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Image

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Indian Society for Non - Destructive Testing
Thiruvananthapuram Chapter

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From Chairman's Desk...

Dear Friends,

The tenure of the present executive committee is coming to an end and as we look back, it is very heartening to note that the team could achieve most of our targets. The past two years had been eventful and hectic with various activities.

Undoubtedly, NDE 2016 was the greatest achievement and much has been written about it in our earlier issue of Image. The chapter could generate some revenue which shall help to sustain our activities for the years to come. Also, NDE2016 has generated the enthusiasm among the professionals and helped to bring the chapter membership to 500 plus elite level. I once again thank the entire team for this great achievement.

It was our long term wish that a consolidated membership directory of our chapter is released for enabling better communication across members. The efforts were started by the previous committee itself and we have added the details of all new members also. The compilation has been made ready and I am really happy to note that same is being distributed during this year's AGM. My kudos to our team members, for realizing the directory.

Another long term wish was the industrial visit to Koodankulam Nuclear Power Plant. I am very pleased to note that the visit was materialized during March, 2017. Considering the tremendous response, a second batch of 70 members is being arranged.

I am also very happy that we have taken initiatives to open student chapters in local engineering colleges, as it was our suggestion to initiate Student Chapter of ISNT. The guidelines for formation of Student Chapters were finalised by ISNT NGC. All the formalities for formation of Student Chapters in College of Engineering, Trivandrum and Government Engineering College, Barton Hill are completed and its inauguration can be done by the first week of August 2017. Realizing the employment potential of NDT field, especially for the educated youth of Kerala, we could finalise a proposal to set up a Skill Development Centre for NDT, under the Government of Kerala. I hope that the State Government will be greatly interested and take initiative in setting up the centre.

I hope, the present committee could achieve most of its promises with the team work of the entire Executive Committee and the consistent support of all our beloved members. I am confident that the incoming team will take forward our initiatives and bring our chapter to greater heights.

Wishing you all the best,

G.Levin
Chairman,
Trivandrum Chapter

Secretary's Report
April - June 2017

Inside Executive Committee

During this period, two EC meetings were arranged. Various programs like NDT courses in colleges, skill development program etc were discussed. Annual report and audit statement were approved for presentation in AGM. Agenda points for AGM were discussed. Student Chapter inauguration was also discussed. An award proposal by our chapter was discussed and finalized.

Student Members, ISNT - Trivandrum

S.No.	Name
	CET, Trivandrum
1	VIJAYASREE.B
2	JOSE.S
3	SREELAKSHMI.A
4	SARATH.R.N
5	ANJNA PRASAD
6	JIYAD P
7	DAYAL KURIAN VARGHESE
8	ALEX AURTIN
9	PREET K LAWREL
10	BIJEESH D
11	MANOD K M
12	SHAISE K JOHN
13	JOSNIYA JOSE
14	NEETHU M
15	AKHILA JOBIE EAPEN
16	MUHAMMED ANAS K
17	AMY DE SAM
18	FRAJITHA FRANKLIN
19	PAWAN JOSE
20	ANUPAMA ANIL KUMAR P
21	ANJANA SREE
22	ANOOJA U P
23	ARYA K V
24	ATHIRA M K
25	NASLA V
26	MARIYA JOSE
27	REMYASREE C P
28	ATHIRA
29	ATHIRA M S
30	VINITHA V S
31	SACHIN SUNIL
32	GHANASYAM J
33	ANCIA KURIAN
34	NEELACHANA K J
35	SHABANA S
36	ATUL JOSEPH
37	HASNA HANEEF
38	AKSHAY RANJITH
39	SURAJ UDAY
40	MEGHNA MURALI
41	ANN SOPHY T S A
42	ABIYA B
43	DONA MARIA ANTHRAPER
44	ASIF K
45	KIRAN KARTHIKEYAN
46	AKSHAY VARMA R.
47	NIDHISH M.C.
48	AKHIL NATH E
49	AJITHLAL K.P.
50	NAVANEETH A.
51	SHIBIN MOHAN
52	SARATH K.
53	AFSIN V
54	SOORAJ SUSEELAN
55	ARAVIND K. SURESH
56	BASIL M.K.
57	KIRAN PRASAD
58	BHADRA J.
59	RESHMA K.S.
60	HARIKRISHNAN K.S.
61	SHOBIN REJI
62	SRUTHI A SURESH
63	SUJITH C.
64	AKHIL JOHNSON
65	K.P. ANJALI
66	JIJI L. JAYAN
67	KIRAN GOPAL
	GEC Barton Hill
68	MUHAMMED JASEEM S
69	VISHNU K.S
70	RAKESH G VIJAYAN
71	SUNEESH C.O
72	AKASH VISWAM V.S
73	ANANDU S
74	ANDARSH S MOOSATH
75	HARIKRISHNAN R
76	HARIKRISHNAN M
77	VILEESH V
78	AKSHAY O.S
79	MUHAMMAD ANEES
80	ANFAL MOHAMMED
81	AMIN ZAMEEL N
82	JUBIN K.P
83	SACHIN B.S
84	SARATH S LAL
85	ROJIN GOMEZ
86	ANNA MARY JOSE
87	ASSAD B.P
88	AVINASH V NAIR
89	AKHIL MANOJ
90	RAHUL G
91	NANDAKISHORE K
92	S.GAYATHRY
93	ATHUL P
94	REUBEN M SHIBU
95	VISHAL PRASAD
96	AUGUSTEN RAJU
97	AKHIL A
98	NIKUL R.L
99	ABHI P.M
100	ARJUN CHANDRAN
101	ROJINI S.R
102	RAMESH M
103	INDRAJITH B
104	SANDEEP SUNIL
105	ABHINAV P SEKHAR
106	SREEHARI S
107	VARUN S
108	UNNIKRISHNAN R
109	SEBASTIAN JOSEPH
110	MUHAMMED ABEER
111	ABHINAV AJITH
112	RAHUL RAJKUMAR
113	NAVANEETH V
114	VAISHAKH J.B
115	FIROZ A ELAH

