Kandula Srinivasa Reddy Memorial College of Engineering (Autonomous)

Kadapa-516003. AP

(Approved by AICTE, Affiliated to JNTUA, Ananthapuramu, Accredited by NAAC)

(An ISO 9001-2008 Certified Institution)

Department of Mechanical Engineering

Certification Course

on

" NON DESTRUCTIVE TESTING "

Resource Person : Shaik Shakeel Ahmed , Associate Professor, Dept.of ME,KSRMCE

Course Coordinator: K.Mahaboob Basha , Assistant Professor, Dept.of ME,KSRMCE

Date: 11/04/22 to 29/04/22

K.S.R.M. COLLEGE OF ENGINEERING

(UGC-AUTONOMOUS)

Kadapa, Andhra Pradesh, India– 516 003

Approved by AICTE, New Delhi & Affiliated to JNTUA, Ananthapuramu.

An ISO 14001:2004 & 9001: 2015 Certified Institution

Lr./KSRMCE/ME/2021-22/ Date: 8-04-2022

To
The Principal,
KSRMCE,
Kadapa.

Sub: Permission to Conduct Certificate Course on "NON DESTRUCTIVE TESTING" from 11-04-2022 to 29-04-2022 – Reg.

Respected Sir,

The Department of Mechanical Engineering is planning to offer a certification course on "NON DESTRUCTIVE TESTING " to B. Tech students. The course will be conducted from 11-04-2022 to 29-04-2022. In this regard, we are requesting you to grant permission to conduct certificate course.

Thanking you

Forwarded to Principal Sir. 08/04/2022

Yours faithfully

(Sri S.Shakeel Ahmed , Asso.Professor

Sri.K.Mahaboob Basha , Asst.Professor)

Permitted
V.S.S. Murthy

K.S.R.M. COLLEGE OF ENGINEERING

(UGC-AUTONOMOUS)

Kadapa, Andhra Pradesh, India– 516 003

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KSNR lives on..

Cr./KSRMCE/ME/2021-22/ Date: 09/04/2022

Circular

The Department of Mechanical Engineering is offering a certification course on "NON DESTRUCTIVE TESTING " From 11-04-2022 to 29-04-2022 to B.Tech students. In this regard, interested students are required to register for the Certification Course. The registration link is given below.

https://forms.gle/EU3uxhQGw2Mmisr6A

The Course Coordinators and Resource Persons
Sri S.Shakeel Ahmed , Asso.Professor
Sri K.Mahaboob Basha , Asst.professor
Dept. of Mechanical Engg.-KSRMCE.

HoD

Professor & Head
Department of Mechnical Engineerin
K.S.R.M. College of Engineering
KADAPA - 516 003.

Cc to

IQAC-KSRMCE

Registration for Certificate Course on "Non Destructive Testing" From 11/04/2022 to 29/04/2022

1. Roll No

   ____

2. Name of the Student

   ____

3. Branch

   ____

4. Year&Semester

   ____

K.S.R.M.COLLEGE OF ENGINEERING, KADAPA.			
DEPARTMENT OF MECHANICAL ENGINEERING.			
			TIME STAMP
S.NO	ROLL NO	NAME OF THE STUDENT	REGISTRATION DETAILS
1	179Y1A0337	O.C.PENCHALIAH	4/9/2022 18:45:01
2	189Y1A0301	ABDHULLAGARI RAHIMULLA	4/9/2022 10:46:08
3	189Y1A0302	AMBAVARM RAMESH REDDY	4/9/2022 10:48:01
4	189Y1A0303	AMIREDDY VAMSI	4/9/2022 20:57:48
5	189Y1A0304	B. VEERA PRATHAP REDDY	4/9/2022 21:04:09
6	189Y1A0305	B. PRANAY KUMAR REDDY	4/9/2022 21:08:50
7	189Y1A0306	BANDAPALLI TEJESWAR REDDY	4/9/2022 21:19:38
8	189Y1A0307	BANDLA SUJITH	4/9/2022 21:23:03
9	189Y1A0308	BOGGU SAI RAHUL	4/9/2022 21:26:59
10	189Y1A0309	BUKKE CHANDRA NAIK	4/9/2022 21:27:11
11	189Y1A0310	CHAGALAMARRI VENKATA SAI	4/9/2022 22:13:33
12	189Y1A0311	CHEEMALA ARAVIND REDDY	4/9/2022 22:29:38
13	189Y1A0312	CHILAKALA ASHOK	4/9/2022 11:28:48
14	189Y1A0313	DASARI BHARATH KUMAR REDDY	4/9/2022 13:09:13
15	189Y1A0314	DUDDELA SANDEEP KUMAR	4/9/2022 8:20:23
16	189Y1A0315	DUDYALA RAVI KUMAR	4/9/2022 11:10:10
17	189Y1A0316	G. S.M. NASEERUDDIN	4/9/2022 11:10:45
18	189Y1A0317	GOVINDU VIKAS	4/9/2022 11:12:33
19	189Y1A0318	GOWRIGALLA ASHOK	4/9/2022 11:13:03
20	189Y1A0319	GUGULA SAI KUMAR	4/9/2022 11:13:09
21	189Y1A0320	JUTURU VIKAS	4/9/2022 11:13:41
22	189Y1A0321	KAMPARAJU RAVI SANKAR	4/9/2022 11:14:48
23	189Y1A0322	KANDUKURI JANARDHAN REDDY	4/9/2022 11:15:20
24	189Y1A0323	KATIKA YASHWANTH REDDY	4/9/2022 11:18:48
25	189Y1A0324	K.CHANDRASEKHAR REDDY	4/9/2022 11:26:07
26	189Y1A0325	KURAKU HARI KRISHNA	4/9/2022 11:26:58
27	189Y1A0326	KURUVA MAHESH BABU	4/9/2022 11:27:39
28	189Y1A0327	L. SIVA VENKATA SAI REDDY	4/9/2022 11:28:23
29	189Y1A0328	MAJJARI VENKATA BHASKAR	4/9/2022 11:28:42
30	189Y1A0329	MALKAPURAM THIRUMALESH	4/9/2022 11:29:32
31	189Y1A0361	SHAIK VAYALPAD ABDUL KHAVI	4/9/2022 12:38:19
32	189Y1A0362	SHAIK ZUBAIR	4/9/2022 11:18:48
33	189Y1A0363	SHAIK ZUBAIR HUSSAIN	4/9/2022 11:26:07
34	189Y1A0364	S.K. KHALEEL AHAMED	4/9/2022 11:26:58
35	189Y1A0365	SHARON SAMUEL	4/9/2022 11:27:39
36	189Y1A0366	SIDDAREDDY LINGAMAIAH	4/9/2022 11:28:23
37	189Y1A0367	SOORABOINA VENKATESH	4/10/2022 11:28:42
38	189Y1A0368	SYED GHAYAZ AHMED	4/10/2022 11:29:32
39	189Y1A0369	TALUPULA AVINASH	4/10/2022 11:29:49
40	189Y1A0370	THAMBALA VEERESH	4/10/2022 11:30:31
41	189Y1A0371	THIRUVAIPATI SASIKANTH	4/10/2022 11:30:36
42	189Y1A0372	THUMMALA MOHAMMED HAROON	4/10/2022 11:30:42
43	189Y1A0373	V. MAHESH KUMAR	4/10/2022 11:31:04
44	189Y1A0374	VADDEMANI LOKESWAR REDDY	4/10/2022 11:31:24
45	189Y1A0375	VADDIREDDY RAJA KALYAN REDDY	4/10/2022 11:32:01
46	189Y1A0376	Y ANDERSON	4/10/2022 11:32:48

47	189Y1A0377	Y. CHENNA KESAVA REDDY	4/10/2022 11:37:57
48	199Y5A0301	A.MABU BASHA	4/10/2022 11:40:38
49	199Y5A0303	A.MAHESH BABU	4/10/2022 11:41:53
50	199Y5A0304	B.SATISH KUMAR	4/10/2022 12:00:45
51	199Y5A0305	B.SAI BHARATH	4/10/2022 12:12:58
52	199Y5A0306	B.OBULA REDDY	4/10/2022 12:13:06
53	199Y5A0307	C.SREENIVASULU	4/10/2022 12:15:35
54	199Y5A0308	CH.AMARENDRA KUMAR	4/10/2022 12:38:19
55	199Y5A0309	G.VEERAPASAD	4/10/2022 13:58:53
56	199Y5A0310	G.VAMSI	4/10/2022 15:14:20
57	199Y5A0312	J.SUBHAN	4/10/2022 17:19:54
58	199Y5A0313	K.VAMSI KRISHNA	4/10/2022 11:31:04
59	199Y5A0314	K.BHARGAV	4/10/2022 11:31:24
60	199Y5A0315	K.SIVARAM NAIK	4/10/2022 11:32:01
61	199Y5A0316	K.VENKATESH	4/10/2022 11:32:48
62	199Y5A0317	K.V.S.MANORANJAN	4/10/2022 11:37:57
63	199Y5A0338	S.SHAKSHAVALI	4/10/2022 11:28:48

Syllabus of Certification Course

Course Name: NON DESTRUCTIVE TESTING

Duration: 30 Hours

Unit-1: Introduction

Fundamentals of and introduction to destructive and non-destructive testing. Scope and limitations of NDT, Visual examination methods, Different visual examination aids.

Unit-2: Dye penetrant Testing/ Liquid Penetrant Testing

Principle, procedure, characteristics of penetrant, types of penetrants, penetrant testing materials, fluorescent penetrant testing method– sensitivity, application and limitations

Unit-3: ULTRASONIC TESTING

Basic principles of sound propagation, types of sound waves, Principle of UT, methods of UT, their advantages and limitations, Piezoelectric Material, Various types of transducers/probe, Calibration methods, use of standard blocks, technique for normal beam inspection, flaw characterization technique, defects in welded products by UT, Thickness determination by ultrasonic method.

Unit-4: RADIOGRAPHIC TESTING

RADIOGRAPHIC TESTING , Fundamental principles , The method of radiographic testing , Sources for radiographic testing, Different forms of radiographic testing , Applications of radiographic testing method

Unit-5: ADVANCED NDT TECHNIQUES-II

Introduction to Acoustic Emission Testing, A Brief History of AE Testing , AE Sources: Wave Propagation Wave Mode and Velocity , Computed Tomography:

Refrences.

1. NDT with Ultrasonics - Introduction to the Basic Principles ; Michael Berke, Krautkramer
2. Ultrasonic Inspection 2 - Training for Nondestructive Testing; E.A. Ginzel; Prometheus Press Canada
3. Nondestructive Testing Handbook, second edition: Volume 7, Ultrasonic Testing 1991 ; Part: Glossary of terms for Ultrasonic Testing;

Coordinator

HOD

Professor & Head
Department of Mechnical Engineering
K.S.R.M. College of Engineering
KADAPA - 516 003.

SCHEDULE

Department of Mechanical Engineering

Certification course
on
" Non Destructive Testing "

Date	Timing	Course Instructor	Topic to be covered
09/04/2022	4 PM to 6 PM	S.SHAKEEL AHMED	Fundamentals of and introduction to destructive and non-destructive testing.
11/04/2022	4 PM to 6 PM	S.SHAKEEL AHMED	Scope and limitations of NDT,
12/04/2022	4 PM to 6 PM	K.MAHABOOB BASHA	Visual examination methods, Different visual examination aids
13/04/2022	4 PM to 6 PM	K.MAHABOOB BASHA	Principle, procedure, characteristics of penetrant
16/04/2022	4 PM to 6 PM	S.SHAKEEL AHMED	types of penetrants, penetrant testing materials, fluorescent penetrant testing method
18/04/2022	4 PM to 6 PM	S.SHAKEEL AHMED	sensitivity, application and limitations
19/04/2022	4 PM to 6 PM	K.MAHABOOB BASHA S.SHAKEEL AHMED	Basic principles of sound propagation, types of sound waves, Principle of UT, methods of UT
20/04/2022	4 PM to 6 PM	K.MAHABOOB BASHA	advantages and limitations, Piezoelectric Material, Various types of transducers/probe, Calibration methods,
21/04/2022	4 PM to 6 PM	K.MAHABOOB BASHA	use of standard blocks, technique for normal beam inspection, flaw characterization technique
22/04/2022	4 PM to 6 PM	S.SHAKEEL AHMED	defects in welded products by UT, Thickness determination by ultrasonic method
23/04/2022	4 PM to 6 PM	S.SHAKEEL AHMED	RADIOGRAPHIC TESTING , Fundamental principles ,

25/04/2022	4 PM to 6 PM	K.MAHABOOB BASHA	The method of radiographic testing , Sources for radiographic testing
26/04/2022	4 PM to 6 PM	S.SHAKEEL AHMED K.MAHABOOB BASHA	Different forms of radiographic testing
27/04/2022	4 PM to 6 PM	S.SHAKEEL AHMED	Applications of radiographic testing method
28/04/2022	4 PM to 6 PM	S.SHAKEEL AHMED	Introduction to Acoustic Emission Testing, A Brief History of AE Testing , AE Sources: Wave Propagation Wave Mode and Velocity , Computed Tomography

Coordinator:

HOD

Professor & Head
Department of Mechnical Engineering
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Department of Mechanical Engineering

Attendance sheet of Certification course on "NON DESTRUCTIVE TESTING" from 11 APRIL 2022 to 29 APRIL 2022

Sl. No.	Roll No.	Name	11/4	12/4	13/4	16/4	18/4	19/4	20/4	21/4	22/4	23/4	25/4	26/4	27/4	28/4	29/4
1	179Y1A0337	O.C.PENCHALIAH	P	P	P	P	P	A	P	P	P	A	P	P	P	P	P
2	189Y1A0301	ABDHULLAGARI RAHIMULLA	P	P	P	P	A	P	P	P	P	P	A	P	P	P	A
3	189Y1A0302	AMBAVARM RAMESH REDDY	P	A	P	P	P	P	A	P	P	P	A	P	P	A	P
4	189Y1A0303	AMIREDDY VAMSI	P	P	P	P	A	P	P	P	P	P	P	A	P	P	P
5	189Y1A0304	B. VEERA PRATHAP REDDY	P	P	A	P	P	P	P	P	P	P	A	P	P	P	A
6	189Y1A0305	B. PRANAY KUMAR REDDY	P	P	P	P	A	P	A	A	P	A	P	P	A	P	P
7	189Y1A0306	BANDAPALLI TEJESWAR REDDY	P	P	P	A	P	P	P	P	A	P	P	A	P	P	P
8	189Y1A0307	BANDLA SUJITH	P	P	P	P	P	A	P	P	P	A	P	P	P	A	P
9	189Y1A0308	BOGGU SAI RAHUL	P	P	A	P	P	P	P	P	P	A	P	P	P	P	A
10	189Y1A0309	BUKKE CHANDRA NAIK	A	P	P	P	P	P	A	P	P	P	P	P	A	P	P
11	189Y1A0310	CHAGALAMARRI VENKATA SAI	P	P	P	P	P	A	P	A	P	P	P	P	P	P	P
12	189Y1A0311	CHEEMALA ARAVIND REDDY	P	P	P	A	P	P	P	P	P	A	P	P	P	A	P
13	189Y1A0312	CHILAKALA ASHOK	P	P	P	P	P	A	P	P	A	P	A	P	P	P	A
14	189Y1A0313	DASARI BHARATH KUMAR REDDY	P	A	P	P	P	P	P	A	P	P	P	P	A	P	P
15	189Y1A0314	DUDDELA SANDEEP KUMAR	P	P	P	P	A	P	P	A	P	P	P	A	P	A	P

16	189Y1A0315	DUDYALA RAVI KUMAR	P	P	P	P	A	P	P	P	A	P	P	P	P	P	P
17	189Y1A0316	G. S.M. NASEERUDDIN	A	P	P	P	P	P	P	P	A	P	P	P	A	P	P
18	189Y1A0317	GOVINDU VIKAS	P	P	P	A	P	P	P	P	P	P	A	P	P	P	P
19	189Y1A0318	GOWRIGALLA ASHOK	P	A	P	P	P	P	P	P	P	P	A	P	P	P	P
20	189Y1A0319	GUGULA SAI KUMAR	P	P	P	P	P	A	P	P	P	P	P	P	A	P	P
21	189Y1A0320	JUTURU VIKAS	P	P	A	P	P	P	P	P	P	P	A	P	P	P	P
22	189Y1A0321	KAMPARAJU RAVI SANKAR	P	A	P	P	P	P	P	A	P	P	P	P	P	P	P
23	189Y1A0322	KANDUKURI JANARDHAN REDDY	P	P	P	P	A	P	P	P	P	P	P	A	P	P	P
24	189Y1A0323	KATIKA YASHWANTH REDDY	P	P	P	A	P	P	P	P	A	A	P	P	P	P	P
25	189Y1A0324	K.CHANDRASEKHAR REDDY	A	P	P	P	P	P	P	P	P	P	P	P	A	P	P
26	189Y1A0325	KURAKU HARI KRISHNA	P	P	P	P	A	P	A	P	P	A	P	P	P	P	P
27	189Y1A0326	KURUVA MAHESH BABU	P	P	P	A	P	P	P	A	P	A	P	P	P	P	P
28	189Y1A0327	L. SIVA VENKATA SAI REDDY	P	A	P	P	P	P	P	P	P	P	P	A	A	P	P
29	189Y1A0328	MAJJARI VENKATA BHASKAR	P	P	P	P	P	A	P	P	P	P	P	P	P	A	P
30	189Y1A0329	MALKAPURAM THIRUMALESH	P	P	A	P	P	P	P	P	P	P	P	P	P	P	A
31	189Y1A0361	SHAIK VAYALPAD ABDUL KHAVI	P	P	P	P	P	A	P	A	P	P	P	P	P	P	P
32	189Y1A0362	SHAIK ZUBAIR	P	P	P	A	P	P	P	P	P	P	P	P	P	A	P
33	189Y1A0363	SHAIK ZUBAIR HUSSAIN	P	P	P	P	P	P	A	P	P	A	P	P	P	P	P
34	189Y1A0364	S.K. KHALEEL AHAMED	A	P	P	P	P	P	P	P	P	P	A	P	P	P	P
35	189Y1A0365	SHARON SAMUEL	P	P	P	P	P	P	A	P	P	P	P	P	P	P	A
36	189Y1A0366	SIDDAREDDY LINGAMAIAH	P	P	P	P	A	P	P	P	P	P	A	P	P	P	P
37	189Y1A0367	SOORABOINA VENKATESH	P	A	P	P	P	P	A	P	A	P	P	P	P	P	P
38	189Y1A0368	SYED GHAYAZ AHMED	P	P	P	P	P	A	P	P	P	P	P	P	P	A	P
39	189Y1A0369	TALUPULA AVINASH	P	P	P	P	A	P	P	A	P	P	P	P	P	P	P
40	189Y1A0370	THAMBALA VEERESH	P	P	A	P	P	P	A	P	A	P	P	P	P	P	P
41	189Y1A0371	THIRUVAIPATI SASIKANTH	A	P	P	P	P	P	P	A	P	P	P	P	P	P	P
42	189Y1A0372	THUMMALA MOHAMMED HAROON	P	P	P	A	P	P	P	P	P	P	P	P	P	P	A
43	189Y1A0373	V. MAHESH KUMAR	P	P	A	P	P	P	P	P	A	P	P	P	P	P	P

