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Official Newsletter of ISNT Chennai Chapter

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Dear members,

Happy New Year and Lavish Pongal wishes to you all, from the board.

My chest swells in pride, when I comprehend the progress our Sound Bytes has traversed. In the recently conducted 34th conference of ISNT, I could perceive the depth of penetration that our magazine has diffused by interacting with several individuals. This achievement is due to the efforts put in by the past office bearers of ISNTCC right from its first publication on June 2021 the contribution of authors and the advertisers combined with your unstinted support.

I can proclaim that we are maturing. From a normal newsletter publishing the chapter news, we have evolved into a magazine that is catering to all the needs of an NDT practitioner. This issue especially carries an article on a very significant aspect of our working life.

Several of our brethren work in severe climatic conditions of scorching sun with high humidity. In the Middle East countries restrictions are imposed. No work is carried out when the temperature soars above 50°C and the temperature is displayed prominently on a sign.

A point to note is, that this temperature is not applicable to our country which in several places is not only hot but also humid. At this instance wet and dry bulb temperatures come onto play. On 6th October 2024, the 92nd anniversary air show of 74 aircrafts attracted a holiday crowd of 15 lakhs people to the Marina beach at Chennai. Show time was 11.00AM to 1.00PM. The temperature recorded was around 36°C and the humidity was around 80%. It was a great show but ended with a tragedy of 5 people losing their lives and several being admitted to various hospitals. This grave occurrence educates us an important aspect of our working life, the personnel safety. This issue throws light on this attribute through an article by Sri.Manimohan on "Wet & Dry bulb temperature including the precautions to be observed by us when we work under hot sun in a humid atmosphere.

This issue also carries an article on the inspection time has been reduced from many numbers of hours to a few seconds to match with the high-speed manufacturing. Yet another article on IR reads like a science fiction, in which the author is predicting the future path of welding technology wherein repair of the defects is carried out even before the weld cools with the help of Artificial intelligence. That change throws a new challenge and change in the pattern of our learning.

Yet another serial article authored by Prof.Prabhu Rajagopal illustrates the importance of innovation for survival in the ever changing world scenario - The sutras for innovation.

We promise you that your magazine will touch all elements of our lives and will progress towards a well-rounded one completing the transformation to a monarch butterfly.

Once again season's greetings to you all and wishing a contented reading.

Ram

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NDE 2024: A Grand Success Story of Professional Excellence, Innovation, and Collaboration!

Cmde Vijaykumar D, Executive Director, ISNT.

The **NDE 2024 conference and exhibition** held at Chennai Trade Centre from **12-14 December 2024** was an extraordinary celebration of **Non-Destructive Evaluation** (NDE) and Enabling Technologies. With an overwhelming response from the industry, academia and the global community, **ISNT** has truly raised the bar for future events. Here's a glimpse of this remarkable event highlights:

(a) Technical Excellence: -

Eminent speakers and industry experts inspired attendees with their wisdom and encouraged young talents.

Special Industry Sessions focused on vital sectors like Oil & Gas, Nuclear, Aviation & Aerospace, featuring many prominent invited speakers from leading organizations.

Two pre-conference tutorials (PCTs)on Civil Infrastructure and Data Engineering-Phased Array, conducted as a collaborative session of Indo-German and Indo-UK attracted over **80 registered delegates.**

Over **170+ contributory papers** presented across 5 parallel sessions and 20 poster panels each in 3 poster sessions enabled excellent knowledge sharing

Special Student session career opportunities in NDE&T attracted **370+ students and faculty**, the largest gathering for a single session besides the inaugural event.

(b) Exhibition & Industry Impact: -

Over **125+ exhibition stalls**, including stalls by startups and young entrepreneurs, showcased cutting-edge products, innovations, and their unique capabilities.

A **special booth for product launches and branding** provided ample opportunities for companies to showcase their expertise besides gain more visibility.

Joint sessions on international certifications (ICN 9712) and well-coordinated joint session chaired by ICNDT and APFNDT societies strengthened international collaborations.

-The **exhibition approved under MSME PMS Scheme** enabled eligible MSME industries to claim substantial refunds as reimbursements for their stalls charges thus attracting a large no of udhayam certificate holders to partake.

(c) Academia & Research Contributions: -

Significant participation from **academia, student communities, research scholars, and incubators**.

900+ participants as delegates attended the grand inaugural function and the event saw a mammoth **2300+ visitors** participating in the event ensuring steady flow of footfalls throughout the 3 days of the conference.

(d) Hospitality & Arrangements: -

Scintillating **cultural shows** portrayed diverse Indian art, dance, culture, and traditions, leaving all the attendees spellbound.

Great hospitality reflecting the warmth and vibrancy of Indian traditions, ensured a seamless experience for everyone reinforcing the true Indian Spirit of Athithi Devo Bhava.

Perfect coordination and professionalism by ISNT set a new benchmark for hosting such mega events giving enough reasons for everyone to rejoice and remember.

(e) Key Statistics: -

1000+ registered delegates and **2300+ footfalls** across three days.

Special recognition of contributions for excellence under National ISNT NDT awards presented to deserving individuals, including the prestigious **Lifetime Achievement Award.**

Large opportunities for **networking, collaboration, and business growth**, enabling participants to enhance their reach and renew connections.

A Proud Milestone for ISNT

The unmatched success of **NDE 24** reinforces ISNT's commitment to excellence and professionalism. This event not only elevated the standards for future conferences but also cemented **ISNT**'s position as the leading host and a professional society to reckon with amongst the NDT community across the globe.

We now set our sights on **NDE 2025**, ready to rewrite history again in **December** at**Mumbai**. Looking forward to meeting you at **Jio Convention Centre, Mumbai**.

ISNT hosts conference & expo on Non Destructive Evaluation

Chennai, Dec 11. The Non Destructive Evaluation & Enabling Technologies 2024 Conference & Exhibition, slated to be the flagship event of India Society for Non-Destructive Testing in India, is set to unfold at the Chennai Trade Centre in Chennai, Tamil Nadu, from December 12 to 14, 2024.

This highly anticipated gathering will play host to a convergence of global expertise, cutting-edge technologies, and groundbreaking insights, firmly establishing itself as a milestone in the realm of NDT.

The annual exhibition on Non-destructive evaluation feature 50 keynote talks, 40 technical sessions, 120 exhibitors, 300 technical papers, 2000 participants.

Talking to media Krishnan Balasubramaniam, President ISNT, Komal Kapoor, Chairman NDE, Unnikumar Anand, Convenor NDE said, "With participation from over 120 exhibitors hailing not only from India but also across the globe, the exhibition at NDE 2024 promises to be a dynamic marketplace, from established industry players to emerging startups, exhibitors showcase their products and services, offering attendees a firsthand glimpse into the forefront of NDT technology.

Companies, industry leaders, and innovators will showcase the latest advancements in NDT technologies, tools, and solutions, providing attendees with a hands-on experience and a glimpse into the future of non-destructive testing.

The heart of the conference lies in its comprehensive lineup of over 200 paper presentations. Covering a wide spectrum of NDT methodologies, these sessions will delve into the intricacies of aerospace, automobile manufacturing, power generation, infrastructure, and other key industrial sectors. From case studies to future trends and challenges, the presentations will provide a deep dive into the evolving landscape of NDT, offering valuable insights to the 1500 anticipated delegates.

The NDE 2024 Conference & Exhibition does not merely serve as a platform for showcasing the present state of NDT but also lays the foundation for the future. The event features keynote addresses from thought leaders and visionaries in the field, providing a roadmap for the evolution of NDT in the coming years. Emerging technologies, such as artificial intelligence and robotics, are highlighted as catalysts for transforming the landscape of non-destructive testing, promising increased efficiency, accuracy and cost-effectiveness across aerospace, automobile, power, and other industries."

The event is expected to attract around 1500 delegates, forming a diverse and influential gathering representing various sectors of the industry. NDE 2024 aims to address the specific needs and challenges of a myriad of industries, including aerospace, automobile manufacturing, power generation, infrastructure, and more.

The NDE 2024 Conference & Exhibition is poised to be a transformative event, setting the stage for the future of Non-Destructive Testing in India and beyond. From the bustling exhibition halls to the knowledge-packed presentations and discussions, this conference promises to be a melting pot of innovation, collaboration, and progress, solidifying its status as a beacon in the ever-evolving world of NDT.

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HAVE WE RAISED THE BAR!

ISNT Chennai Chapter News

Addition of Members – **Newly Added Members up to December 2024**

Life Corporate Member

1. Thiagarajar College of Engineering, Madurai
2. TeraLumen Solutions Pvt Ltd, Navalur, Chennai
3. XYMA ANALYTICS PRIVATE LIMITED, Chennai
4. Rajalakshmi Engineering College, Chennai
5. Suthan Brother Engineering Private Limited, Chennai

Life Member

1. Eswar Karunanidhi, Chennai
2. Mr.Nishanth Raja, Xyma Analytics Pvt. Ltd., Chennai
3. Mr.Prashanth M., IIT, Dhanbad

Member

1. Mr.Arulananda Jerry, EIL, Chennai
2. Mr.Prajil, EIL, Chennai

MEMBERSHIP STATUS UP TO DECEMBER 2024

PARTICULARS	Sep 2024	Newly added	Sep 2024
LIFE CORPORATE MEMBER	54	5	59
CORPORATE MEMBER	3		3
LIFE FELLOW	14		14
HONORARY FELLOW	9		9
LIFE MEMBER	613	3	616
MEMBER	19	2	21
ASSOCIATE MEMBER	7		7
STUDENT MEMBER	202		202
TOTAL	921	10	931

Course Conducted

Surface NDT (MT & PT) Level-II course and examination from 7th November 2024 to 16th November 2024. No. of candidates attended the course and examination was 9. Mr.C.Karuppasamy was the Course Director.

Courses Planned for the next 3 months

1. **UT Level-II course from 20th January 2025 to 01st February 2025**
2. **RT Level-II course from 12th February 2025 to 22nd February 2025.**

MT & PT LEVEL-II COURSE VALIDECTORY ON 14.11.2024

Respected Guru's of NDT
Thank U so much for teaching us, sharing valuable knowledge and experiences and bringing us more closer to the wonderful and exciting world of NDT. Thank U - We are Thankful to staff of ISNT Chennai chapter for taking good care of us during our stay at Chennai. Looking forward to attend future courses conducted by ISNT Chennai chapter and NDE 2024.
Mithileh pavan kumar

Respected Faculty of NDT
Thank you very much each one of you, for teaching the subjects with such ease...clearly we can see difference in ourselves after attending classes.
–**Kiran Singam**

EC meeting

1.The 5th EC Meeting for the financial year 2024-2025 was held on 20th October 2024

2.The 6th EC meeting for the financial year 2024-2025 was held on 24th November 2024.

WORKSHOP ON EDDY CURRENT

A two days Workshop on Applications and Advances in Eddy Current Testing Technologies was conducted on 4th & 5th October 2024 at Anna University, Sardar Patel Road, Chennai-600025 was organized by ISNT Chennai Chapter and PFMB-ISNT. No. of Participants attended 30.
Principal Sponsor by M/s. FOERSTER Instruments India Private Limited and Sponsor by M/s.Eddyfi Technologies.

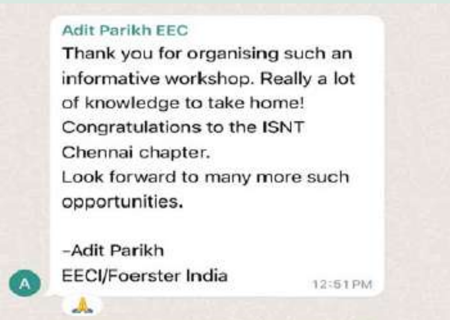
The workshop was addressed by Prof.Dr.J.Prakash, Registrar, Anna University, Prof Dr.R.Velraj, Former VC, Anna University and Mr.Rajul R.Parikh, MD EECI.

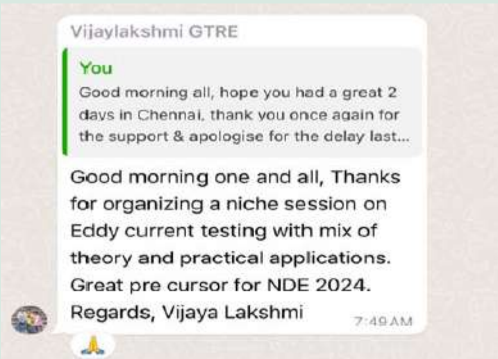
Faculties were from Mr.Arbind Kumar, BARC, Mumbai, Mr.T.V.Nageswara Rao, NFC Hyderabad, Dr.S.Thirunavukkaru, Mr.V.Arjun, IGCAR, Kalpakkam, Mr.Jitender Yadav, Eddyfi, Mumbai, Mr.Abhinar, Ex HAL, Koraput, Dr.M.T.Shyamsunder.

