

Image

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

January-June 2022

2nd Edition

www.isnttvm.org



A C D G A L V P O K L R
F S O [REDACTED] S W
O I I [REDACTED] K L
V F M G H S V X Z
K L A C J K H A V
K L G X G X Z K L
J V E N G L J X Z
O I F S G Z A S V
Z V X F S U S G F
O I F S G Z A S V
F J X [REDACTED] L V
B Z H [REDACTED] G D

Image

Chairman's Desk

Dear fellow ISNT members,

Warm greetings to all the esteemed members!

This edition of IMAGE would be reaching you when the preparations for our flagship event Seminar and Exhibition on NDE and Allied Methods (SENDAM 2022) would be in full swing. The much-awaited event is scheduled on 29th and 30th July 2022 at VSSC, Thiruvananthapuram. The seminar features invited talks on the latest advanced techniques in NDT as well as the recent developments in mechanical testing. An exhibition will also be conducted along with the seminar to showcase the advancements in this field by leading national and international suppliers and service providers. The organizing team members have been putting in their best efforts to make this event a grand success. May I request all the members to give wide publicity to the event and to ensure active participation.

This edition features a new section titled 'Showcase' that showcases the recent notable achievements by our chapter members. Members are requested to convey the inputs to the editorial team members.

I am happy to congratulate our senior members Shri. Harikrishna S who has been selected as the Secretary of Training and Management Board, ISNT as well as Dr. Nallaperumal M, who delivered an invited lecture on the topic "Neutron Imaging for Aerospace Applications – past, present & future" at DAE-BRNS, a two-day meeting on Strategic Planning for Enhancing Research Reactor Utilization (RRU-2022) held on May 6-7, 2022 at BARC, Mumbai. They have brought great pride to our chapter.

The Young Engineers forum team continues its excellent work by conducting two technical lectures. We also had the ISNT Day Celebration on 20.04.2022. In spite of the disruptions due the pandemic, our Students Chapter at Sree Chitra Thirunal College of Engineering (SCTCE), Thiruvananthapuram conducted a technical lecture program. Another notable achievement was the release



Dr. Mohan Kumar

of the updated website of our chapter, which shall contribute significantly for our SENDAM 2022 seminar also.

In addition to the detailed reports on the activities of the chapter, this edition of IMAGE also features a highly informative technical article on the Ultrasonic testing of Composites. It vividly explains the various technical aspects of the ultrasonic data presentations for composites in simple terms. In the 'Bookworm's Corner', the summary of a paper published in the International Journal of Acoustics and Vibration is provided in a concise manner for the benefit of our members. This paper details the use of mathematical tools, like cross-correlation, Wavelet Transforms and entropy based denoising, on the AE signals to extract and identify events related to failure from all the other irrelevant signals. The popular 'Backbenchers' Quiz' is also featured in this edition.

In conclusion, the last six months had been an active and vibrant one for our chapter with a variety of programmes. Looking forward to meeting you at SENDAM 2022.

Wishing all the members good health and happiness,

Dr. Mohan Kumar L

Chairman

ISNT, Thiruvananthapuram Chapter

New in this edition:

Showcase: A new section that showcases the recent notable achievements by the chapter members.

Secretary's Report

(January - June 2022)

Inside Executive Committee: The chapter had two EC meetings during the time period. Discussions were focused on revamping the ISNT Thiruvananthapuram Chapter website, conducting SENDAM 2022-committee formation, Training and Management Board decisions for implementing Authorized Training Centre (ATC), Young Engineers Forum and next edition of Image Newsletter. Regular updates of Chapter activities are sent to Head Quarters as and when the information is sought. The chapter had communicated its opinion on ATC and audits thereafter in TMB meeting through Shri. Harikrishna S. It is heartening to inform that Shri. Harikrishna S, senior executive member of our chapter is selected as Secretary of Training and Management Board, ISNT and chapter congratulates him for the same.

Chapter conducted two technical lectures through its ever-vibrant Young Engineers forum. Dr. CVS Kiran, Lead Engineer, Skyroot Aerospace Pvt. Ltd., Hyderabad and Dr. Deepesh Vimalan, Sr. Manager, BHEL, Trichy delivered lectures through online platform on 15th January and 24th February 2022 respectively.

Chapter conducted ISNT Day Celebration in Hotel SP Grand Days, Panavila Junction, Thiruvananthapuram on 20.04.2022 with a lecture from Shri. S Sridhar, former Vice Chairman, ISNT Thiruvananthapuram Chapter.

Our Students Chapter at Sree Chitra Thirunal College of Engineering (SCTCE), Thiruvananthapuram conducted a technical lecture program on Ultrasonic Inspection on 7th May, 2022. The lecture was delivered by Shri. Raju G, Scientist/Engineer, QIT, QCG-MM, MME, VSSC which was well appreciated by the participants.

Dr. Nallaperumal M, DGM, NDTF/RPP delivered an invited lecture on the topic "**Neutron Imaging for**

Aerospace Applications – past, present & future" at DAE-BRNS, a two-day meeting on Strategic Planning for Enhancing Research Reactor Utilization (RRU-2022) held on May 6-7, 2022 at BARC, Mumbai.



Girish N Namboodiri

We had two meetings to discuss about conducting SENDAM 2022 in a grand manner. Advisory and Organizing Committee members guided the new Sub-Committee members on how to proceed ahead in the initial meeting and the second meeting reviewed the progress made by the sub committees. The Chapter has received necessary approvals from Director, VSSC for conducting SENDAM 2022 in Dr. Srinivasan Auditorium and HRDD halls on 29th and 30th July, 2022.

ISNT Thiruvananthapuram Chapter has updated its website and the same was launched by Dr. Mohan Kumar L, Chairman of the chapter. Chapter submitted the audit report upto 31st March, 2022 to the Head Quarters.

New Image Newsletter has come out with a large variety of contents and it is planned to take a place in the SENDAM 2022 delegate kit as well. Accordingly, the team has worked out and brought out this edition.

Shri. Karthick N K, Scientist/Engineer MPD, MME, VSSC and Shri. Sudarshan Rao Gundi, Scientist/Engineer, MTD, MME, VSSC joined the Chapter as life members during the time period.

Girish N Namboodiri

Secretary

ISNT, Thiruvananthapuram Chapter

ISNT Day Lecture

21st April, 2022

ISNT Day is celebrated on 21st April of every year in memory of the registration of ISNT as a professional society in 1989. As part of the celebration, ISNT Thiruvananthapuram Chapter organized a technical lecture by Shri. Sridhar S, Group Head, CCQG / CMSE, VSSC, on 20th April 2022 at 06.30PM in Hotel SP Grand Days, Thiruvananthapuram. The lecture was organized, in part, also as a felicitation to Shri. Sridhar S for his long service to the NDE community and on his superannuation from VSSC on April 30, 2022. Shri. Sridhar S has a long and exemplary career in Ultrasonic Testing and Pulsed Infra-red Thermography of Composites. He was instrumental in establishing a world class inspection facility at CMSE, VSSC and has served in ISNT Thiruvananthapuram Chapter in the capacities of Secretary and Vice-chairman. Shri. S Sridhar spoke about his life and times at VSSC & ISNT and engaged in a live interaction with the members. He was felicitated by the senior members of the chapter, Shri. Levin G, Dr. Annamalai Pillai and Dr. Unnikrishnan Nayyar V.