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
44	189Y1A0374	VADDEMANI LOKESWAR REDDY	A	P	P	P	P	P	P	A	P	P	P	P	P	P	P
45	189Y1A0375	VADDIREDDY RAJA KALYAN REDDY	P	P	P	A	P	P	P	P	A	P	A	P	P	P	P
46	189Y1A0376	Y ANDERSON	P	P	A	P	P	P	P	P	P	P	A	P	P	P	A
47	189Y1A0377	Y. CHENNA KESAVA REDDY	P	P	P	P	A	P	P	P	P	P	A	P	P	P	P
48	199Y5A0301	A.MABU BASHA	A	P	P	P	P	P	P	P	P	P	P	A	P	P	P
49	199Y5A0303	A.MAHESH BABU	P	P	P	A	P	P	P	A	P	P	P	P	P	P	A
50	199Y5A0304	B.SATISH KUMAR	P	A	P	P	P	P	P	P	A	P	P	P	P	P	P
51	199Y5A0305	B.SAI BHARATH	P	P	P	P	A	P	P	P	P	P	P	A	P	A	P
52	199Y5A0306	B.OBULA REDDY	P	P	P	P	P	A	P	P	P	P	P	A	P	P	P
53	199Y5A0307	C.SREENIVASULU	A	P	P	P	P	P	P	A	P	P	P	P	P	P	P
54	199Y5A0308	CH.AMARENDRA KUMAR	P	P	P	P	P	P	A	P	P	P	P	A	P	P	P
55	199Y5A0309	G.VEERAPASAD	P	A	P	P	P	P	P	P	A	P	P	P	P	A	P
56	199Y5A0310	G.VAMSI	P	P	P	A	P	P	P	P	P	P	P	P	A	P	A
57	199Y5A0312	J.SUBHAN	P	P	A	P	P	P	P	P	P	A	P	P	P	P	P
58	199Y5A0313	K.VAMSI KRISHNA	P	P	P	P	P	A	P	P	P	P	A	P	P	P	P
59	199Y5A0314	K.BHARGAV	A	P	P	P	P	P	P	A	P	P	P	P	P	P	P
60	199Y5A0315	K.SIVARAM NAIK	P	P	A	P	P	P	P	P	P	P	P	P	A	A	A
61	199Y5A0316	K.VENKATESH	P	P	P	A	P	P	P	P	P	P	A	P	P	P	P
62	199Y5A0317	K.V.S.MANORANJAN	P	P	P	P	A	P	A	P	P	P	P	P	A	P	A
63	199Y5A0338	S.SHEKSHAVALI	P	P	A	P	P	P	P	P	A	P	P	P	P	P	P

Coordinators

HoD-Mechanical Engg.

Professor & Head
Department of Mechnical Engineer…
K.S.R.M. College of Engineering
KADAPA - 516 003.

KSRM COLLEGE OF ENGINEERING
(UGC - AUTONOMOUS)
Approved by AICTE, New Delhi & Affiliated to JNTUA, ANanthapuramu
Kadapa,Andhra Pradesh, India - 516 003

LIGHTED TO LIGHTEN

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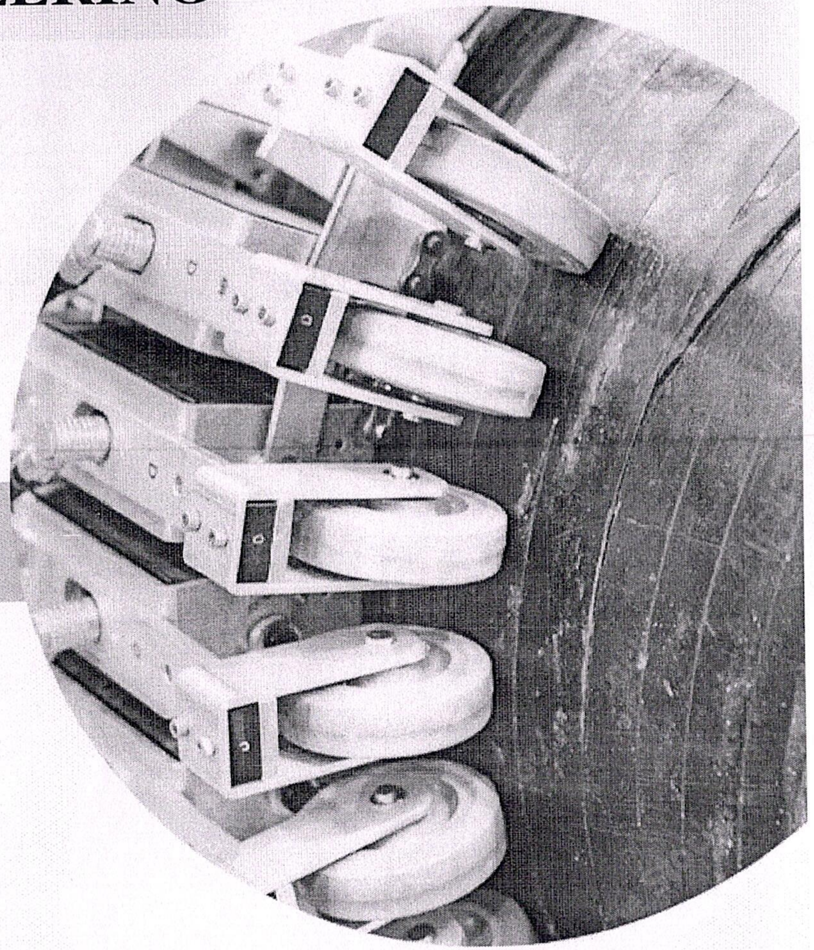
DEPARMENT OF MECHANICAL ENGINEERING



A Certification Course on "NON DESTRUCTIVE TESTING"

Department of ME

11/04/2022 to 29/04/2022

ME 206

Co-ordinator
Sri.k.Mahaboob Basha
Assistant Professor
Mech.Engg.Dept.

Resource Person
Dr.Shaik ShakeelAhamed
Assistant Professor
Mech.Engg.Dept.

Report of
Certification Course on "NON DESTRUCTIVE TESTING"
From 11/04/2022 to 29/04/2022

Target Group	:	**Students**
Details of Participants	:	**63 Students**
Co-coordinator(s)	:	**Sri K.Mahaboob Basha**
Resource Persons	:	**Sri S.Shakeel Ahmed**
Organizing Department	:	**Mechanical Engineering**
Venue	:	**Seminar Hall, Mechanical Department**

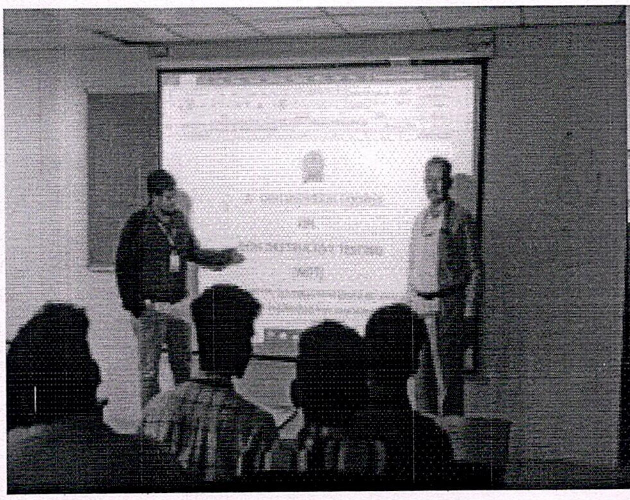
Description:

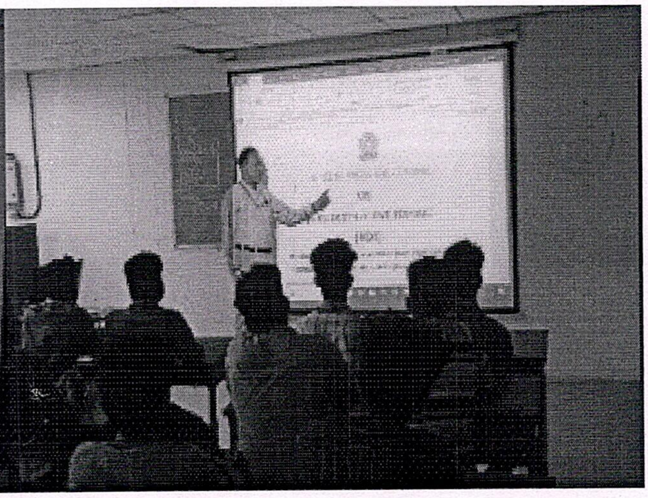
The Department of Mechanical Engineering conducted a certification course on " Non Destructive testing " from 11th april 2022 to 29th april 2022. The course duration was 30 hours .The course Resource Persons are Sri S.Shakeel Ahmed, Assoc Professor and Sri K.Mahaboob Basha, Asst. Professor Department Mechanical Engineering, KSRMCE.

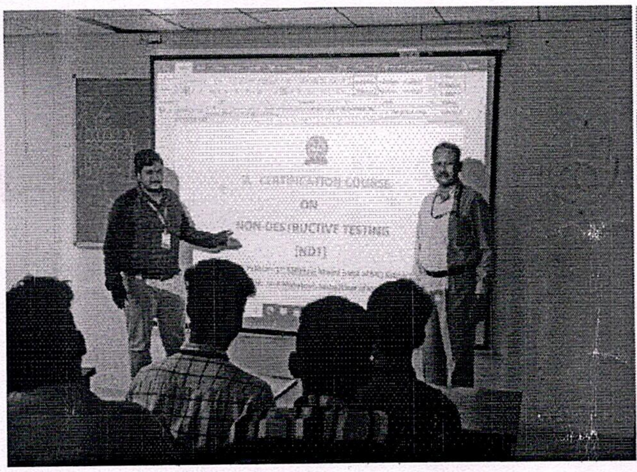
The main objective of this course is to introduce the fundamental concepts of non destructive testing. Non-destructive testing (NDT) is the process of inspecting, testing, or evaluating materials, components or assemblies for discontinuities, or differences in characteristics without destroying the serviceability of the part or system. In other words, when the inspection or test is completed the part can still be used.

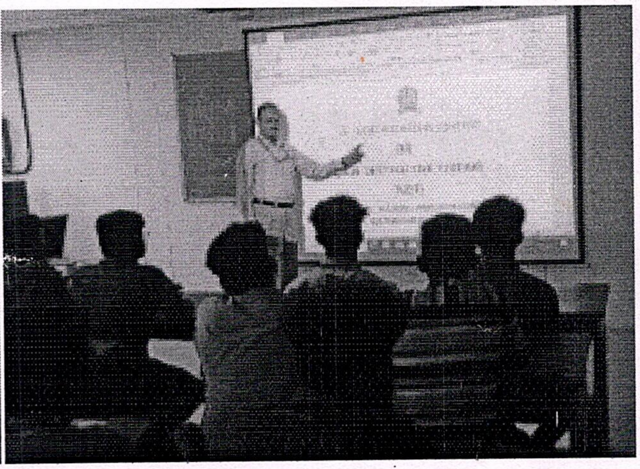
In contrast to NDT, other tests are destructive in nature and are therefore done on a limited number of samples ("lot sampling"), rather than on the materials, components or assemblies actually being put into service.

These destructive tests are often used to determine the physical properties of materials such as impact resistance, ductility, yield and ultimate tensile strength, fracture toughness and fatigue strength, but discontinuities and differences in material characteristics are more effectively found by NDT.









Coordinator

HoD

Professor & Head
Department of Mechnical Engineering
K.S.R.M. College of Engineering
KADAPA - 516 003.

K.S.R.M. COLLEGE OF ENGINEERING

(UGC - Autonomous)

Kadapa, Andhra Pradesh, India– 516 003

Approved by AICTE, New Delhi & Affiliated to JNTUA, Ananthapuramu.

KSNR lives on...

LIGHTED TO LIGHTEN

Certificate of Completion

This to certify that Mr/~~Mrs~~. B. PRANAY KUMAR REDDY Bearing the Roll Number 189Y1A0305 has Successfully Completed Certification Course on "NON- DESTRUCTIVE TESTING" from 11-04-2022 to 29-04-2022, Organized by Department of Mechanical Engineering, KSRMCE, Kadapa.

Coordinator

HOD ME

Head, Department of Mechnical Engineering, K.S.R.M. College of Engineering, KADAPA - 516 003.

V. S. S. Murthy

Principal

PRINCIPAL, K.S.R.M. COLLEGE OF ENGINEERING, KADAPA - 516 003. (A.P.)

K.S.R.M. COLLEGE OF ENGINEERING

(UGC - Autonomous)

Kadapa, Andhra Pradesh, India– 516 003

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Certificate of Completion

This to certify that Mr/Mrs. S. SHAKSHAVALI Bearing the Roll Number 199Y5A0338 has Successfully Completed Certification Course on " NON-DESTRUCTIVE TESTING " from 11-04-2022 to 29-04-2022 Organized by Department of Mechanical Engineering, KSRMCE, Kadapa.

Coordinator

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KADAPA - 516 003.

V. S. S. Murthy

Principal

PRINCIPAL
K.S.R.M. COLLEGE OF ENGINEERING
KADAPA - 516 003. (A.P.)

K.S.R.M. COLLEGE OF ENGINEERING

(UGC - Autonomous)

Kadapa, Andhra Pradesh, India– 516 003

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KSNR lives on.

Certificate of Completion

This to certify that Mr/~~Mrs.~~ S. GHAYAZ AHMED Bearing the Roll Number 189Y1A0368 has Successfully Completed Certification Course on " NON-DESTRUCTIVE TESTING " from 11-04-2022 to 29-04-2022, Organized by Department of Mechanical Engineering, KSRMCE, Kadapa.

Coordinator

HOD, ME

& Head
Department of Mechanical Engineering
K.S.R.M. College of Engineering

V. S. S. Murthy
Principal

PRINCIPAL
K.S.R.M. COLLEGE OF ENGINEERING

Feedback on Certificate Course on " Non Destructive Testing" From 11/04/2022 to 29/04/2022

*Required

1. Student Name (Optional)

2. Roll Number (Optional)

3. The objectives of the course were met (Objective) *

Mark only one oval.

- Excellent
- Good
- Satisfactory
- Poor

4. The pace of the course was appropriate to the content and attendees(Content) *

Mark only one oval.

- Excellent
- Good
- Satisfactory
- Poor

5. The content of the course was organized and easy to follow (Delivery) *

Mark only one oval.

Excellent
Good
Satisfactory
Poor

6. The Resource Persons were well prepared and able to answer any questions (Interaction) *

Mark only one oval.

Excellent
Good
Satisfactory
Poor

7. The exercises / role play were helpful and relevant (Syllabus Coverage) *

Mark only one oval.

Excellent
Good
Satisfactory
Poor

8. The venue was appropriate for the course (About Venue)*

Mark only one oval.

Excellent
Good
Satisfactory
Poor

9. The Course satisfy my expectation as a value added Programme (Course Satisfaction) *

Mark only one oval.