New Members who joined ISNT Trivandrum April-June 2017

S.No.	Name	Type of member	Organization
1	Tushar R Phadnis	Life Member	VSSC
2	Nitish Kumar	Life Member	VSSC
3	Sudhir S Nair	Life Member	VSSC
4	Sathis Kumar P.S.	Life Member	VSSC
5	College of Engineering, Trivandrum	Life Corporate Member	College of Engineering Trivandrum
6	GEC Barton Hill	Life Corporate Member	GEC Barton Hill
7	Santhosh Kumar SV	Life Member	GEC Barton Hill
8	Rakesh P Dr.	Life Member	GEC Barton Hill

Annual General Body Meeting, M.R.Kurup Memorial Lecture and Family Get Together

Date & Time : 22nd July, 2017, (Saturday) at 18.00 Hrs.
Venue : The Residency Tower, Press Road, Trivandrum

Programme:

18.00 to 18.30 : **Registration, Welcome drink**

18.30 to 19.30 : **M. R. Kurup Memorial Lecture**

Shri P A Suresh Babu,
Chief Engineer (QA)
Kudankulam Nuclear Power Plant

Topic: **"Nuclear energy – An inevitable source of energy for future"**

19.30 to 20.30 : **AGM 2017**

Family entertainment program

20.30 Hrs. : **Dinner**

AGM 2017 Agenda:

1. Welcome address: Chairman, ISNT TVM chapter
2. Confirmation of minutes of AGM- 2016
3. Report on activities for the year 2016-2017: Secretary
4. Presentation of audited accounts for April 2016 to March2017: Treasurer
5. Election of the new executive committee
6. Address by new committee
7. Vote of thanks: Joint Secretary

STUDIES ON NEUTRON RADIOGRAPHY TECHNIQUE FOR NDE OF PYRO DEVICES USING A LOW FLUX NEUTRON SOURCE

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Abstract

Neutron radiography (NR) is a unique technique for detecting a low density material present inside a highly attenuating material. Pyro devices are mission critical devices used in satellite launch vehicle which contains a low density explosive charge inside a high density metallic hardware. For detecting presence and integrity of explosive charge, NR is a mandatory inspection for accepting a pyro device for a mission.

