels

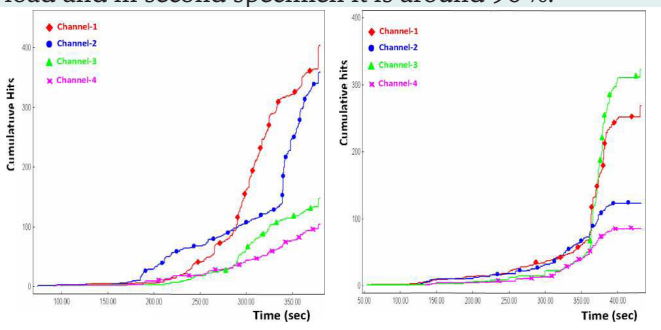
The initiation of intermittent emissions with higher magnitude was captured beyond 50% of total deflection is showing the initiation of micro-level activities in the sandwich specimen. There is a sudden variation AE parameters and the peak amplitude goes above 90dB and the duration is of the order of ~5millisec and energy is ~2000. An abrupt change in AE activity has occurred beyond 75% (~0.9mm) of total deflection as expected. The amplitude peaked to 99dB and the magnitude of duration and energy increased to ~8milli sec and ~8000 respectively. Audible sounds were heard at this period and specimens failed. The core crushing with local buckling of the skin is seen in post test inspection. The results show that the local core shearing occurred initially and the small incremental load on the specimen leads defect growth culminating in core failure.



Specimen-1 *Specimen-2*

Fig.5. Variation of Cumulative Counts with respect to deflection

The abrupt change in AE activity in the final phase is clearly seen in the cumulative AE counts shown in Fig.5. This is the third phase in which the small increments of core failure leads to the unstable growth which reduces the stiffness and thereby results in total failure. In first specimen the failure process took around 85% of failure load and in second specimen it is around 90%.



Specimen-1 *Specimen-2*

Fig.6. Individual channel cumulative AE hits with respect to time

The local failure of the first specimen occurred on the upper side near the centre towards channel-1 while in the case of second specimen, the failure occurred on both upper and lower faces of one side where AE sensors 1&3 where fixed. The individual channel plots of the cumulative hits as shown in Fig.6 clearly shows the regions where the trend change occurred on both specimens. This demonstrate the capability of AE to locate the region of

initiation of degradation. In specimen- 1, the cumulative hits shows higher values for sensor 1 & 2 and the slop of the curve first changed in sensor-1 and subsequently in sensor-2. This provides clarity in the detection of zone of failure initiation, which is on the top face and is towards sensor-1. In the case of specimen-2, the values peaked up for sensors 1&3 and the slope change occurred almost at an instant. This indicates that the failure happened on the top and bottom face of the specimen at one side, which is, confirmed in the post test observations.

1.1 The threshold amplitude factor (THA)

As per the literature, the threshold amplitude factor (THA) which is the ratio of threshold amplitude to peak amplitude of the AE event less than 0.7 indicate the debond growth and subsequent failure in the sandwich structure . The THA recorded by individual channel of both the specimens are shown in Fig.7 & 8. In the case of first specimen, the sensors 1&2 fixed on the top skin showing the events of <0.7 THA while in second specimen the sensors 1&3 showing the cluster.