- Excellent
- Good
- Satisfactory
- Poor

10. Any Other comments

	Feedback on Certificate Course on"NON DESTRUCTIVE TESTING" from 11/04/22 to 29/04/22										
S.N	Timestamp	The object	The pa	The conten	The Reso	The exercis	The venu	The Cour	Student Name(Optional)	Roll Number	Any Other comments
1	29/4/2022 5:40:36 PM	Excellent	Excelle	Excellent	Excellent	Excellent	Excellent	Excellent	O.C.PENCHALIAH	179Y1A0337	
2	29/4/2022 5:40:36 PM	Excellent	Excelle	Excellent	Excellent	Excellent	Excellent	Excellent	A. RAHIMULLA	189Y1A0301	
3	29/4/2022 5:40:36 PM	Excellent	Good	Excellent	Excellent	Good	Excellent	Good	A. RAMESH REDDY	189Y1A0302	
4	29/4/2022 5:40:36 PM	Good	Good	Good	Good	Good	Good	Good	A. VAMSI	189Y1A0303	--
5	29/4/2022 5:40:36 PM	Excellent	Excelle	Excellent	Good	Excellent	Excellent	Excellent	B. V. PRATHAP REDDY	189Y1A0304	
6	29/4/2022 5:40:36 PM	Excellent	Excelle	Excellent	Excellent	Excellent	Excellent	Excellent	B. PRANAY KUMAR REDDY	189Y1A0305	
7	29/4/2022 5:40:36 PM	Excellent	Excelle	Excellent	Excellent	Excellent	Good	Good	B.TEJESWAR REDDY	189Y1A0306	We need some more
8	29/4/2022 5:40:36 PM	Excellent	Excelle	Excellent	Good	Excellent	Good	Good	BANDLA SUJITH	189Y1A0307	
9	29/4/2022 5:40:36 PM	Satisfactor	Satisfa	Satisfactory	Satisfacto	Satisfactory	Satisfacto	Satisfacto	BOGGU SAI RAHUL	189Y1A0308	No
10	29/4/2022 5:40:36 PM	Good	Excelle	Good	Excellent	Good	Excellent	Excellent	BUKKE CHANDRA NAIK	189Y1A0309	
11	29/4/2022 5:40:36 PM	Excellent	Excelle	Excellent	Excellent	Excellent	Good	Good	C. VENKATA SAI	189Y1A0310	
12	29/4/2022 5:40:36 PM	Excellent	Good	Good	Excellent	Good	Good	Excellent	C. ARAVIND REDDY	189Y1A0311	
13	29/4/2022 5:40:36 PM	Good	Good	Good	Good	Good	Satisfacto	Satisfacto	C. ASHOK	189Y1A0312	
14	29/4/2022 5:40:36 PM	Good	Good	Good	Good	Good	Good	Good	D. BHARATH KUMAR REDDY	189Y1A0313	It is useful for us
15	29/4/2022 5:40:36 PM	Good	Good	Good	Good	Good	Good	Good	D.SANDEEP KUMAR	189Y1A0314	--
16	29/4/2022 5:40:36 PM	Excellent	Excelle	Excellent	Excellent	Excellent	Excellent	Excellent	D.RAVI KUMAR	189Y1A0315	
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18	29/4/2022 5:40:36 PM	Excellent	Good	Excellent	Good	Excellent	Excellent	Good	G VIKAS	189Y1A0317	i Learned something
19	29/4/2022 5:40:36 PM	Excellent	Excelle	Excellent	Excellent	Good	Good	Good	G.ASHOK	189Y1A0318	
20	29/4/2022 5:40:36 PM	Good	Good	Good	Excellent	Good	Good	Excellent	G. SAI KUMAR	189Y1A0319	
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23	29/4/2022 5:40:36 PM	Excellent	Good	Good	Satisfacto	Excellent	Excellent	Excellent	K. JANARDHAN REDDY	189Y1A0322	
24	29/4/2022 5:40:36 PM	Excellent	Excelle	Excellent	Excellent	Excellent	Excellent	Excellent	K. YASHWANTH REDDY	189Y1A0323	-
25	29/4/2022 5:40:36 PM	Excellent	Excelle	Excellent	Excellent	Excellent	Excellent	Excellent	K.CHANDRASEKHAR REDDY	189Y1A0324	Nothing to say
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39	29/4/2022 5:40:36 PM	Excellent	Excelle	Excellent	Excellent	Excellent	Excellent	Excellent	T. AVINASH	189Y1A0369	
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42	29/4/2022 5:40:36 PM	Excellent	Excelle	Excellent	Excellent	Excellent	Excellent	Excellent	T. MOHAMMED HAROON	189Y1A0372	
43	29/4/2022 5:40:36 PM	Good	Good	Good	Good	Good	Good	Good	V. MAHESH KUMAR	189Y1A0373	
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46	29/4/2022 5:40:36 PM	Good	Good	Good	Good	Good	Good	Good	Y ANDERSON	189Y1A0376	
47	29/4/2022 5:40:36 PM	Excellent	Excelle	Good	Good	Excellent	Excellent	Good	Y. CHENNA KESAVA REDDY	189Y1A0377	Nothing
48	29/4/2022 5:40:36 PM	Good	Good	Good	Good	Good	Good	Good	A.MABU BASHA	199Y5A0301	__
49	29/4/2022 5:40:36 PM	Excellent	Good	Excellent	Good	Good	Excellent	Excellent	A.MAHESH BABU	199Y5A0303	
50	29/4/2022 5:40:36 PM	Excellent	Excelle	Excellent	Excellent	Excellent	Excellent	Excellent	B.SATISH KUMAR	199Y5A0304	
51	29/4/2022 5:40:36 PM	Good	Excelle	Good	Good	Good	Good	Good	B.SAI BHARATH	199Y5A0305	Ok
52	29/4/2022 5:40:36 PM	Excellent	Excelle	Excellent	Excellent	Excellent	Excellent	Excellent	B.OBULA REDDY	199Y5A0306	
53	29/4/2022 5:40:36 PM	Excellent	Excelle	Good	Good	Good	Good	Good	C.SREENIVASULU	199Y5A0307	
54	29/4/2022 5:40:36 PM	Good	Good	Excellent	Good	Excellent	Excellent	Excellent	CH.AMARENDRA KUMAR	199Y5A0308	
55	29/4/2022 5:40:36 PM	Excellent	Excelle	Excellent	Excellent	Excellent	Excellent	Excellent	G.VEERAPASAD	199Y5A0309	
56	29/4/2022 5:40:36 PM	Good	Excelle	Excellent	Good	Good	Good	Good	G.VAMSI	199Y5A0310	
57	29/4/2022 5:40:36 PM	Excellent	Excelle	Excellent	Excellent	Excellent	Excellent	Excellent	J.SUBHAN	199Y5A0312	
58	29/4/2022 5:40:36 PM	Excellent	Excelle	Good	Good	Good	Good	Good	K.VAMSI KRISHNA	199Y5A0313	
59	29/4/2022 5:40:36 PM	Excellent	Good	Excellent	Good	Excellent	Good	Excellent	K.BHARGAV	199Y5A0314	
60	29/4/2022 5:40:36 PM	Excellent	Excelle	Good	Satisfacto	Good	Good	Good	K.SIVARAM NAIK	199Y5A0315	
61	29/4/2022 5:40:36 PM	Excellent	Excelle	Excellent	Excellent	Excellent	Excellent	Excellent	K.VENKATESH	199Y5A0316	
62	29/4/2022 5:40:36 PM	Good	Good	Excellent	Excellent	Excellent	Excellent	Excellent	K.V.S.MANORANJAN	199Y5A0317	
63	29/4/2022 5:40:36 PM	Excellent	Excelle	Excellent	Good	Excellent	Excellent	Excellent	S.SHAKSHAVALI	199Y5A0338	

K.S.R.M. COLLEGE OF ENGINEERING (AUTONOMOUS), KADAPA-516003
DEPARTMENT OF MECHANICAL ENGINEERING
VALUE ADDED COURSE ON
NON DESTRUCTIVE TESTING 11/04/2022 TO 29/04/2022
AWARD LIST

S.No	Roll Number	Name of the Student	Marks Obtained
1	179Y5A0337	O.C.Penchaliah	14
2	189Y1A0301	Abdhullagari Rahimulla	13
3	189Y1A0302	Ambavarm Ramesh Reddy	14
4	189Y1A0303	Amireddy Vamsi	13
5	189Y1A0304	B. Veera Prathap Reddy	12
6	189Y1A0305	B. Pranay Kumar Reddy	12
7	189Y1A0306	Bandapalli Tejeswar Reddy	13
8	189Y1A0307	Bandla Sujith	12
9	189Y1A0308	Boggu Sai Rahul	13
10	189Y1A0309	Bukke Chandra Naik	13
11	189Y1A0310	Chagalamarri Venkata Sai	14
12	189Y1A0311	Cheemala Aravind Reddy	13
13	189Y1A0312	Chilakala Ashok	14
14	189Y1A0313	Dasari Bharath Kumar Reddy	13
15	189Y1A0314	Duddela Sandeep Kumar	12
16	189Y1A0315	Dudyala Ravi Kumar	12
17	189Y1A0316	G.S.M. Naseeruddin	14
18	189Y1A0317	Govindu Vikas	13
19	189Y1A0318	Gowrigalla Ashok	14
20	189Y1A0319	Gugula Sai Kumar	13
21	189Y1A0320	Juturu Vikas	12
22	189Y1A0321	Kamparaju Ravi Sankar	13
23	189Y1A0322	Kandukuri Janardhan Reddy	12
24	189Y1A0323	Katika Yashwanth Reddy	12
25	189Y1A0324	K.Chandrasekhar Reddy	13
26	189Y1A0325	Kuraku Hari Krishna	14
27	189Y1A0326	Kuruva Mahesh Babu	12
28	189Y1A0327	L. Siva Venkata Sai Reddy	12
29	189Y1A0328	Majjari Venkata Bhaskar	13
30	189Y1A0329	Malkapuram Thirumalesh	12
31	189Y1A0361	Shaik Vayalpad Abdul Khavi	`13
32	189Y1A0362	Shaik Zubair	13
33	189Y1A0363	Shaik Zubair Hussain	13
34	189Y1A0364	S.K. Khaleel Ahamed	14
35	189Y1A0365	Sharon Samuel	13
36	189Y1A0366	Siddareddy Lingamaiah	14
37	189Y1A0367	Sooraboina Venkatesh	14
38	189Y1A0368	Syed Ghayaz Ahmed	13
39	189Y1A0369	Talupula Avinash	14
40	189Y1A0370	Thambala Veeresh	12
41	189Y1A0371	Thiruvaipati Sasikanth	12

42	189Y1A0372	Thummala Mohammed Haroon	12
43	189Y1A0373	V. Mahesh Kumar	13
44	189Y1A0374	Vaddemani Lokeswar Reddy	12
45	189Y1A0375	Vaddireddy Raja Kalyan Reddy	13
46	189Y1A0376	Y Anderson	13
47	189Y1A0377	Y. Chenna Kesava Reddy	12
48	199Y5A0301	A.Mabu Basha	13
49	199Y5A0303	A.Mahesh Babu	14
50	199Y5A0304	B.Satish Kumar	13
51	199Y5A0305	B.Sai Bharath	14
52	199Y5A0306	B.Obula Reddy	14
53	199Y5A0307	C.Sreenivasulu	13
54	199Y5A0308	Ch.Amarendra Kumar	14
55	199Y5A0309	G.Veerapasad	12
56	199Y5A0310	G.Vamsi	12
57	199Y5A0312	J.Subhan	12
58	199Y5A0313	K.Vamsi Krishna	13
59	199Y5A0314	K.Bhargav	12
60	199Y5A0315	K.Sivaram Naik	13
61	199Y5A0316	K.Venkatesh	13
62	199Y5A0317	K.V.S.Manoranjan	12
63	199Y5A0318	S.Shakshavali	13

K. Mahabub Basha

Coordinator

HoD

Professor & Head
Department of Mechnical Engineering
K.S.R.M. College of Engineering
KADAPA - 516 003.

K.S.R.M. COLLEGE OF ENGINEERING (AUTONOMOUS), KADAPA-516003
DEPARTMENT OF MECHANICAL ENGINEERING
VALUE ADDED /CERTIFICATE COURSE ON
NON DESTRUCTIVE TESTING
FROM 11/04/2022 TO 29/04/2022
ASSESSMENT TEST

14

Roll Number: 189Y1A0312 **Name of the Student:** C. Ashok

Time: 20 Min **(Objective Questions)** **Max.Marks: 20**

Note: Answer the following Questions and each question carries **one** mark.

1. Dye penetrant method is generally used to locate [b]
(a) Core defects
(b) Surface defects
(c) Superficial defects
(d) Temporary defects

2. What is used as the source of rays for radiography? [b]
(a)Uranium-235 (b) Tellurium (c) Cobalt-60 (d) Manganese dioxide

3. Which material can't be tested by MPI? [d]
(a) Co (b) Fe (c)Ni (d)Mg

4. What is the disadvantage of liquid penetrant test? [d
(a)Expensive (b) Slow (c) Not reliable (d) Depth restriction

5. Which order is right for liquid penetrant test? [a]
(a) Penetrant apply, development, inspection, surface preparation
(b) Surface preparation, penetrant apply, development, inspection
(c) Penetrant apply, development, surface preparation, inspection
(d) Development, surface preparation, penetrant apply, inspection

6. Which principle defines eddy current inspection? [c
(a)Lenz law (b)Biot savart law
(c)Electromagnetic induction principle (d)Faraday's law

7. In which type of test the capillary action principle is used? [c]
(a) Probe test (b) Bend liquid test (c) Dye penetrant test (d) None of the above

8. Non-destructive testing is used to determine [d]
(a) Location of defects (b) chemical composition (c) corrosion of metal (d) All of these

9. Which among the following is not a type of Non-destructive testing? [a
(a) Compression test (b) visual testing

(c) Ultrasonic testing (d) eddy current testing

10. Identify the type of destructive testing [c]
(a) Radiographic test (b) Dye penetrant test
(c) Creep test (d) All of the above

11. Which among the following is the last step in magnetic particle test method? [c]
(a) Observation and inspection (b) circular magnetization
(c) Demagnetization (d) magnetization

12. Which of the following statements is/are true for ultrasonic test? [a]
(a) Equipment used for ultrasonic testing is portable (b) Complicated shapes can be easily scanned
(c) Waves generated are health hazardous (d) All the above statements are true

13. During radiography test, which region absorbs less radiation and transmits more? [C]
(a) Low and high density regions absorb and transmit same amount of radiation
(b) High density region
(c) Low density region
(d) None of the above

14. Which test is used to determine dimensions of any object? [a]
(a) Ultrasonic test
(b) Torsion test
(c) Eddy current test
(d) All of these tests can be used to determine dimensions of any object

15. Eddy current test is used to detect [b]
(a) Cracks (b) hardness (c) conductivity (d) All of the above

16. What is the disadvantage of liquid penetrant test? [d]
(a) Expensive (b) Slow (c) Not reliable (d) Depth restriction

17. Which test can be performed without skilled labor? [b]
(a) Dye penetrant testing (b). Visual testing
(c). Ultrasonic testing (d). Magnetic particle test

18. What is the disadvantage of liquid penetrant test? [a]
(a) Expensive (b) Slow (c) Not reliable (d) Depth restriction

19. What does NDT stands for [b]

(a) Non-driving test (b) Non-destructive test

(c) Non-Danger test (d) Non-Dial test

20. Which of the following is NDT testing method [a]

(a) Metallographic testing (b) Hardness testing

(c) Stress testing (d) Radiography

K.S.R.M. COLLEGE OF ENGINEERING (AUTONOMOUS), KADAPA-516003
DEPARTMENT OF MECHANICAL ENGINEERING
VALUE ADDED /CERTIFICATE COURSE ON
NON DESTRUCTIVE TESTING
FROM 11/04/2022 TO 29/04/2022
ASSESSMENT TEST

12

Roll Number: 189Y1A0370 **Name of the Student:** J. Veeresh

Time: 20 Min **(Objective Questions)** **Max.Marks: 20**

Note: Answer the following Questions and each question carries **one** mark.

1. Dye penetrant method is generally used to locate [b]
(a) Core defects
(b) Surface defects
(c) Superficial defects
(d) Temporary defects

2. What is used as the source of rays for radiography? [d]
(a)Uranium-235 (b) Tellurium (c) Cobalt-60 (d) Manganese dioxide

3. Which material can't be tested by MPI? [d]
(a) Co (b) Fe (c)Ni (d)Mg

4. What is the disadvantage of liquid penetrant test? [d]
(a)Expensive (b) Slow (c) Not reliable (d) Depth restriction

5. Which order is right for liquid penetrant test? [a]
(a) Penetrant apply, development, inspection, surface preparation
(b) Surface preparation, penetrant apply, development, inspection
(c) Penetrant apply, development, surface preparation, inspection
(d) Development, surface preparation, penetrant apply, inspection

6. Which principle defines eddy current inspection? [C]
(a)Lenz law (b)Biot savart law
(c)Electromagnetic induction principle (d)Faraday's law

7. In which type of test the capillary action principle is used? [d]
(a) Probe test (b) Bend liquid test (c) Dye penetrant test (d) None of the above

8. Non-destructive testing is used to determine [d]
(a) Location of defects (b) chemical composition (c) corrosion of metal (d) All of these

9. Which among the following is not a type of Non-destructive testing? [b]
(a) Compression test (b) visual testing

(c) Ultrasonic testing (d) eddy current testing

10. Identify the type of destructive testing [c]
(a) Radiographic test (b) Dye penetrant test
(c) Creep test (d) All of the above

11. Which among the following is the last step in magnetic particle test method? [c]
(a) Observation and inspection (b) circular magnetization
(c) Demagnetization (d) magnetization

12. Which of the following statements is/are true for ultrasonic test? [a]
(a) Equipment used for ultrasonic testing is portable (b) Complicated shapes can be easily scanned
(c) Waves generated are health hazardous (d) All the above statements are true

13. During radiography test, which region absorbs less radiation and transmits more? [b]
(a) Low and high density regions absorb and transmit same amount of radiation
(b) High density region
(c) Low density region
(d) None of the above

14. Which test is used to determine dimensions of any object? [c]
(a) Ultrasonic test
(b) Torsion test
(c) Eddy current test
(d) All of these tests can be used to determine dimensions of any object

15. Eddy current test is used to detect [a]
(a) Cracks (b) hardness (c) conductivity (d) All of the above

16. What is the disadvantage of liquid penetrant test? [d]
(a) Expensive (b) Slow (c) Not reliable (d) Depth restriction

17. Which test can be performed without skilled labor? [a]
(a) Dye penetrant testing (b). Visual testing
(c). Ultrasonic testing (d). Magnetic particle test

18. What is the disadvantage of liquid penetrant test? [b]
(a) Expensive (b) Slow (c) Not reliable (d) Depth restriction

19. What does NDT stands for [d] ✗

(a) Non-driving test
(b) Non-destructive test
(c) Non-Danger test
(d) Non-Dial test

20. Which of the following is NDT testing method [d] ✓

(a) Metallographic testing
(b) Hardness testing
(c) Stress testing
(d) Radiography

K.S.R.M. COLLEGE OF ENGINEERING (AUTONOMOUS), KADAPA-516003
DEPARTMENT OF MECHANICAL ENGINEERING
VALUE ADDED /CERTIFICATE COURSE ON
NON DESTRUCTIVE TESTING
FROM 11/04/2022 TO 29/04/2022
ASSESSMENT TEST

14

Roll Number: 199Y5A0306 **Name of the Student:** B-Obula Reddy

Time: 20 Min **(Objective Questions)** **Max.Marks: 20**

Note: Answer the following Questions and each question carries **one** mark.

