M. Tech. DEGREE
NON DESTRUCTIVE TESTING

SYLLABUS
FOR
CREDIT BASED CURRICULUM
(2009 -2010)

DEPARTMENT OF PHYSICS
NATIONAL INSTITUTE OF TECHNOLOGY
TIRUCHIRAPPALLI – 620 015, INDIA.
M. Tech. (NON DESTRUCTIVE TESTING)

The total minimum credits required for completing the M. Tech (Non destructive Testing) Course is 61.

**SEMESTER I**

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M. Tech. (Non Destructive Testing)

ELECTIVES

Semester I

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* Any other courses from other department with the consent of HOD
PH 601 - RADIOGRAPHIC TESTING AND RADIATION SAFETY


Film Radiography: X-ray film – structure and types for industrial radiography - sensitizer properties -use of film, characteristic curves (H & D curve) - latent image formation on film - radiographic exposure, reciprocity law, photographic density - X-ray and gamma ray exposure charts - exposure time calculations -film handling and storage - Effect of film processing on film characteristics - Processing defects and their appearance on films - control and collection of unsatisfactory radiographs - Automatic film processing.

Radiographic Image Quality and Radiographic Techniques: Radiographic Contrast, film Contrast, Subject Contrast, Definition, Radiographic density- penetrameters or Image Quality Indicators - Intensifying screens -intensification factor, control of scattered radiation, filters, diaphragms, masks- Radiography of Weldments – single and double wall Radiography - panaromic radiography-interpretation of radiographs and inspection standards - applicable codes, standards and specifications (ASME, ASTM, AWS, BS, IBR etc.)


Radiation Safety: Special and SI Units of radiation - Photoelectric effect, Compton effect, Pair production - Principle of radiation detectors - ionisation chamber, proportional counter, G. M. counters, scintillation counters, solid state detectors - Biological effect of ionising radiation - Operational limits of exposures - Radiation hazards evaluation and control - Design of radiography installation and shielding calculations.

References


PH 603 - BASIC METALLURGY AND FRACTURE MECHANICS

Structure of Metals: Different types of bonding in solids - Elements of crystal structure. Imperfections in crystals – dislocation theory - Grain boundaries and poly crystalline aggregates - Principles of Alloying - Solid solutions and intermediate phases - Gibbs phase rule and equilibrium diagram - types of binary phase diagrams - Isomorphous - Eutectic -
Peritectic and Peritectoid reactions - The Iron-carbon system - Peritectic, eutectic and eutectoid reactions, structural changes on slow and rapid cooling - martensitic transformation - concept of hardenability - TTT and CCT diagrams. Effects of carbon and alloying elements - Classification of steels.

**Heat treatment of steels:** Annealing (various types), normalizing, quenching and tempering - Case hardening, Austempering and martempering - Solidification of Metals and alloys - Nucleation and crystal growth from the liquid phase - Ingot structure dendritic freezing - Segregation effects and grain size control – strength mechanisms – solute, dispersion and precipitation hardening.

**Mechanical behaviour of materials:** Elements of plastic deformation - work hardening, recovery, recrystallization and grain growth, types of fractures in materials and their identification - Basic Principles and different types of corrosion - Corrosion tests - protection against corrosion.

**Fracture Mechanics:** Types of fractures - Ductile and brittle fractures - features of fracture - surface for ductile, brittle and mixed modes – fractography.

**Modes of failure** Stresses around cracks - linear elastic fracture mechanics - fracture toughness testing in practice - General yielding fracture mechanics- Notch bar fracture mechanics and the micro mechanics of cleavage fracture. The cleavage fibrous transition - fibrous fracture and impact testing - Applications of fracture mechanics to crack growth by fatigue or stress - corrosion mechanisms.

**References**


**PH 605 - SURFACE NDE METHODS**

**Visual Testing:** Fundamentals of Visual Testing - Vision, lighting, material attributes, environmental factors, Visual perception, direct and indirect methods - mirrors, magnifiers, Boroscopes Fibroscopes, closed circuit television, light sources and special lighting, A systems, computer enhanced system - Employer defined applications, metallic materials including raw materials and welds - Inspection objectives, inspection checkpoints, sampling plan, inspection pattern etc. classification of indications for acceptance criteria - Codes, Standards and Specifications (ASME,ASTM,AWS etc.)