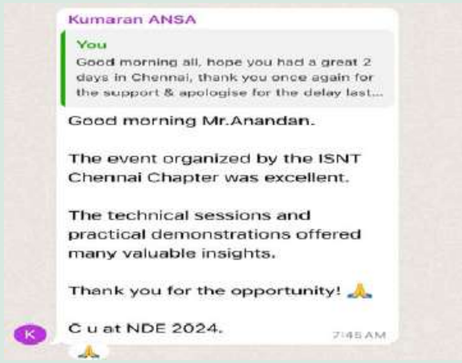


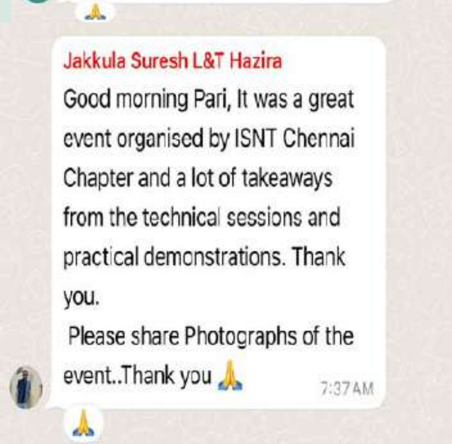


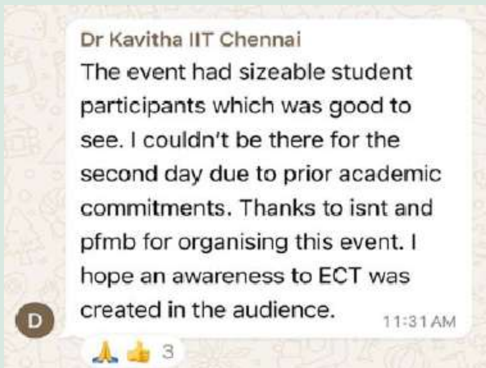

WORKSHOP ON ECT - COMMENTS BY PARTICIPANTS











TECHNICAL TALK

Technical Meeting

S.No.	Date	Topic	Speaker	Venue
1.	20.10.2024	"Thermal Imaging For Material Evaluation" was conducted on 20.10.2024	By Ms. M. Menaka, Heading, Radiation and Meteorology Section, IGCAR, Kalpakkam and Sponosed By M/S. Meena International, Paruthipattu, Chennai	ISNT Head Office Conference Hall , Chennai

CORPORATE MEET

Corporate meet was held on 5th October 2024 at Hotel Feathers, Chennai. 55 members from various company attended the meeting. The meeting was welcomed by Chairman ShriR.Balakrishnan, About ISNT by CMDE Vijay Kumar ED ISNT, Role of corporate by Dr.Jaitheerth Joshi, NDE 2024 by Mr.Umakanthan Anand, VP, Reliance, NDE 4.0 by Dr.Shyam Sunder

Dr.Prabhu Rajagopal was honored for recipient of Shanti Swarup Bhatnagar Award

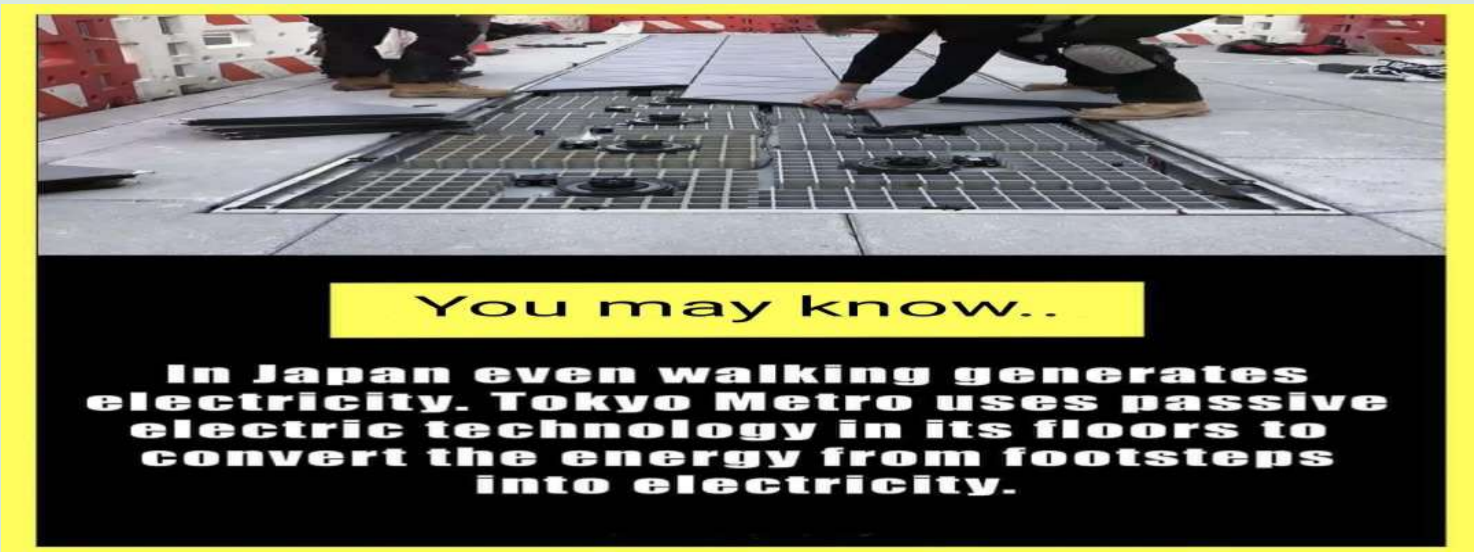
Birthday celebration of EC members during the EC Meeting held on 20.10.2024 and 24.11.2024

ISNT Chennai Chapter News

ISNT Chennai Chapter E-Newsletter—Sound bytes 14 was released during the inaugural function of workshop on Eddy current testing held on 4th October 2024

ISNT Chennai Chapter has exhibit a stall at Corcon 2024 conference held at Chennai Trade centre on 20th to 23rd November 2024.

Snippets



Some interesting mathematical facts of the year, 2025 :-

1. 2025, itself is a square = 45 x 45 = 2025

2. It's a product of two squares, = $9^2 \times 5^2 = 2025$

3. It is the sum of 3-squares, = $40^2 + 20^2 + 5^2 = 2025$

4. It's the first square after the year 1936 = 44 x 44 = 1936

5. It's the sum of cubes, of all the single digits, from 1 to 9, = $1^3+2^3+......9^3$ = 2025

Happy New Year 2025

WET-BULB TEMPERATURE

By Mr.M.Manimohan, Manager (Retired), NDTL, BHEL, Trichy

Many parts of India, reel under severe heat wave since mid-May.

In some areas of the national capital, the temperature was recorded over 48-49°C, while in Rajasthan the mercury touched 50°C in some places.

Deaths due to heatstroke and related ailments were reported in several areas, which brings us to the question how much heat can a human body tolerate.

13 people died of sunstroke in Maharashtra recently, but these headlines do not tell the whole story as they only talk about one factor which is high temperature.

People can die from dehydration and heatstroke when their bodies are unable to cope with extreme heat and fluid loss. Both conditions, if untreated, can become life-threatening.

According to Centre for Science Environment (CSE), Delhi, the body works best within a narrow range of body temperature 36°C(97.8°F) to 37.5°C (99.5°F).

Once 40°C(104°F) is reached, it can be dangerous even with low humidity levels.

With temperature touching 50°C(122°F), the situation is critical

When it comes to the impact of high temperatures on humans, we generally ignore humidity, which also plays a huge role in how we actually experience heat.

Recently Five people who attended the air show at Marina Beach, Chennai, Tamil Nadu, died from suspected dehydration.

The day temperature was35°C (measured at Chennai Airport) with the humidity level of 70%

The temperature 35°C which is called as Ambient temperature, is usually measured with a dry bulb thermometer.

It is called "Dry Bulb" because the air temperature is indicated by a thermometer not affected by the moisture of the air.

Another temperature is called as **Wet bulb temperature**, which is calculated based on the humidity present in the air.

The wet bulb temperature is a meteorological term used to describe the lowest temperature that can be reached by evaporating water into the air.

This temperature helps measure humidity and understand how much water can evaporate into the air.

Wet Bulb temperature can be measured by using a thermometer with the bulb wrapped with muslin cloth which has been soaked in water at ambient temperature (a **wet-bulb thermometer**) and over which air is passed.

The evaporation of water from the thermometer bulb and the cooling effect is indicated by a "wet bulb temperature" lower than the "dry bulb temperature" in the air.

The rate of evaporation from the wet bandage on the bulb, and the temperature difference between the dry bulb and wet bulb, depends on the humidity of the air.

When the air temperature is 46.1°C(115°F)with a relative humidity of 30%, the wet bulb temperature is 30.5 °C(86.9° F).

Even heat-adapted people cannot carry out normal outdoor activities past a wet-bulb temperature of 32 °C (90 ° F), equivalent to a heat index of 55 °C (131 °F).

A reading of 35 °C (95 °F) wet bulb temperature is equivalent to a heat index of 71 °C (160 °F) is considered the theoretical human survivability limit for up to six hours of exposure.

Very humid heat wave is a lot more dangerous than a very dry heat wave.

Our bodies are designed to work pretty much right at 36° C, so there's a constant balance between heat loss and heat gain.

Our body works to maintain its core temperature in hot environments mostly by sweating.

The sweat we produce evaporates into the air, sucking heat from our skin and cooling down.

Humidity cripples this cooling method, if it's so humid that there's already a lot of water vapor in the air, then sweat can't evaporate as quickly, and sweating won't cool down as much.

Problems starts when our bodies can't lose heat fast enough.

Wet-bulb temperature and health

As long as the wet-bulb temperature is well below the skin temperature, the body can release heat to your surroundings through sweating.

But as the wet-bulb temperature approaches our core temperature, we lose the ability to cool down, hence the discomfort

At such extremely high wet-bulb temperatures, there is so much moisture in the air that sweating becomes ineffective at removing the body's excess heat.

After about six hours or more, it can lead to organ failure and death in the absence of access to artificial cooling.

In order to protect ourselves from sunstroke, it is advisable to avoid prolonged exposure to the sun and to have plenty of water, even if not thirsty, to avoid dehydration.

Extreme heat can lead to major kidney and heart problems, and even brain damage.

Impact of wet bulb temperature over NDT personnel working in hot condition and high humidity

Personal risk factors, such as age, medical conditions, medication use, and acclimatization level, can influence an individual's response to heat

In extreme heat conditions, worker efficiency can decline by up to 78%, and the risk of accidents can increase due to heat-induced fatigue and cognitive impairment.

Personal Protection

Ordinary clothing like pure cotton, provides protection from heat radiated by surrounding hot surfaces.

Specially designed heat-protective clothing is available for working in extremely hot conditions.

In hot and humid workplaces, light clothing allows maximum skin exposure and efficient body cooling by sweat evaporation.

While working in outdoor areas, wearing the cap is recommended.

How to prevent heat-related illnesses

People are generally unable to notice their own heat stress-related symptoms like heavy sweating and a rapid drop-in pulse rate, Heat exhaustion, heat cramps and heatstroke.

Their survival depends on their coworker's ability to recognize these symptoms and seek timely first aid and medical help.

Salt and Fluid Supplements:

A person working in a very hot environment loses water and salt through sweat.

This loss should be compensated by water and salt intake.

Fluid intake should equal fluid loss.

On average, about one litre of water each hour may be required to replace the fluid loss.

Plenty of cool (10-15°C) drinking water should be available on the job site, and workers should be encouraged to drink water every 15 to 20 minutes even if they do not feel thirsty.

Sport drinks and fruit juice:

Drinks specially designed to replace body fluids and electrolytes may be taken.

Fruit juice and electrolyte drinks, diluted to half the strength with water, is another option.

Drinks with alcohol or caffeine should be avoided, as they dehydrate the body.

Employer's **responsibilities:**

companies can proactively manage the health risks of working in hot conditions.

This involves adjusting the duration and intensity of work and implementing hydration breaks to prevent dehydration

Limiting outdoor work to 45 minutes and a 15-minute rest break in a shaded area.

Imparting training for the personnel to manage the hot and humidity related work environment.

An emergency action plan has to be prepared to meet the extreme environments.

The plan should include procedures for providing affected workers with first aid and medical care.

Highest recorded wet-bulb temperatures

The following locations in India have recorded wet-bulb temperatures of 34 °C (93 °F) or higher

(Measured at airports, so other locations in the city may have experienced higher values.)

WT (°C)	City	State
34.6	Machilipattinam	Andra Predesh
34.5	Balasore	Odisha

TITBITS

The Innovation Sutras | (Sutra 1) Innovation bridges the gap between ideas and practical implementation

(Professor Prabhu Rajagopal, Faculty in-charge, Centre for Innovation (CFI), IIT Madras; recipient of prestigious early career awards including the IEI-National Design Award, and the National Swarna Jayanti Fellowship)

IIT Madras has become the foremost hub for innovation and entrepreneurship in the deep-tech space in the country, led by its pioneering incubation cell and fed by channels including the student-led Centre for Innovation, pre-incubator Nirmaan, and Laboratory-to-market focused Gopalakrishnan Deshpande Center (GDC).

Passionate about technology transfer and finding solutions to practical challenges, several faculty members including the author are enthusiastic participants in this trend, balancing IP commercialisation and spin-outs with teaching and research.

IITM startups are today making a difference in diverse, socially, and industrially relevant sectors taking digitalization solutions down the district levels in the country. IIT Madras has thus been topping the Ministry of Education, Government of India's Atal Ranking of Institutions on Innovation Achievements (or ARIA) listings for several years in a row.

For those familiar with Indian philosophical systems, the Sutra literature presents vast and complex ideas condensed in the form of terse statements. This article series distills the learnings from experiences in the form of some essential maxims so that those interested in innovation in the context of product development and startups can quickly access and adopt them.

While the textbook meaning of 'innovation' means any process of 'new creation', in the context of startups, it is important to have a clear conception of Innovation as the pathway to new products and solutions.

In the race to the development of an elegant solution to any given problem, several candidate approaches always emerge.

For example, at the beginning of the era of internet search engines, at least a dozen different websites offered them. In the end, it was only Google that managed to capture the popular imagination and market, to the extent today, we even use the phrase 'Google it' to refer to searching for something on the internet.

In the world of sensors, for example, although there are many ways of generating and capturing sound, the one using piezoelectricity has gained wide currency due to the ease of fabrication of lead zirconate titanate (or PZT) which in turn made it widely scalable.

Therefore, innovation, more formally, can be seen as the power of a solution to overcome the 'valley of death', or the chasm between ideation and field deployment.

Many technologies perish in this chasm straddling the challenging field of work beyond the initial proof of concept which is often exciting with many funding options and disruptive advances with scope for high-impact publications.

However, at higher technology readiness levels (TRLs), the scientific advances may not be as significant as those required to productize the solution and make it deployable on the field.

At this stage, typically funding from traditional academic or research sources dries up: but even industry or the market may not step in immediately until the technology reaches maturity.

However, if the solution is well crafted in terms of its innovation quotient vis- -vis the customer requirement, elegant and cost-effective to implement, and scalable in its realisation, it is sure to attract the funding and support to reach the market.

It is not enough to create something afresh or recreate it 'here', but to make it in a way that is mindful of the market needs, costs, and scalability.