1. Dye penetrant method is generally used to locate [b]
(a) Core defects
(b) Surface defects
(c) Superficial defects
(d) Temporary defects

2. What is used as the source of rays for radiography? [c]
(a)Uranium-235 (b) Tellurium (c) Cobalt-60 (d) Manganese dioxide

3. Which material can't be tested by MPI? [d]
(a) Co (b) Fe (c)Ni (d)Mg

4. What is the disadvantage of liquid penetrant test? [d]
(a)Expensive (b) Slow (c) Not reliable (d) Depth restriction

5. Which order is right for liquid penetrant test? [a]
(a) Penetrant apply, development, inspection, surface preparation
(b) Surface preparation, penetrant apply, development, inspection
(c) Penetrant apply, development, surface preparation, inspection
(d) Development, surface preparation, penetrant apply, inspection

6. Which principle defines eddy current inspection? [c]
(a)Lenz law (b)Biot savart law
(c)Electromagnetic induction principle (d)Faraday's law

7. In which type of test the capillary action principle is used? [d]
(a) Probe test (b) Bend liquid test (c) Dye penetrant test (d) None of the above

8. Non-destructive testing is used to determine [d]
(a) Location of defects (b) chemical composition (c) corrosion of metal (d) All of these

9. Which among the following is not a type of Non-destructive testing? [a]
(a) Compression test (b) visual testing

(c) Ultrasonic testing (d) eddy current testing

10. Identify the type of destructive testing [c]
(a) Radiographic test (b) Dye penetrant test
(c) Creep test (d) All of the above

11. Which among the following is the last step in magnetic particle test method? [a]
(a) Observation and inspection (b) circular magnetization
(c) Demagnetization (d) magnetization

12. Which of the following statements is/are true for ultrasonic test? [a
(a) Equipment used for ultrasonic testing is portable (b) Complicated shapes can be easily scanned
(c) Waves generated are health hazardous (d) All the above statements are true

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(d) Radiography

Unit-1:

Introduction

What Is Non Destructive Testing?

Non-destructive testing (NDT) is the process of inspecting, testing, or evaluating materials, components or assemblies for discontinuities, or differences in characteristics without destroying the serviceability of the part or system. In other words, when the inspection or test is completed the part can still be used.

In contrast to NDT, other tests are destructive in nature and are therefore done on a limited number of samples ("lot sampling"), rather than on the materials, components or assemblies actually being put into service.

These destructive tests are often used to determine the physical properties of materials such as impact resistance, ductility, yield and ultimate tensile strength, fracture toughness and fatigue strength, but discontinuities and differences in material characteristics are more effectively found by NDT.

Today modern non destructive tests are used in manufacturing, fabrication and in-service inspections to ensure product integrity and reliability, to control manufacturing processes, lower production costs and to maintain a uniform quality level. During construction, NDT is used to ensure the quality of materials and joining processes during the fabrication and erection phases, and in-service NDT inspections are used to ensure that the products in use continue to have the integrity necessary to ensure their usefulness and the safety of the public.

NDT Test Methods:

The six most frequently used test methods are MT, PT, RT, UT, ET and VT. Each of these test methods will be described here, followed by the other, less often used test methods.

1. Visual Testing (VT)
2. Liquid Penetrant Testing (PT),
3. Magnetic Particle Testing (MT),
4. Ultrasonic Testing (UT), 5.Radiographic Testing (RT) and

6.Electromagnetic Testing (ET).

Test method names often refer to the type of penetrating medium or the equipment used to perform that test. Current NDT methods are:

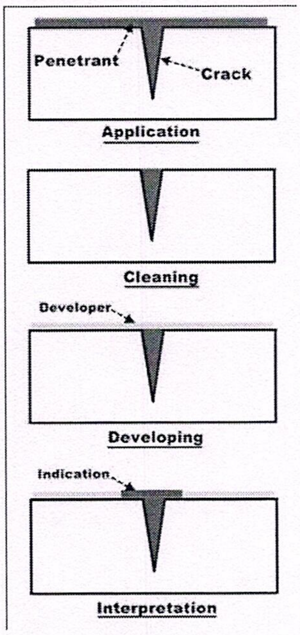
- Acoustic Emission Testing (AE),

- Electromagnetic Testing (ET),
- Guided Wave Testing (GW),
- Ground Penetrating Radar (GPR),
- Laser Testing Methods (LM),
- Leak Testing (LT),
- Magnetic Flux Leakage (MFL),
- Microwave Testing,
- Liquid Penetrant Testing (PT),
- Magnetic Particle Testing (MT),
- Neutron Radiographic Testing (NR),
- Radiographic Testing (RT),
- Thermal/Infrared Testing (IR),
- Ultrasonic Testing (UT),
- Vibration Analysis (VA) and Visual Testing (VT).

Visual Testing (VT)

Visual testing is the most commonly used test method in industry. Because most test methods require that the operator look at the surface of the part being inspected, visual inspection is inherent in most of the other test methods. As the name implies, VT involves the visual observation of the surface of a test object to evaluate the presence of surface discontinuities. VT inspections may be by Direct Viewing, using line-of sight vision, or may be enhanced with the use of optical instruments such as magnifying glasses, mirrors, boroscopes, charge-coupled devices (CCDs) and computer-assisted viewing systems (Remote Viewing). Corrosion, misalignment of parts, physical damage and cracks are just some of the discontinuities that may be detected by visual examinations.

Liquid Penetrant Testing(PT)



The basic principle of liquid penetrant testing is that when a very low viscosity (highly fluid) liquid (the penetrant) is applied to the surface of a part, it will penetrate into fissures and voids open to the surface. Once the excess penetrant is removed, the penetrant trapped in those voids will flow back out, creating an indication. Penetrant testing can be performed on magnetic and non-magnetic materials, but does not work well on porous materials. Penetrants may be "visible", meaning they can be seen in ambient light, or fluorescent, requiring the use of a "black" light. The visible dye penetrant process is shown in Figure . When performing a PT inspection, it is imperative that the surface being tested is clean and free of any foreign materials or liquids that might block the penetrant from entering voids or fissures open to the surface of the part. After applying the penetrant, it is permitted to sit on the surface for a specified period of time (the "penetrant dwell time"), then the part is carefully cleaned to remove excess penetrant from the surface. When removing the penetrant, the operator must be careful not to remove any penetrant that has flowed into voids. A light coating of developer is then be applied to the surface and given time ("developer dwell time") to allow the penetrant from any voids or fissures to seep up into the developer, creating a visible indication. Following the prescribed developer dwell time, the part is inspected visually, with the aid of a black light for fluorescent penetrants. Most developers are fine-grained, white talcum-like powders that provide a color contrast to the penetrant being used.

Visual inspection is by far the most common nondestructive examination (NDE) technique . When attempting to determine the soundness of any part or specimen for its intended application, visual inspection is normally the first step in the examination process. Generally, almost any specimen can be visually examined to determine the accuracy of its fabrication. For example, visual inspection can be used to determine whether the part was fabricated to the correct size, whether the part is complete, or whether all of the parts have been appropriately incorporated into the device .

While direct visual inspection is the most common nondestructive examination technique, many other NDE methods require visual intervention to interpret images obtained while carrying out the examination. For instance, penetrant inspection using visible red or fluorescent dye relies on the inspector"s ability to visually identify surface indications. Magnetic particle inspection falls into the same category of visible and fluorescent inspection techniques, and radiography relies on the interpreter"s visual judgment of the radiographic image, which is either on film or on a video monitor. The remainder of this article provides a summary of the visual testing method, which at the minimum requires visual contact with the portion of the specimen that is being inspected. In arriving at a definition of visual inspection, it has been noted in the literature that experience in visual inspection and discussion with experienced visual inspectors revealed that this NDE method includes more than use of the eye, but also includes other sensory and cognitive processes used by inspectors. Thus, there is now an expanded definition of visual inspection in the literature: "Visual inspection is the process of examination and evaluation of systems and components by use of human sensory systems aided only by mechanical enhancements to sensory input such as magnifiers, dental picks, stethoscopes, and the like. The inspection process may be done using such behaviors as looking, listening, feeling, smelling, shaking, and twisting.

Fig: Visual inspection of a torpedo tube aboard a Navy attack submarine

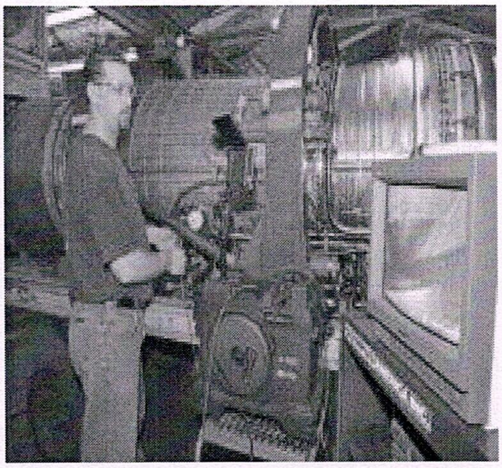
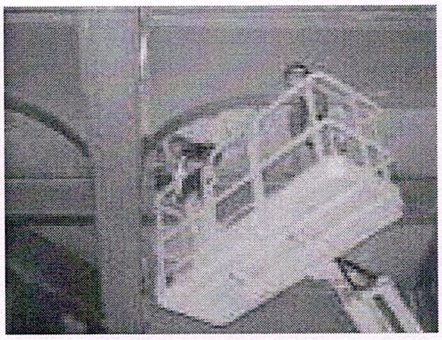


Fig: An inspector at Tinker Air Force base gets a magnified view of an engine‟s high-pressure turbine area with a new digital fiber-optic bore scope.



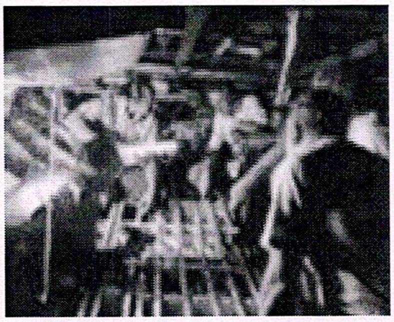


Fig: Part of a routine bridge Fig.: Part of an in-depth bridge Fig: Visual
inspection experiment inside a Boeing 737. visual inspection

Unit-2:

Dye penetrant Testing/ Liquid Penetrant Testing

Principle, procedure, characteristics of penetrant, types of penetrants, penetrant testing materials, fluorescent penetrant testing method– sensitivity, application and limitations.

LIQUID PENETRANT TESTING (PT)

This is a method which can be employed for the detection of open-to-surface discontinuities in any industrial product which is made from a non-porous material. In this method a liquid penetrant is applied to the surface of the product for a certain predetermined time after which the excess penetrant is removed from the surface. The surface is then dried and a developer is applied to it. The penetrant which remains in the discontinuity is absorbed by the developer to indicate the presence aswell as the location, size and nature of the discontinuity. The process is illustrated in Figure.

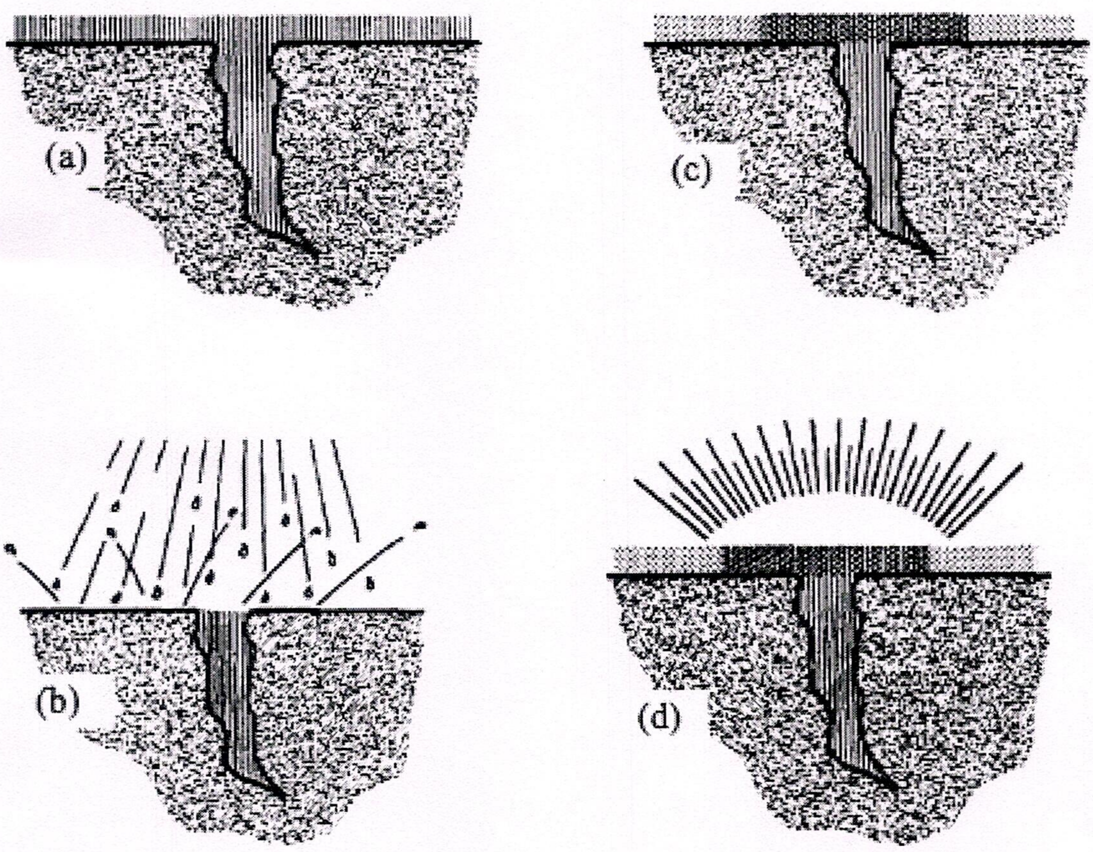


Figure: Four stages of liquid penetrant process.

(a) Penetrant application and seepage into the discontinuity.

(b) Removal of excess penetrant.

(c) Application of developer.

(d) Inspection for the presence of discontinuities.

General procedure for liquid penetrant inspection

(a) Cleaning the surface to be examined:

There should be no material such as plating, or coatings of oxide or loose dirt surface. This is to prevent false Jications and to expose hidden discontinuities to the penetrant. Solid containers such as carbon, engine varnish, paints and similar materials should be removed by vapor blast, chemical dip or other acceptable methods . Methods such as shot blasting, emery cloth, wire brushing or metal scrapping should not be used, especially for soft materials, since these cleaning methods will cover up defects by cold working the surface.

Contamination can occur due to the presence of lubricants, protective oils, metal dust polymerization, oxidation, carbonaceous deposits, protective paints, etc. Various solvents have been developed by different companies to remove them. Contamination due to inorganic corrosion products, heat treatment scale, operationally formed refractory oxides, etc. is conveniently removed by abrasive blasting with glass beads, etc. combined with a chemical cleaning. Whichever method is employed the use of trichlorethylene vapour degreasing as a final stage is strongly recommended.

(b) Drying the surface:

If, for any reason, separations are filled with liquid, they will prevent entry of penetrant, hence drying is an essential operation . It should be realized that although the surface may seem dry, separations may still be filled with liquid. With "dismountable cracks" used to evaluate penetrants, it is remarkable how long a liquid can stay in a small separation after the outer surface has become dry. The lesson is that improper drying may be worse than no cleaning, because the remaining solvent may present a barrier to the penetrant too. If penetrant liquid does reach into the separation, it will be diluted by the solvent, and this also makes the treatment less effective.

(c) Application of penetrant:

The penetrant is applied with the help of a brush or by spray or by dipping the test piece into a bath of penetrant. After this a certain residence time or 'dwell time' is allowed for the penetrant to seep into discontinuities. The residence time varies with the temperature, the type of penetrant, the nature of the discontinuity and the material of the test specimen.

It usually varies between 5 and 30 minutes. In special cases it may be as long as one hour.

(d) Removal of superfluous penetrant:

The excess penetrant on the surface should be removed to obtain optimum contrast and to prevent misleading indications. The appropriate remover is usually recommended by the manufacturer of the penetrant. Some penetrants are water washable while others need application of an emulsifier before they can be removed with water. The removal method is to use a sponge or water spray. There are special penetrant removers which are essentially solvents.

It is most important that removal of the penetrant is restricted to the surface and that no penetrant is washed out of the flaws which can easily happen when the cleaning is too rigorous. When the surface is smooth washing can be less intensive than for rough surfaces; in the latter case there is a definite risk that penetrant may be washed out of small imperfections.

A general criterion for the removal operation is that it must be fast and should be prolonged long enough to make the surface almost clean. It is better to leave small traces of penetrant on the surface than to carry out excessive cleaning. When removing fluorescent penetrants, the effect of the treatment should preferably be watched under black light.

(e) Drying the surface:

The surface can be dried with a dry cloth or an air blower. Drying is generally needed to prepare the surface for the application of a powder developer, which would otherwise clot at wet places. It also decreases the adverse effect of insufficiently removed traces of penetrant. Here again excess should be avoided. Penetrant liquid left in flaws should not be allowed to dry, and this can happen when hot air is used for drying.