ASTM E-545 describes the mandatory quality requirements of a neutron radiograph. To generate a neutron radiograph of category I or category II, a high flux neutron source such as nuclear reactor/sub critical assembly is essential. A nuclear reactor based NR setup requires huge costs, space, manpower, safety etc. which is a major hurdle for any organization for NR facility establishment. Para 5.2 of the ASTM E545 enables to consider other options such as accelerator based neutron sources for NR.As per para 5.2 of ASTM-545 "the only truly valid sensitivity indicator is a reference standard part". A reference standard part is a material or component that is the same as the object being neutron-radiographed except with a known standard discontinuity, inclusion, omission, or flaw. The sensitivity indicators were designed to substitute for the reference standard such that achieving/detecting a standard discontinuity is adequate to qualify a neutron radiograph.

Current paper describes the NR experiments carried out using a D-T generator based source. It explains the effect of various parameters such as source to detector distance, neutron flux, image processing/enhancing techniques etc. on image quality. It describes the various trials carried out to get the optimized image of reference standard along with the identified aerospace components. The reference radiographs were generated as basis for the evaluation standard. The optimized parameters are basis for generation of standard practice. By evolving standard practice and evaluating standards, the technique is established for the identified components.

Introduction

Neutron radiography (NR) is a well-known NDT technique and it is used only for some of the special applications. The information obtained from this technique is complementary to x-ray/γ radiography. It finds immense applications in the field of nuclear engineering, civil engineering, biological studies, aerospace etc. This technique is highly useful in detecting a low density material present inside a highly attenuating material. Because the attenuation characteristics of neutron for a particular material depends on the absorption and scattering cross sections of the constituting elements rather than density of the material. Neutron radiography is similar to the x/γ radiography however neutrons are used in place of x/γ rays, converter screen are used in combination to the radiographic films (as neutrons cannot interact directly with the radiography films). Neutron radiography can be carried out with cold, thermal and fast neutrons. Thermal neutrons are widely used for neutron radiography. These thermal neutrons are produced by moderation of fast neutrons .The thermalised neutrons are collimated for imaging.

Pyro devices are mission critical components in a satellite launch vehicle used for several applications such as ignition, initiation, stage separation, satellite deployment etc. These devices contain explosive charges inside a metallic hardware. The high velocity gases released upon their firing will be used to perform mechanical action. The explosive charges used in the pyrodevices includes PETN, RDX, Nitrocellulose, boron based compositions etc. These major elements in these explosives are of low atomic number and possess high attenuation to neutrons. When these explosive charges are kept inside metallic hardware, the integrity of the charges cannot be confirmed by the x/γ radiography. However the details of the charges can be revealed by using NR.

ASTM E-545 describes the mandatory quality requirements of a neutron radiograph. As per the standard the radiograph shall be of Category I or Category II. Generation of such a good quality radiographs requires higher L/D ratio of the collimator, which inturn requires a high flux neutron source such as nuclear reactor/sub critical assembly, which can produce thermalised neutron flux of 10^6-10^7 n/cm^2-sec. The other type of neutron sources such as D-D, D-T accelerators, californium-252 isotope etc. cannot achieve such a higher L/D ratio. Establishment of reactor based NR facilities requires huge costs, money, space, manpower, safety etc. Due to this, establishing a dedicated reactor facility inside a space centre is not a viable option.

ASTM E 545 uses a beam purity indicator (BPI) and a sensitivity indicator (SI) as reference standard to classify a neutron radiograph category. However as per para 5.2 of ASTM-545, "the only truly valid sensitivity indicator is a reference standard part". A reference standard part is a material or component that is the same as the object being neutron-radiographed except with a known standard discontinuity, inclusion, omission, or flaw. The sensitivity indicators were designed to substitute for the reference standard, which can be interpreted as if we could be able to generate a reference standard with intended defects and the defects thus generated could be captured by the technique used for NR then it is not essential to achieve Category I or Category II. It gives a scope to use low flux sources for designing NR facility provided it could be able to discern the intentionally induced defect.

The current paper discusses in detail about various trials carried out to get the optimized image of reference standard along with the identified similar pyro devices.