Young Engineers Forum

The Young Engineers Forum organized two technical lectures through webinar mode on the Microsoft Teams platform.

Lecture 1:

Advancements in Materials Characterization with special reference to Aerospace materials

Speaker: **Dr. CVS Kiran**, Lead Scientist, Skyroot Aerospace Pvt. Ltd., Hyderabad



Dr. C V S Kiran
Lead Scientist
Skyroot Aerospace,
Hyderabad

Dr. CVS Kiran spoke about Additive Manufacturing (AM) process implemented in his area and the advances in material characterization. The lecture was focused on correlative characterization of materials which help in improving the understanding of existing materials and exploit high throughput synthesis, processing and testing methods to develop materials with bespoke properties.

He also dealt with the future directions for correlative characterization. He explained the latest advances in AM to meet the requirements of various materials in aerospace industry. Significant cost reduction, mass reduction of components through better design, lead time reduction are some area where AM has helped the industries. He also explained about the 3D printed engines developed at Skyroot which were successfully tested and qualified. He highlighted the requirement of a correlative health monitoring system to monitor large scale and complex AM components.

Lecture 2:

Digital Radiography and Image Processing

Speaker: **Dr. Deepesh Vimalan**, Senior Manager, BHEL, Trichy



Dr. Deepesh Vimalan
Senior Manager
Bharat Heavy
Electricals Limited,
Trichy

The speaker explained about digital radiography implemented at BHEL, Trichy for radiography of their products. He explained how the transformation from film to digital imaging has helped in making radiography process simpler with the images of welds being inspected by third party inspector also who is located in a different state.

He explained that all the quality control activities are meticulously followed as per code for inspection of welds using digital radiography as well. He displayed few typical digital radiographs of weldments and also explained about the realtime scanning of pipe joints with the system.

The second part of his talk was focused on digital image processing. Basics of image processing with corresponding examples from each type of processing methods were explained.

Students Chapter Activities

ISNT Thiruvananthapuram Students Chapter in association with Sree Chitra Thirunal College of Engineering (SCTCE), Thiruvananthapuram conducted a Half Day workshop on “*Ultrasonic Inspection- Theory and Practice*” on 7th May 2022 at SCTCE.

The lecture was delivered by Shri. Raju G, Scientist/Engineer, QIT, MME, VSSC, after a short introduction to basic NDE techniques by Shri. Binu B, Scientist/Engineer, EXMD, STR, VSSC. The lectures were followed by practical sessions in UT. The program was well received by students and faculty of SCTCE.”



SENDAM 2022

SEMINAR & EXHIBITION ON NDE & ALLIED METHODS



Indian Society for Non-Destructive testing (ISNT), Thiruvananthapuram chapter is organizing a two days Seminar and Exhibition on NDE and Allied Methods (SENDAM 2022) on 29th and 30th July 2022 at VSSC, Thiruvananthapuram.

The theme of the Seminar is “Advances in NDE and Mechanical Testing” which will be conducted for two days with parallel sessions on NDE & Mechanical Testing by eminent invited speakers, who are experts in these domains. The seminar will serve as a launch pedestal for latest

trends in both the areas with focus on original research findings. The invited talks in NDT are planned to cover latest advanced techniques in NDT like PAUT, TOFD, TFM, CT, Terahertz Imaging, Advanced thermography, Long Range UT, Advanced Eddy Current Testing, Optical techniques etc. covering various materials. In mechanical testing, fatigue & fracture testing for Gaganyaan, Cryo testing, Creep & Stress Rupture Testing, High Speed Testing, Testing of composites, Instrumented Impact Testing, Experimental Mechanics of Strain Measurement etc. will be covered by domain experts in the respective areas.

An exhibition will also be conducted along with the seminar to showcase the advancements in this field by leading national / international suppliers and service providers.





Modified Website of ISNT Thiruvananthapuram Chapter

ISNT Thiruvananthapuram Chapter launched its modified website on latest web platform on 14.06.2022. Inauguration of the website was carried out by Chairman, ISNT Thiruvananthapuram Chapter. The chapter website www.isntttvm.org has updated all the information about the activities of the chapter till date. The chapter shall henceforth use the website to communicate the latest information about chapter activities to its members. Image Newsletter soft copies, Brochures and registration forms of chapter programs, past events, contacts, EC members list, achievements of chapter, member list etc are updated. All members may send the photos and details of chapter activities which can be updated as and when they are received and the same may be carried out through Secretary, ISNT Thiruvananthapuram Chapter.



Technical Article from the Chapter

ULTRASONIC TESTING OF COMPOSITES

1. Introduction

Non-Destructive Testing (NDT) plays a major role during the development stages of any products and provide feedback about the product integrity during initial development trials, thus enabling to decide the various process parameters for a defect free product. Subsequently it is also tested at different stages of qualification. After the product is qualified for flight, NDT plays a vital role during the realization of flight product and after its acceptance tests.

Ultrasonic testing is one of the important non-destructive test methods that use mechanical vibration or sound wave of frequency greater than 20 KHz. Ultrasound has come a long way since the discovery of piezoelectricity by Pierre and Jacques Curie in 1876 and its first application by Richardson in 1913 for

sonar. Ultrasound is widely used in medical field for non-invasive diagnostics and in industry for non-destructive testing. Ultrasonics has wide application for integrity assessment of aerospace components especially composite products. Ultrasonic test is classified as dry coupled, wet coupled and air-coupled based on the coupling medium used. The development of air-coupled ultrasonics has led to many applications on low density, porous and hygroscopic material.



Abilash
Editorial Team

This article briefly describes the ultrasonic testing of composites and different ultrasonic data presentations.



2. NDT of Composites

Composite materials are increasingly being used in many applications. They offer many advantages such as specific strength, specific stiffness, directional tailorability etc., and are the preferred for structural applications. NDT of composites is different from those of metals. Composites are heterogeneous and mostly of layered construction. They are very attenuative, non-magnetic and porous in nature.

Among all the NDT techniques, none can be considered as universal for composites. They are complimentary to each other. Usually more than one technique is adopted in composites testing. Several NDT techniques used in conjunction can only bring out the most successful evaluation of a composite structure. A judicious combination of NDT techniques is chosen for testing composite products considering the following factors:

- Material (Carbon phenolic/ Silica phenolic/ Carbon epoxy / Kevlar epoxy / Carbon-Carbon etc.)
- Type of construction (Laminate/ sandwich/ tape wound / filament wound etc.)
- Probable defects (delamination / debond / porosity etc.)
- Size / geometry (conical/cylindrical/flat/ curved etc.)