(f) Application of **developer:**

Developers are usually of two types namely dry and wet developer. Dry developer consists of a dry, light coloured powdery material. It is applied to the surface after removal of excess penetrant and drying of the part. It can be applied either by immersing the parts in a tank containing powder, or by brushing it on with a paint brush (usually not a desirable technique) or by blowing the powder onto the surface of the part.

Wet developer consists of a powdered material suspended in a suitable liquid such as water or a volatile solvent. It is applied to the parts immediately following the water washing operation. Developers should be such that they provide a white coating that contrasts with the coloured dye penetrant, and draw the penetrant from the discontinuities to the surface of the developer film, thus revealing defects. The dry developers are applied generally with fluorescent penetrants. They are applied just prior to the visual inspection process. The wet developers are also used in connection with fluorescent penetrants. They are applied after the washing operation and before the drying operation. The solvent based developers are generally used with the visible dye-penetrants. They are applied after cleaning off extra penetrant. A short time should be allowed for development of indications after the developer has been applied. This time should be approximately one half that allowed for penetration. Developer coating is removed after inspection by water stream, spray nozzle, brush, etc. The powder concentration of the liquid developer should be carefully controlled to obtain the required thin and uniform layer over the surface.

(g) Observation and interpretation of indications:

An indication in the developer will become visible after a certain lapse of time. Because all penetrant inspection methods rely upon the seeing of an indication by the inspector, the lighting provided for this visual examination is extremely important. For best results, inspection for fluorescent indications should be done in a darkened area using black light. For the interpretation of indications, it is very important to observe their characteristics at the very moment they appear. As soon 67 as the flaws have bled out the indications may run to larger spots, depending on size and depth, and at this stage it is difficult to derive characteristic information from a flaw.

The extent to which observation of developing indications can be realized in practice depends largely on the size and complexity of the surface to be examined as well as on the number of components to be tested. A brief guide to the penetrant indications is given here. A crack usually shows up as a continuous line of penetrant indication. A cold shut on the surface of a casting also appears as a continuous line, generally a relatively narrow one. A forging lap may also cause a continuous line of penetrant indication. Rounded areas of penetrant indication signify gas holes or pin holes in castings.

Deep crater cracks in welds frequently show up as rounded indications. Penetrant indications in the form of small dots result from a porous condition. These may denote small pin holes or excessively coarse grains in castings or may be caused by a shrinkage cavity. Sometimes a large area presents a diffused appearance. With fluorescent penetrants, the whole surface may glow feebly. With dye penetrants, the background may be pink instead of white. This diffused condition may result from very fine, widespread porosity, such as microshrinkage in magnesium. Depth of defects will be indicated by richness of colour and speed of bleed out. The time required for an indication to develop is inversely proportional to the volume of the discontinuity.

Penetrant processes and equipment:

Penetrants are classified depending on whether the dye fluoresces under black light or is highly contrasting under white light. A second major division of the penetrants is determined by the manner is which they can be removed from the surface. Some penetrants are water washable and can be removed from the surface by washing with ordinary tap water. Other penetrants are removed with special solvents. Some penetrants are not in themselves water washable but can be made so by applying an emulsifier as an extra step after penetration is completed. During a short emulsification period this emulsifier blends with the excess penetrant on the surface of the part after which the mixture is easily removed with a water spray.

The fluorescent penetrant water washable penetrant process uses this method. The fluorescent method is used for greater visibility; can be easily washed with water; is good for quantities of small parts; is good on rough surfaces; is good in keyways and threads; is high speed, economical of time and good for a wide range of defects. The post emulsification fluorescent process has fluorescence for greater visibility, has highest sensitivity for very fine defects; can show wide shallow defects; is easily washed with water after emulsification; has a short penetration time; high production; especially satisfactory for chromate surfaces.

The water emulsifiable visible penetrant process has greater portability; requires no black light; can be used on suspected local areas of large parts; aids in rework or repair; can be used on parts where water is not available; can be used where parts are to be repaired in ordinary light; best of all techniques on contaminated defects; sensitive to residual acidity or alkalinity; high sensitivity to very fine defects.

Fluorescent materials generally respond most actively to radiant energy of a wavelength of approximately 3650A. This is just outside the visible range on the blue or violet side but not sufficiently far removed to be in the chemically active or ultraviolet range : this is "black light". Four possible sources of black light are incandescent lamps, metallic or carbon arcs, tubular "BL" fluorescent lamps and enclosed mercury vapour arc lamps. Mercury vapour arc lamps are generally used. One of the advantages of this is that its light output can be controlled by design and manufacturing. At medium pressures (from 1 to 10 atmospheres) the light output is about evenly distributed between the visible, black light and hard ultraviolet ranges.

These medium pressure lamps are ordinarily used for inspection purposes. A red purple glass is used to filter the light not desired. Factors such as the nature of inspected surface, extraneous white light entering the booth, the amount and location of fluorescent materials near the inspector and the speed with which inspection is to be carried out have an effect on the black light intensity necessary at the inspected surface. The light level, once it is set for a practical job, should be maintained. Good eyesight is also a requisite.

Areas of application of liquid penetrants:

Liquid penetrants can be used for the inspection of all types of materials such as ferrous and non-ferrous, conductors and non-conductors, magnetic and non-magnetic and all sorts of alloys and plastics. Most common applications are in castings, forgings and welding.

Range and limitations of liquid penetrants:

All imperfections which have an opening to the surface are detectable no matter what their orientation be. Sub-surface defects which are not open to the surface will not show up and consequently will not interfere with the interpretation. No indications are produced as a consequence of differences in permeability (a weld in dissimilar steels, transition zones, etc.). There is no risk of surface damage which may occur, for example, during careless magnetization with prods in the current flow method. The equipment is also low cost.

Flaws may remain undetected by penetrant inspection if magnetic particle testing has been previously used, because the residual iron oxide may fill or bridge the defect. Similarly fluorescent penetrant will often fail to show discontinuities previously found by dye-penetrant because the dye reduces or even kills fluorescence. Reinspection should be done with the same method. Surface condition may affect the indications. Surface openings may be closed due to dirt, scale, lubrication or polishing. Rough or porous areas may retain penetrant producing irrelevant indications. Deposits on the surface may dilute the penetrant, thus reducing its effectiveness. If all the surface penetrant is not completely removed in the washing or rinse operation following the penetration time, the unremoved penetrant will be visible.

Such parts should be completely reprocessed. Degreasing is recommended. Another condition which may create false indications is where parts are press fitted to each other. The penetrant from the fit may bleed out and mask the true defect. Some of the precautions necessary for liquid penetrant inspection are briefly summarized here. Only one process should be used. Change of process is not advisable for reinspection. Contamination leads to a loss of test sensitivity and reliability. Contamination of water with penetrants should be avoided. Wet developer bath should be at the recommended concentration. The temperature should not exceed certain limits depending on materials used. The penetrant should not be heated.

Avoid contact of penetrant with skin by wearing gloves. Keep penetrants off clothes. Check for traces of fluorescent penetrant on skin and clothes and inside gloves by examining under black light. Excessive mounts of dry penetrants should not be inhaled. Improperly arranged black lights may cause some eye fatigue. The materials used with visible penetrant process are flammable and should not be stored or used near heat or fire. Do not smoke while using them.

Unit-3:
ULTRASONIC TESTING

Fundamental principles:

Nature and type of ultrasonic waves:

Ultrasonic inspection is a non-destructive testing method in which high frequency sound waves are introduced into the material being inspected and the sound emerging out of the test specimen is detected and analyzed. Most ultrasonic inspection is done at frequencies between 0.5 and 25 MHz well above the range of human hearing, which is about 20 Hz to 20 kHz. Ultrasonic waves are mechanical vibrations of the particles of the medium in which they travel. The waves are represented by a sinusoidal wave equation having a certain amplitude, frequency and velocity. Amplitude is the displacement of the particles of the medium from their mean position. Frequency is the number of cycles per second and the length of one cycle is called wavelength. The relationship between frequency, wavelength and velocity is given by v = □*f* where v is the velocity of a wave (in a medium) having frequency f and wavelength.□.

There are two main types of ultrasonic waves. Longitudinal waves or compressional waves are those in which alternate compression and rarefaction zones are produced by the vibration of the particles. The direction of oscillation of the particles is parallel to the direction of propagation of the waves. Because of its easy generation and detection, this type of ultrasonic wave is most widely used in ultrasonic testing. Almost all of the ultrasonic energy used for the testing of materials originates in this mode and is then converted to other modes for special test applications. This type of wave can propagate in solids, liquids and gases. In transverse or shear waves the direction of particle displacement is at right angles to the direction of propagation. For all practical purposes, transverse waves can only propagate in solids. This is because the distance between molecules or atoms, the mean free path, is so great in liquids and gases that the attraction between them is not sufficient to allow one of them to move the other more than a fraction of its own movement and so the waves are rapidly attenuated. In a particular medium the velocity of transverse waves is about half that of the longitudinal waves.

2.2 Equipment for ultrasonic testing

The equipment for ultrasonic testing mainly consists of a flaw detector, transducers and the test or calibration blocks. These are briefly described here. Below figure shows the block diagram for a typical flaw detector. A pulse generator generates pulses of alternating voltages which excite the crystal in the probe to generate specimen by coupling the probe to it. The waves are reflected from the far boundary of the test specimen or from any discontinuities within it and reach the probe again. Here through the reverse piezoelectric effect the ultrasonic waves are converted into voltage pulses and are fed to the y-plates of a cathode ray tube through an amplifier. These then are displayed on the CRT screen as pulses of definite amplitude and can be interpreted as signals from the back wall of the test specimen or from the discontinuity present within it.

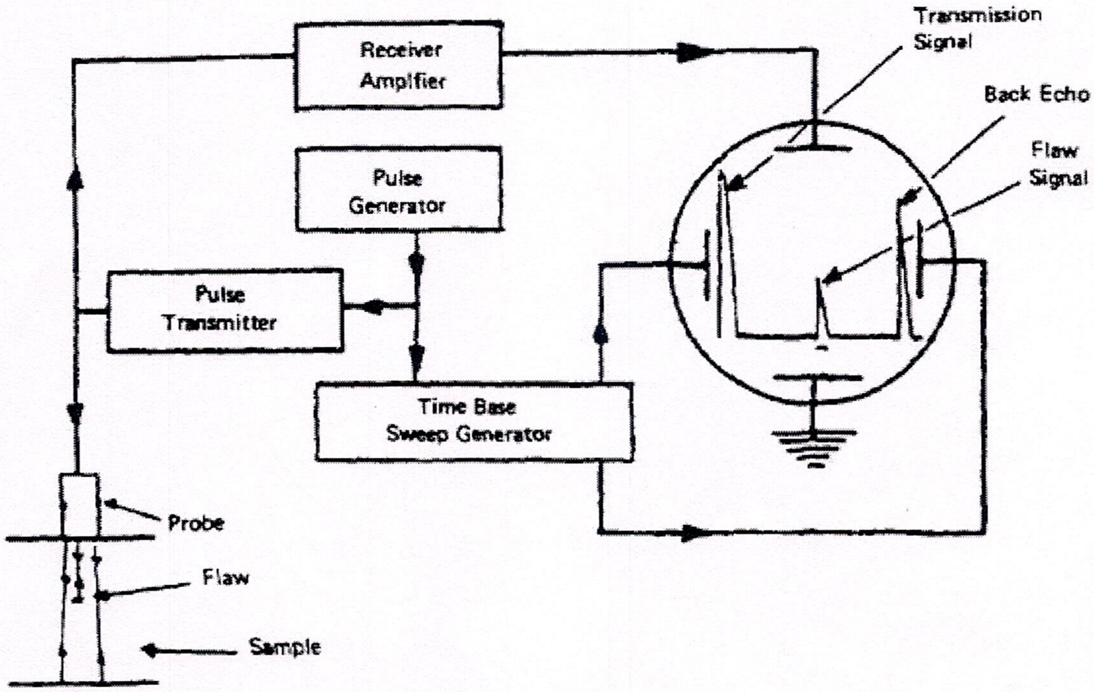


Figure: A typical ultrasonic test unit.

Ultrasound is generated in certain natural and artificially made crystals which show the effect of piezoelectricity i.e. they produce electric charges on being subjected to mechanical stresses and vice versa. Thus on the application of electric pulses of appropriate frequency these crystals produce ultrasonic pulses which are mechanical vibrations. The most commonly used materials are quartz, lithium sulphate, barium titanate and lead metaniobate. The properly cut crystal is contained in a housing, the whole assembly being termed as an ultrasonic probe. The two faces of the crystal are provided with electrical connections. On the front face of the crystal (the face which comes in contact with the test specimen) a perspex piece is provided to avoid wear and tear of the crystal. At the rear of the crystal there is damping material such as a spring or tungsten araldite. This damping material is necessary to reduce the vibration of the crystal after transmitting the ultrasonic pulse so that the crystal can be more efficient as a receiver of sound energy. Damping is necessary therefore to improve the resolution of the probe. A typical probe is shown in Figure 3.19. The probe generates ultrasound of a particular frequency which depends upon the thickness of the piezoelectric crystal. The sound comes out of the probe in the form of a cone-like beam which has two distinct regions namely the near field and the far field. Most of the testing is performed using the far field region of the beam. The probes that send the ultrasonic beams into the test specimen at right angles to the surface are called normal beam probes while those that send beams into the specimen at a certain angle are termed as angle beam probes. In angle beam probes the crystal is mounted on a perspex wedge so that the longitudinal waves fall on the surface of the test specimen obliquely. Then through the phenomenon of mode conversion and choosing a suitable angle of incidence, shear waves can be sent into the test specimen at the desired angle. These angle beam probes are used specially for the inspection of welds whose bead has not been removed.

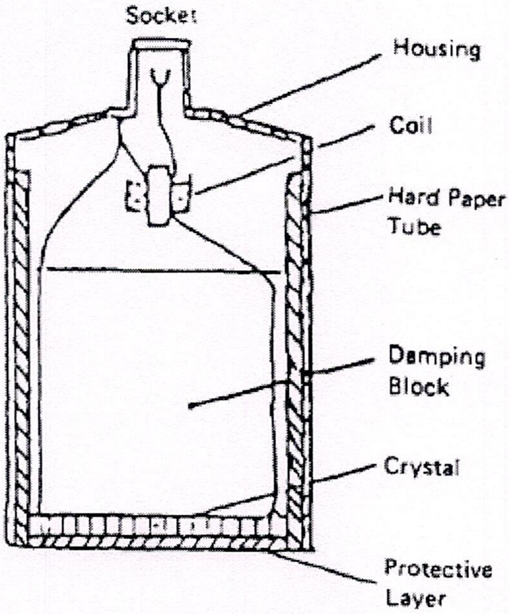


Figure: A typical normal beam single crystal ultrasonic probe.

General procedure for ultrasonic testing

The most commonly used method of ultrasonic testing is the pulse-echo or reflection method. In this case the transmitter and receiving probes are on the same side of the specimen and the presence of a defect is indicated by the reception of an echo before that of the boundary or backwall signal. The CRT screen shows the separation between the time of arrival of the defect echo compared to that of the natural boundary of the specimen, therefore, location of the defect can be assessed accurately. Usually one probe acts simultaneously as a transmitter and then as a receiver and is referred to as a TR probe. The principle of the pulse echo method is illustrated in above Figure

The time base of the CRT can be calibrated either in units of time or, if the velocity of sound in the material is known, in units of distance. If "1" is the distance from the transducer to the defect and "t" the time taken for waves to travel this distance in both directions then, 1 = vt/2 where v is the sound velocity in the material.

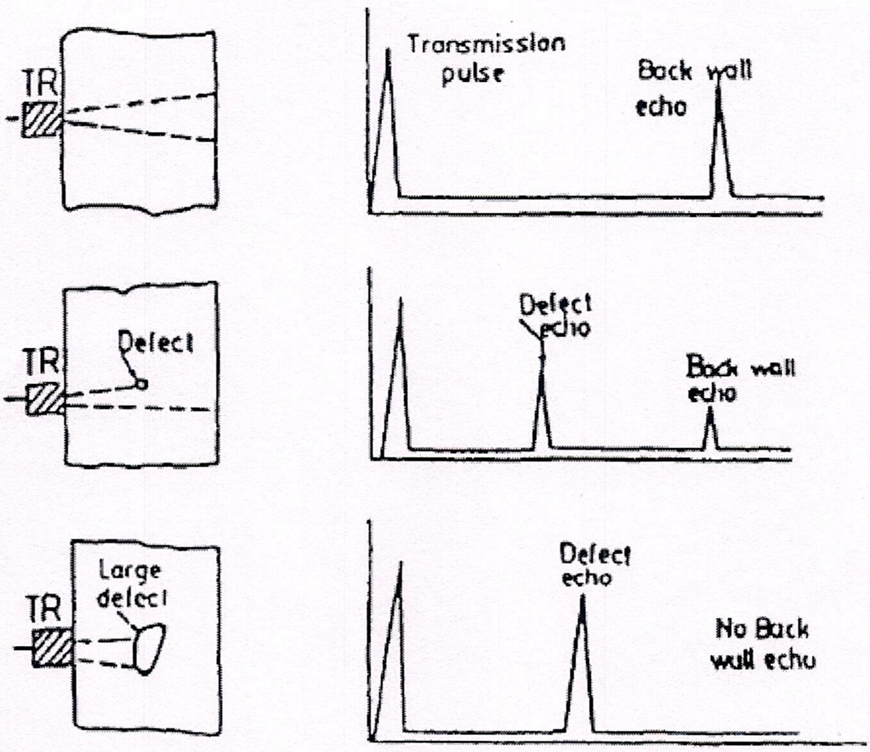


Figure: Principle of pulse echo method of ultrasonic testing (a) defect free specimen (b) specimen with small defect (c) specimen with large defect.