**Liquid Penetrant Testing:** Principles – types and properties of liquid penetrants - developers – advantages and limitations of various methods - Preparation of test materials - Application of penetrants to parts, removal of surface penetrants, post cleaning - Control and measurement of penetrant process variables - selection of penetrant method - solvent removable, water washable, Post emulsifiable – Units and lighting for penetrant testing - Interpretation and evaluation of test results - dye penetrant process, applicable codes and standards.
**Magnetic Particle Testing:** Theory of magnetism - ferromagnetic, Paramagnetic materials - characteristics of magnetic fields - magnetic hysteresis - magnetisation by means of direct and alternating current - surface strength characteristics - Depth of penetration factors, Direct pulsating current typical fields, advantages - Circular magnetisation techniques, field around a strength conductors, right hand rule field - Prods technique, current calculation - Longitudinal magnetization - field produced by current in a coil, shape and size of coils, field strength, current calculations, Magnetic Burghausan Noise Analysis (MBN).

**Equipments:** Selecting the method of magnetisation, inspection materials, wet particles, dry particles - portable, mobile and stationary equipment - capabilities of equipments - magnetic particle inspection of castings and welding - Dry continuous method, wet residual method - Interpretation and evaluation of test indications - Principles and methods of demagnetisation - Residual magnetism, - applicable codes and standards.

**Eddy Current Testing:** Generation of eddy currents - effect of created fields - effect of change of impedance on instrumentation - properties of eddy currents - eddy current sensing elements, probes, type of arrangement - a) absolute b) differential lift off, operation, applications, advantages, limitations - Through encircling or around coils, type of arrangements a)absolute b) differential fill factor, operation, application, advantages, limitations - Factors affecting sensing elements and coil impedance - test part and test system - Signal to noise ratio, relationship to eddy current testing - equipment’s, reference samples, calibration, inspection of tubes, cylinders, steelbars. welds, welded tubing and pipes, Remote Field Sensing - Interpretation/Evaluation.

**References**


**PH 607 – PRACTICALS - I [Radiographic Testing and Magnetic Particle Inspection]**

**List of Practicals**

1. Familiarisation of X-ray, Gamma ray equipments and Film Processing
2. Safety equipments and Calibration of Survey Meters
3. RT of plate butt weld by Single wall Single Image Technique - X-ray
4. RT of pipe butt weld by Panoramic Technique- Gamma rays
5. RT of pipe butt weld by Double wall Single image Technique - Gamma rays
6. RT of pipe butt weld by Double wall Double Image Technique- Gamma rays
7. Interpretation of Radiographs
8. Magnetic Particle Inspection of Welds - Dry method
9. Magnetic Particle Inspection of Welds - Wet and Fluorescent methods
10. Read Time Radiography of Tube welds.
PH 609 - FABRICATION TECHNOLOGY (Elective)


Gas Metal arc welding: Considerations of electrode polarity - shielding gas and filler composition nature and conditions for spray transfer - difficulties for thin sheet - Dip transfer - and CO welding - flux cored, narrow gap and pulsed MIG welding.


References

3. Theoretical structure metallurgy - AH. Cottrell.

PH 611 - DIGITAL SIGNAL AND IMAGE PROCESSING (Elective)

Discrete Time signal and systems: Discrete-time signals - Sequences - Linear shift-invariant systems-Stability and Causality- Linear constant Co-efficient difference equations - Frequency-domain- Representation of Discrete-time systems and signals- Representation of discrete-time signals by Fourier transform.


**Reference**


**PH 613 - ELECTRICAL AND ELECTRONIC MEASUREMENT TECHNIQUES**

( Elective)

**Measurement and Error:** Accuracy and preccession - Types of Error - Statistical analysis - standards and calibration - Performance Characteristics of Instruments - static and dynamic characteristics - step and ramp response of first and second order instruments - frequency responses.


**Measurement of Energy:** General Motor meters, braking, friction - energy meters for A.C. Circuits, single phase Induction types watt-hour meters - construction, theory and operation - lag adjustment devices, light load or friction compensation creep - over-load compensation, voltage compensation, temperature compensation, errors, adjustments - polyphase energy meters, two element energy meters, industrial metering and tariffs - maximum demand indicators, measurement of Vah and Varh - Varh metering and measurement.
Display Devices and Recorders: Digital display Units, strip chart and X-Y recorders, Galvanometers, CRO, Magnetic Tape Recorders.

References


PH 602 - ULTRASONIC TESTING

Principles of Acoustics: Nature of sound waves, wave propagation - modes of sound wave generation - longitudinal waves, transverse waves, surface waves, lamb waves - Velocity, frequency and wavelength of ultrasonic waves - Ultrasonic pressure, intensity and impedance - Attenuation of ultrasonic waves - reflection, refraction and mode convection - Snell’s law and critical angles - Fresnel and Faunhofer effects - ultrasonic beam split.