Experimental details:

M/s Sodern make D-T source is used as neutron source. It emits the neutrons with14 MeV energy by means of following reaction

$$_1H^3 + _1H^2 \rightarrow _2He^4 + _0n^1 \text{ (14 MeV)}$$

Thermal neutrons are required for NR for the indented application & hence the fast neutrons have to be moderated & collimated. However this process reduce the neutron flux of 10^9-10^{10}n/cm^2-sec to 10^4-10^5 n/cm^2-sec. Usage of Gd/Dy foil based imaging techniques will lead to higher exposure times which intern consumes the life time of the neutron source. Hence a CCD camera based Neutron imaging system is used for capturing the NR image. It uses a Neutron scintillator screen of ^{6}LiF:ZnS:Ag (0.4 mm thick) with peak emission at 450nm to match intensifier photo cathode response. The reaction of neutron with Li emits alpha ray which intern reacts with ZnS to produce a photon. This camera could able to capture the image with in few minutes at lower neutron flux. NR experimental set up is shown in Fig.1.

The neutron source assembly, object and camera are maneuvered by using a custom made object manipulator.

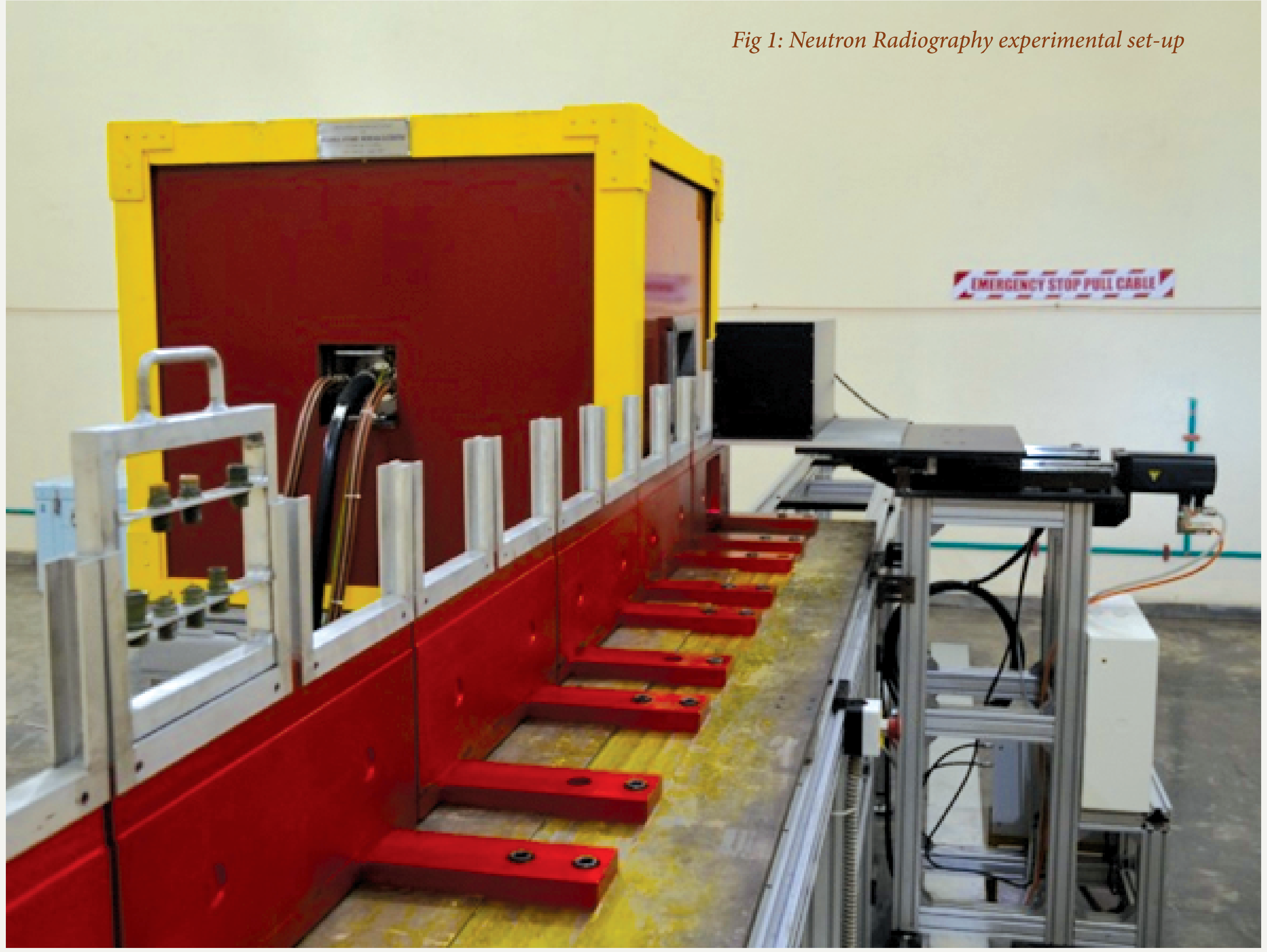

Fig 1: Neutron Radiography experimental set-up