Thus, innovation must be seen as the inherent ability of a solution to organically overcome challenges and outcompete other possible approaches addressing the same problem, racing away to productization and field deployment.

Acknowledgement: The above article authored by Prof.Prabhu Rajagopal was published in India Today (10th April 2023) is republished in this Sound bytes, as we found it informative and an excellent guide for people in any walk of life. Our sincere thanks to India Today for publishing it.

Automated Inspection of castings using DDAs

by Mr. S. Ramakrishnan, SGM- Head Corporate QA, Brakes India-Foundry

1. Introduction of Brakes India
2. X Ray Inspection
3. Customer Expectation and Challenges
4. Automated Inspection of castings using DDAs
5. Way forward

Introduction:

- Brakes India Foundry is the leading foundry for automotive iron castings globally. It is part of TSF group (was part of Erstwhile TVS Group)
- Exporting 60% of safety critical parts to various countries such as US, Mexico, UK, Germany, Italy, Sweden, France, Japan, etc.
- The foundry produces over 186,000 tons of iron castings
- Proud recipient of the prestigious Deming Award, TPM Special Award and CII Green Product Certificate.
- Every automotive player in India uses our castings and Every 3rd car in Europe has our iron castings.
- 75% of Buses and Trucks in India has our brakes
- There are four manufacturing sites spread across in India and Oman and all sites are installed with X ray facilities to ensure quality castings to customer
- Ultimate Customers: Rolls Royce, Audi, GM, Ford, Jaguar, BMW, VW, Mercedes Benz, MAN, Stellant is etc.

Products and its applications

Turbocharger Parts

Brake Caliper – Housings and Carriers

Knuckles

Chassis Parts

X Ray Inspection

Casting is a widely used manufacturing process, but it is not without its flaws. X-ray inspection can help reveal internal discontinuities and improve the quality of castings.

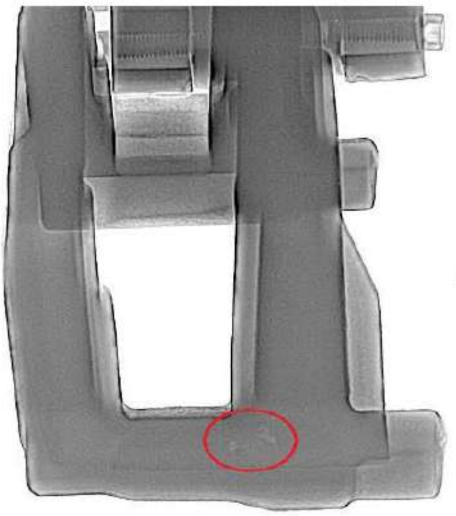
Casting Process: Casting is the process of pouring molten metal into a mould created out of refractory material with a cavity which is generated using a pattern (exactly replica of the desired object). The molten metal is allowed to cool and takes the shape of the mold cavity.

Foundry Inspection Challenges

Foundries face several challenges when it comes to quality control, such as detecting internal discontinuities, identifying material inclusions, and ensuring consistent production. X-ray inspection provides a non-destructive and efficient way to address these challenges.

What is X-ray Inspection?

X-ray inspection involves exposing the casting to radiation and capturing the resulting image. The image is then analyzed for any anomalies. Different techniques can be used, such as computed tomography and digital radiography. X-ray inspection is a non destructive method that allows for accurate detection of discontinuities

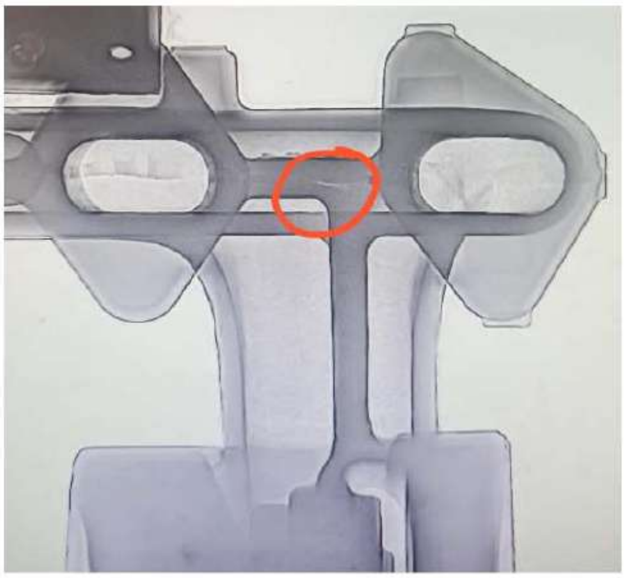


How Real-Time Radiography Works?

Real-time radiography uses X-rays to create images of the internal dis continuities of objects. The X-rays pass through the object and are detected by a digital detector. The detector converts the X-rays into electrical signals, which are then processed by a computer to create an image

Types of Discontinuities

Internal discontinuities in castings can include voids, cracks, porosity, and inclusions. These defect scan weaken the casting and cause it to fail under stress. Evaluating these discontinuities is crucial to ensuring the integrity of castings. X-ray inspection can detect these discontinuities and aide suitable corrective action to be taken.



X-ray Inspection Benefits

X-ray inspection provides several benefits, including improved product quality, reduced scrap and rework, and increased efficiency. It is non-destructive, allowing for repeated inspections without damaging the casting. It is also accurate, detecting even small discontinuities. Additionally, it can be used to inspect complex shapes and internal features, ensuring that the final product meets the required standards. This can reduce the risk of failure and improve the performance of the casting

X-ray Inspection Standards

X-ray inspection standards, such as ASTM E446, E2868, and E2660, provide guidelines for consistent and accurate results. These standards define the types of discontinuities that can be detected, and the acceptance criteria for the casting.

Interpreting X-ray Images

Interpreting X-ray images requires knowledge of the casting process and the types of discontinuities that can occur. X-ray images can reveal the size, shape, and location of discontinuities. This information can be used to determine the severity of the defect and the appropriate corrective action. certified Level I & Level II operators are Qualified for x-ray image interpretation.

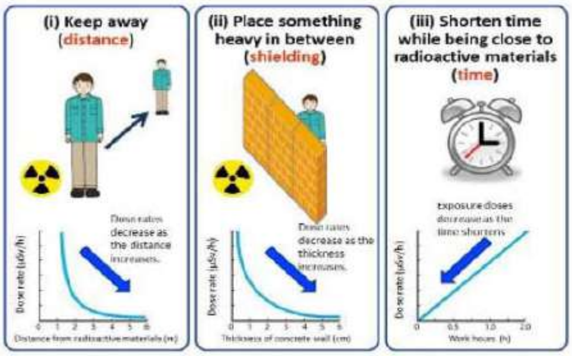
X-ray Inspection Challenges

Despite its benefits, X-ray inspection also poses some challenges, such as equipment cost and maintenance, operator training, and radiation safety. These challenges can be addressed through proper planning, training, and equipment selection.

Real-time radiography has some limitations, including limited penetration through dense materials, limited contrast between different materials, and radiation exposure to personnel. These limitations must be considered when using real-time radiography.

Safety Precautions

- Safety precautions must be taken when using real-time radiography.
- We should fulfill all safety precautions as defined by BARC / AERB
- The area around the X-ray machine must be restricted, and warning signs must be posted.



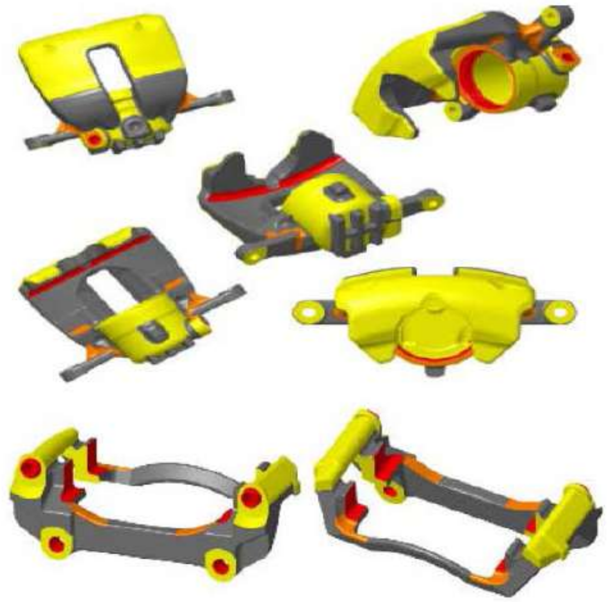
Case Studies

Several case studies have demonstrated the benefits of using X-ray inspection in foundries. For example, one foundry was able to reduce scrap and rework by 30%after implementing X-ray inspection. Another foundry was able to detect and correct a defect that was causing a 20% rejection rate.

Customer Expectation and Challenges (Example)

No discontinuities are allowed in the RED identified regions

Stage	Brake Calipers	Steering Knuckles
New Part Submission	100 %	100%
SOP	30 to 15%	100%
Regular Supplies	On Sampling basis	100%



Requirement	Challenges in X Ray
Product are to be supplied with in acceptable defect range	Defects are not visible perfectly in X Ray
On time delivery	Multiples layers caused hiding of defects
No field failure	Qualified personnel for operations and defect evaluatio
	Productivity - X Ray cycle time ideally for 25 sec for 3 images and with in 35 Sec for more than 3 images
	Quality - No defect is missed
	Controls in OK and NOK parts management in X ray
	Auto detection of defect with less manual intervention

X-Ray Inspection process

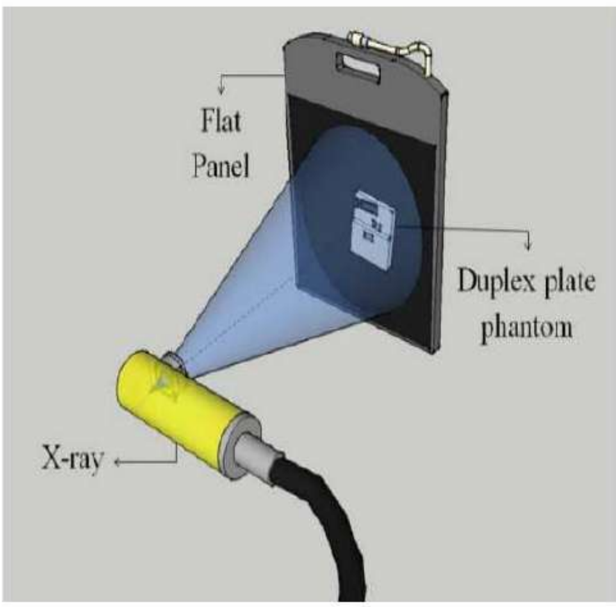
- Our part plays a crucial role in automobiles, defective parts can cause a catastrophic failure for end users.
- Customers specify higher quality control during New product development, During SOP (Start of serial supplies) and regular monitoring

Automated Inspection of casting using Digital Detection Array

Key Components of X Ray System

- X-rays are produced when electrons strike a positively charged nucleus
- The kinetic energy of the electrons is converted into electromagnetic radiation (X-rays)

- The panel works by converting penetrating radiation passing through the test specimen into minute electrical charges.
- The panel contains many microelectronic capacitors. The capacitors form an electrical charge pattern image of the specimen.
- Each capacitors charge is converted into a pixel which forms the digital image



X Ray Laboratory in Brakes India

Three Factor Control Sensitivity

1. Contrast – Depends on kV and scattered Radiation
2. SNR – mA, Integration time and # of frames
3. Definition – Basic special resolution of the detector and geometrical un-sharpness

Focal spot size:

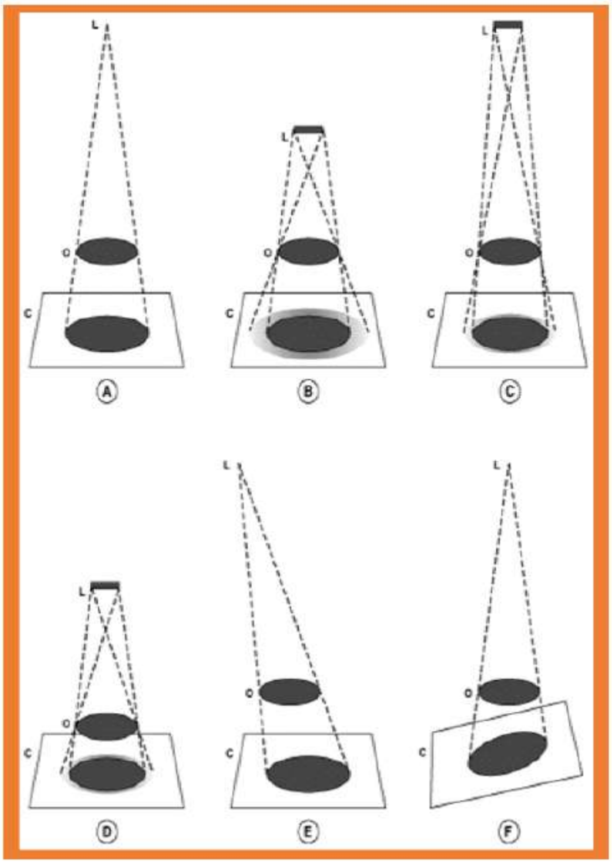
Focal spot size decreases the geometrical un sharpness also decreases and the quality of the image increases

Source to Object Distance:

Source to object distance increases also increase the quality of the image and decrease the geometrical un sharpness.

Object To Detector Distance:

Object to detector distance kept small as help to decrease the geometrical un sharpness and increase the quality of the image.



X Ray Quality: Image Quality Indicators

- Image quality is critical for accurate assessment of a test specimen's integrity.
- IQI's / Penetrometers used to measure radiographic sensitivity, and the quality of the radiographic technique used
- Image quality indicatorsfoundin many shapes and forms due to the various codes and standards.

