SEMESTER I

21YN01 STATISTICAL QUALITY CONTROL AND DESIGN OF EXPERIMENTS 3 1 0 4

STATISTICAL QUALITY CONTROL: Methods and philosophy of statistical process control – chance and assignable causes of quality variation, statistical basis of control charts - control charts for variables - \( \bar{X} \), R - control charts for attributes – p, np, c and u charts. (10+3)

ACCEPTANCE SAMPLING: Lot-by-Lot acceptance sampling for attributes – single sampling plans for attributes, double and sequential sampling plans, acceptance sampling by variables - chain sampling, continuous sampling, skip-lot sampling plans. (12+4)

DESIGN OF EXPERIMENTS: Fundamentals of experimental design, guidelines for designing experiments, Analysis of Variance, experiments with one factor, completely randomized design, randomized block design, factorial experiments, Latin square design. (12+4)

RESPONSE SURFACE METHODOLOGY: Empirical models – linear regression models, estimation of parameters in linear regression models, confidence interval and hypothesis testing in multiple regression, 2-level factorial design – 2\(^3\) design, design for fitting second order models – class of Central Composite Design. (11+4)

Total L: 45 +T: 15 = 60

REFERENCES:

21YN02 PHASE TRANSFORMATIONS 3 1 0 4

CRYSTALLOGRAPHY & PHASE EQUILIBRIA: Crystalline, nano-crystalline and amorphous structures. Crystal Systems – brief discussion of BCC, FCC and HCP structures. Defects in atomic arrangements- types of defects (point, line and area) and their significance - Solid solution types- Rules for formation of solid solutions and compounds – Fundamental concepts of phase diagrams- discussion of isomorphous and eutectic systems - Fe-C equilibrium diagram. (11 + 3)

DIFFUSION: Mechanisms and modes of diffusion – Laws of diffusion - mass transfer in porous materials and related transport phenomena. Interfaces and surfaces: free energy of interfaces, grain boundaries and interphase interfaces, coherent and incoherent interfaces. Recrystallization and grain growth - transformations with short range diffusion. (11 + 4)

FUNDAMENTALS OF PHASE TRANSFORMATIONS: Time scale for phase transformations- types of transformations. Thermodynamic basis of phase transformations (nucleation & growth, spinodal decomposition and massive transformations) - transformation kinetics- kinetics of solid state reactions occurring at elevated temperatures – nucleation, growth and overall transformation kinetics - Sintering & crystallization in ceramics and glass forming systems. (12 + 4)

SOLID STATE PHASE TRANSFORMATIONS: Diffusion controlled transformations – Pearlitic and Bainitic transformations - mechanism, nucleation and growth kinetics- Factors influencing the transformations - effect of alloying elements. Diffusionless transformation - characteristics, thermodynamics and kinetics, nucleation and growth, morphology and crystallography of martensitic transformation in steels - Nonferrous martensites- Shape Memory Effect. Precipitation hardening – kinetics - precipitate coarsening. (11 + 4)

Total (L=45 +T=15): 60

REFERENCES:
DISLOCATION THEORY: Theoretical cohesive strength - dislocation types, Burgers Vector and dislocation loops - dislocations in FCC, BCC and HCP. Stress fields and energies of dislocations, forces on dislocations, forces between dislocation - interaction of dislocations, dislocation intersection, dislocation multiplication, dislocation pileups, Interaction with point defects. (12 + 4)

PLASTIC DEFORMATION OF CRYSTALS: Slip in a perfect lattice, slip by dislocation movement, Peierls-Nabarro stress, Critical Resolved Shear Stress for slip- deformation of single crystals and polycrystalline materials - deformation by twinning - concept of strain hardening- factors influencing strain hardening. (11 + 4)

STRENGTHENING MECHANISMS: Grain boundaries - Low angle and high angle grain boundaries. Grain boundary strengthening, Hall-Petch relation- Grain Boundary Engineering- Yield point phenomenon and strain aging. Solid solution strengthening - factors influencing solid solution strengthening. Work hardening, transformation hardening and texture strengthening. (11 + 4)