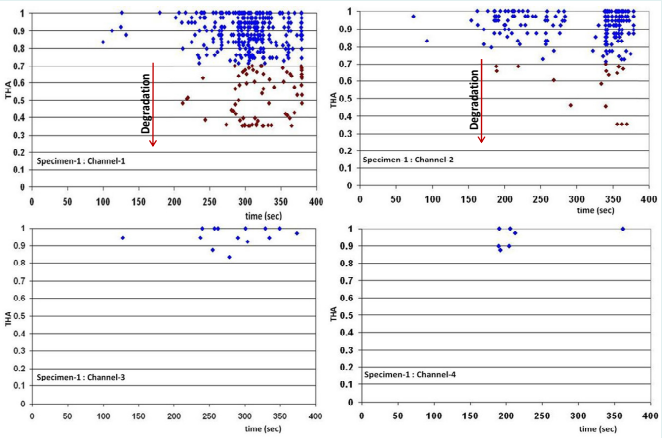


Fig.7. Threshold Amplitude Factor (THA) Vs Time - Specimen No. 1

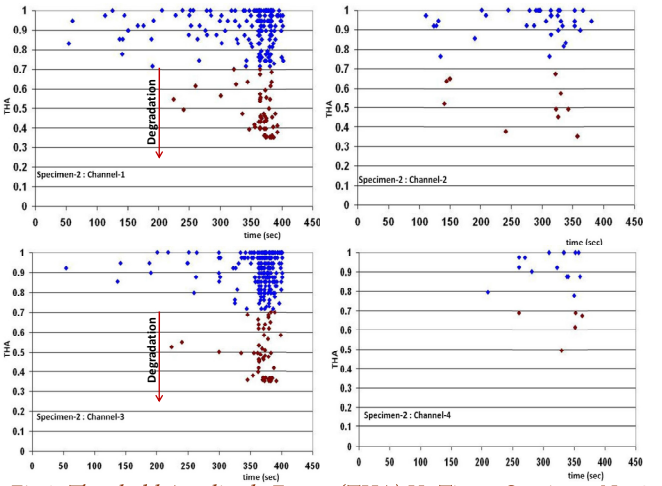


Fig.8. Threshold Amplitude Factor (THA) Vs Time - Specimen No. 2

The post-test NDT using Fokker Bond Tester showed that there is no debond growth in both specimens and based on post test observations, the failure is due to the core shearing which lead to local core crushing and subsequent failure. The overall failure process happened in the final 20% of total load and above 80% of total deflection. Corresponding trend variations are distinctively seen in AE parameters and which correlates well with the AE events having lower THA (<0.7). It is brought out from the results that the lower THA can be expected not only for debond growth but also due to the failure initiation in sandwich panels with good adhesive system due to core shearing.

The variation of AE energy with respect to THA is shown in Fig.9. There is an observable change in trend is seen in energy for THA less than 0.5. The cumulative growth of AE energy from defect initiation to subsequent failure and the changes in THA with respect to the same shows that the core crushing in sandwich panels can give AE events with THA lower than 0.5. The results throws light on the usefulness of AE application for the characterization of adhesive system used for the sandwich panels. Here it is observed that the adhesive is intact as the failure is in the core and adhesive sustains the loads required in this case.

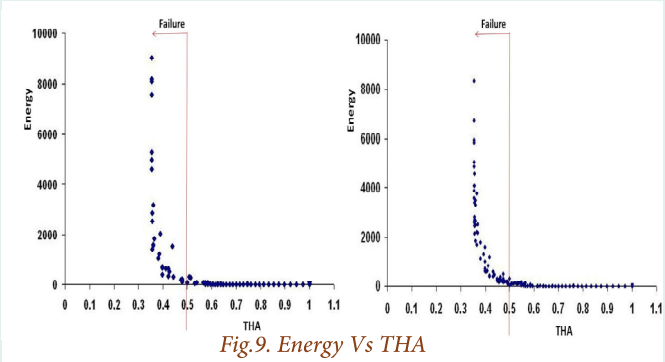


Fig.9. Energy Vs THA

Conclusion

The capability of Acoustic Emission technique for detecting the initiation of failure in honeycomb sandwich material is studied. The results are encouraging and the variation in the magnitude of AE parameters amplitude, duration, energy and counts corresponding to the failure initiation and propagation are distinct. This will help to evolve a real-time criteria for the evaluation of HC structures based on the AE parameters. Also it is brought out from the results that the THA corresponding to core shearing will have values lower than 0.5.

Acknowledgement

We acknowledge Shri. Shripati Ingale, Senior Technical Assistant, EXMD and Shri. Bibin John, Senior Technical Assistant, HPDD for their whole hearted support and efforts put for completing testing.

Reference:

- A fatigue characterization of honeycomb sandwich panels with a defect, Boualem Keskes, Yves Menger, Ahmed Abbadi, Joseph Gilgert, Nourredine Bouaouadja, Zitouni Azari

Mirror Image

We had a guest who had come for a lecture here in Thiruvananthapuram and was enquiring about bronze and gun metal produced in Kerala. Mannar is a place near Mavelikara where these metals are cast and traded. When we told about this, he asked "How you distinguish a pure bronze?". The color and weight can aid in identifying bronze being heavier and having copper tinge. Brass is lighter and more golden in color. Bronze is an alloy of copper and tin whereas brass is an alloy of copper and zinc. Brass is magnetic and bronze is not, he exclaimed. But you need a very strong magnet to detect. Another method is to use SQUID sensors and have NDT carried out.