3. Ultrasonic testing of Composite Products

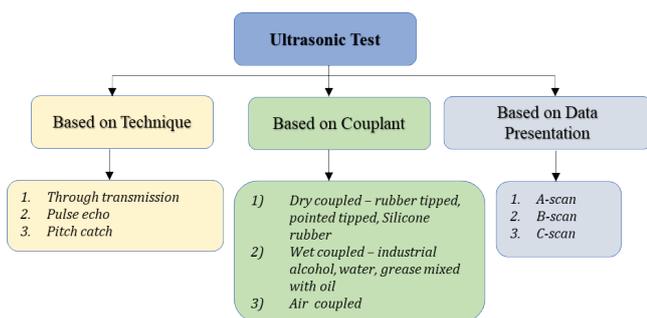


Figure 1. Classification of Ultrasonic testing

Ultrasonic testing (UT) employs a sound wave of frequency greater than 20 KHz. It is used to detect and locate variations in structure, presence of cracks or other physical discontinuities, measure the thickness of materials etc.

When the sound wave is sent into the test object through a couplant, it undergoes attenuation and reflections / transmissions at interfaces. These reflections and

transmissions at an interface depend on a physical parameter called Acoustic Impedance. Acoustic impedance is the product of density and sound wave velocity in the test product. A couplant is used facilitate effective transfer of sound energy into the test product.

Ultrasonic testing is classified into different variants and is depicted in Figure 1.

3.1. Conventional Ultrasonics with liquid couplant

Conventional UT with liquid couplant can be conducted either by the pulse-echo technique or the through-transmission technique.

Pulse echo technique uses a single transducer which acts as both transmitter and receiver. The sound wave is introduced into the test product and allowed to propagate through the thickness, until it reached the back-wall and is reflected (back wall echo or thickness reflection). A flaw is indicated by the presence of a reflected signal ahead of the back wall echo. Based on the size of the defect, there will be either reduction in back wall echo or total loss of back wall echo. The frequency of probes used for testing composite products ranges from 1 MHz to 10 MHz.

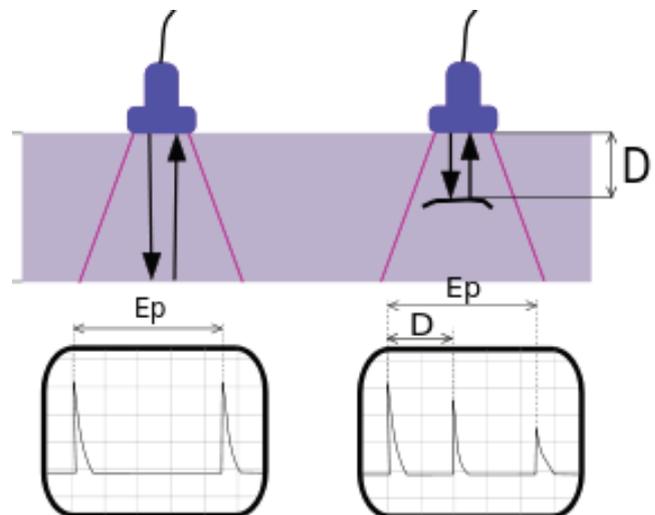


Figure 2. Ultrasonic signal at good and defect region in Pulse Echo test

The distance of the test product can be related to the time of flight of the echo, by calibrating the sound velocity in the test product. Based on the ratio between time of flight of defect echo (D) and back echo (Ep), the depth of the defect can be estimated. The schematic of the pulse echo ultrasonic test is represented in Figure 2.

Through-transmission technique uses two transducers, with the transmitter on one side and the receiver on the other side of the component under test. The sound energy is sent into the test product and after passing through the product, the energy will be picked up by the receiver. A flaw is indicated by the reduction or absence of a transmitted signal.

Any internal defects like delamination, debond makes the reflection of sound at the defect interfaces. Hence, the received energy at the receiver end decreases resulting in the loss of signal amplitude (Figure 3). This technique gives very good sensitivity but needs access on both sides of the component and perfect alignment of two transducers.

UT using liquid couplants like water, gels etc., are to be avoided while testing composite nozzle liners because of their porous nature, as the liquid couplant may ingress inside the liners thereby affecting performance and further processing.

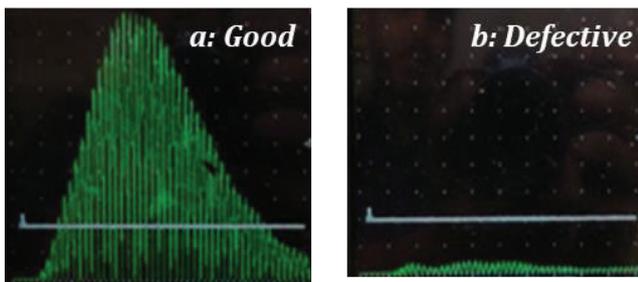


Figure 3. Ultrasonic signal pattern at good and defective region

3.2. Dry coupled Ultrasonics

In dry coupled ultrasonics uses the so called dry-coupled probes (soft tipped or roller probes) instead of the liquid couplant. These probes use a layer of synthetic rubber to provide acceptable coupling between the probe and test piece. Dry coupled pulse echo technique is feasible for small sizes of components. Though it is easier compared to through transmission technique, it is not recommended for components with non-uniform and/or higher thicknesses. In such cases, dry-coupled through transmission technique is adapted using soft tipped rubber probe or roller probes. Application of roller probes in through transmission mode make the testing faster and easier when compared to the soft tipped probes. Since the probes are pressed against the product, proper care is needed to keep this pressure within limits. A common disadvantage is that to work reliably they require significant pressure to be applied, which may render the technique unsuitable for testing

delicate materials. In some cases, the pressure applied may mask critical defects such as detached skin on composite materials.

3.3. Pitch-catch ultrasonics

In this technique, two separate transducer elements are housed inside the same probe housing. One element namely Transmitter will be pitching and another element namely Receiver will be catching. The frequency will be very low (less than 50 KHz). This test can be conducted if one side is accessible. Couplant is not required for this test as the probes are point tipped.

The dual element pitch-catch piezoelectric transducer and the schematic of testing is represented in Figure 4. This type of testing is of qualitative and is mostly used for testing the bond integrity of thinner composites.