Automation in X Ray inspection Facilities

Stage / Area

- Engraving the traceability Sl.No in the castings
- X Ray conveyor – Infeed and Out feed
- Robot integration with X Ray system
- X Ray setting
- Management of OK / NOK parts

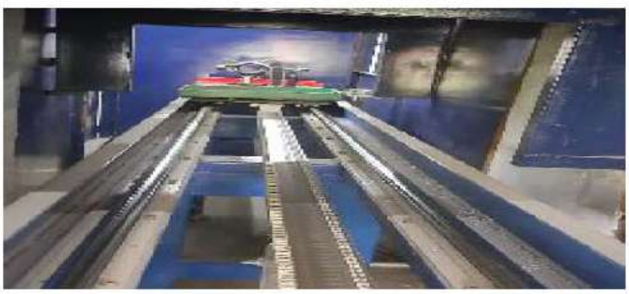
Automation

- Engraved Sl No is linked with X Ray image by Scanning the bar code or actual engraved letters to the X Ray images
- X Ray conveyor with sensors is integrated with robot with software for casting feeding, pick up, manipulation and drop
- Operators need to press only the button to inspect all views of castings as System and robot are integrated
- X ray setting (kV and mA) are automated with respect to casting thickness by digital controller
- Disposal of OK / NOK parts are automated based on decision by inspector to put in GREEN or RED pallets

Bar code printers and scanners are being used to identify the parts and their integration with robot and X Ray system.

Reading the traceability letter by vision system

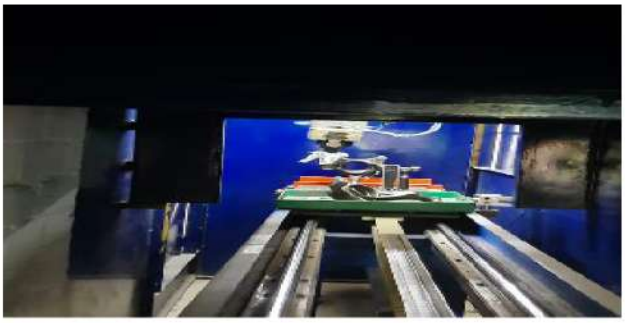
Using of conveyor to move the castings inside the chamber



Sensors are provided to detect the pallet while loading

Fixtures designed with POKA YOKE to prevent loading of wrong part

Robots pick up of the part from conveyor after getting the signal



- Sensors are provided to detect the part and linked with Robot to pick
- Robot will pick up the part at designated orientation and location

Manipulating the part in front of the X ray Tube and detector for getting desired images

Preprogrammed orientation

No missing of shots

Speed and Accuracy

Live monitoring and decision making

- Selection available for auto running of shots
- Selection available for each shot monitoring
- Selection available for rejecting the part
- X Ray control – kV & mA w.r.t. part thickness automated. So, image quality is ensured
- Digital images of ASTM stds for easy comparison
- Images are stored w r t to traceability identification which is automated

Disposition of the tested sample w.r.t. OK or NOK decision

Part will be put in the green or red pallet – Automated

Pusher mechanism to move the part to RED automatically based on decision given

Way Forward

Automatic Dis-Recognition / AI in X Ray Testing

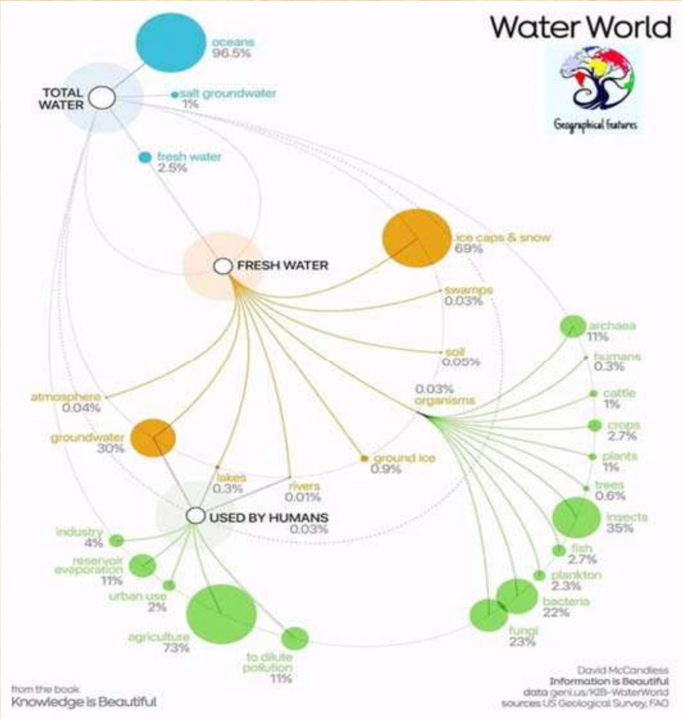
The future of real-time radiography includes advancements in automation and artificial intelligence. Automated systems can perform inspections faster and more accurately, while artificial intelligence can analyze images and detect discontinuities more efficiently.

Currently these systems are running the currently in manual mode for decision making. Each system is operated by a human inspector that performs the evaluation of the images.

This requires availability of skilled people and even increases the consistency and quality of the inspection. Through a new platform powered by Artificial Intelligence (AI), set out to reduce these effects as much as possible.

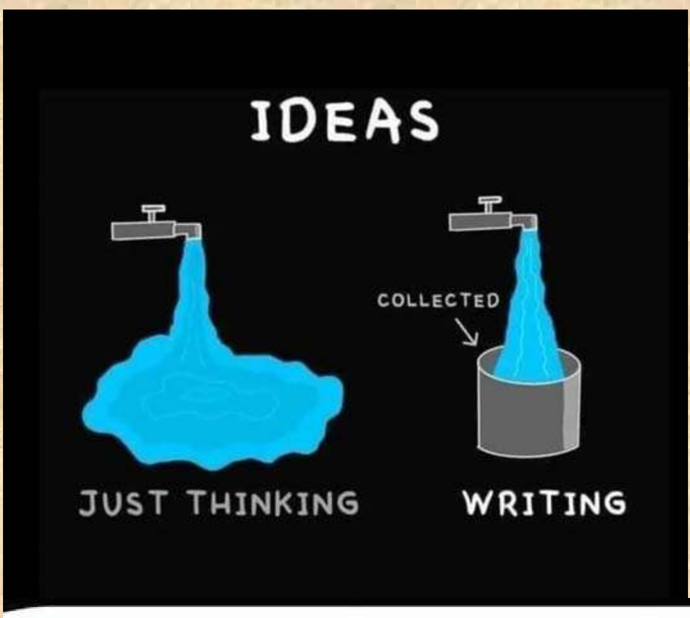
The algorithms require significantly less maintenance efforts and highly reduce the false calls. On the other hand, the AI training requires an initial development time longer and training effort.

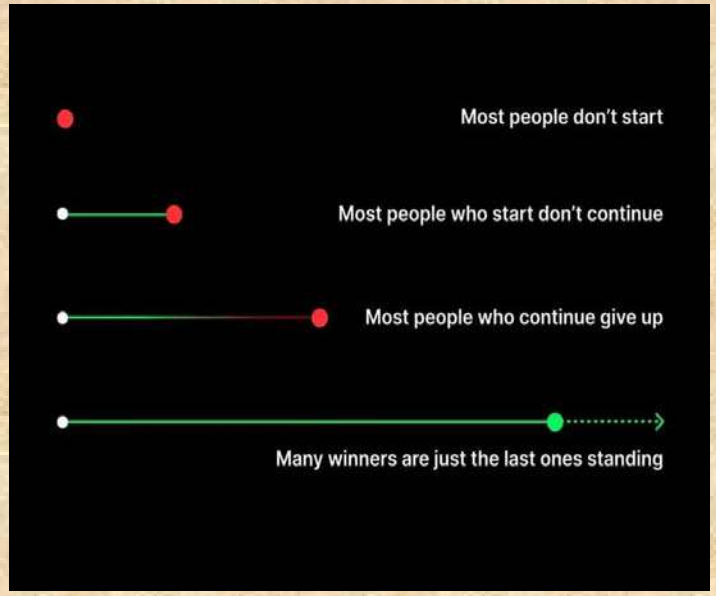
Snippets

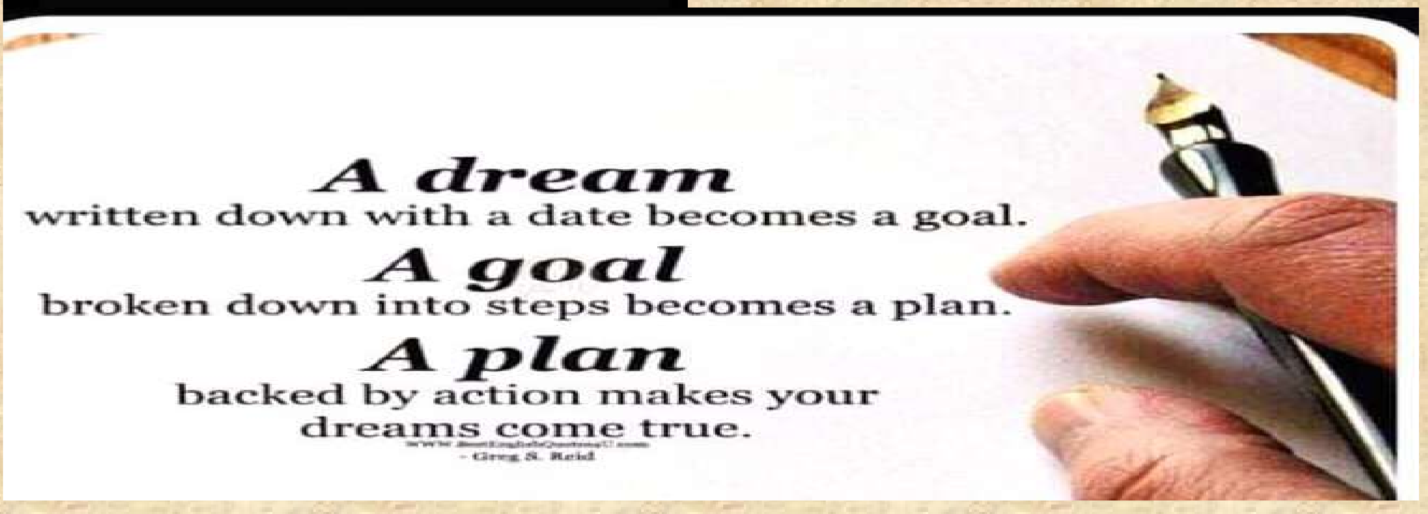


In 1959, Volvo engineer Nils Bohlin developed the modern three-point seat belt. The company made the patent available to all vehicle manufacturers for free, prioritizing public safety. This decision proved to be very beneficial to the world. Today, the three-point seat belt is a requirement in all vehicles. So, you could say there is a little – but essential – part of Volvo in every vehicle on the road.

When Volvo invented the three-point seat belt in 1959, they made the patent free for all competitors to use in order to save lives because it had more value as a free life-saving tool than something to profit from.







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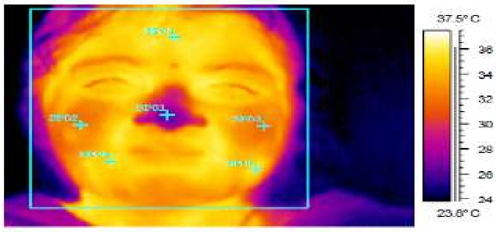
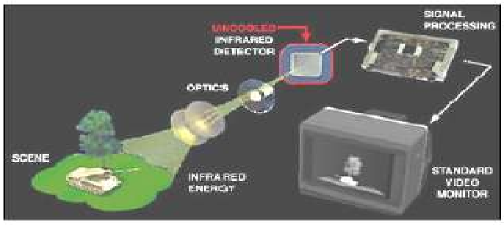
Thermal Imaging for Material Evaluation

By Ms.**M. Menaka,** Head, Radiation Application and Metrology Section, Radiation Application and Technology Division, Safety, Quality and Resource Management Group. Indira Gandhi Centre for Atomic Research, Kalpakkam -603 102.

Introduction

- Thermal imaging or Thermography is the mapping of temperature profiles on the surface of the object or component.
- Technique based on IR radiations
- Any object (> 0 k) emits EM radiations
- At ambient temperatures and above these are in the IR band of EM spectrum
- Using appropriate detectors these can be converted to suitable electrical signals and displayed on the monitor.





Discovery of Infrared Physics

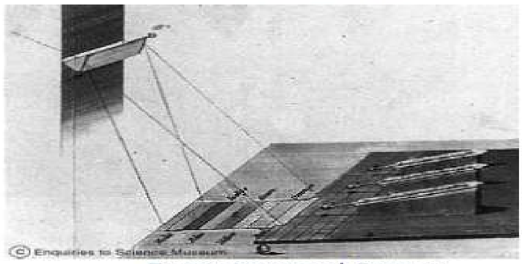
In the year 1800, Sir Frederick William Herschel discovered a form of light (or radiation) beyond red light.

The sunlight was allowed to pass through a glass prism to create a spectrum and he measured the temperatures of the colors, he noticed that the temperature of the colors increased from the violet to the red part of the spectrum.

The region beyond the red portion of the spectrum he found the highest temperature of all. He called these rays as "calorific rays".

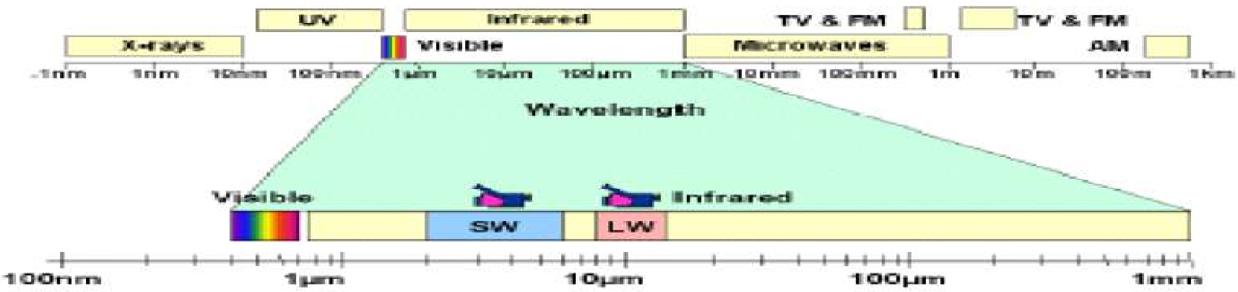
These "calorific rays" were later renamed infrared rays or infrared radiation (the prefix infra means `below').