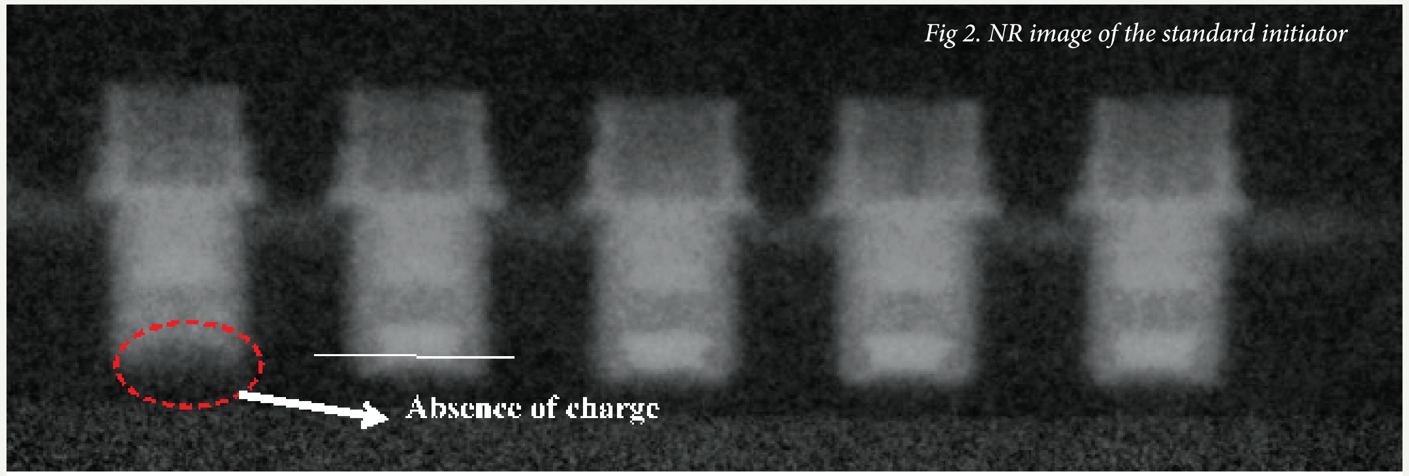

Fig 2. NR image of the standard initiator

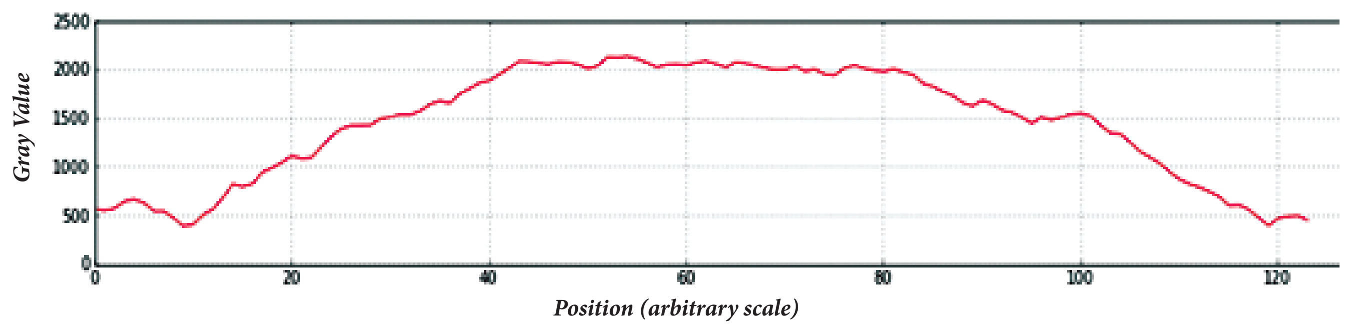

Fig 3. Line profile of the charge region of normal sample marked with white line in Fig 2

Studies were carried out on two different pyro devices viz. Standard initiator and Pyro puller cartridge. Before carrying out NR, the reference standard part is to be prepared. Each item along with reference standard part is fixed in their respective fixtures and kept over the object manipulator. The major parameters to be varied for optimum image quality are distance between camera and object, distance between collimator end face and camera and neutron flux. In addition to this, camera image capturing parameters such as frame rate, no. of frames, intensifier gain etc. and image enhancement/processing mechanisms such as frame averaging, background subtraction, flat-field correction etc. were applied to obtain a better quality image. The camera used for imaging captures a 12 bit image. All the images are taken for 10 frames and averaged for noise reduction. Background subtraction is applied for all the images taken to negate the effects of dark current.