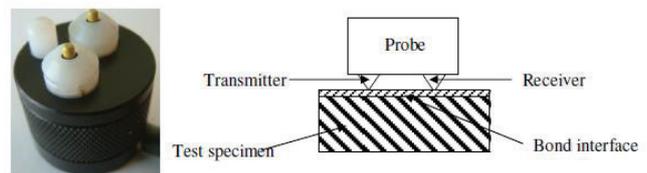


Figure 4. Pitch-catch probe and schematic of testing

The parameters in the instrument are set to detect the built-in defects incorporated in the specimen. With the same parameters, test is conducted on the actual product. The signal patterns corresponding to the good and defective regions are represented in Figure 5. At the defective location, the energy of reflection at the interface increases and the signal pattern goes beyond the threshold level set in the instrument.

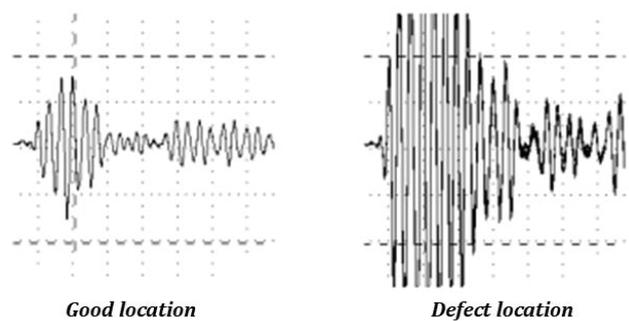


Figure 5. Signal pattern at good and defect location

3.4. Air-coupled Ultrasonics

Air Coupled Ultrasonics is a non-contact ultrasound technique that uses air or gas as coupling medium. The development of air-coupled mode would allow many more applications of ultrasound in characterizing porous and hygroscopic material and in medical

diagnosis. But the very high acoustic impedance mismatch between the coupling medium (air) and the test medium is the limitation that prevents widespread use. Acoustic impedance (Z) is given by the product of material density and velocity of ultrasound through the material.

The fraction of ultrasound energy transmitted at the couplant-material interface is given by:

$$T = \frac{4Z_1Z_2}{(Z_1 + Z_2)^2}$$

Where Z_1 is the acoustic impedance of coupling medium, and Z_2 is the acoustic impedance of the test medium.

Transmission of ultrasound between a probe and a test piece across air is extremely inefficient. The very high mismatch between acoustic impedance of air and the test material offers enormous resistance for transmission of ultrasound through the interface. This, together with the extremely high attenuation of ultrasound (in MHz region) by air, further complicates the use of air as couplant.

To overcome these problems, conventional ultrasonic testing employs a liquid coupling medium such as water, glycerin or a variety of oil and water-based gels. Some of the systems use solid such as silicone-based rubber. The physical coupling increases the transmitted energy in two ways:

- a. The couplant has an intermediate acoustic impedance between the probe and test material thus reducing the effect of impedance mismatch.
- b. The attenuation of ultrasound in a liquid is much less than in a gas.

Extremely high attenuation of ultrasound in air further aggravates the difficulty. However, for air-coupled ultrasonics to become a reality, we need the transducers and electronic systems sensitive enough to transmit and detect ultrasound without contact with the test medium. Hence, for air-coupled ultrasonics to become reality, the following approaches are incorporated:

- a. Obtain maximum acoustic output from the transmitter
- b. Attempt to minimize losses throughout the system

- c. Maximize the sensitivity of the receiver
- d. Process the signal to maximize signal to noise

By using combinations of improvements in transducers as well as equipment design, air coupled technology has now become a practical inspection tool. The frequency of air-coupled probes used for testing composite products ranges from 50 KHz to 400 KHz.

One of the primary difficulties of using air coupled testing is using it in pulse echo mode. Normally air-coupled ultrasonic testing is done in through transmission mode. Precise tuning and proper alignment of the probes are essential for the air-coupled testing. The probes must maintain a predefined stand-off distance from the component surface during the testing based on air-coupled probe characteristics. Suitable probe fixing and manipulating mechanisms are also required to maintain the specified stand-off distance on either side of the test surface. So, field applications of the same are limited. Also, scanning small objects is difficult because of ultrasound leakage around the edges.

4. Ultrasonic data presentations

Ultrasonic data can be collected and displayed in several different formats. The three most common formats are A-Scan, B-Scan, and C-Scan presentations. Each presentation mode provides a different way of looking at and evaluating the region of material being inspected. B-Scan and C-Scan are synthesized from A-Scan only. Modern computerized ultrasonic scanning systems can display data in all three presentation forms simultaneously.

4.1. A-Scan Presentation

The A-scan presentation displays the amount of received ultrasonic energy as a function of time. The relative amount of received energy is plotted along the vertical axis and the elapsed time (which may be related to the sound energy travel time within the material) is displayed along the horizontal axis. Most instruments with an A-scan display allow the signal to be displayed in its natural radio frequency form (RF), as a fully rectified RF signal or as either the positive or negative half of the RF signal. The typical A-scan presentation is represented in Figure 6.

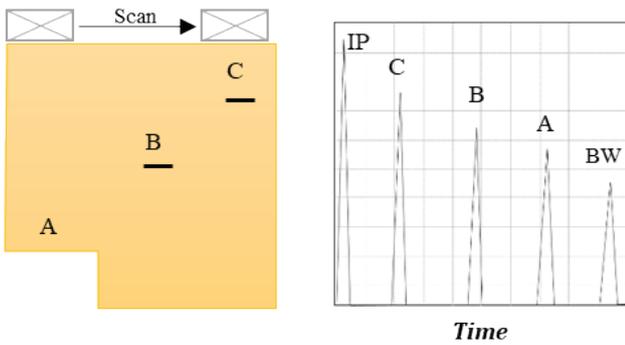


Figure 6. A-Scan representation

In the above illustration of the A-scan presentation, the initial pulse generated by the transducer is represented by the signal *IP*, which is near time zero. As the transducer is scanned along the surface of the part, four other signals are likely to appear at different times on the screen.

- When the transducer is in its far-left position, only the *IP* signal and signal *A*, the sound energy reflecting from surface *A*, will be seen on the trace.
- As the transducer is scanned to the right, a signal from the backwall *BW* will appear later in time, showing that the sound has traveled farther to reach this surface.
- When the transducer is over flaw *B*, signal *B* will appear at a point on the time scale that is approximately halfway between the *IP* signal and the *BW* signal. Since the *IP* signal corresponds to the front surface of the material, this indicates that flaw *B* is about halfway between the front and back surfaces of the sample.
- When the transducer is moved over flaw *C*, signal *C* will appear earlier in time since the sound travel path is shorter and signal *B* will disappear since sound will no longer be reflecting from it.

The A-Scan presentation is instantaneous in nature and there is no recording of signal. The above signals will be seen only when the probe is at those locations. All the signals would not be displayed together at any instant.

4.2. B-Scan Presentation

The B-Scan presentation is a profile (cross-sectional) view of the test specimen. In the B-Scan, the time-of-flight (travel time) of the sound energy is displayed

along the vertical axis and the linear position of the transducer is displayed along the horizontal axis. From the B-scan, the depth of the reflector and its approximate linear dimensions in the scan direction can be determined. A typical B-scan is shown in the Figure 7.