REFERENCES:

SOLIDIFICATION METALS AND ALLOYS: Solidification pure metals and alloys - effect of composition, moulding materials and cooling rate on solidification pattern of alloys - segregation patterns in steel castings. Types of Shrinkage- linear and volume shrinkages - example calculations. Centre line feeding resistance - solidification rate: Chvorinov's Rule, calculation of solidification time in metals and alloys. Directional Solidification of castings - hot tearing criteria. (11)


REFERENCES:
21YN05 METALLURGY OF FORMING


FORGING, ROLLING AND EXTRUSION: Forging - classification: open die forging and closed die forging - die design - presses and hammers - calculation of forging loads - friction hill diagram - defects, causes and remedies - applications, Rolling : types of rolling mills - flat and shape rolling - forces and geometrical relationship in rolling - analysis of rolling load, torque and power - rolling defects - applications. Extrusion: direct and indirect extrusion - hydrostatic extrusion. Analysis of extrusion - tube extrusion - defects causes and remedies - applications. (11)


REFERENCES:

21YN06 Research Methodology and IPR
vide Automotive Engineering 21AE06

21YN72 AUDIT COURSE I
vide Automotive Engineering 21AE72

21YN51 MICROSTRUCTURAL ANALYSIS LABORATORY

LIST OF EXPERIMENTS:
1. Macro and Micro Examination of Castings and Welds.
2. Inclusion rating of Steels and Grain size measurement in Ferritic and Austenitic Steels.
3. Study of morphology and characteristics of graphites in various cast irons.
4. Identification of plain carbon and alloy steels from their microstructures.
5. Determination of mechanical working and heat treatment condition of steels.
6. Evaluation of ferrite and austenite content in different types of stainless steels.
7. Study of microstructures of hardened steels and tool steels.
8. Microstructural examination of Al – Si Cast Alloys, Brasses and Bronzes.
10. Microstructural investigations on Carburized and borided steels.

REFERENCES:
1. Microstructural Analysis Laboratory Manual - Department of Metallurgical Engg., PSG College of Technology, 2021
LIST OF EXPERIMENTS
1. Free energy calculations and CALPHAD approach - basics.
5. Study of precipitation kinetics in Steels using TC - PRISMA software.
6. Simulation of Scheil Solidification of Steels using Thermo Calc software.
10. Study of homogenization of binary Fe-Ni alloy using DICTRA software.

REFERENCES:

SEMESTER II

21YN07 METALLURGY OF WELDING

BASICS AND POWER SOURCES: Joining techniques - Welding processes and classes - welding terminology - AWS specifications for classification. Metal transfer modes - polarity and shielding gases. Power sources - Static and dynamic characteristics - CC and CV power source designs - current and voltage relationships. Solid state power sources - wave form controlled power sources. (11 + 4)


WELDING METALLURGY: Heat flow in welding - weld metal cooling curves - peak temperature and cooling rate calculations. Weld metal solidification - gas-metal and slag-metal reactions - weldment terminology - solid state transformation during welding - microstructural changes in cold worked, transformation hardened and age hardened alloys during welding. (11+3)


REFERENCES:

21YN08 FAILURE MECHANISMS AND ANALYSIS


FAILURE CAUSED BY MECHANICAL FORCES: Failure due to static overloading with example case studies – yielding, bending and buckling. Failure due to dynamic overloading with case studies - fatigue, creep, fatigue – creep interaction, stress rupture and low temperature embrittlement. Failure due to contact interaction with case studies - wear, erosion and abrasion - related case studies.