Sir Herschel



Experimental Setup

Infrared Physics



The Electromagnetic Spectrum

- Wavelength Range 0.75-1000μm.
  Near infrared range: 0.75 – 3 μm
  Middle infrared range: 3 – 6 μm
  Far infrared range: 15 – 1000 μm
- Properties – similar to electromagnetic waves

Advantages of Thermography

- Non–contact Method
- On-line Monitoring
- Full Field View
- Range of applications

Limitations of Thermography

- Difficulty to uniformly heat a large surface
- Quantitative estimation(emissivity & thermal losses)
- Cost of the equipment is high
- Detects only surface and slightly subsurface defects
- Limitation on thickness of material.

Analytical Tools

- Planck's Law

$$W_{\lambda b} = \frac{2\pi hc^2}{\lambda^5 \left(e^{hc/\lambda KT} - 1 \right)} \times 10^{-6} \text{ [Watts/m}^2\mu\text{m]}$$

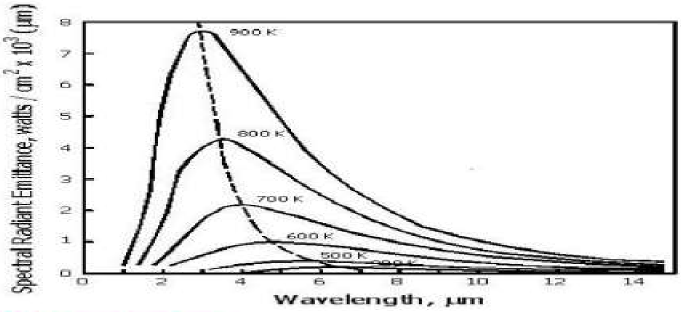
Emitted energy as a function of the wavelength for a given temperature.

- Stefan Boltzmann's Law

$$W = \sigma T^4$$

- Wein's Displacement Law

$$\lambda_{max} = 2897.7 / T$$



IR Imaging System

A typical system essentially consists of

- Infrared camera
- Control unit
- Image display
- Image acquisition and analysis unit
- Software

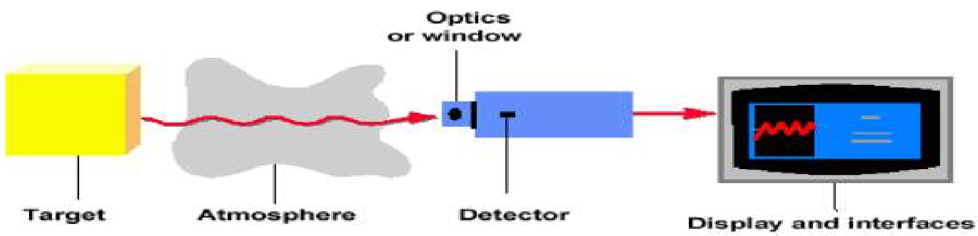


Fig. 1: Infrared measuring system

Infrared Detectors

Thermal Detectors

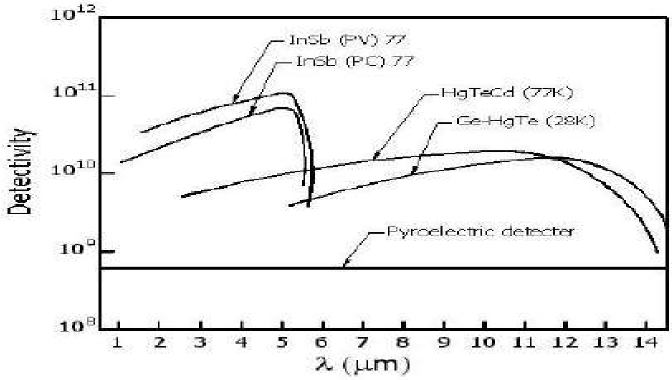
IR is absorbed and produce electric charge in detector/ No cooling required/ Wide spectral response

Photonic Detectors

IR is absorbed and affects atomic states and free electrons within semiconductor/ Excellent Detectivity / Cooling is required

Focal plane Arrays

Recent development – detector in array form reducing the task of mechanical scanning. (unlike single element detector).



Typical detectivity curves

Choice of Detector and associated processing especially for process industries important.

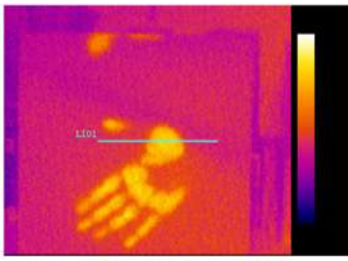
Detector Cooling Systems

- Liquid Nitrogen (-196ºC)
- Joule Thompson gas expansion (-185ºC)
- Stirling Cycle engine

Repetitive compression and expansion of gases.
Best cooling system.
Noise reduction

Performance Parameters

- Spectral Range
- Detectivity
- Temperature range
- Absolute Accuracy and Repeatability
- Frame Rate
- Spatial Resolution and thermal Sensitivity
- Environment or Operating Conditions



Thermal Sensitivity

Techniques of Thermography

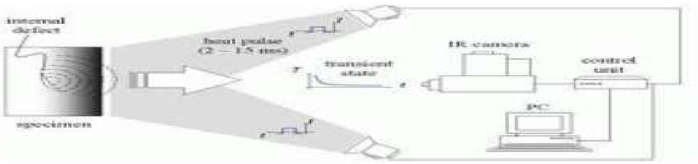
Passive Technique

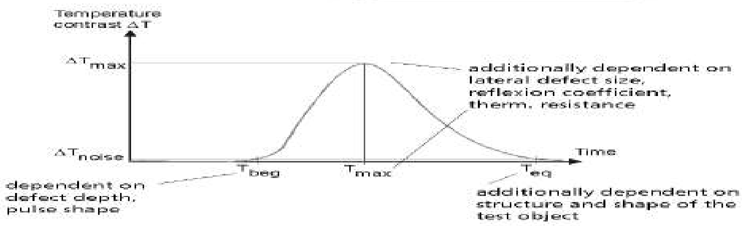
- Natural heat distribution of the object is monitored.
- Applied for condition monitoring of plant components.
- It can be used to find defects which manifest in change in the surface temperature

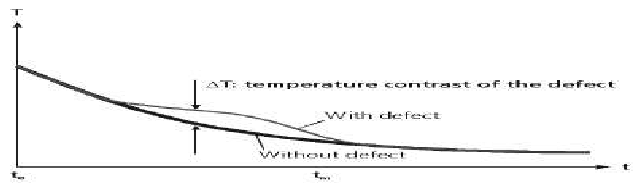
Active Thermography

- Equilibrium state of the object with ambient is disturbed by heating or cooling the sample
- Heating or cooling sources
- Resistance to the heat flow of the defect helps to evaluate it
- In depth defects can be seen.

Pulsed Thermography







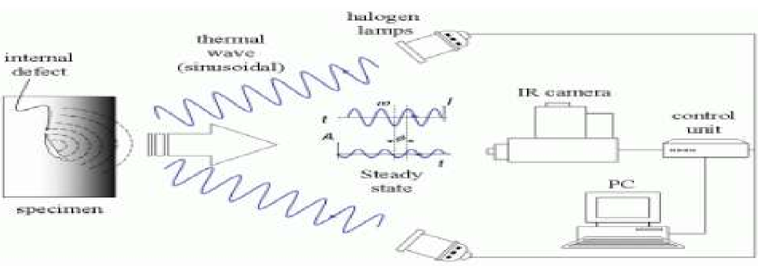
Specimen is briefly heated and temperature decay curve monitored
$t = Z^2/\alpha$; $c \sim 1/Z^3$

Lock-in Thermography

Periodic heat flux is incident on the surface of interest
The surface temperature is measured and local variations in the phase and/or amplitude are sought

Thermal diffusion Length: $\mu=\sqrt{(2\alpha/\omega)}$ (1)

thermal conductivity *k*, mass density ρ , specific heat *c* and modulation frequency ω



$$A(z) = \sqrt{(I_3 - I_1)^2 + (I_4 - I_2)^2}$$

$$\phi(z) = \tan^{-1}\left(\frac{I_3 - I_1}{I_4 - I_2}\right)$$

Method Four Point Correlation

Experimental Set up

Camera

Model: CEDIP Silver 420

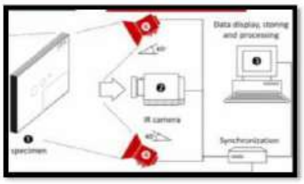
Detector: InSb

Pixel Array: 320x256

Pixel Size: 25 µm

Frame Rate: 178 Hz (Max)

Temperature Resolution: 25 mK



Lock in Thermography

HAMEG – 15 MHz Function Generator

PULSAR – Amplifier

Lamps: Halogen

Maximum Power: 1000 W

Software: Altair LI

Pulsed Thermography

NEXUS A3200

Lamps: Xenon Flash Lamp

Maximum Power: 1600 W each

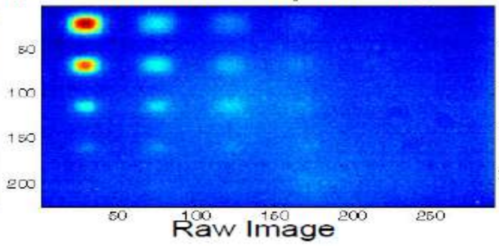
Flash Duration: 2 ms

Image Acquisition Software: Altair

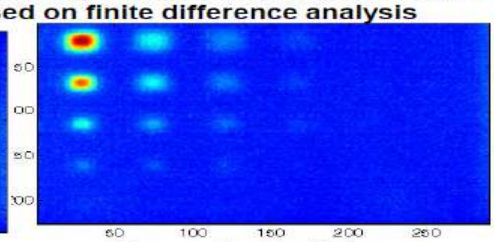
Defect Detection Limits in Austenitic Stainless Steel – Pulsed Thermography

To evaluate accuracy of these empirical Pulsed Thermography (PT) techniques for defect size and depth estimation in type 316 L and compare with theoretical modelling based on finite difference analysis

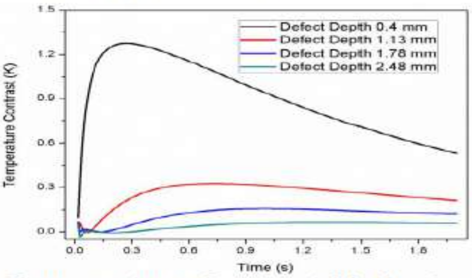
Photograph of the Sample



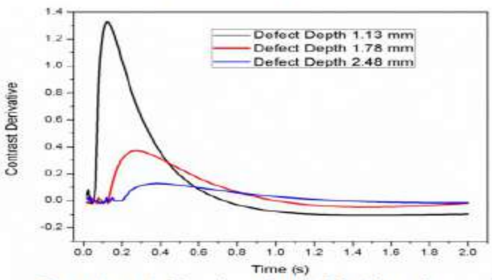
Raw Image



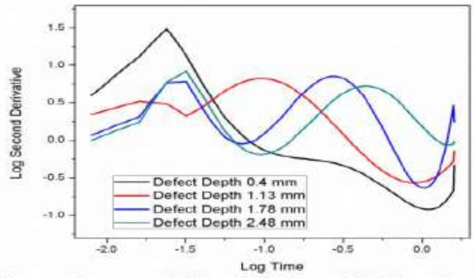
Reconstructed Image



Temperature Contrast Method



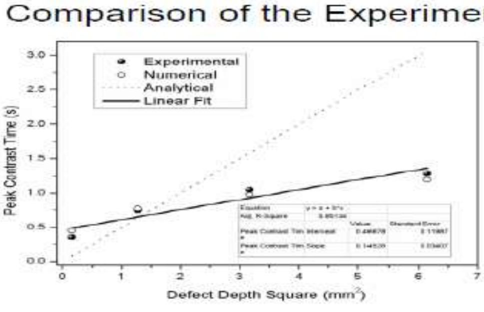
Contrast Derivative Method



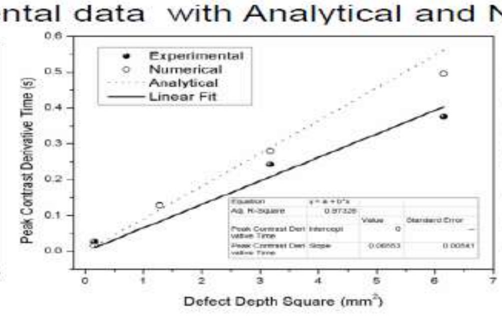
Log Second Derivative Method

Defect Detection Limits in Austenitic Stainless Steel –Pulsed Thermography

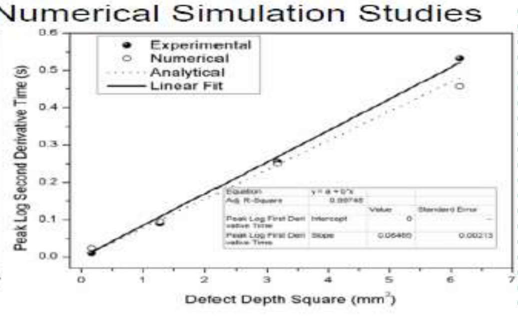
Comparison of the Experimental data with Analytical and Numerical Simulation Studies



Temperature Contrast Method



Contrast Derivative Method



Log Second Derivative Method

Actual Depth (mm)	Temperature Contrast Method		Contrast Derivative Method		Log First Derivative Method		Log Second Derivative Method	
	Predicted Depth (mm)	% Error	Predicted Depth (mm)	% Error	Predicted Depth (mm)	% Error	Predicted Depth (mm)	% Error
0.5	0.4	20	0.45	10	0.57	14	0.44	12
1.15	1.30	13	1.05	8.7	1.28	11.3	1.06	7.8
1.83	2.04	11.5	1.70	7.1	1.93	6.01	1.92	5

Defect Characterization Using PT

Defect Sizing

Line profile over defective area has Gaussian profile.