The B-Scan is typically produced by establishing a trigger gate on the A-Scan. Whenever the signal intensity is great enough to trigger the gate, a point is produced on the B-Scan. The gate is triggered by the sound reflecting from the backwall of the specimen and by smaller reflectors within the material.

- In the B-Scan image above, line *A* is produced as the transducer is scanned over the reduced thickness portion of the specimen. When the transducer moves to the right of this section, the backwall line *BW* is produced.
- When the transducer is over flaws *B* and *C*, lines that are similar to the length of the flaws and at similar depths within the material are drawn on the B-scan.

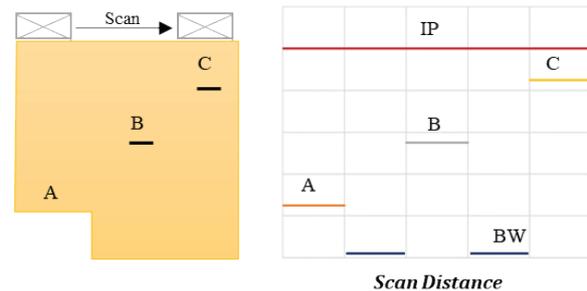


Figure 7. B-Scan representation

4.3. C-Scan Presentation

The C-Scan presentation provides a plan-type view of the location and size of test specimen. The plane of the image is parallel to the scan pattern of the transducer. C-Scan presentations are produced with an automated data acquisition system, where both the probe positions (position co-ordinates) and ultrasonic data are captured simultaneously.

Typically, a data collection gate is established on the A-Scan and the amplitude, or the time-of-flight of the signal is recorded at regular intervals as the transducer is scanned over the test piece. The relative signal amplitude or the time-of-flight is displayed as a shade of grey or a color for each of the positions where data

was recorded. The C-Scan presentation (Figure 8) provides an image of the features that reflect and scatter the sound within and on the surfaces of the test piece.

Typical C-Scan images captured for composite products using an automated air-coupled ultrasonic C-Scan system are shown in Figure 9.

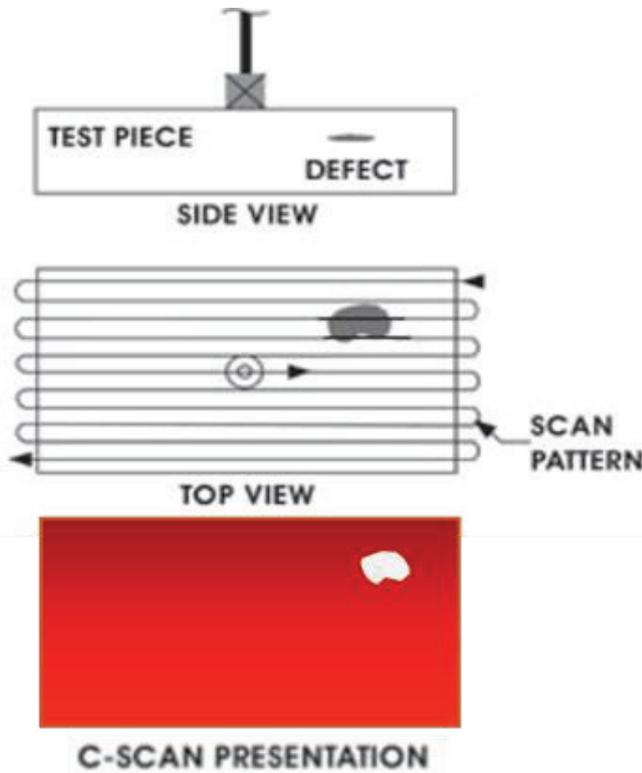


Figure 8. C-Scan presentation

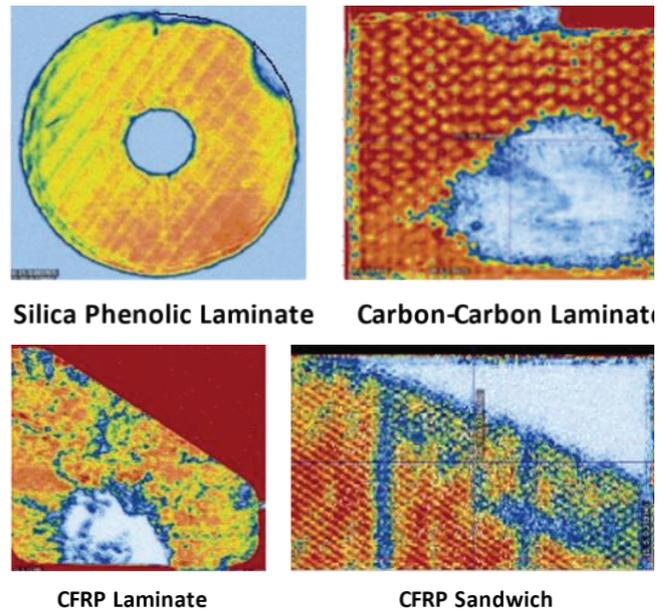


Figure 9. Typical C-Scan images

5. Conclusion

Non-Destructive Testing plays a major role for the quality assessment of composite products. NDT of composites is different from those of metals. Among all the NDT techniques, none can be considered as universal for composites. They are complimentary to each other. Usually more than one technique is adopted in composites testing. A judicious combination of NDT techniques is chosen for testing of composite products. Ultrasonic testing is one of the important non-destructive test methods that is employed for composite products. This article has briefed about ultrasonic testing of composites, various ultrasonic techniques and different types of ultrasonic data presentations.



Recent NDT Patents

Eddy current array probe with independent transmitters

Patent number: 10794864

Abstract: This patent describes an eddy current array probe for detection and depth sizing of a surface-breaking defect in metallic materials. The said eddy current array probe comprises of a probe body with a plurality of probe elements arranged in a linear configuration, the probe elements each comprises of at least one coil. The probe body is adapted to be displaced along the surface of the metallic material so that the longitudinal axis of the coil remains parallel to the surface under inspection. The coil, when in use, induces an eddy current within the metallic material and senses variations when it interacts with metallurgical changes. The active elements also can be selectively operated at a plurality of time-spaced instances.