Superconductive Quantum Interference Devices (or SQUIDs in short), are highly accurate devices for measuring magnetic flux. In fact, they are probably the most accurate measuring devices known to man at this point of time. They can be used to find out very minute changes in the magnetic field induced and thus enable detection.

Magnetometers have been used to detect submarines since the Second World War. They are able to do this because they can measure an anomaly in Earth's magnetic field like the one caused by a massive hunk of metal. But today's devices can only detect a submarine at fairly short range, so tend to be used to home in the location once the submarine has already been spotted on sonar. You could widen their range if you had a magnetometer based on a superconducting quantum interference device, or SQUID. But these very sensitive devices fall a prey to minuscule disturbances that occur outside laboratory. Still SQUID array sensors are developed now that will enhance the detection of a submarine at a distance of 6 km in reality.

SQUIDs can be utilized to image a wide variety of effects in the test subject. SQUIDs can be applied to measure image (a) intrinsic currents, (b) remnant magnetization, (c) flaw-induced perturbations in applied currents, (d) Johnson noise in conductors, (e) eddy currents and their perturbations by flaws, (f) hysteretic magnetization in ferromagnetic materials in the presence of an applied stress, and (g) diamagnetic and paramagnetic materials in an applied field. In a sense it can help us in telling whether a laughing statue of Buddha is made of brass or bronze.

A SQUID can be used to map the intrinsic current, or rather the magnetic fields such currents produce, either in printed or integrated circuit. It can also be used to map the currents that result from corrosion of the sample. The corrosion is an electrochemical process that involves the dissociation of atoms into ions and electrons. As migration of ions in the solution and electrons in the metal causes the intrinsic electrical currents to appear in the sample and these in turn produce magnetic fields that can be measured with magnetometers. SQUIDs are ideal for corrosion studies, since they don't have to contact the sample in obtaining the measurement. The SQUID based system can be used to monitor the corrosion in a sample as it happens, which is especially important when testing the materials for future corrosion.

Physics leads the way in NDE and SQUID sensors are no exception.

KR Mohan Ananthanarayanan

Editor

Glossary on DIGITAL RADIOGRAPHY:

- Digital Radiography (DR):Digital X-Ray imaging where digital X-ray sensors including flat panel detectors are used instead of traditional photographic film for static radiographs.
- Flat Panel Detectors (FPD): These detectors convert incident radiation intensity into proportional and digitised electronic signals. These digital signals can, by means of a computer and screen (workstation), without intermediate steps, be presented as a coherent radiographic image.
- Charge Coupled Device Detectors (CCD): A CCD is a light-sensitive sensor for recording images that consists of an integrated circuit containing an array of linked or coupled capacitors. X-ray energy is converted into light by a scintillator such as Tl-doped cesium iodide. The amount of light emitted is then recorded by the CCD, and the light is converted into electrical charges.
- Exposure indicator (EI). A quantitative method, expressed as an EI value, to estimate the incident radiation exposure required to acquire a diagnostic-quality radiograph. The EI is called by many other names, depending on the vendor.
- Gray scale. The different shades of gray that a computer system can store and display in relation to the number of bits the system uses to digitize images.
- Luminance. The measure that describes the amount of light that passes through or is emitted from a surface. In DR, this is the display monitor.
- Bit depth. The number of bits, or binary digits, per pixel. They encode the signal intensity (gray scale) of each pixel for the digital image.
- Contrast resolution: also known as gray-scale resolution. This is a digital system's ability to display objects at different signal (x-ray) intensities so that they can be easily distinguished.
- Pixel. A picture element, or the smallest component of a digital image and piece of information that a digital monitor can display. Pixels are represented by numerical codes.
- Spatial resolution. Spatial resolution is the ability to differentiate between small and adjacent objects. It is measured in line pairs per millimeter (lp/mm).
- Standard deviation index (DI). An index that provides feedback based on signal-to-noise ratio and the target index value for each digital examination. The purpose of the index is to help radiographers know if the technique they used for a specific examination was appropriate for optimal display of the anatomy of interest.
- Modulation transfer function: The Modulation Transfer Function (MTF) is a method of determining the response of an imaging system to different spatial frequencies in the images. Spatial frequency is generally expressed as cycles, or line pairs, per millimeter (lp/mm).

Image

Published on behalf of Executive Committee, **ISNT Thiruvananthapuram Chapter.**

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