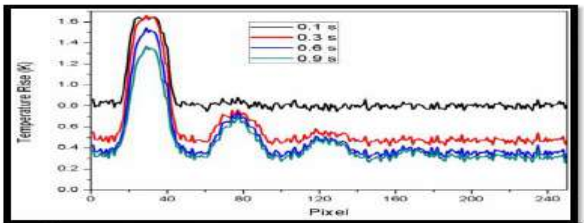
The FWHM gives defect size

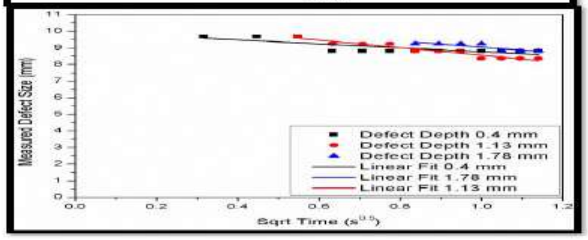
The defect size decreases with time due to the diffusion of thermal waves around the Defect

$FWHM = D - 1.08(\alpha t)^{0.5}$

Defect Depth (mm)	Defect Size (mm)		
	Actual	Measured	% Error
0.4	9.99	9.96	0.3
1.13	9.94	10.83	8.9
1.86	9.9	10.89	10

PT was successfully used for defect depth prediction and size measurement in AISI 316 L SS

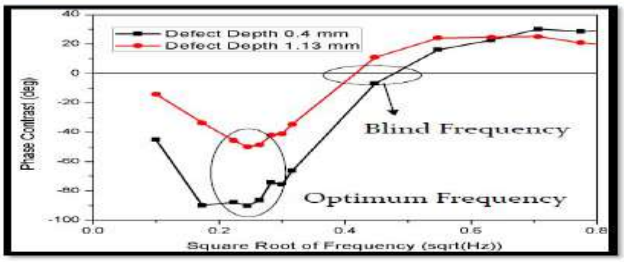




Defect Characterization Using LT

Phase Contrast: Phase angle difference between defective and reference area

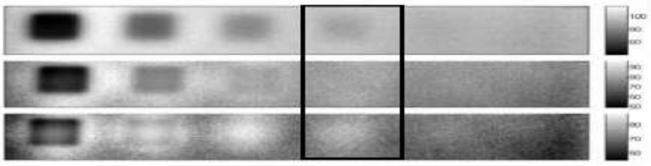
$$\Delta\phi = \phi_d - \phi_s$$



Optimum frequency is the frequency where maximum phase contrast is observed

Blind frequency is the frequency where the phase angle of defective area becomes equal to that of non defective area

Phase Inversion occurs beyond blind frequency



0.1Hz

0.15Hz

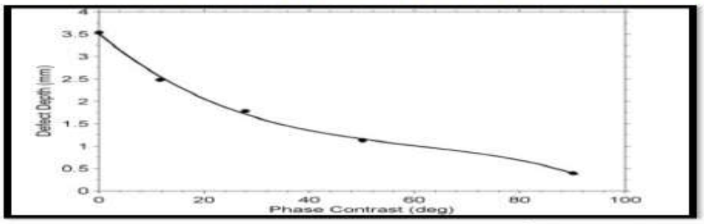
0.2 Hz

Phase images at 0.1 Hz, 0.15 Hz and 0.2 Hz of defects of size 10 mm x 10 mm
The image clearly shows the effect of blind frequency and phase inversion

Defect Characterization Using LT

Phase Contrast Method

Phase image at optimum frequency (0.07 Hz) was considered for analysis



Plot of defect depth vs phase contrast with polynomial fit of order 3 for defects of size 10 mm x 10 mm

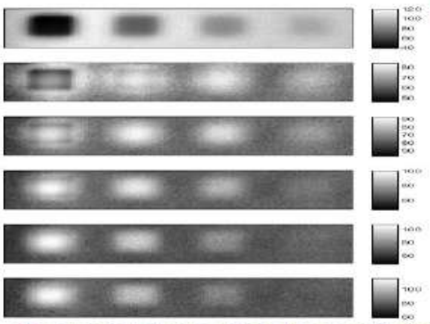
Depth prediction using phase contrast method and error associated with it

Actual Depth (mm)	Predicted Depth (mm)	% Error
0.5	0.47	6.0
1.15	1.22	6.1
1.83	1.91	4.4

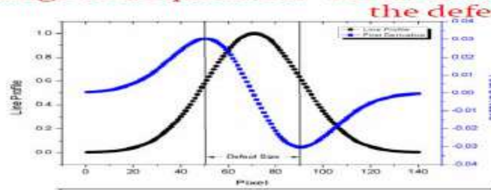
Defect Sizing Aspects in Lock-in Thermography: An Experimental Investigation

In LT, the excitation frequency has pronounced effect on apparent size of defect and image definition

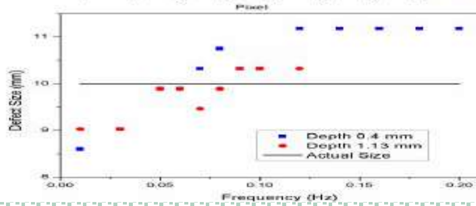
After phase inversion, the phase image loses its definition for a range of frequencies, which should be avoided while measuring the defect size



Phase images of defects of size 10 mm x 10 mm at excitation frequencies 0.1 Hz, 0.2 Hz, 0.3 Hz, 0.4 Hz, 0.5 Hz and 0.6 Hz



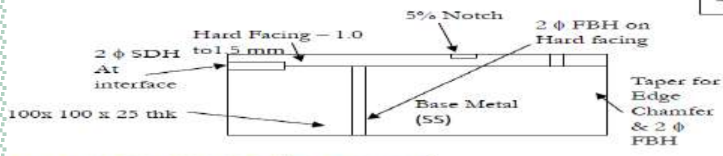
Line profile over centre of defective region is drawn and the first derivative is used to measure the defect size

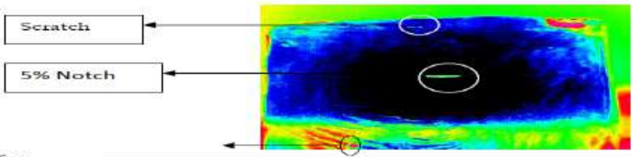


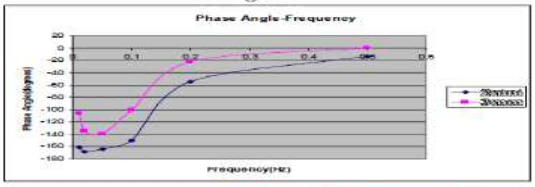
The apparent defect size increases with increase in frequency and better estimation is obtained at frequency where thermal diffusion length is comparable to sample thickness

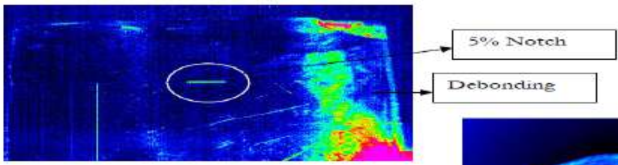
Defect Detection in Coatings Sample

Sketch of the Sample

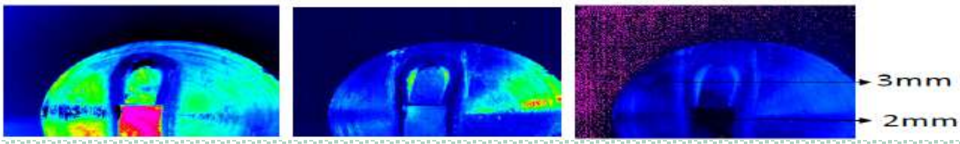




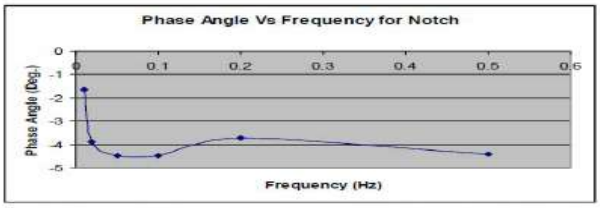




Sample consists of 1 to 1.5 mm of Colomony coating on the stainless steel (AISI 316 LN) substrate.

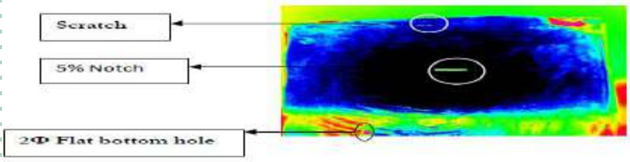


Defect Detection Studies on Hardfacing Overlays

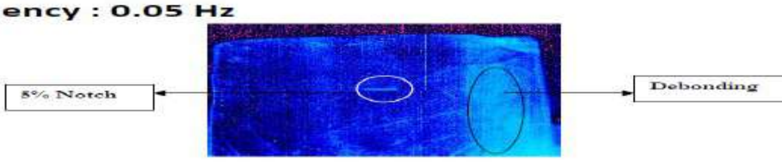


Optimization of Frequency- Defect Detection

Frequency : 0.05 Hz



Amplitude thermal image

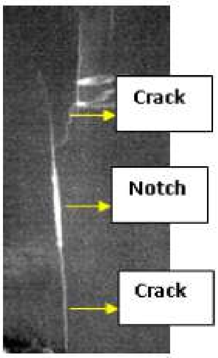


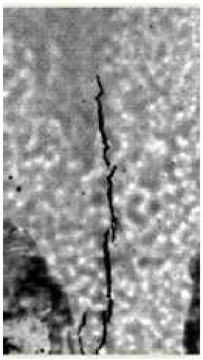
Phase thermal image

Defect Detection and Quantification of cracks using Active Thermography in 550 NB pipe elbow model at SML

Active Thermography inspection was carried out on **550 NB AISI 304 pipe** elbow with 15mm thickness and 90° pipe bend for **PFBR Secondary Sodium Circuits.**

Photograph of the Experimental Set up of Lock in Thermography





Phase images of a) Notch with cracks and b) Natural Crack

- IR Camera used- Cedip Silver 420
- FPA Detector
- Thermal sensitivity - 25 mK
- Frame rate - 50 Hz
- Frequency used - 0.008Hz – 0.5 Hz.

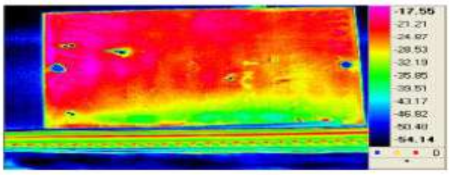
Experimental Parameter

Length of the upper crack and branched crack of the notch is 20.16mm and 36.8 mm respectively. Length of the crack from the bottom of the notch is 43.89 mm

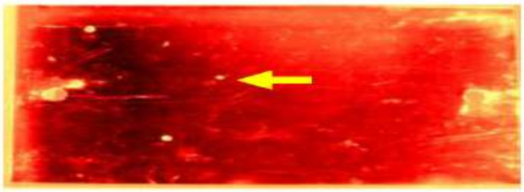
Natural crack which was created due to cyclic stress was observed at the opposite side to the notch. The natural crack has been labelled as top middle and bottom crack with measured length of 103.2 mm, 18.36 mm and 33.21 mm was respectively.

Lock-in thermography could successfully quantify the cracks.

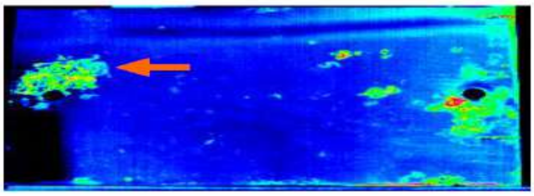
Characterization of Stainless Steel Coupons for Corrosion and Biofouling by Lock-in Thermography



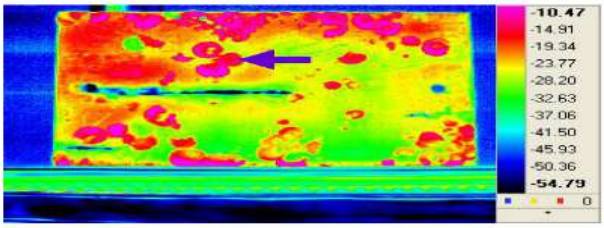
Exposed for 2 months



Exposed for 5 months

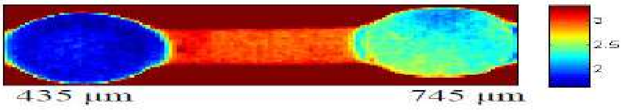


Exposed for 7 months

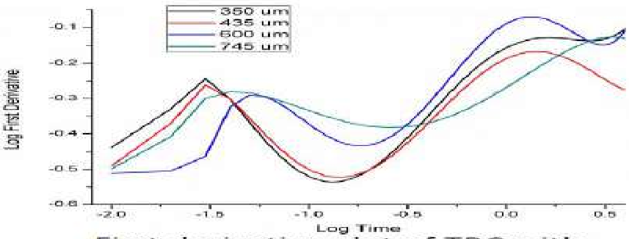


Exposed for 8 months

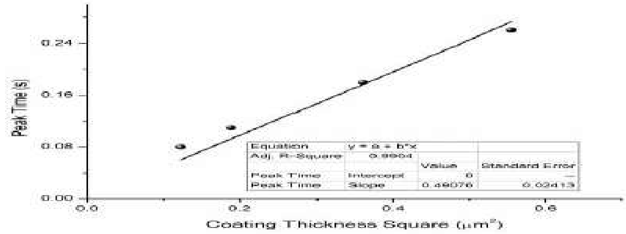
Coating Characterisation



Thermal image of Thermal Barrier Coating after 0.1 s of flash



First derivative plot of TBC with different thickness



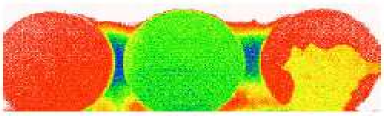
Calibration plot

Yttria Coating Characterization using Active Thermography

Yttria coating is proposed to use as Thermal Barrier Coating on High Density Graphite Crucible for pyro reprocessing application. The coating samples are received from CSTD for thickness evaluation and delamination detection using PT and LT

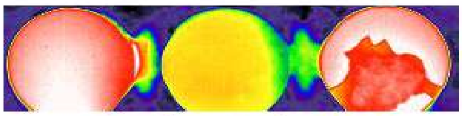
Sample 1 – Reference HDG sample
Sample 2 – Yttria+SiC coated HDG (Typical thickness 500 μm)
Sample 3 – Yttria+SiC delaminated coating on HDG (coating thickness 250 μm, exposed)