Date of Patent: October 6, 2020

Assignee: EDDYFI NDT INC., Canada

Inventors: Mich el Sirois, St fan Parmentier, Marc Grenier, Nathan Decourcelle



The Bookworm's Corner

Name of the article: Acoustic Emission Signal Analysis and Event Extraction through Tuned Wavelet Packet Transform and Continuous Wavelet Transform while Tensile Testing the AA 2219 Coupon

Authors: P. Arun Bose, T. Sasikumar, P. Arul Jose and Jeby Philip

Journal: *International Journal of Acoustics and Vibration, Vol.23, Issue 2*

Publisher: International Institute of Acoustics and Vibration

Link: <https://doi.org/10.20855/ijav.2018.23.21447>

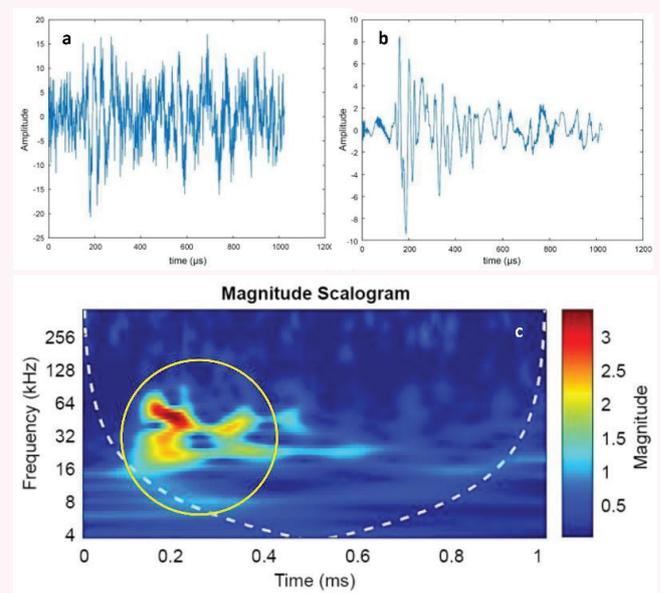
Summary: This paper details the use of mathematical tools, like cross-correlation, Wavelet Transforms & entropy based denoising, on the AE signals to extract and identify events related to failure from all the other irrelevant signals. The authors initially construct the reference signal from the Pencil Lead Break (PLB), as it has the closest resemblance with those from a crack. Atmospheric noise, rubbing noise and random gaussian white noise were added to the PLB signal to simulate test conditions. The authors then selected the Daubechies wavelet, *db4*, as the mother wavelet for the study as it has highest correlation coefficient with the AE signals acquired from the tensile testing of the AA2219 specimen at 25, 30, 35 and 40dB respectively. Wavelet Packet decomposition with the db4 mother wavelet and Shannon entropy based denoising were performed on the constructed reference signal. Then finally, to extract the events related to failure, Continuous Wavelet Transform (CWT) was obtained for the denoised PLB. Crack related events have high frequency, high wavelet coefficient and less duration. The wavelet diagram clearly demarcated the event related to crack as marked by yellow circle in figure. The authors, after successfully validating the algorithm on two independent test samples, went on to apply the same on the AE signals acquired on the AA2219 tensile specimen and the AE Hits could be successfully categorized into Category I (pure noise) and Category II (pure crack, noise + Cracks).

Relevance: Acoustic Emission Testing of propellant reservoirs for aerospace application is performed simultaneously with the proof pressure test as part of integrity assessment. However, due to the prevailing

noisy environment of the proof pressure test, the identification of relevant signatures especially those produced by unacceptable events like crack propagation is a major challenge. The aforesaid algorithm of signal analysis can be implemented for better visibility of propagating and initiating cracks during the proof pressure testing of aerospace grade propellant reservoirs and help in generating better and more robust AE test procedures to provide confident flight clearance especially for manned flights.



Manu Joseph
Editorial Team



(a) The constructed Pencil Lead Break signal (PLB),
(b) The denoised PLB and (c) the wavelet diagram after db4

The Back-benchers' quiz

- Which of the following penetrating liquid is used in a liquid penetrant test?
 - Water
 - Chlorine based
 - Petroleum based
 - Fluorine based
- What is a scintillator
 - Absorbs light and convert energy to x-rays
 - Absorbs light and converts to light
 - Absorbs x-rays and convert energy to light
 - Absorbs x-rays and converts to carbon
- What is the scintillation phosphor typically used in Digital Radiography?
 - CsI
 - A-Si
 - A-Se
 - All of the above
- What are two types of Direct Readout Digital Radiography
 - Indirect Scintillator and Direct Photoconductor
 - Indirect Scintillator and Direct Scintillator
 - Indirect Photoconductor and Direct Photoconductor
 - Indirect Photoconductor and Direct Scintillator
- Compressive strength of hardened concrete is done by
 - Cube test
 - Tensile splitting test
 - Concrete core test
 - Flexure test
- This is the typical reconstruction method for CT images
 - Back propagation
 - Back projection
 - Filtered Back-projection
 - Iterative construction
- During radiography test, which region absorbs less radiation and transmits more?
 - Low- and high-density regions absorb and transmit same amount of radiation
 - High density region
 - Low density region
 - None of the above
- Which of the following statements are correct for DIC (Digital image correlation)?
 - Is a 3D full-field, non-contact optical technique?
 - It can measure contour, deformation, vibration and strain on almost any material
 - Can be coupled with many tests like tensile test, torsion, bending, static and dynamic application.
 - All of the above
- What did Hsu-Nielsen invent
 - an acoustic emission transducer
 - an aid to simulate an acoustic emission event
 - a signal filter technique
 - Felicity ratio
- What is an important wave mode in Acoustic Emission testing?
 - Longitudinal wave
 - Transverse Wave
 - Lamb wave
 - None of these



Anish Kumar
Editorial Team

Ans: 1c, 2c, 3a, 4a, 5a, 6c, 7c, 8d, 9b, 10d

Showcase

Dr. P Sasikumar works as a Scientist / Engineer at VSSC, Vattiyoorkavu and is a life member of the ISNT Thiruvananthapuram Chapter. He renders his services as the Treasurer of the Chapter and is an active member of the Executive Committee. Dr. P Sasikumar has visited more than 50 schools in the past 15 years as part of World Space Week celebrations and finds immense pleasure in interacting with school children. He is passionate about imparting knowledge to the young ones especially in basic sciences and rocketry. But, due to his busy schedules and other official commitments, he seldom finds time to visit schools and meet the students in person. So, he has

channeled his passion into writing and publishing science books in Tamil for school students. Dr. P Sasikumar has adopted a very lucid and thought-provocative style of writing in his books such that the children can read, learn; and simultaneously enjoy the teacher's experience. He has published six books in several topics ranging from bi-cycles to Rocket systems which can be viewed at this URL: <https://thamizhbooks.com/product-tag/p-sasikumar/>

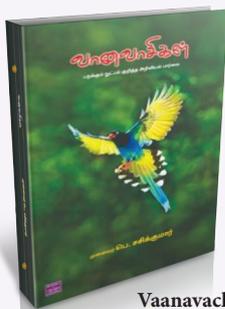


Dr. P. Sasikumar



Vinnveli Manitharkal

A book about astronauts, their training, life in space, research area etc.