The geometrical un-sharpness (U_g) for a neutron radiography set-up is expressed as

$$U_g = D\,(L_f/L_s)$$

where D- size of inlet aperture of collimator

L_f-Object to detector distance

L_s-Source to object distance

If $L_f << L_s$ the geometrical un-sharpness equation can be re-written as

$$U_g = D\,(L_f/L)$$

Where L is the source to the image plane distance.

With increase in the distance between the object and the camera, the geometrical un-sharpness increases, resulting in image quality deterioration. Therefore the object is kept as close as possible to image plane around 3.5 mm.

Results and discussion

a. Standard Initiator

Standard initiator is the initiator used for ignition of cryo stages. Trials are carried out with a reference standard made without the explosive charge along with the normal initiators. The optimized parameters are 150kV, 800μA, 35 sec(x 10frames) and collimator end face to the image plane distance =100mm.The image taken with the mentioned parameters is shown in Fig.2

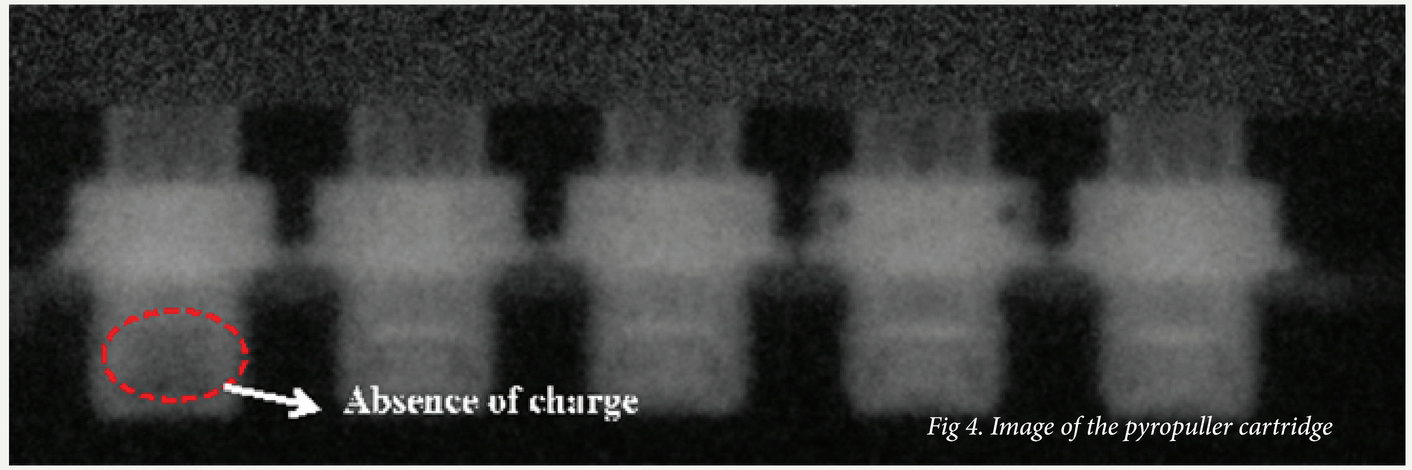

Fig 4. Image of the pyropuller cartridge

The absence of charge in the reference standard is clearly seen. The line profile taken on the charge region of normal sample is shown in Fig 3 confirms the adequacy of exposure.

The images used for interpretation and plotting above line profiles are negatives. However the captured images are positive. Being a 12 bit image the gray values varies from 0 to 4095 and the gray values mentioned in above graph are values subtracted from 4095. Increasing the exposure increases the contrast. However we cannot increase the exposure above a certain value. The exposure required is decided on primarily two factors, one is utilization of the available gray values and the second is practical constraints such as limitation of the machine & higher duration of exposure. Flat field correction is one of the important corrections to be done to improve the image quality in CCD based imaging. This is to remove the artifacts caused by pixel to pixel sensitivity variation and distortions in the optical path. Flat field correction is the process of compensating for different gains and dark currents.