The procedure to conduct an ultrasonic test is influenced by a number of factors. Also the nature of the test problems in industry varies over a wide range. Therefore it is difficult to define a method which is versatile enough to work in all situations. However, it is possible to outline a general procedure which will facilitate the inspection by ultrasonics in most cases.

(i) The test specimen

Specimen characteristics such as the condition and type of surface, the geometry and the microstructure are important. Very rough surfaces may have to be made smooth by grinding, etc. Grease, dirt and loose scale or paint should be removed. The geometry of the specimen should be known since this has a bearing on the reflection of sound inside the specimen. Some reflections due to a complex geometry may be confused with those from genuine defects. The material microstructure or grain structure affects the degree of penetration of sound through it. For a fixed frequency the penetration is more in fine grained materials than in coarse grained materials.

(ii) Types of probes and equipment

The quality of ultrasonic trace depends on the probes and equipment which in turn determine the resolving power, the dead zone and the amount of sound penetration. It is difficult to construct a probe which will provide good detection and resolution qualities and at the same time provide deep penetration. For this reason, a variety of probes exist some of which are designed for special purposes. For the examination of large surface areas it is best to use probes with large transducers in order to reduce the time taken for the test. However the wide beam from such a probe will not detect a given size of flaw as easily as a narrower one. The probability of detecting flaws close to the surface depends on the type of equipment and probes used. The dead zone can be decreased in size by suitably designing the probe and also shortening the pulse length. The selection of the test frequency must depend upon previous experience or on preliminary experimental tests or on code requirements. The finer the grain structure is, the greater is the homogeneity of the material and the higher is the frequency which can be applied. The smaller the defects being looked for the higher the frequency used. Low frequencies are selected for coarse grained materials such as castings, etc. After the selection of the probe and the equipment has been finalized, its characteristics should be checked with the help of test blocks.

(iii) Nature of defects

Defect characteristics which include the type, size and location, differ in different types of materials. They are a function of the design, manufacturing process and the service conditions of the material. The detection and evaluation of large defects is not normally a difficult problem. The outline of a defect can be obtained approximately by moving the probe over the surface of the test specimen. The flaw echo increases from zero to a maximum value as the probe is moved from a region free from defects to a point where it is closest to a defect. Information as to the character of a defect can be obtained from the shape of the defect echo. For small defects, the size of the defect is estimated by comparing the flaw reflectivity with the reflectivity of standard reflectors. If the standard reflector is of the same shape and size as the unknown flaw, the reflectivity will be the same at the same beam path length. Unfortunately this is seldom the case since reference reflectors are generally flat bottomed holes or side drilled holes and have no real equivalence to real flaws. Theoretically it is possible under favourable conditions to detect flaws having dimensions of the order of half a wavelength. Indications obtained with an ultrasonic flaw detector depend to a great extent on the orientation of the defect in the material. Using the single probe method, the largest echoes are obtained when the beam strikes the surface of the specimen at right angles. On a properly calibrated time base the position of the echo from a defect indicates its location within the specimen. The determination of the type, size and location of defects which are not at right angles to the sound beam is complicated and needs deep understanding and considerable experience.

(iv) Selection of couplant

The couplant provides impedance matching between the probe and the test specimen. The degree of acoustic coupling depends on the roughness of the surface and the type of couplant used. In general the smoother the surface the better the conditions for the penetration of ultrasonic waves into the material under test. Commonly used couplants are water, oils of varying degrees of viscosity, grease, glycerine and a mixture of 1 part glycerine to 2 parts water. Special pastes such as Polycell mixed with water are also used.

(v) Scanning procedure

Before undertaking an ultrasonic examination, the scanning procedure should be laid down. For longitudinal probes this is simple but care must be taken with angle or shear wave probes. For instance in the inspection of welds using an angle probe scanning begins with the probe at either the half skip or full skip positions and continues with the probe being moved in a zigzag manner between the half skip and full skip positions. There are in general four scanning movements in manual scanning, rotational, orbital, lateral and traversing. The half skip position is recommended for critical flaw assessment and size estimation whenever possible. In some special applications the gap scanning method is employed. Here, an irrigated probe is held slightly away from the material surface by housing it in a recess made in a contact scanning head. Probe wear can be avoided by interposing a free running endless belt of plastic ribbon between the probe and the test surface. Acoustical coupling is obtained by enclosing the probe in an oil filled rotating cylinder in which case only the surface requires irrigation. Immersion scanning, which is most commonly used in automatic inspection, is done by holding the probe under water in a mechanical or electronic manipulator, the movement of which controls the movement of the probe.

(vi) Defect sizing

After the flaws in the test specimen have been detected it is important to evaluate them in terms of their type, size and location. Whereas the type and location of the flaw may be inferred directly from the echo on the CRT screen; the size of the flaw has to be determined. The commonly used methods for flaw sizing in ultrasonic testing are 6 dB drop method, 20 dB drop method, maximum amplitude method and the DGS diagram method. The basic assumption in the 6 dB drop method is that the echo height displayed when the probe is positioned for maximum response from the flaw will fall by one half (i.e. by 6 dB and hence the name) when the axis of the beam is brought in line with the edge of the flaw. The method only works if the ultrasonic response from the flaw is essentially uniform over the whole reflecting surface. If the reflectivity of the flaw varies considerably the probe is moved until the last significant echo peak is observed just before the echo drops off rapidly. This peak is brought to full screen height and then the probe is moved to the 6 dB point as before. A similar procedure is followed for the other end of the flaw. The 6 dB drop method is suitable for the sizing of flaws which have sizes of the same order or greater than that of the ultrasonic beam width but will give inaccurate results with flaws of smaller sizes than the ultrasonic beam. It is therefore generally used to determine flaw length but not flaw height. The 20 dB drop method utilizes for the determination of flaw size, the edge of the ultrasonic beam where the intensity falls to 10% (i.e. 20 dB) of the intensity at the central axis of the beam. The 20 dB drop method gives more accurate results than the 6 dB drop method because of the greater control one has on the manipulation of the ultrasonic beam. However, size estimation using either the 6 dB or 20 dB drop method have inherent difficulties which must be considered. The main problem is that the amplitude may drop for reasons other than the beam scanning past the end of the defect due to any of the following reasons:

(a) The defect may taper in section giving a reduction in cross sectional area within the beam. If this is enough to drop the signal 20 dB or 6 dB the defect may be reported as finished while it in fact continues for an additional distance.

(b) The orientation of the defect may change so that the probe angle is no longer giving maximum response, another probe may have to be used.

(c) The defect may change its direction.

(d) The probe may be twisted inadvertently.

(e) The surface roughness may change.

(vii) Test report

In order that the results of the ultrasonic examination may be fully assessed it is necessary for the tester's findings to be systematically recorded. The report should contain details of the work under inspection, the code used, the equipment used and the calibration and scanning procedures. Also the probe angles, probe positions, flaw ranges and amplitude should be recorded in case the inspection needs to be repeated. The principle is that all the information necessary to duplicate the inspection has to be recorded.

Applications of ultrasonic testing

Thickness measurements

Thickness measurements using ultrasonics can be applied using either the pulse echo or resonance techniques. Some typical applications are:

(i) Wall thickness measurement in pressure vessels, pipelines, gas holders, storage tanks for chemicals and accurate estimate of the effect of wear and corrosion without having to dismantle the plant.

(ii) Measurement of the thickness of ship hulls for corrosion control.

(iii) Control of machining operations, such as final grinding of hollow propellers.

(iv) Ultrasonic thickness gauging of materials during manufacture.

(v) Measurement of wall thickness of hollow aluminium extrusions.

(vi) Measurement of the thickness of lead sheath and insulating material extruded over a core of wire. Inspection of heat exchanger tubing in nuclear reactors. wire. Inspection of heat exchanger tubing in nuclear reactors

(viii)Measurement of the wall thickness of small bore tubing including the canning tubes for reactor fuel el

Flaw detection

Typical flaws encountered in industrial materials are cracks, porosity, laminations, inclusions, lack of root penetration, lack of fusion, cavities, laps, seams, corrosion, etc. Some examples of the detection of these defects are as follows:

- Examination of welded joints in pressure vessels, containers for industrial liquids and gases, pipelines, steel bridges, pipelines, steel or aluminium columns, frames and roofs (during manufacturing, pre-service and inservice).
- Inspection of steel, aluminium and other castings,
- Inspection of rolled billets, bars and sections.
- Inspection of small bore tubes including the canning tubes for nuclear fuel elements.
- Ultrasonic testing of alloy steel forgings for large turbine rotors,
- Testing of turbine rotors and blades for aircraft engines.
- Early stage inspection in the production of steel and aluminium blocks and slabs, plates, bar sections, tubes, sheets and wires.
- Detection of unbonded surfaces in ceramics, refractories, rubber, plastics and laminates.
- Detection of honeycomb bond in the aircraft industry.
- Inspection of jet engine rotors.
- Detection of caustic embrittlement failure in riveted boiler drums in the power generation industry.
- Detection of cracks in the fish plate holes in railway lines and in locomotive and bogey axles.
- Detection of hydrogen cracks in roller bearings resulting from improper heat treatment.
- In service automatic monitoring of fatigue crack growth.
- Detection of stress corrosion cracking.
- Detection of fatigue cracks in parts working under fluctuating stress.
- Inspection of fine quality wire.
- Testing of wooden components such as utility poles.
- Application of ultrasonics to monitor material characteristics in the space environment.
- Determination of lack of bonding in clad fuel elements,
- Detection of flaws in grinding wheels.
- Varieties of glass which are not sufficiently transparent to allow optical inspection can be tested ultrasonically.
- Quality control in the manufacture of rubber tyres by locating voids, etc.
- Inspection of engine crankshafts.

Advantages

The principal advantages of ultrasonic inspection as compared to other methods for non-destructive inspection of metal parts are:

1. Superior penetrating power which allows the detection of flaws deep in the part. Ultrasonic inspection is done routinely to depths of about 20 ft in the inspection of parts such as long steel shafts and rotor forgings.
2. High sensitivity permitting the detection of extremely small flaws.
3. Greater accuracy than other non-destructive methods in determining the position of internal flaws, estimating their size and characterizing their orientation, shape and nature.
4. Only one surface needs to be accessible.
5. Operation is electronic, which provides almost instantaneous indications of flaws. This makes the method suitable for immediate interpretation, automation, rapid scanning, on-line production monitoring and process control. With most systems, a permanent record of inspection results can be made for future reference.
6. Volumetric scanning ability, enabling inspection of a volume of metal extending from the front surface to the back surface of a part.
7. Is not hazardous to operators or to nearby personnel, and has no effect on equipment and materials in the vicinity.

Disadvantages

1. Manual operation requires careful attention by experienced technicians.
2. Extensive technical knowledge is required for the development of inspection procedures.
3. Parts that are rough, irregular in shape, very small or thin, or not homogeneous are difficult to inspect.
4. Discontinuities that are present in a shallow layer immediately beneath the surface may not be detectable.
5. Couplants are needed to provide effective transfer of ultrasonic wave energy between transducers and parts being inspected.
6. Reference standards are needed, both for calibrating the equipment and for characterizing flaws.

Unit-4:

RADIOGRAPHIC TESTING

Fundamental principles

The method of radiographic testing

The method of radiographic testing involves the use of a source of radiation from which the radiations hit the test specimen, pass through it and are detected by a suitable radiation detector placed on the side opposite to that of the source. This is schematically shown in the Figure 3.11. While passing through the test specimen the radiations are absorbed in accordance with the thickness, physical density and the internal defects of the specimen and the detector system therefore receives the differential radiations from different parts of a defective specimen which are recorded onto the detector.

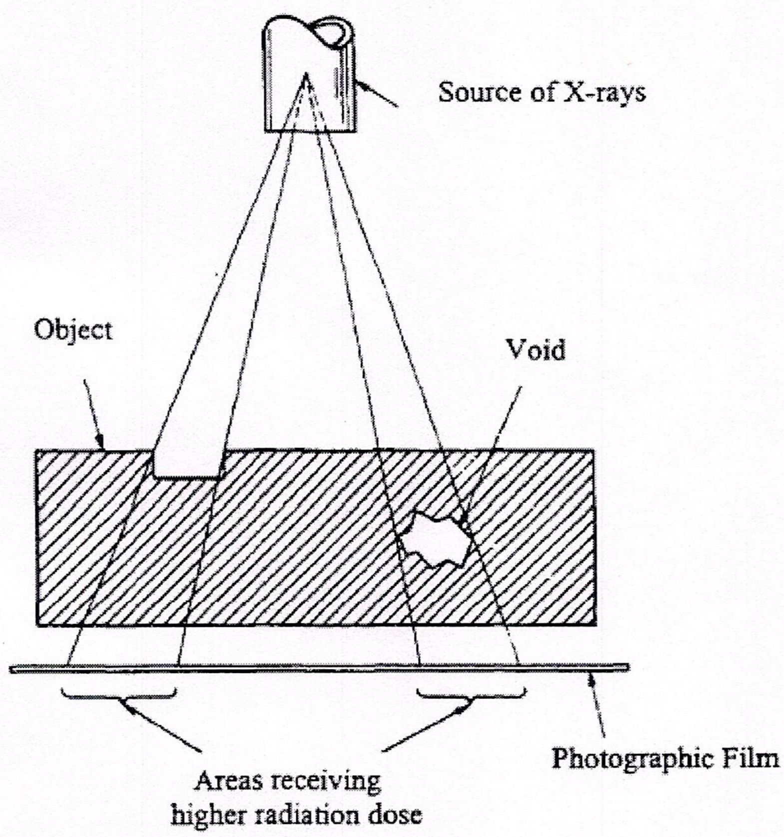


Figure : Arrangement of source, specimen and film in a typical radiographic set up

Properties of radiations

X-rays and gamma rays are electromagnetic radiations which have the following common properties.

(i) They are invisible.

(ii) They cannot be felt by human senses.

(iii) They cause materials to fluoresce. Fluorescent materials are zinc sulfide, calcium tungstate, diamond, barium platinocyanide, napthalene, anthracene, stilbene, thalium activated sodium iodide etc.

(iv) They travel at the speed of light i.e. 3×10^{10} cm/sec.

(v) They are harmful to living cells.

(vi) They can cause ionization. They can detach electrons from the atoms of a gas, producing positive and negative ions.

(vii) They travel in a straight line. Being electromagnetic waves, X-rays can also be reflected, refracted and diffracted.

(viii) They obey the inverse square law according to which intensity of X-rays at a point is inversely proportional to the square of the distance between the source and the point. Mathematically I a $1/r^2$ where I is the intensity at a point distant r from the source of radiation.

(ix) They can penetrate even the materials through which light cannot. Penetration depends upon the energy of the rays, the density and thickness of the material. A monoenergetic beam of X-rays obeys the well known absorption law, I = Io exp (-ux) where Io = the incident intensity of X-rays and 1= the intensity of X-rays transmitted through a thickness x of material having attenuation coefficient u .

(x) They affect photographic emulsions.

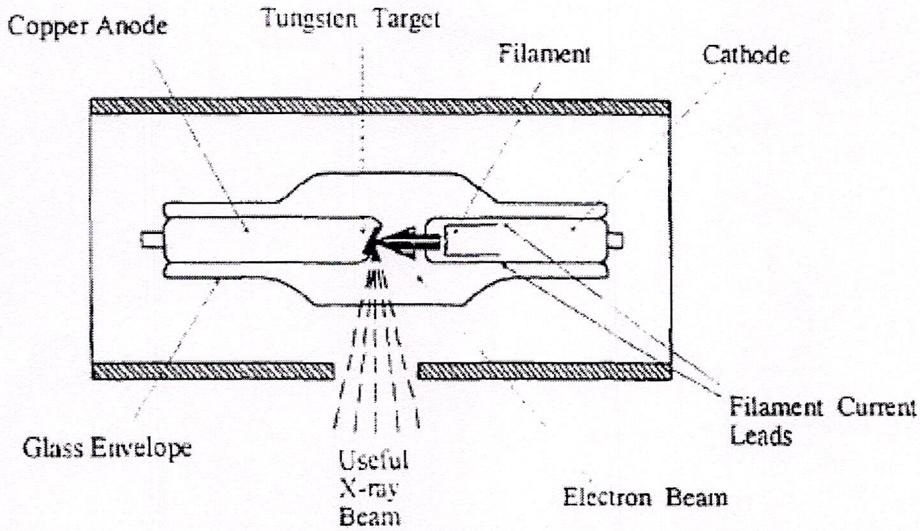
(xi) While passing through a material they are either absorbed or scattered.

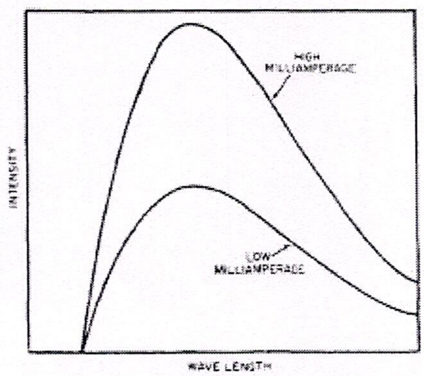
Properties (vii), (viii), (ix), (x), (xi) are mostly used in industrial radiography.

Sources for radiographic testing

(i) X ray **machines**

X rays are generated whenever high energy electrons hit high atomic number materials. Such a phenomenon occurs in the case of X ray tubes, one of which is shown in above figure . The X ray tube consists of a glass envelope in which two electrodes called cathode and anode are fitted. The cathode serves as a source of electrons. The electrons are first accelerated by applying a high voltage across the cathode and the anode and then stopped suddenly by a solid target fitted in the anode. The sudden stoppage of the fast moving electrons results in the generation of X rays, These X rays are either emitted in the form of a cone or as a 360 degree beam depending upon the shape and design of the target. The output or intensity of X rays depend upon the kV and the tube current which control the number of electrons emitted and striking the target. The energy of X rays is mainly controlled by the voltage applied across the cathode and the anode which is of the order of kilovolts. The effect of a change in the tube current or the applied voltage on the production of X rays is shown in above Figure.