Generation of ultrasonic waves: Various methods of ultrasonic wave generation - Piezo electric effect, Piezo electric materials and their properties - crystal cuts and mode of vibration - Ultrasonic search Units (transducers), types (straight, angle, dual) - Construction materials and shapes - Beam intensity, characteristics, sensitivity, resolution and damping - Transducer operation, manipulations.

Ultrasonic Inspection Methods, Equipment/Materials: Principle of pulse echo method, through transmission method, resonance method - Advantages, limitations - contact testing, immersion testing, couplants - Data presentation A, B and C scan displays, comparison of contact and immersion method. Pulse Echo instrumentation, controls and circuits, pulse generation, signal detection, display and recording methods, gates alarms and attenuators, basic instrument calibration, calibration blocks (IIW Block, ASTM Blocks, Distance Amplitude. Area Amplitude Block, etc.), cables, connectors, test specimens etc. Reference reflectors for calibration (side drilled holes, notches, etc.) - Inspection calibration, comparison with reference blocks, reference for planned tests (straight beams angle beam. etc.), transmission factors.

Recent advances in ultrasonic testing, Ultrasonic imaging, Synthetic Aperture Focussing Techniques (SAFT), Time of Flight Diffraction (TOFD), Signal Analysis, Artificial Intelligence, Neural Network, Fussy logic, Guided waves ultrasonic testing.

Testing/Evaluation/interpretation: Ultrasonic testing and evaluation of base material product forms (a) Ingot, (b) Plate and Sheet (c) Bar and Rod (d) Castings (e) Forgings (f) Pipe and Tubular products – weld geometries, root inspection - weld body examination with normal and angle beam by DAC and DGS methods - types, origin and typical orientation of discontinuities - response of discontinuities to ultrasound - Applicable codes standards, specifications (ASME, ASTM, AWS, BS. etc.) - Variables affecting ultrasonic test results
References


PH 604 - FIELD WORK


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PH 606 - PRACTICALS – II [Ultrasonic Testing and Liquid Penetrant Testing]

List of Practicals

1. Familiarisation of operations of Ultrasonic equipment
2. Basic calibrations of UT equipment
3. Drawing of DAC Curves by normal and angle probes
4. Ultrasonic Testing of Plate butt welds
5. Ultrasonic Testing of Pipe butt welds
6. Ultrasonic Testing of Tube butt welds
7. Testing of Raw materials - Plate
8. Testing of Raw materials - Forgings
9. Testing of Raw materials - Catings
10. Penetrant Testing of welds - Solvent Removable method

PH 608 – THIN FILM TECHNOLOGY AND APPLICATIONS (Elective)

Preparation of Thin-films: Kinetic aspects of Gases in a vacuum chamber - Classifications of vacuum ranges Production of vacuum - Pressure measurement in vacuum systems - Physical vapour deposition - Evaporation Techniques - Sputtering (RF & DC) - Pulsed Laser deposition- Liquid Phase Epitaxy- Vapour Phase Epitaxy- Molecular Beam Epitaxy.
**Film growth and measurement of thickness:** Thermodynamics and Kinetics of thin film formation - Film growth – five stages - Incorporation of defects and impurities in films - Deposition parameters and grain size - structure of thin films - Microbalance technique - quartz crystal monitor photometric - Ellipsometry and interferometers - Measurement of rate of deposition using ratemeter - cleaning of substrate.

**Characterization:** X-ray Diffraction(XRD) - SEM, Photoluminescence(PL) - Raman Spectroscopy, UV-Vis-IR Spectrophotometer – AFM - Hall effect – SIMS - X-ray Photoemission Spectroscopy (XPS) - Vibrational Sample Magnetometers, Rutherford Back Scattering (RBS).

**Properties of thin films:** Dielectric properties - Experimental techniques for dielectric film - annealing effect, effect of film thickness on dielectric properties – determination of optical constants – Experimental techniques for determination of optical parameters - Magnetic and mechanical properties - Hall effect compilations - Adhesion, stress, strength, Raleigh surface waves - Ferromagnetic properties of Thin films - Experimental methods for measurement of mechanical properties of thin films.

**Applications:** Micro and optoelectronic devices, quantum dots, Data storage, corrosion and wear coatings - Polymer films, MEMS, optical applications - Applications in electronics – electric contacts, connections and resistors, capacitors and inductances - Applications of ferromagnetic and super conducting films - active electronic elements, micro acoustic elements using surface waves - integrated circuits - thin films in optoelectronics and integrated optics.

**Reference**


**PH 610 - ELECTRICAL, MAGNETIC AND OPTOELECTRONIC MATERIALS**

**Electrical and Dielectric Materials:** Review of electrical conduction - resistivity and dielectric phenomena - concept of polarization - effects of composition, frequency and temperature on these properties - discussion on specific materials used as conductors (OFHC Copper, Al alloys, Fe-Si alloys, amorphous metals) - discussion on specific materials used as dielectrics (ceramics and polymers) - dielectric loss, dielectric breakdown - ferro electricity-piezo and pyro electricity.