Vaavachikal

Science behind bird's flight and natural design of a bird's system



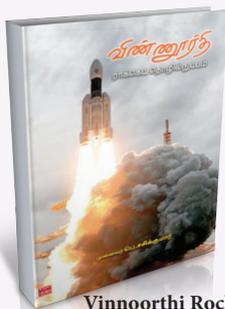
Tharame Tharakamanthiram

History of quality and quality principals for day-to-day life.



Kaithariyum Kaniporiyum

15 articles about science behind day-to-day activities including dosatawa, Sambar, spider web, handloom etc.



Vinoorthi Rocket Thozhilutpam

Basic working of rockets - design concepts and world rockets



Rayile Rayile

Science, history and technology of trains from steam engine to hyper loop.

BARC Radiographic Testing Level II Batch #85

Shri. Manu Joseph, QCNG/ SRQA/ LPSC, and Shri. Anish Kumar, NDTF/ MME/ VSSC attended and secured top and runner-up positions in the 85th Batch of RT Level II course conducted by BARC from May 17th to June 10th and brought laurels to ISRO and ISNT Thiruvananthapuram chapter.



Glossary of Terms for Ultrasonic Examination

(Reference: ASME Sec V-2019, Article 1)

Acoustic pulse: the duration of time between the start and end of the signal when the amplitude reaches 10% of the maximum amplitude.

Alternative reflector: a reflector, other than the specified reflector, whose ultrasonic response has been adjusted to be equal to or greater than the response from the specified reflector at the same sound path distance in the basic calibration block.

Amplitude: the vertical pulse height of a signal, usually base to peak, when indicated by an A-scan presentation.

Calibration: correlation of the ultrasonic system response(s) with calibration reflector(s).

Calibration reflector: a reflector with a dimensioned surface which is used to provide an accurately reproducible reference level.

Dynamic calibration: calibration that is conducted with the search unit in motion, usually at the same speed and direction of the actual test examination.

Attenuation: a factor that describes the decrease in ultrasound intensity with distance; normally expressed in decibel per unit length.

Attenuator: a device for altering the amplitude of an ultrasonic indication in known increments, usually decibels.

Computerized imaging: computer processed display or analysis and display of ultrasonic data to provide two- or three-dimensional images of reflectors.

A-scan: a method of data presentation utilizing a horizontal base line that indicates distance, or time, and a vertical deflection from the base line which indicates amplitude.

B-scan (parallel scan): scan that shows the data collected when scanning the transducer pair in the direction of the sound beam transversely across a weld.

C-scan: an ultrasonic data presentation which provides a plan view of the test object, and discontinuities therein.

D-scan (non-parallel scan): scan that shows the data collected when scanning the transducer pair perpendicular to the direction of the sound beam along a weld.

Multiple back reflections: in ultrasonic straight beam

examination, successive reflections from the back and front surfaces of the material.

Piezoelectric element: crystal or poly crystal materials which when mechanically deformed, produce electrical charges, and conversely, when intermittently charged, will deform and produce mechanical vibrations.

Transducer: an electro-acoustical device for converting electrical energy into acoustical energy and vice versa.

Primary reference response (level): the ultrasonic response from the basic calibration reflector at the specified sound path distance, electronically adjusted to a specified percentage of the full screen height.

Refraction: the angular change in direction of the ultrasonic beam as it passes obliquely from one medium to another, in which the waves have a different velocity.

Ringing time: the time that the mechanical vibrations of a piezoelectric element continue after the electrical pulse has stopped.

Simulation block: a reference block or other item in addition to the basic calibration block that enables correlation of ultrasonic system response initially obtained when using the basic calibration block.

Static calibration: calibration for examination wherein the search unit is positioned on a calibration block so that the pertinent reflectors can be identified and the instrumentation adjusted accordingly.

Back-wall signal: sound wave that travels between the two transducers with a longitudinal velocity that reflects off the materials back surface.

Back-wall echo: a specular reflection from the back-wall of the component being examined.

Base line: the time of flight or distance trace (horizontal) across the A-scan CRT display (for no signal condition).

Beam spread: a divergence of the ultrasonic beam as the sound travels through a medium.

Diffacted signals: diffracted waves from the upper and lower tips of flaws resulting from its interaction with the incident sound wave.

Lateral wave: sound wave that travels directly between the transducers with a longitudinal velocity just below the surface of the material.

Time-of-flight: the time it takes for a sound wave to travel from the transmitting transducer to the flaw, and then to the receiving transducer.

Angle beam: a term used to describe an angle of incidence or refraction other than normal to the surface of the test object, as in angle beam examination, angle beam search unit, angle beam longitudinal waves, and angle beam shear waves.

Wedge: in ultrasonic angle-beam examination by the contact method, a device used to direct ultrasonic energy into the material at an angle.

Automated ultrasonic examinations (AUT): a technique of ultrasonic examination performed with equipment and search units that are mechanically mounted and guided, remotely operated, and motor-controlled (driven) without adjustments by the technician. The equipment used to perform the examinations is capable of recording the ultrasonic response data, including the scanning positions, by means of integral encoding devices such that imaging of the acquired data can be performed.

Contact testing: a technique in which the search unit makes contact directly with the test piece through a thin layer of couplant.

Couplant: a substance used between the search unit and examination surface to permit or improve transmission of ultrasonic energy.

Damping, search unit: limiting the duration of a signal from a search unit subject to a pulsed input by electrically or mechanically decreasing the amplitude of successive cycles.

Decibel (dB): twenty times the base ten logarithm of the ratio of two ultrasonic signal amplitudes, $dB = 20 \log 10$ (amplitude ratio).

Holography (acoustic): an inspection system using the phase interface between the ultrasonic wave from an object and a reference signal to obtain an image of reflectors in the material under test.

Immersion testing: an ultrasonic examination method in which the search unit and the test part are submerged (at least locally) in a fluid, usually water.

Indication: that which marks or denotes the presence of a reflector.

Initial pulse: the response of the ultrasonic system display to the transmitter pulse (sometimes called main bang).

Interface: the boundary between two materials.

Lateral wave: a compression wave that travels by the most direct route from the transmitting probe to the receiving

probe in a TOFD configuration.

Linearity (amplitude): a measure of the proportionality of the amplitude of the signal input to the receiver, and the amplitude of the signal appearing on the display of the ultrasonic instrument or on an auxiliary display.

Linearity (time or distance): a measure of the proportionality of the signals appearing on the time or distance axis of the display and the input signals to the receiver from a calibrated time generator or from multiple echoes from a plate of material of known thickness.

Linear scanning (also termed line scanning): a single pass scan of the search unit parallel to the weld axis at a fixed stand-off distance.

Longitudinal wave: those waves in which the particle motion of the material is essentially in the same direction as the wave propagation.

Loss of back reflection: an absence or significant reduction in the amplitude of the indication from the back surface of the part under examination.