PT



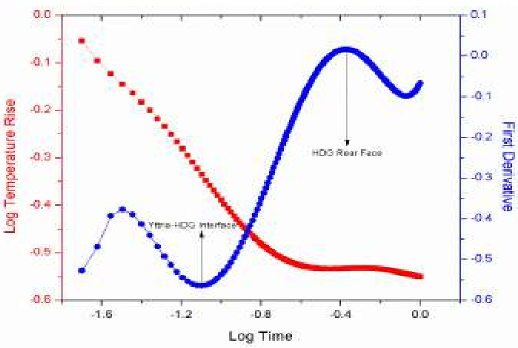
Thermogram of reference, Yttria and debonded Yttria samples after 1.5 s of flash

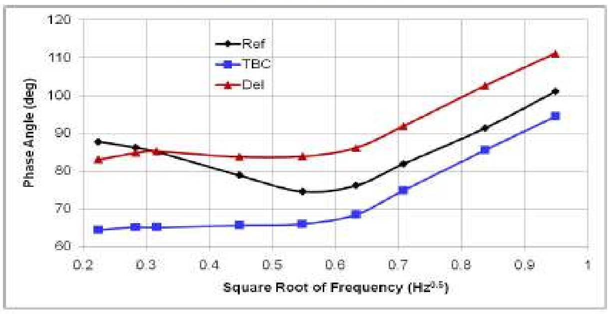
LT



Phase image at f = 0.05 Hz

Plot of temperature-time response in log scale and first derivative plot



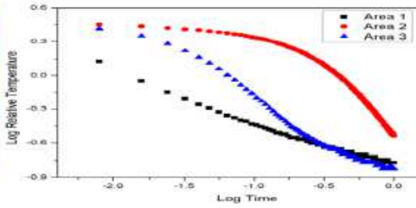


Phase angle variation as a function of square root of frequency

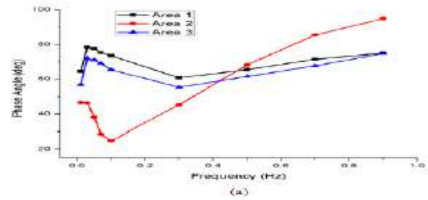
TBC thickness and debonds detection was successfully carried out using PT and LT

Quality Evaluation of Micro-Coating

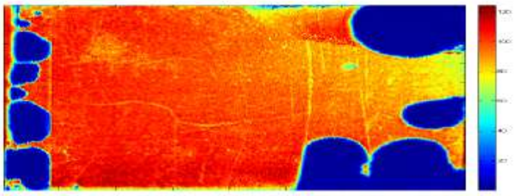
Ni-B Coating on SS 316L

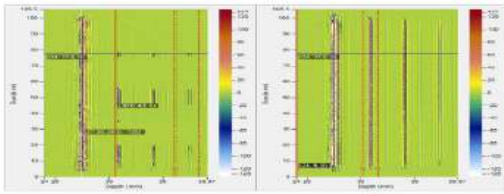


Pulsed Thermography



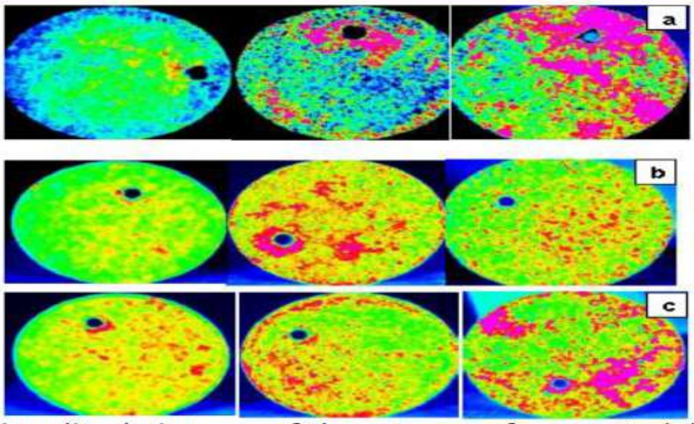
Lock-in Thermography





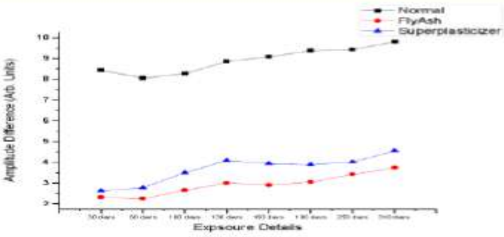
C scan image using immersion UT and B Scan images (a) Debonded area (b) Sound area

Biofilm Formation and Thermographic Evaluation of Fly Ash concrete in sea water

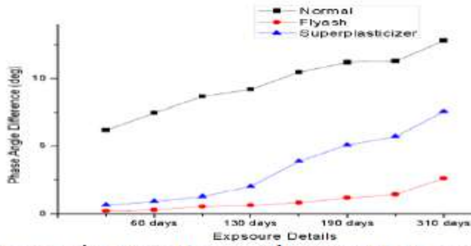


Amplitude images of three types of concrete (a) control (b) fly ash and (c) superplasticizer with different exposure times

Concrete Research Letters Vol3(2)-June 2012 pp 426- 438



Amplitude difference on concrete surfaces with different exposure times



Phase angle variation with seawater exposure time for three types of concrete specimens

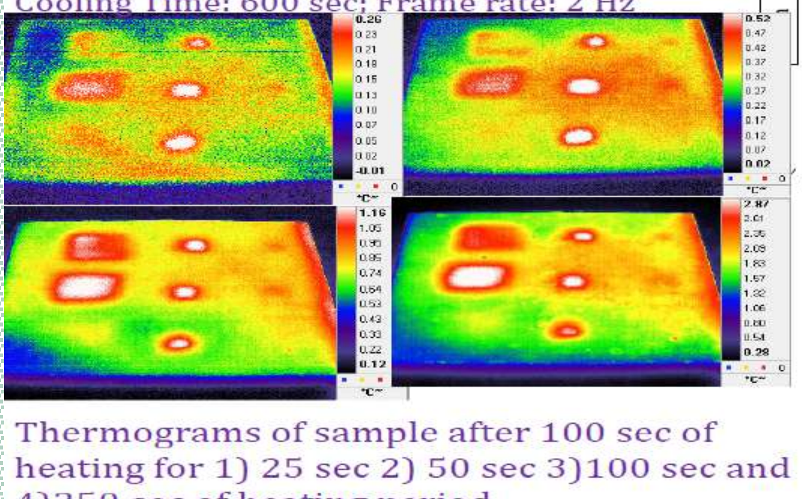
Detection of Defects in Concrete

Sample: Concrete

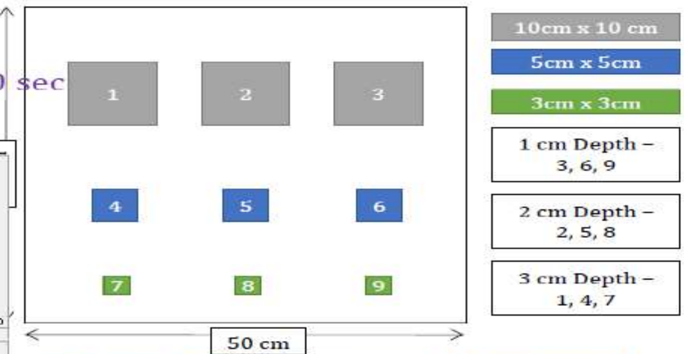
Dimension: 50 cm x 50 cm x 10 cm

Step Heating: Heating period: 25 sec, 50 sec, 100 sec and 250 sec

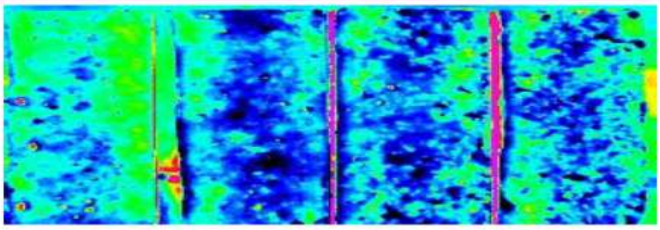
Cooling Time: 600 sec; Frame rate: 2 Hz



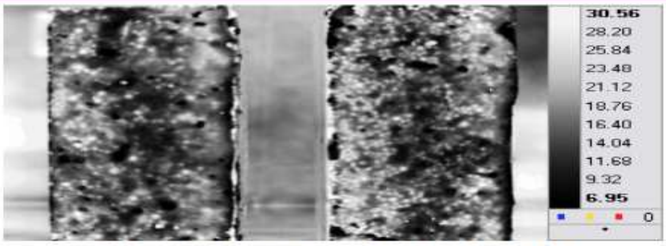
Thermograms of sample after 100 sec of heating for 1) 25 sec 2) 50 sec 3)100 sec and 4)250 sec of heating period



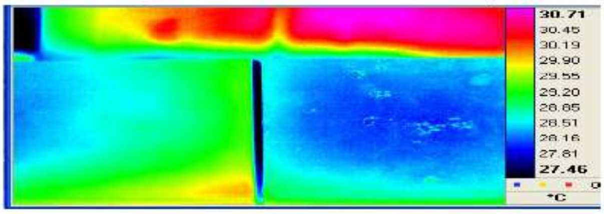
Characterization of High Density Concrete

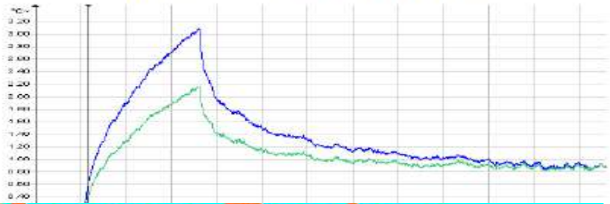


Phase Image of A, B, C and D samples



Phase Image of C and D samples





Thermography for Plasma Facing Components (PFC)

Diverters of fusion reactor are fabricated from high temperature materials to be resistance against with plasma in a high vacuum.

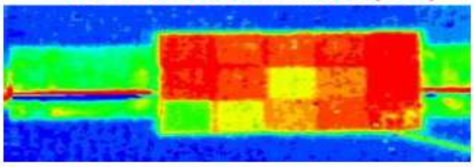
Role of the diverter- reduces the amount of plasma flowing directly into the first wall as a result of plasma disruption

Damage caused to the PFC shortens service life significantly.

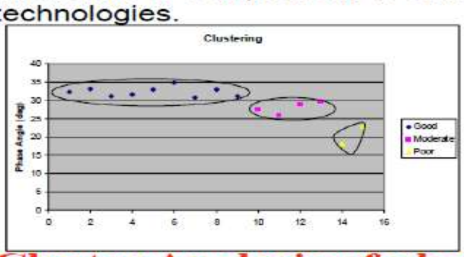
Infrared thermography as one of NDTs has been widely used over the decades to evaluate the integrity of joints in wide range of industries.

It provides a fast, safe, non-destructive and non-contact detection of subsurface defect, and can be used as an alternative or complement to conventional inspection technologies.

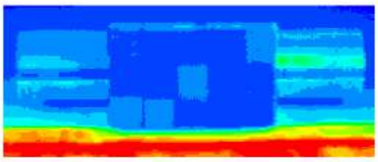
Hot and Cold Simulation (IPR)



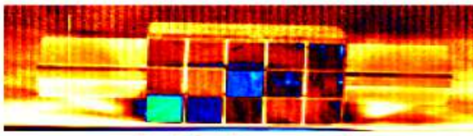
Induction Heating (IIT, Chennai)



Cluster Analysis of phase angle



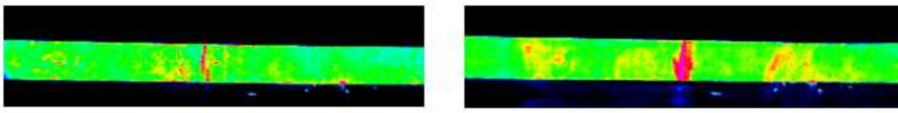
Pulsed thermography



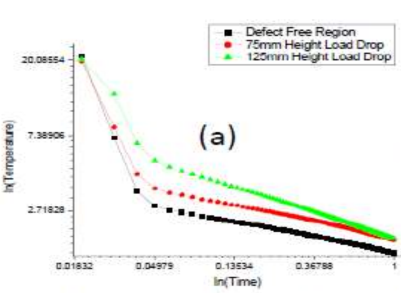
Lock-in thermography

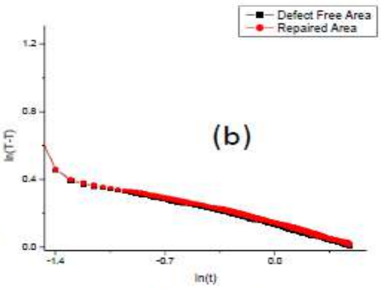
Evaluation of Effectiveness of Repair of Impact Damage in Glass Epoxy Laminates using Pulsed and lock-in Thermography

GFRP composite laminates

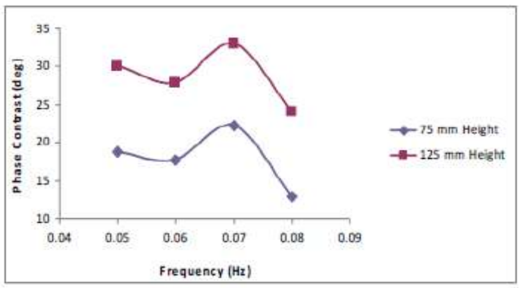


Thermal images of GFRP composite laminates with impact damage

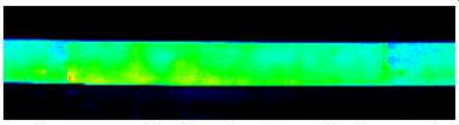




Thermal decay curve for (a) Damaged sample (b) Repaired sample

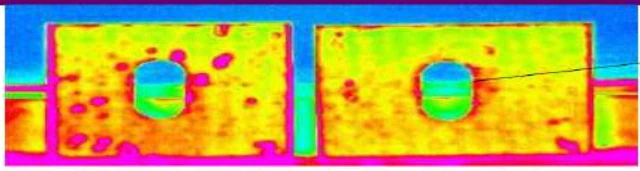


Phase contrast variation of impact damage created by two different dropping height