**Magnetic Materials:** Introduction to dia, para, ferri and ferro magnetism - hard and soft magnetic materials - iron- silicon alloys – iron, nickel alloys - ferrites and garnets - (Ag - Mn - Al) alloys - (Cu - Ni- Co) alloy - fine particle magnets - applications of hard and soft magnetic materials - Giant magneto resistance- Nanomaterials.

**Semiconducting and Superconducting Materials:** Review of semiconducting materials - concept of doping - simple and compound semi conductors - amorphous silicon, oxide semiconductors; amorphous semiconductors - FER, MOSFET and CMOS - Concept of super
conductivity - theories and examples for high temperature superconductivity - discussion on specific super conducting materials - comments on fabrication and engineering applications.

**Production of Electronic Materials:** Review of electronic materials - methods of crystal growth for bulk single crystals - zone melting-refining, leveling - synthesis of epitaxial films by VPE, PVD, MBE and MOCVD techniques - lithography; production of silicon - starting applications.


**References**


**PH 612 - NANOSCIENCE AND TECHNOLOGY & APPLICATIONS (Elective)**


**Nanomagnetism:** Mesoscopic magnetism – Magnetic measurements: Miniature Hall Detectors, Integrated DC SQUID Microsusceptometry – Magnetic recording technology, Biological Magnets


**Biomedical Applications of Nanotechnology:** Biological structures and functions – Bio molecular motors - Drug delivery systems – Nanofluidics.

**References**


Department of Physics, National Institute of Technology, Tiruchirappalli – 620 015.
PH 614 - ADVANCED NDT TECHNIQUES – I

Acoustic emission inspection: Types of acoustic emissions - Basic concepts - instrumentation and read out - signal description - background noise - inspection of pressure vessels - flaw location - inspection of wire ‘ropes’ - inspection of welds - inspection of ceramic materials - Brazed metal to ceramic bonds - inspection of composite materials.


Principles of Thermography: Contact and non contact inspection methods - Heat sensitive paints - Heat sensitive papers - thermally quenched phosphors liquid crystals - techniques for applying liquid crystals - calibration and sensitivity - other temperature sensitive coatings - non contact thermographic inspection - Advantages and limitation - infrared radiation and infrared detectors, Instrumentations and methods, applications.

Industrial Computed Tomography (CT): Computed Tomography, Radiation Sources, X-Ray Detectors - CT image reconstruction algorithm - Capabilities, comparison to other NDT methods - industrial CT applications, CT System design and equipment - CT scanning geometries, data acquisition system - Image quality, Image artifacts, Special features, reconstruction techniques.


References


PH 616 - ADVANCED NDT TECHNIQUES – II (Elective)

Rockwell Hardness Test - Brinell Hardness Test - Vickers Hardness Test - Mohs Hardness Test.


**Acoustical Holography:** Liquid Surface Acoustical Holography - Optical System, Object size and shape, sensitivity and resolution, commercial liquid surface equipment - Scanning Acoustical Holography - Reconstruction, Object size, Sensitivity and resolution, Commercial Scanning equipment - Comparison of liquid surface and scanning systems - Readout methods, calibration, Interpretation of results - Applications - Inspection of welds in thick materials.

**Stress Analysis:** Polariscop - compensators -model materials - calibration of photo elastic materials - isochromatic and isoclinical fringes - stress determination - time edge effects - three dimensional photo - elasticity - Moire fringes techniques - Photo elasticity, strain gages, X- ray residual stress analysis.

**Basics of Magnetic resonance Imaging:** Tomographic window, contrast and sensitivity - Magnetic resonance phenomenon - Chemical shift, relaxation phenomena - Back projection imaging techniques, two dimensional and three dimensional back methods - Practical considerations of experimental set up - Magnetic Resonance Imaging System - Applications - Composite and elastometric material imaging.

**References**


**PH 647 - PROJECT WORK - Phase I**

**Proposed work**

a) Problem Identification.
b) Literature survey.
c) Finalization of scope of study.
d) Specimen Preparation.
e) Search Unit identification and procurement necessary.
f) Preliminary studies related to phase II.
g) Report.
PH 648 - PROJECT WORK AND VIVA VOICE - Phase II

Proposed work (Continuation of Phase 1):

a) Design of Experiment.
b) Experimental measurement.
c) Observations and analysis.
d) Comparison with references.
e) Conclusion and suggestions for future work.