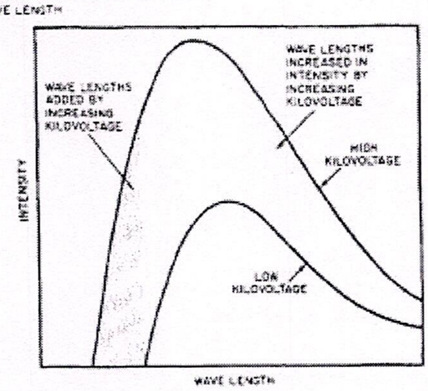


Figure : Effect of tube current (mA) and voltage (kV) on the intensity of X rays.

There is a variety of X ray machines available for commercial radiographic testing. Some of these emit X rays in a specified direction while others can give a panoramic beam. There are machines which have a very small focal spot size for high definition radiography. These are called micro focus machines. Some machines are specially designed to give very short but intense pulses of X rays. These are called flash X ray tubes and are usually used for radiography of objects at high velocity. Typically X ray machines of up to a maximum of about 450 kV are commercially available for radiographic testing.

(ii) Gamma ray sources:

These are some elements which are radioactive and emit gamma radiations. There are a number of radioisotopes which in principle can be used for radiographic testing. But of these only a few have been considered to be of practical value. The characteristics which make a particular radioisotope suitable for radiography include the energy of gamma rays, the half life, source size, specific activity and the availability of the source. In view of all these considerations the radioisotopes that are commonly used in radiography along with some of their characteristics are given in Table 3.1.

(iii) Radiographic linear accelerators:

For the radiography of thick samples, X ray energy in the MeV range is required. This has now become possible with the availability of radiographic linear accelerators. In a linear accelerator the electrons from an electron gun are injected into a series of interconnected cavities which are energized at radio frequency (RF) by a klystron or magnetron. Each cavity is cylindrical and separated from the next by a diaphragm with a central hole through which the electrons can pass. Due to the imposed RF, alternate diaphragm hole edges will be at opposite potentials at all times and the field in each cavity will accelerate or decelerate the electrons at each half cycle. This will tend to bunch the electrons and those entering every cavity when the field is accelerating them will acquire an increasing energy at each pass. The diaphragm spacing is made such as to take into account the increasing mass of electrons as their velocity increases. They impinge on a target in the usual way to produce X rays. Linear accelerators are available to cover a range of energies from about 1 MeV to about 30 MeV covering a range of steel thicknesses of up to 300 mm. The radiations output is high (of the order of 5000 Rad per minute) and the focal spot sizes usually quite reasonable to yield good quality radiographs at relatively low exposure times

Films for radiographic testing

The detection system usually employed in radiographic testing is the photographic film usually called an X ray film. The film consists of a transparent, flexible base of clear cellulose derivative or like material. One or both sides of this base are coated with a light sensitive emulsion of silver bromide suspended in gelatin. The silver bromide is distributed throughout the emulsion as minute crystals and exposure to radiation such as X rays, gamma rays or visible light, changes its physical structure. This change is of such a nature that it cannot be detected by ordinary physical methods, and is called the latent image.

Radiographic film is manufactured by various film companies to meet a very wide diversified demand. Each type of film is designed to meet certain requirements and these are dictated by the circumstances of inspection such as (a) the part (b) the type of radiation used (c) energy of radiation (d) intensity of the radiation and (e) the level of inspection required. No single film is capable of meeting all the demands. Therefore a number of different types of films are manufactured, all with different characteristics, the choice of which is dictated by what would be the most effective combination of radiographic technique and film to obtain the desired result.

The film factors that must be considered in choosing a film are : speed, contrast, latitude and graininess. These four are closely related; that is, any one of them is roughly a function of the other three. Thus films with large grain size have higher speed than those with a relatively small grain size. Likewise, high contrast films are usually finer grained and slower than low contrast films. Graininess, it should be noted, influences definition or image detail. For the same contrast, a small grained film will be capable of resolving more detail than one having relatively large grains. The films are generally used sandwiched between metallic screens, usually of lead. These screens give an intensification of the image and thus help to reduce the exposure times besides cutting down the scattered radiation.

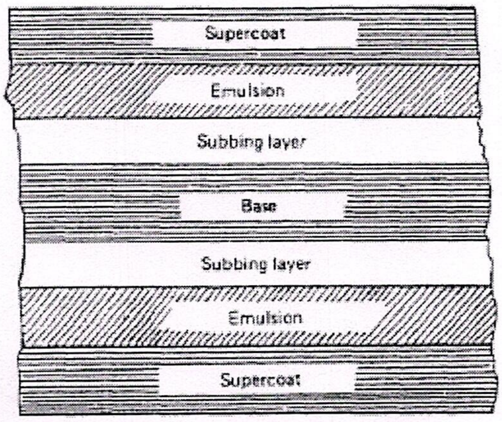


Figure : Construction of radiographic films

General procedure for radiographic testing

The test specimen is first of all properly cleaned and visually inspected and all the surface imperfections are noted. A properly selected film, usually sandwiched between intensifying screens and enclosed in a light proof cassette is prepared. The source of radiation, the test specimen and the film are arranged as shown in Figure 3.11. Image quality indicators and lead identification letters are also placed on the source side of the test specimen. From a previously prepared exposure chart for the material of the test specimen, the energy of radiations to be used and the exposure (intensity of radiations x time) to be given are determined. Then the exposure is made. After the source of radiation has been switched off or retrieved back into the shielding (in case of gamma ray source), the film cassette is removed and taken to the dark room. In the dark room, under safe light conditions, the film is removed from the cassette and the screens and processed. The processing of the film involves mainly four steps. Development reduces the exposed silver bromide crystals to black metallic silver thus making the latent image visible. Development is usually done for 5 minutes at 20°C. After development the film is fixed whereby all the unexposed and undeveloped crystals of film emulsion are removed and the exposed and image-forming emulsion is retained on the film. The fixing is done for approximately 2-6 minutes. The film is then washed preferably in running water for about 20-30 minutes and dried Finally the film is interpreted for defects and a report compiled. The report includes information about the test specimen, the technique used and the defects. It also sometime says something about acceptance or rejection of the reported defects. The report is properly signed by responsible persons.

Different forms of radiographic testing

(i) Fluoroscopy

In the general radiographic process, if the film is replaced by a fluorescent salt screen then the image of the test specimen can be visually seen. The X rays passing through the object excite the fluorescent material producing bright spots in the more heavily irradiated areas. The fluorescent screen may be viewed directly or by means of a mirror or by using a camera and a closed circuit television. The whole set-up of X ray tube, the test specimen and the fluorescent screen are encased in a protective shielding.

In many cases castings of up to about 10 mm thickness, thin metal parts, welded assemblies and coarse sandwich constructions are screened by this method and castings with obvious large defects are rejected before usual inspection using film radiography.

Plastic parts may be checked for the presence of metal particles or cavities. Other applications include inspection of electrical equipment such as switches, fuses, resistors, capacitors, radio tubes, cables and cable splices in which breaks of metal conductors, short circuiting or wrong assembly may cause troublesome electrical testing. Ceramics, fire bricks and asbestos products lend themselves perfectly to fluoroscopy. Packaged and canned foods are examined for the amount of filling and for the presence of foreign objects.

(ii) Micro radiography

Specially prepared thin samples are radiographed at extremely low energies (e.g. 5 KV) on an ultrafine grain film. The radiograph when enlarged gives the structural 92 details of the specimen. Micro-radiography is mainly applied in metallurgical studies.

(iii) Enlargement radiography

In some situations an enlarged image of an object is desired. To get the enlargement of the image the object to film distance is increased. To overcome the penumbral effects a source of an extremely small size is used. **(iv) High speed or flash radiography**

For the radiography of moving objects, the exposure time should be very small and, at the same time, the intensity of the X rays should be extremely high. This is achieved by discharging huge condensers through special X ray tubes which give current of the order of thousands of amperes for a short time (of the order of a millionth of a second). This technique is normally applied in ballistics.

(v) Auto radiography

In this case the specimen itself contains the material in radioactive form. When a film is placed in contact with the specimen, an autoradiograph is obtained showing the distribution of the radioactive material within the specimen. The technique is mainly used in the field of botany and metallurgy

(vi) Electron transmission radiography

A beam of high energy X rays is used to produce photo-electrons from a lead screen. These electrons after passing through the specimen (of very low absorption like paper, etc.) expose the film and an electron radiograph is obtained. **(vii) Electron emission radiography**

In this case a beam of X rays is used to produce photoelectrons from the specimen itself. These electrons expose the film which is placed in contact with the specimen. Since emission of electrons depends upon atomic number of an element, the electron emission will give the distribution of elements of different atomic numbers. **(viii) Neutron radiography**

In this case a neutron beam is used to radiograph the specimen. The recording system will, therefore, not be a photosensitive film since it is insensitive to neutrons. The following methods are used to record the image:

(1) A gold foil is used which records the image, in terms of the activity produced. This image can be transferred onto a film by taking an autoradiograph of the foil. Some other suitable materials such as indium and dysprosium can replace gold.

(2) The metallic foil upon neutron bombardment does not become radioactive but instead emits spontaneous gamma rays which expose the film placed in contact with it. Examples of metals suitable for this are lithium and gadolinium.

(3) Neutrons transmitted through the specimen are made to strike a thin neutron scintillator plate. The scintillations thus produced expose the film which is in contact with the scintillator.

In certain cases neutron radiography is advantageous as compared to X or gamma radiography, for example:

(a) If the specimen is radioactive.

(b) If the specimen contains thermal neutron absorbers or light elements.

(c) Two elements whose atomic number is not very different may be easily distinguished.

(ix) Proton radiography

For special type of studies a proton beam can also be used. The number of protons transmitted through a specimen whose thickness is close to the proton range is very sensitive to exact thickness. This helps in detecting very small local variations in density and thickness.

(x) Stereo radiography

Two radiographs of the specimen are taken from two slightly different directions. The angle between these directions is the same as the angle subtended by the human eyes while viewing these radiographs. In the stereo viewer the left eye sees one radiograph and the right eye the other. In this way a realistic three dimensional effect is obtained giving the visual assessment of the position of the defect.

(xi) Xeroradiography

This is considered as a "dry" method of radiography in which a xerographic plate takes the place of X ray film. The plate is covered with a selenium powder and charged electrostatically in the dark room. Exposure to light or radiation causes the charge to decay in proportion to the amount of radiation received and a latent image is formed.

The developing powder is sprayed on the plate in a light-tight box. The particles are charged by friction while passing through the spray nozzle. White powders have best contrast with the black selenium surface but present problems in transferring the picture to paper. Coloured powders on transfer produce negative images while fluorescent powder gives the same picture as white powder and can be viewed under black light both before and after transfer.

Applications of radiographic testing method

Radiographic testing is mainly applied for the detection of flaws such as cracks, porosity, inclusions, lack of root penetration, lack of fusion, laps, seams, shrinkage, corrosion, etc. in weldments and castings, in pressure vessels, containers for industrial liquids and gases, pipelines, steel bridges, steel and aluminium columns and frames and roofs, nuclear reactors and nuclear fuel cycle, boiler tubes, ships and submarines, aircraft and armaments. In most of these cases weld inspection is involved. Welds in plates are tested using an arrangement more or less similar to the one shown in above When the diameter of pipes becomes large enough, the circular welds may be examined using a panoramic technique. In this the source is placed at the centre inside the pipe and the film is wrapped all around the weld on the outside. Thus in this case the whole weld can be radiographed in a single exposure while for all other situations in above figure multiple exposures are required for full coverage.

Radiography is also extensively used for the inspection of castings and forgings. The regular shaped and uniformly thick specimens can be inspected as usual like welds in plates while special considerations need to be made for testing of specimens of varying thickness. Double film technique is usually employed wherein two films of different speeds are used for a single exposure. In this way correct density is obtained under the thick sections on the faster film whereas the slower films record correct images of the thin sections.

Radiography is used in inspection of explosives contained within casings, sealed boxes and equipment. In the field of electronics it is employed for the inspection of printed circuit boards and assemblies for checking adequacy of connections.

limitations of radiographic testing

Radiographic testing method is generally applicable for the inspection of all types of materials, e.g. metallic, nonmetallic and plastics, magnetic and non-magnetic, conductors and non-conductors, etc. as long as both sides of the test specimen are accessible for placement of source and the film on either side. The film needs to be placed in contact with the specimen and whenever this is not possible due to the geometry of the test specimen, radiographs of poorer quality will result.

The penetration of the radiation through the test specimen depends upon its thickness and density. For high density materials, as well as for larger thickness of the same material, higher energies are needed. Although, in principle, these higher energies are now available from betatrons and linear accelerators, these sources of radiation are extremely expensive and therefore not available for common use. Table 3.1 shows that among the commonly available radiation sources including the commercial X ray machines of up to about 420 KV, the strongest source is that of cobalt-60 which can be used for radiography of steel of thickness up to about 150 mm.

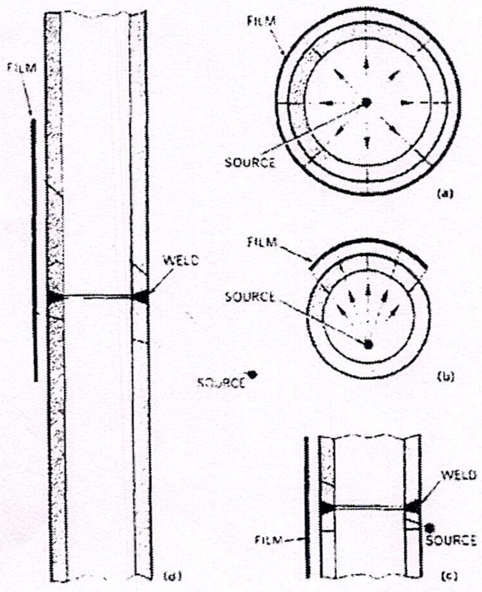


Figure: Various techniques for weld inspection.

The factors affecting radiographic quality and consequently the sensitivity of flaw detection by radiographic testing method need to be carefully considered while selecting the technique for a particular test. For example, for high sensitivity or to be able to detect smaller flaws, it is recommended that largest possible source-to film distance is used with a source of the smallest possible dimensions, the slowest and fine-grained film should be used and film processing should be done as per recommendations of the manufactures (usually for 5 minutes at 20°C). The lowest energy compatible with the thickness and density of the test specimen should be chosen. In practice a compromise has to be made between these ideal requirements to achieve an optimum level of sensitivity. But a radiograph made with a technique of poor sensitivity will need a more critical inspection, since defect images will not be so easily seen and may in fact be missed. There is a definite tendency to make a more cursory examination when defect images are only faintly seen. Similarly very small defects below the sensitivity limits of the technique employed may be missed. Such a situation can also arise due to improper viewing conditions and the training and experience of the interpreter.

Sensitivity of flaw detection decreases with an increase in thickness of the test specimen.

Radiographic picture is a two-dimensional shadow of a three-dimensional defect. The orientation of the defect with respect to the direction of the beam is therefore an important consideration. Thus planar defects such as cracks, laminations, lack of fusion in welds or similar defects may not be detected if their plane is at right angles to the incident beam. Elongated defects like pipes and wormholes may show up and be misinterpreted as spherical defects.

Smaller defects located behind the larger ones in the direction of the beam will not be detected.

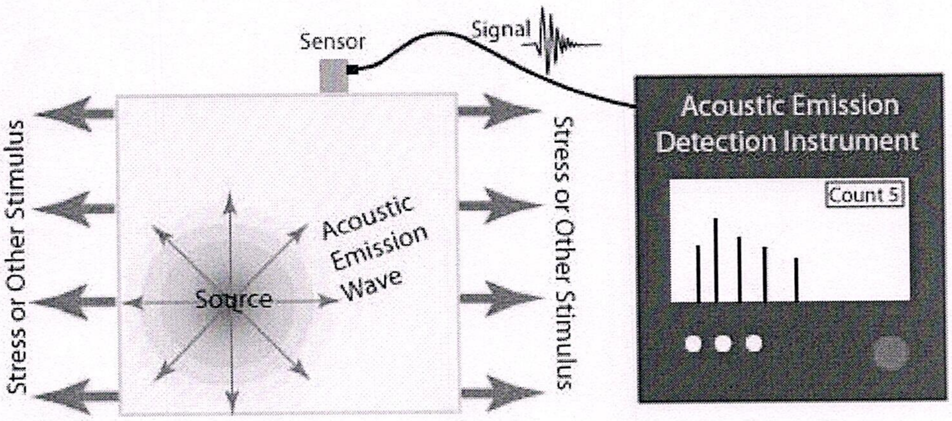
A serious limitation with the radioisotope sources used for radiography is the fact that even unused their activity decreases with time. While they have the distinct advantage of needing no power for field radiography applications, they need special shielded enclosures to house them and the radiographic sensitivity achievable with them is usually inferior to that for X rays.

Lastly, exposure to radiations can be dangerous for human health and therefore special precautions are required which may include construction of specially shielded enclosures and cordoning off of the area where radiography is being performed. Mostly it involves either stopping of all other work and removal of the workers from the work place while carrying out radiography or to do the radiographic testing work during off hours.