As a general practice flat field correction is applied to images of all the items that are subjected to NR. The major advantages of flat field correction are uniformity of the image and higher area of uniform illumination which inturn increases the no. of components imaged in a frame.

b. Pyro puller cartridge

Pyro puller cartridge is one of the important pyro device used for various applications. Trials are carried out with a reference standard made without the explosive charge along with the normal initiators. The optimized parameters are 150kV, 850μA, 35 sec (x 10frames), collimator end face to the image plane distance =100mm. The image taken with the mentioned parameters is shown in Fig.4.

From fig.4 absence of squib and main charge can be confirmed in the reference standard. The adequacy of exposure is also confirmed as mentioned in standard initiator.

Conclusions

Following are the conclusions drawn from the experiments carried out.

i. Increased distance between the collimator and image plane increases the resolution and requires higher exposure and hence higher flux.

ii. Higher exposure increases the contrast, however it is to be optimized for each device.

iii. Flat field correction, background subtraction & image averaging improves the image quality.

iv. The intentionally created defects in reference standards of Standard initiator and Pyro puller cartridge are successfully detected and the technique is established for these components.

v. With similar trials, the technique can be established for other devices also.

vi. Neutron radiography of pyrodevices by using low neutron flux is demonstrated pertaining to ASTM E-545.

Acknowledgement

The authors sincerely acknowledge the guidance and support extended by Dr.Amar Sinha and his team from BARC, in carrying out these series of experiments..

References:

1. Practical Neutron Radiography, J.C.Domanus et al.1992 , Kluwer academic publishers.

2. ASTM E545 – 05 (Reapproved 2010), Standard Test Method for Determining Image Quality in Direct Thermal Neutron Radiographic Examination.

3. ASTM E 748 – 02 (Reapproved 2008), Standard Practices for Thermal Neutron Radiography of Materials.

Glossary on THERMOGRAPHY

- Absolute Zero: The temperature of -273.15° C, -459.69° F, or 0° K; thought to be the temperature at which molecular motion vanishes and a body would have no heat energy.
- Ambient Operating Range: Range in the ambient temperature over which the instrument is designed to operate.
- Black Body: An ideal thermal radiator that absorbs all of the radiation incident there on, and the radiant emission from which is quantified by Planck's Radiation Law.
- Colored Body or Non Gray Body: A source of thermal emission for which the emissivity depends on wavelength and is not constant.
- Conduction: Transfer of heat through or between two solids.
- Convection: Transfer of heat through fluids.
- Emissivity: At a given wavelength the ratio of infrared energy radiated by an object at a given temperature to that emitted by a blackbody at the same temperature The emissivity of a blackbody is unity at all wavelengths.
- Gray Body: A source of radiant emissions for which the emissivity is less than 1 but constant and, therefore, independent of wavelength.
- Infrared Radiation: Radiation within the portion of the electromagnetic spectrum which extends from 0.75 to 1000 μm.
- Isotherm: A continuous line (not necessarily straight or smooth) on a surface (or chart) comprising points of equal or constant temperature.
- Kirchoff's Law: Emitted Energy + Transmitted Energy + Reflected Energy = 1
- NETD: Noise Equivalent Temperature Difference or the change in temperature of a blackbody target that fills the radiometer Field of View (FOV) which results in a change in the radiometer signal equal to the rms noise of the instrument.
- Radiation: Transfer of energy through electromagnetic waves.
- Reflectance: The ratio of the radiant energy reflected from a surface to that incident on the surface.
- Repeatability: The degree to which a single instrument gives the same reading on the same object over successive measures under the same ambient and target conditions. The ASTM standard E 1256 defines it as the sample standard deviation of twelve measurements of temperature at the center of the span of the instrument. Generally expressed as a temp difference, percent of full scale value, or both.
- Spectral Response: The wavelength region in which the IR Thermometer is sensitive.
- Scatter: Radiant energy reaching the detector of an instrument from the background other than that which is reflected from the target.
- Temperature: The degree of hotness or coldness of an object (e.g. atmosphere, living body) measurable by any of a number of relative scales.

Image

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

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