REFERENCES:

21YN82 AUDIT COURSE II
vide Automotive Engineering 21AE82

21YN53 MATERIAL PROCESSING LABORATORY

List of Experiments:
1. Testing of sand used in green sand moulding.
2. Sand casting of low melting alloys and composition analysis using OES.
4. Demo on SICO (Strain Induced Crack Opening) test using Thermo-Mechanical simulator
5. Determination of n and K from tension test.
7. Compaction and sintering of metal powders with and without ceramic reinforcements.
8. Hardening of EN 8 and EN 19 grade steels with quenchants and subsequent tempering.
9. Solutionizing and Age hardening of Aluminum alloys and their characterization.
10. Molten salt boronizing of steels and nickel alloys.

Total P : 60

REFERENCES:

21YN54 QUALITY INSPECTION LABORATORY

List of Experiments:
1. Vickers micro hardness survey on welded steel and aluminum samples as per ASTM E 18 and 384 standards.
2. Transverse and all weld tension test on steel welds as per ASTM A 370 – E8 standard.
3. Guided bend test for ductility of welds as per ASTM E190-92 standard.
5. Pin on Disc Wear Testing as per ASTM G 99 standard.
6. Visual inspection of castings and welds as per ASME B&PV Code Section V, Subsection A, Article 9 and Section VIII.
7. Penetrant Inspection of components as per ASME B&PV Code Section V, Subsection A, Article 6 and Section VIII.
8. Magnetic particle inspection of Ferromagnetic parts as per ASME B&PV Code Section V, Subsection A, Article 7 and Section VIII.
9. Ultrasonic inspection of components as per ASME B&PV Code Section V, Subsection A, Article 4 and Section VIII.
10. Interpretation of RT film radiographs and digital radiographs as per ASME B&PV Code Section V, Subsection A, Article 2 and Section VIII.

Total : 60

REFERENCES:
2. Handout copies of the above standards
21YN61 INDUSTRIAL VISIT AND TECHNICAL SEMINAR
vide Automotive Engineering 21AE63

SEMESTER – III

21YN71 PROJECT WORK – I
vide Automotive Engineering 21AE71

SEMESTER – IV

21YN81 PROJECT WORK – II
Vide Automotive Engineering 21AE81

PROFESSIONAL ELECTIVE THEORY COURSES (Four to be opted)

21YN09 THERMODYNAMICS OF MATERIALS

3 0 0 3


THERMODYNAMIC POTENTIALS: Fugacity, activity and equilibrium constant. Clausius-Clayperon equation- effect of pressure on the equilibrium temperature. LeChatelier's principles and Van't Hoff's equation. Sievert's law. (10)


REFERENCES:

Total L : 45

21YN10 CHARACTERIZATION TECHNIQUES

3 0 0 3

OPTICAL MICROSCOPY: Optical microscopy - imaging theories - Bright field, Oblique and Dark field illumination. Phase contrast, polarized light and hot stage microscopy. Interference techniques, Introduction to colour Metallography, Quantitative Metallography – image analysis- Calibration techniques. (10)


REFERENCES:

21YN11 IRON AND STEEL MAKING


IRON MAKING: Layout, constructional features of the blast furnace- charging equipment- burden distribution- gas cleaning- hot blast stoves- operational irregularities - Physical chemistry of blast furnace reactions - carbon-oxygen reaction and gas-solid reactions-reactions in stack- bosh and hearth - RAFT calculations - blast furnace productivity - fuel efficiency - modern developments - sponge iron production and smelting reduction processes - alternate routes of iron making.


REFERENCES:

21YN12 SURFACE DEGRADATION OF MATERIALS


CASE STUDIES IN CORROSION: Corrosion failures of pipelines and boilers – Corrosion failures in petrochemical, marine and automobile components – Corrosion failures in biomedical implant.