Manual ultrasonic examinations (MUT): a technique of ultrasonic examination performed with search units that are manipulated by hand without the aid of any mechanical guidance system.

Mode: the type of ultrasonic wave propagating in the materials as characterized by the particle motion (for example, longitudinal, transverse, and so forth).

Multiple back reflections: in ultrasonic straight beam examination, successive reflections from the back and front surfaces of the material.

Noise: any undesired signal (electrical or acoustic) that tends to interfere with the reception, interpretation, or processing of the desired signal.

Pulse: a short wave train of mechanical vibrations.

Pulse-echo method: an inspection method in which the presence and position of a reflector are indicated by the echo amplitude and time.

Range: the maximum sound path length that is displayed.

Reference block: a block that is used both as a measurement scale and as a means of providing an ultrasonic reflection of known characteristics.

Reflector: an interface at which an ultrasonic beam encounters a change in acoustic impedance and at which at least part of the energy is reflected.

Reject (suppression): a control for minimizing or eliminating low amplitude signals (electrical or material noise) so that larger signals are emphasized.

Resolution: the ability of ultrasonic equipment to give

simultaneous, separate indications from discontinuities having nearly the same range and lateral position with respect to the beam axis.

Semi-automated ultrasonic examinations (SAUT): a technique of ultrasonic examination performed with equipment and search units that are mechanically mounted and guided, manually assisted (driven), and which may be manually adjusted by the technician. The equipment used to perform the examinations is capable of recording the ultrasonic response data, including the scanning positions, by means of integral encoding devices such that imaging of the acquired data can be performed.

Sensitivity: a measure of the smallest ultrasonic signal which will produce a discernible indication on the display of an ultrasonic system.

Shear wave: wave motion in which the particle motion is perpendicular to the direction of propagation.

Signal-to-noise ratio: the ratio of the amplitude of an ultrasonic indication to the amplitude of the maximum

background noise.

Through transmission technique: a test procedure in which the ultrasonic vibrations are emitted by one search unit and received by another at the opposite surface of the material examined.

Total focusing method (TFM): a method of image reconstruction in which the value of each constituent datum of the image results from focused ultrasound. TFM may also be understood as a broad term encompassing a family of processing techniques for image reconstruction from full matrix capture (FMC). It is possible that equipment of different manufacture may legitimately generate very different TFM images using the same collected data.

Adaptive total focusing method (ATFM): an iterative process of the total focusing method (TFM) applied typically to layered media to identify the geometry of the refracting or reflecting interface, or both, that allows the processing of the TFM through such interfaces without the prior knowledge or assumption of the geometry.

Editor's message

Dear ISNT fellow members,

The second issue of IMAGE in this year is in your hands. Kudos to the young vibrant editorial team for taking extra efforts in bringing out this special issue to be released during SENDAM 2022.

The overall activities of ISNT Thiruvananthapuram Chapter for the first half of this year have been well summarized by the Chairman, Dr. Mohan Kumar L and the Secretary, Shri. Girish N Namboodiri. The information shared by Dr. CVS Kiran and Dr. Deepesh Vimalan in the Young Engineers Forum have been brought out in a nutshell. A technical article by Shri. Abilash has been published which is sure to kindle the thought process of NDT experts.

We are extremely happy to introduce a new feature "SHOWCASE" from this issue onwards. It is for showcasing the talents of our members and acknowledging their achievements in other areas. I take this opportunity to request all ISNT members

to update and inform us about your achievements which will be worthwhile to publish.

The Book Worm's Corner and recent NDT related Patent search by Shri. Manu Joseph and Shri. Abilash respectively is highly informative. The Back Bencher's Quiz by Shri. Anish Kumar is sure to engross the minds of readers. The glossary of terms for Ultrasonic examination also by Shri. Abilash will serve as a ready reckoner.

On this occasion, I have every hope that the SENDAM 2022 will be a grand success and send my best wishes to the participants for a fruitful and thought-provoking conference.



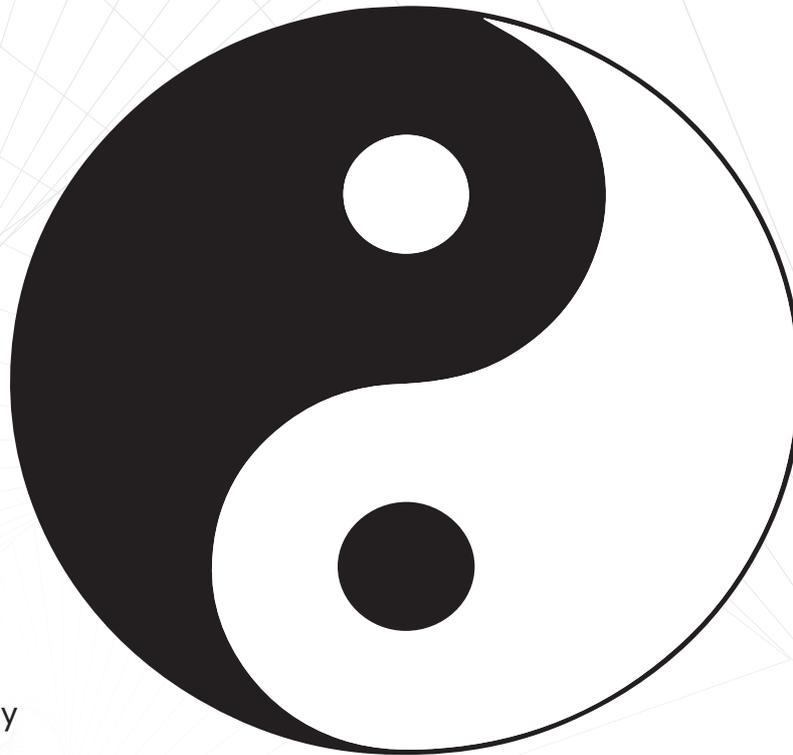
Dr M Nallaperumal

For & on behalf of the team "IMAGE"

Dr M Nallaperumal
Chief Editor.

Cover Design Inspiration

YIN-YANG Symbol



YIN

YANG

- Female energy
- Passive
- Intuitive
- Creative
- Dark
- Stillness
- Cold
- Contracting

- Male energy
- Active
- Light
- Dominating
- Strong
- Movement
- Hot
- Expanding

Outer Circle- represents the universe and everything in it

Small Inner Circles- represents that everything carries the seed of its opposite

Indian Society for



Non-Destructive Testing



Editorial Board: Dr. Nallaperumal M, Shri. Abilash, Shri. Manu Joseph, Shri. Anish Kumar

Image

Published on behalf of Executive Committee, ISNT Thiruvananthapuram Chapter.

Address for communication: VSSC, ISRO Post, Thiruvananthapuram

E-mail: girish_nn@vssc.gov.in

Cover Designed by : Anish Kumar
Editorial Team