Thermal image of repaired composite laminate with impact damage from load drop height of 75mm

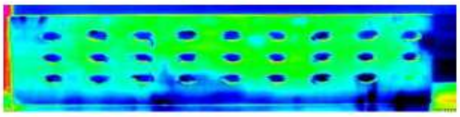
Delaminations Detection and to Study Machining Effects on Composites

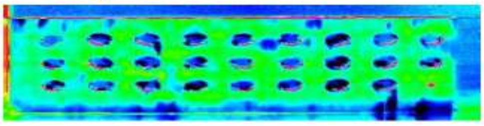


Delamination around the machined region

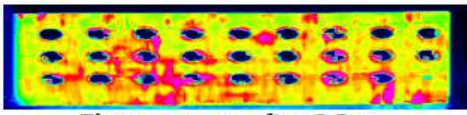
Thermal of Machined Glass Fiber Reinforced Composites

Evaluation of Damage caused to composites due to machining by varying parameters such as speed using thermography



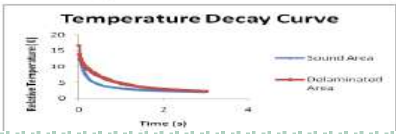


Phase images at f = 0.01 Hz, 0.05 Hz

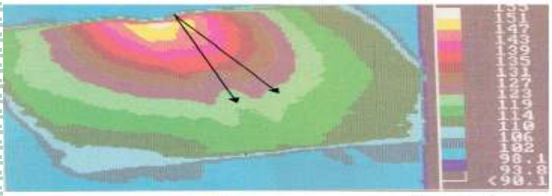


Thermograms after 0.2s

Carbon Fiber reinforced plastic composite
Thickness: 3 mm



Online Defect Detection – Online Possibility of NDE of robotic repair weld



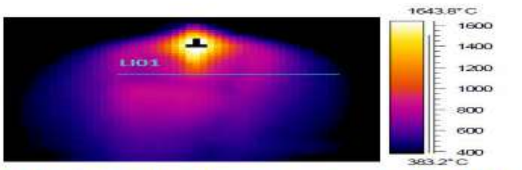
Isothermal profiles. A balanced thermal distribution about weld centre line in the case of root pass of weld. Similar distributions during all passes.

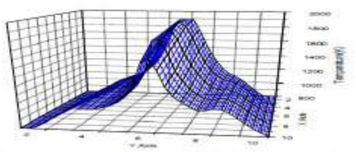
Defects investigated – lack of penetration, lack of fusion, inclusion, porosities.

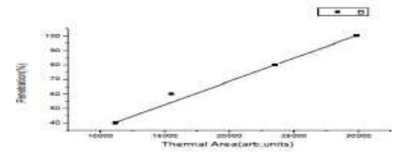
Lack of Penetration,

Tungsten Inclusion

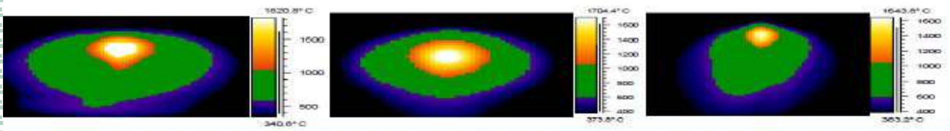
Bead Width and Depth of Penetration



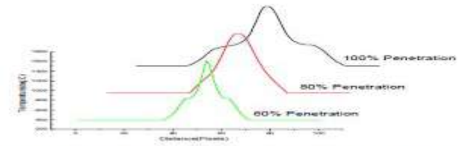




Left is thermal image - while the white region at the centre is the liquid weld pool, the yellow region is the solid metal. On right is a typical 3Dline profile. The points of inflection are clearly seen.



Isothermal patterns for three different depth of penetration



Plot of line profile for three different penetration depth

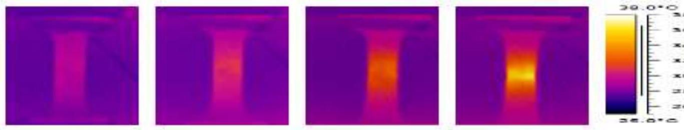
IR Imaging for Tensile Deformation Studies

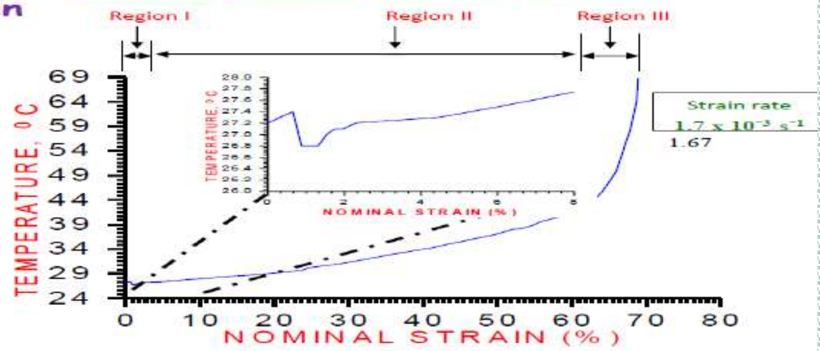
>80% of energy released as heat. Temperature as an indicator of state of material and precursor for major mechanical changes has not been adequately explored.

IR and AE used to characterise all stages of tensile deformation i.e. yielding, plastic deformation and necking and fracture in a nuclear grade AISI type 316 stainless steel.

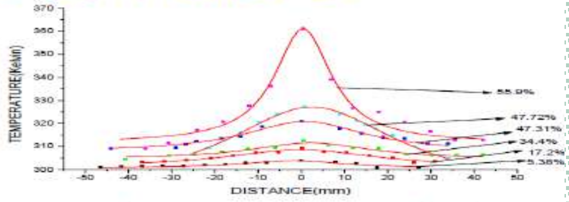
Thermoelastic effect

$$\frac{\delta T}{\delta \varepsilon} = -V_m \alpha E\, T / C_v$$





Early Prediction of Zone of Failure



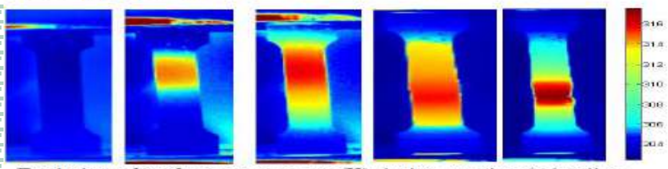
Strain rate of 1.7 x 10^{-3} s^{-1}

Analysis of the thermal images clearly reveal that

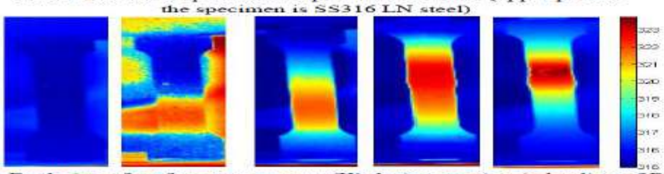
- IR imaging provides a full-field thermal image
- Accurate surface temperature measurements without contacting the specimen are possible.
- Full-field temperature image makes it possible to locate the point and time of strain localization during a test.
- Can predict, identify and delineate the zone of crack growth and failure during tensile deformation much ahead in advance.

Dissimilar Weld Tensile Deformation Mapping using IRT

In collaboration with *Institute of continuous media mechanics, Russia*



Evolution of surface temperature (K) during quasistatic loading of P91-SS316LN specimen. Experimental results (upper part of the specimen is SS316 LN steel)



Evolution of surface temperature (K) during quasistatic loading of P91-SS316LN specimen. Experimental results (upper part of the specimen is P91 steel)

Equation for the determination of the surface temperature :

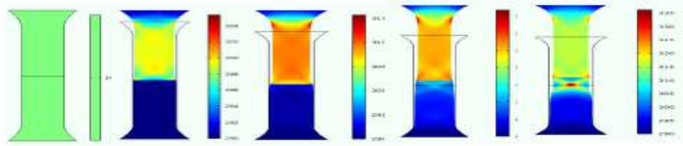
$$T = T_0 + \beta_{int} \frac{W_p}{\rho c}$$

$W_p = \int \sigma_d : d\varepsilon_p$ - plastic work.

T_0 - initial temperature of the specimen.

β_{int} - Taylor-Quinney coefficient which represents the amount of the dissipated heat and remains constant during the loading process. (subscriptint stands for the integral value).

ρ - density, c - Specific heat



Evolution of surface temperature (K) during quasistatic loading of P91-SS316LN specimen taking into account large plastic strains. Results of simulation (upper part of the specimen is P91 steel)

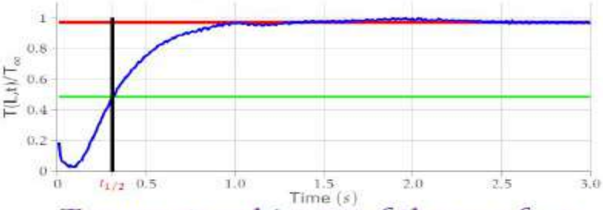
Thermal Diffusivity Measurement Using Pulsed Thermography

In PT, many methods have been reported for thermal diffusivity measurement

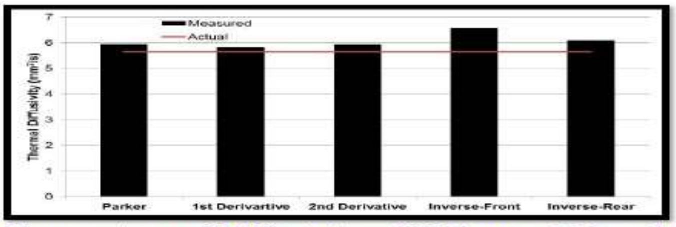
In this study different methods are compared

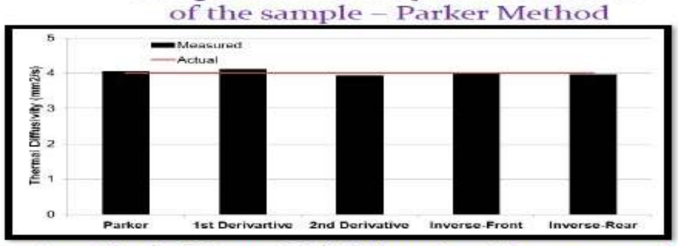
- Parker Method (Transmission)
- Optimization Method
- 1st Derivative Method
- 2nd Derivative Method

Experiment was carried out on SS and Alumina tiles



Temperature history of the rear face of the sample – Parker Method





Comparison of diffusivity of SS (4 mm^2/s) and Alumina tile (5.88 mm^2/s) (Alumina tiles are used in flooring for Na applications)

All the methods give better diffusivity estimation

Conclusions

- Thermal imaging is a versatile and indispensable tool.
- The applications of this technique is just limited by the ingenuity of the practicing thermographers.
- Coupled with process modeling and software analysis such as trending the technique presents itself as an ideal tool for material characterization.

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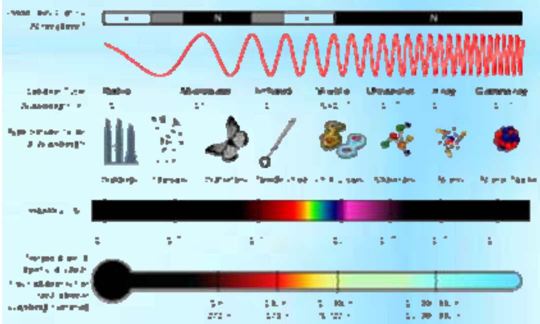
Relevance of Electro Magnetic Spectrum in NDT

The above is the depiction of the full range of electromagnetic radiation sequenced by frequency or wavelength and is commonly known as the electromagnetic spectrum. The spectrum is divided into separate bands, with several names for the electromagnetic waves within each band. From low to high frequency these are: radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays. The electromagnetic waves in each of these bands have multi various characteristics, such as how they are produced, how they interact with matter and their practical applications.



Radio waves

- Radio waves are a type of electromagnetic waves that are used in many applications, including telecommunications, cancer treatment, and MRI imaging:
- Radio waves are the waves having the longest wavelength in the electromagnetic spectrum. These waves are a verity of electromagnetic radiation and have a frequency from high 300 GHz to low as 3 kHz,
- Radio waves can range in length from the size of a football to larger than the planet.
- Radio waves can be natural or man-made.
- Radio waves are too long for humans to detect with their senses, but they can be detected by instruments.
- Radio waves are used in many devices, including mobile phones, smart meters, satellite communications, and microwave ovens.
- Radio waves are also used in cancer treatment by inserting needles into tumor tissue to kill cancer cells.
- Radio waves are also used in MRI imaging to generate detailed images of the inside of the body.

Microwaves

These waves find usage in several aspects of everyday human life. The range in vast and varies from cooking communication, navigation, Weather forecasting, Medical imaging, Radar, Astronomy, Remote sensing, Particle accelerators and Spectroscopy.

Microwaves were originally used to emit radar signals to detect enemy ships and aircraft during World War II.

These are used to detect speeding cars and to send telephone and television communications. Industry uses microwaves to dry and cure plywood, to cure rubber and resins, as well as to raise bread and doughnuts,

- **Cooking**: Microwave ovens are a common kitchen appliance for cooking and reheating food. They can quickly heat food, and are especially useful for foods that might burn or become lumpy in a conventional pan, like chocolate, porridge, or hot butter. Microwaves are also efficient at reheating food without making it soggy, and they retain nutrients.
- **Communication**: They are used in mobile phones, radios, satellite and spacecraft communication, and wireless networks.
- **Navigation**: They are used in aircraft and airplanes for navigation.
- **Weather forecasting**: They are used in weather forecasting.
- **Medical imaging**: They are used in medical imaging technology.
- **Radar**: They are used in the RADAR wave system.
- **Astronomy**: They are used in studying astronomy.
- **Remote sensing**: They are used in remote sensing.
- **Particle accelerators**: They are used in particle accelerators.
- **Spectroscopy**: They are used in spectroscopy to distinguish diverse elements.

Contd in next edition

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