UNIT – V

ADVANCED ND TECHNIQUES

Introduction to Acoustic Emission Testing:



Acoustic Emission (AE) refers to the generation of transient elastic waves produced by a sudden redistribution of stress in a material. When a structure is subjected to an external stimulus (change in pressure, load, or temperature), localized sources trigger the release of energy, in the form of stress waves, which propagate to the surface and are recorded by sensors. With the right equipment and setup, motions on the order of picometers (10 -12 m) can be identified. Sources of AE vary from natural events like earthquakes and rockbursts to the initiation and growth of cracks, slip and dislocation movements, melting, twinning, and phase transformations in metals. In composites, matrix cracking and fiber breakage and debonding contribute to acoustic emissions. AE"s have also been measured and recorded in polymers, wood, and concrete, among other materials.

Detection and analysis of AE signals can supply valuable information regarding the origin and importance of a discontinuity in a material. Because of the versatility of Acoustic Emission Testing (AET), it has many industrial applications (e.g. assessing structural integrity, detecting flaws, testing for leaks, or monitoring weld quality) and is used extensively as a research tool.

Acoustic Emission is unlike most other non destructive testing (NDT) techniques in two regards. The first difference pertains to the origin of the signal. Instead of supplying energy to the object under examination, AET simply listens for the energy released by the object. AE tests are often performed on structures while in operation, as this provides adequate loading for propagating defects and triggering acoustic emissions.

The second difference is that AET deals with dynamic processes, or changes, in a material. This is particularly meaningful because only active features (e.g. crack growth) are highlighted. The ability to discern between developing and stagnant defects is significant.

However, it is possible for flaws to go undetected altogether if the loading is not high enough to cause an acoustic event. Furthermore, AE testing usually provides an immediate indication relating to the strength or risk of failure of a component. Other advantages of AET include fast and complete volumetric inspection using multiple sensors, permanent sensor mounting for process control, and no need to disassemble and clean a specimen.

Unfortunately, AE systems can only qualitatively gauge how much damage is contained in a structure. In order to obtain quantitative results about size, depth, and overall acceptability of a part, other NDT methods (often ultrasonic testing) are necessary. Another drawback of AE stems from loud service environments which contribute extraneous noise to the signals. For successful applications, signal discrimination and noise reduction are crucial.

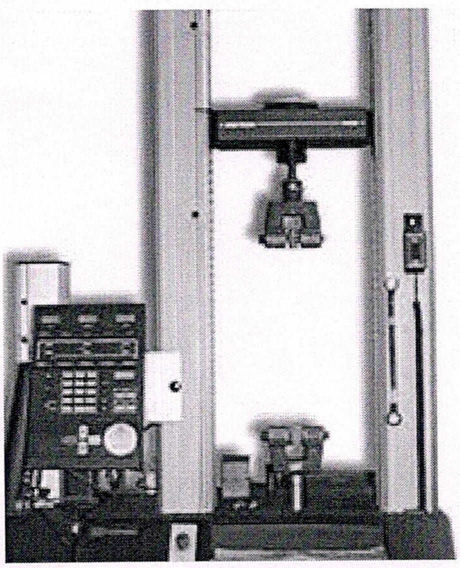


Fig: Modern Tensile Testing Machine (H. Cross Company)

AE Sources:

As mentioned in the Introduction, acoustic emissions can result from the initiation and growth of cracks, slip and dislocation movements, twinning, or phase transformations in metals. In any case, AE"s originate with stress. When a stress is exerted on a material, a strain is induced in the material as well. Depending on the magnitude of the stress and the properties of the material, an object may return to its original dimensions or be permanently deformed after the stress is removed. These two conditions are known as elastic and plastic deformation, respectively.

The most detectible acoustic emissions take place when a loaded material undergoes plastic deformation or when a material is loaded at or near its yield stress. On the microscopic level, as plastic deformation occurs, atomic planes slip past each other through the movement of dislocations. These atomic-scale deformations release energy in the form of elastic waves which "can be thought of as naturally generated ultrasound" traveling through the object. When cracks exist in a metal, the stress levels present in front of the crack tip can be several times higher than the surrounding area. Therefore, AE activity will also be observed when the material ahead of the crack tip undergoes plastic deformation (micro-yielding).

Two sources of fatigue cracks also cause AE"s. The first source is emissive particles (e.g. nonmetallic inclusions) at the origin of the crack tip. Since these particles are less ductile than the surrounding material, they tend to break more easily when the metal is strained, resulting in an AE signal. The second source is the propagation of the crack tip that occurs through the movement of dislocations and small-scale cleavage produced by triaxial stresses.

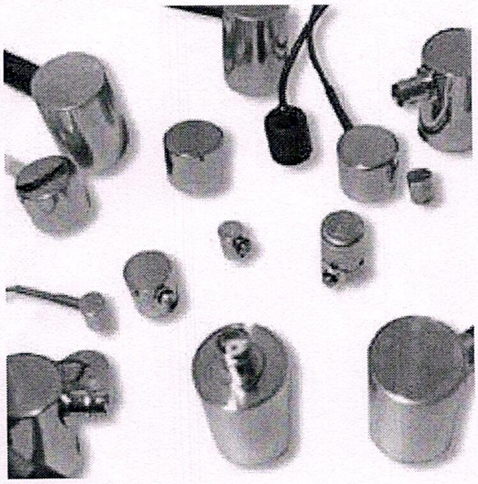
The amount of energy released by an acoustic emission and the amplitude of the waveform are related to the magnitude and velocity of the source event. The amplitude of the emission is proportional to the velocity of crack propagation and the amount of surface area created. Large, discrete crack jumps will produce larger AE signals than cracks that propagate slowly over the same distance.

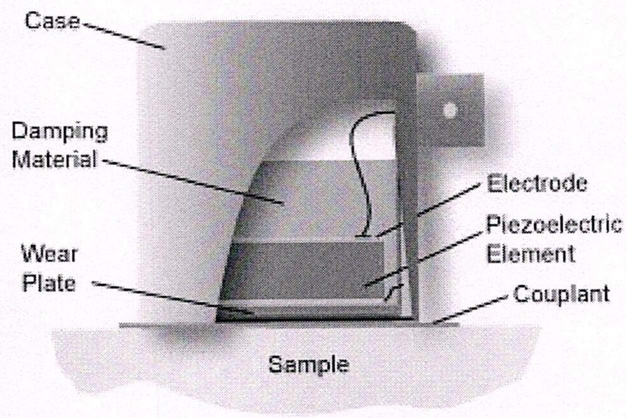
Detection and conversion of these elastic waves to electrical signals is the basis of AE testing. Analysis of these signals yield valuable information regarding the origin and importance of a discontinuity in a material. As discussed in the following section, specialized equipment is necessary to detect the wave energy and decipher which signals are meaningful.

Wave Mode and Velocity

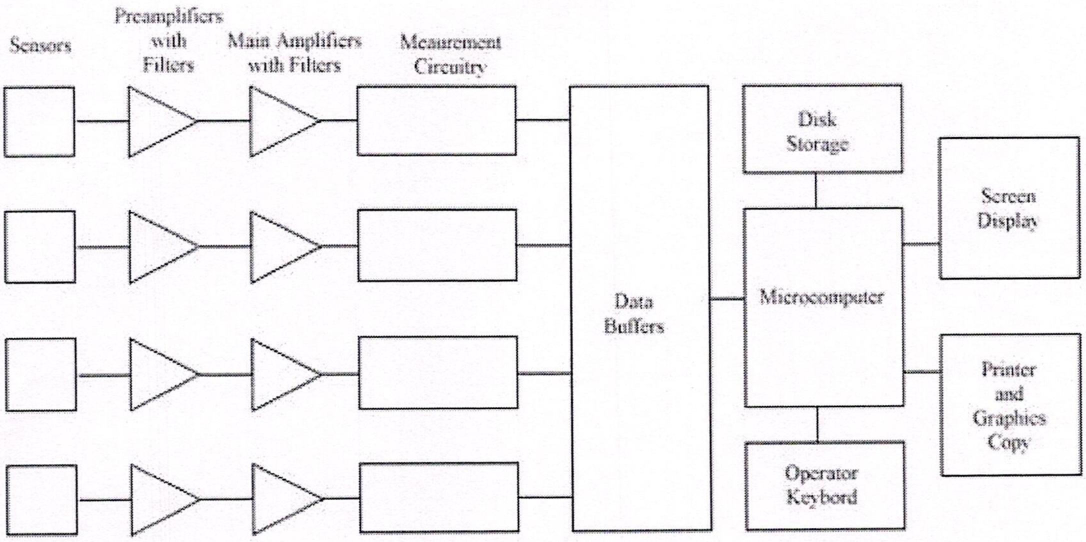
As mentioned earlier, using AE inspection in conjunction with other NDE techniques can be an effective method in gauging the location and nature of defects. Since source locations are determined by the time required for the wave to travel through the material to a sensor, it is important that the velocity of the propagating waves be accurately calculated. This is not an easy task since wave propagation depends on the material in question and the wave mode being detected. For many applications, Lamb waves are of primary concern because they are able to give the best indication of wave propagation from a source whose distance from the sensor is larger than the thickness of the material. For additional information on Lamb waves, see the wave mode page in the Ultrasonic Inspection section.

Equipment:





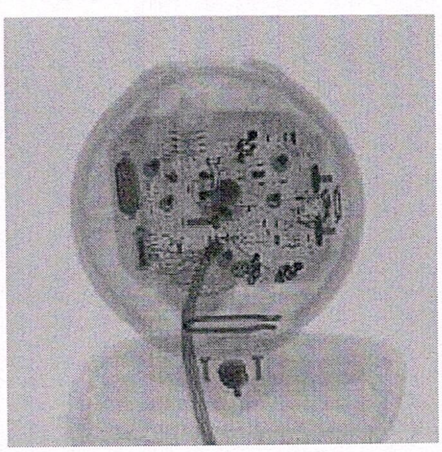
Acoustic emission testing can be performed in the field with portable instruments or in a stationary laboratory setting. Typically, systems contain a sensor, preamplifier, filter, and amplifier, along with measurement, display, and storage equipment (e.g. oscilloscopes, voltmeters, and personal computers). Acoustic emission sensors respond to dynamic motion that is caused by an AE event. This is achieved through transducers which convert mechanical movement into an electrical voltage signal. The transducer element in an AE sensor is almost always a piezoelectric crystal, which is commonly made from a ceramic such as lead zirconate titanate (PZT). Transducers are selected based on operating frequency, sensitivity and environmental characteristics, and are grouped into two classes: resonant and broadband. The majority of AE equipment is responsive to movement in its typical operating frequency range of 30 kHz to 1 MHz. For materials with high attenuation (e.g. plastic composites), lower frequencies may be used to better distinguish AE signals. The opposite holds true as well Ideally, the AE signal that reaches the mainframe will be free of background noise and electromagnetic interference. Unfortunately, this is not realistic. However, sensors and preamplifiers are designed to help eliminate unwanted signals. First, the preamplifier boosts the voltage to provide gain and cable drive capability. To minimize interference, a preamplifier is placed close to the transducer; in fact, many transducers today are equipped with integrated preamplifiers. Next, the signal is relayed to a bandpass filter for elimination of low frequencies (common to background noise) and high frequencies. Following completion of this process, the signal travels to the acoustic system mainframe and eventually to a computer or similar device for analysis and storage. Depending on noise conditions, further filtering or amplification at the mainframe may still be necessary.



Schematic Diagram of a Basic Four-channel Acoustic Emission Testing System

After passing the AE system mainframe, the signal comes to a detection/measurement circuit as shown in the figure directly above. Note that multiple-measurement circuits can be used in multiple sensor/channel systems for source location purposes (to be described later). At the measurement circuitry, the shape of the conditioned signal is compared with a threshold voltage value that has been programmed by the operator. Signals are either continuous (analogous to Gaussian, random noise with amplitudes varying according to the magnitude of the AE events) or bursttype. Each time the threshold voltage is exceeded, the measurement circuit releases a digital pulse. The first pulse is used to signify the beginning of a hit. (A hit is used to describe the AE event that is detected by a particular sensor. One AE event can cause a system with numerous channels to record multiple hits.) Pulses will continue to be generated while the signal exceeds the threshold voltage. Once this process has stopped for a predetermined amount of time, the hit is finished (as far as the circuitry is concerned). The data from the hit is then read into a microcomputer and the measurement circuit is reset.

Computed Tomography:



Industrial computed tomography (CT) scanning is any computer-aidedtomographicprocess; usuallyX-ray computed tomography, that usesirradiationto produce three-dimensional internal and external representations of a scanned object. Industrial CT scanning has been used in many areas of industry for internal inspection of components. Some of the key uses for industrial CT scanning have been flaw detection, failure analysis, metrology, assembly analysis andreverse engineeringapplications.[1][2]Just as inmedical imaging, industrial imaging includes both nontomographic radiography (industrial radiography) and computed tomographic radiography (computed tomography).

Types of scanners:

Line beam scanning is the traditional process of industrial CT scanning. X-rays are produced and the beam is collimated to create a line. The X-ray line beam is then translated across the part and data is collected by the detector.

The data is then reconstructed to create a 3-D volume renderingof the part.

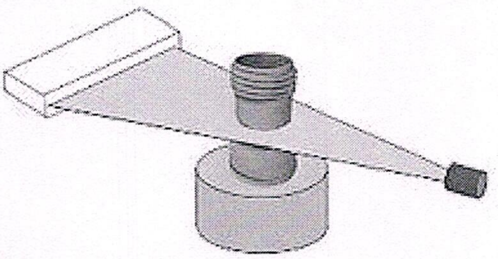


Fig: Line beam scanning

In *cone beam scanning*, the part to be scanned is placed on a rotary table. As the part rotates, the cone of X-rays produce a large number of 2D images that are collected by the detector. The 2D images are then processed to create a 3Dvolume renderingof the external and internal geometries of the part.

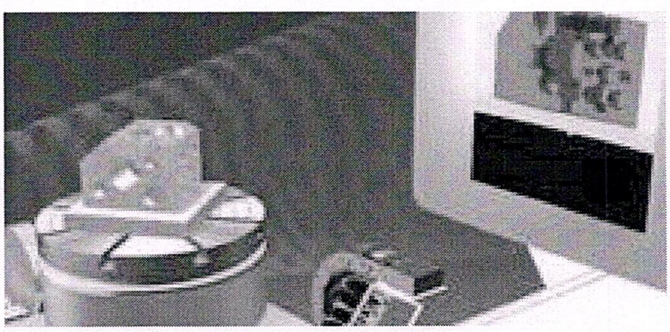


Fig: Cone beam scanner **Analysis and inspection techniques:**

Various inspection uses and techniques include part-to-CAD comparisons, part-to-part comparisons, assembly and defect analysis, void analysis, wall thickness analysis, and generation of CAD data. The CAD data can be used forreverse engineering, geometric dimensioning and tolerance analysis, and production part approval

Assembly:

One of the most recognized forms of analysis using CT is for assembly, or visual analysis. CT scanning provides views inside components in their functioning position, without disassembly. Some software programs for industrial CT scanning allow for measurements to be taken from the CT dataset volume rendering. These measurements are useful for determining the clearances between assembled parts or the dimension of an individual feature.

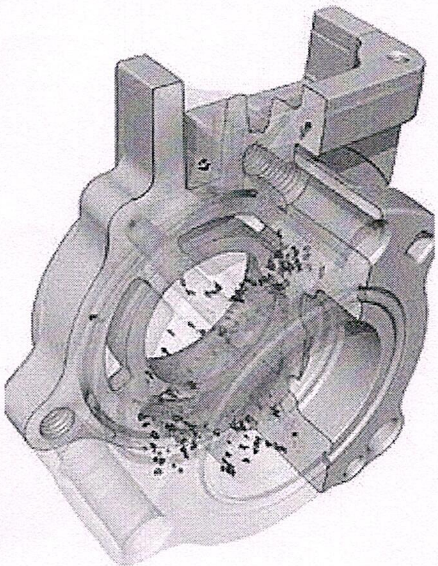


Fig: An industrial computed tomography (CT) scan conducted on an aluminum casting to identify internal failures such as voids. All color coordinated particles within casting are voids/porosity/air pockets, which can additionally be measured and are color coordinated according to size.

Void, crack and defect detection:

Fig: Flight through a 3D reconstruction of a disposable pepper grinder. Glass in blue.

Traditionally, determining defects, voids and cracks within an object would require destructive testing. CT scanning can detect internal features and flaws displaying this information in 3D without destroying the part. Industrial CT scanning (3D X-ray) is used to detect flaws inside a part such as porosity,[7]an inclusion, or a crack.

Metal casting and molded plastic components are typically prone to porosity because of cooling processes, transitions between thick and thin walls, and material properties. Void analysis can be used to locate, measure, and analyze voids inside plastic or metal components.

Geometric dimensioning and tolerance analysis:

Traditionally, without destructive testing, full metrology has only been performed on the exterior dimensions of components, such as with acoordinate-measuring machine(CMM) or with a vision system to map exterior surfaces. Internal inspection methods would require using a 2D X-ray of the component or the use of destructive testing. Industrial CT scanning allows for full non-destructive metrology. With unlimited geometrical complexity,3D printingallows for complex internal features to be created with no impact on cost, such features are not accessible using traditional CMM. The first 3D printed artefact that is optimized for characterization of form using computed tomography CT

Image-based finite element methods

Image-based finite element method converts the 3D image data from X-ray computed tomography directly into meshes forfinite element analysis. Benefits of this method include modelling complex geometries (e.g. composite materials) or accurately modelling "as manufactured" components at the micro-scale.

Applications of Computed Tomography (CT):

The number of industrial applications of Computed Tomography (CT) is large and rapidly increasing. After a brief market overview, the paper gives a survey of state of the art and upcoming CT technologies, covering types of CT systems, scanning capabilities, and technological advances. The paper contains a survey of application examples from the manufacturing industry as well as from other industries, e.g., electrical and electronic devices, inhomogeneous materials, and from the food industry. Challenges as well as major national and international coordinated activities in the field of industrial CT are also presented.