REFERENCES:

21YN13 PARTICULATE TECHNOLOGY

POWDER PRODUCTION AND CHARACTERIZATION: Classification of powder production techniques - preparation of metallic, ceramic and composite powders and their characterization. Basic concepts of sampling and characterization. Techniques for detailed analysis of composition, particle size, shape, apparent and tap densities, particle size distribution and surface area of powders. (11)


POWDER METALLURGY PRODUCTS: Steps in the production of self lubricating bearings, friction materials, carbide tools, cerments, dispersion strengthened alloys and magnetic materials- scope, advantages, limitations and specific examples - Important P/M alloys: Iron base, Aluminium base, Nickel base, titanium base alloys, refractory metals and their processing. Applications of commercial P/M Alloys in automobile, aerospace, defence, industrial nuclear and miscellaneous applications. (12)

REFERENCES:

21YN14 METALLURGY OF STEELS


SPECIAL STEELS: HSLA, bainitic and micro alloyed steels- thermo-mechanical processing, DP steels, IF steels, CP steels, TRIP steels, TWIP steels, MBIP steels, Low density high strength steels (Fe-Al-Mn steels) - line pipe steels. heat treatment processes, structure - property correlation. (12)

STAINLESS STEELS: Composition, structure, property - effect of alloying elements - heat treatment and applications of ferritic, martensitic, austenitic, precipitation hardening, duplex, nickel free austenitic stainless steels and High Nitrogen Stainless(HNS) steels – Specifications - AISI, EN, UNS standards. (12)

STEELS FOR SPECIFIC APPLICATIONS: Manufacture, structure, property, heat treatment and applications of maraging steels, silicon steels, high manganese steels, tool steels and high temperature steels- Cr-Mo, Cr-Mo-V, and Cr-Mo-V-Nb steels and cryogenic steels. (11)

REFERENCES:
COPPER ALLOYS: Properties and applications of metallic copper - influence of alloying elements in copper alloys - classification of copper base alloys, their compositions, heat treatment, microstructure, properties and applications. (10)

ALUMINIUM: Properties and uses of metallic aluminium - classification of aluminium alloys, wrought and cast alloys; heat treatable and non-heat treatable alloys - Physical metallurgy of Al alloys, effect of alloying elements and impurities; properties - strengthening mechanisms in non-heat treatable alloys and heat treatable alloys. (11)

MAGNESIUM ALLOYS: Properties and applications of magnesium and magnesium alloys; influence of alloying elements - Al, Mn, Zn, Si, Ag, Th, Zr; classification-cast alloys and wrought alloys. Properties and applications of low melting alloys TITANIUM: Introduction; Ti and its alloying capability, alloying elements - alpha and beta stabilizers, alpha titanium alloys; beta titanium alloys and alpha-beta titanium alloys – structure-property correlation. (12)


REFERENCES:

POLYMERS: Classification-thermoset, thermoplastics and elastomers. Structure of polymers- crystalline and amorphous polymers - concept of Glass Transition Temperature (Tg). Polymerization- types and mechanisms with examples-Degree of Polymerization - molecular weight of polymers-numerical problems. Polymer additives-Examples and applications of engineering plastics. Elastomers - types, properties, examples and applications. (10)


PROPERTIES AND APPLICATIONS OF ENGINEERING CERAMICS: Elasticity and brittle fracture - toughening mechanisms, Weibull statistics and design - thermal shock resistance. Glass-elastic behaviour, strength and fracture. Mechanical, electrical, thermal and optical properties of engineering ceramics - examples and applications - Bioceramics - examples and applications. (12)

REFERENCES:

Classification of composites: Metal Matrix Composites, Ceramic Matrix Composites and Polymer Matrix Composites. Particulate composites, fibre reinforced composites and structural composites. Properties and applications of composites - comparison with monolithic materials.


**MECHANICAL PROPERTIES:** Stiffness and Strength: geometrical aspects - volume and weight fraction. Unidirectional continuous fibre, discontinuous fibers, short fiber systems, woven reinforcements - Mechanical Testing: determination of stiffness and strengths of unidirectional composites; tension, compression, flexure and shear.

**STRUCTURAL COMPOSITES:** Laminate, sandwich and monolithic structures. Laminates: plate stiffness and compliance – Assumptions. Strains, Stress Resultants, Computation of Stresses, Types of Laminates: symmetric laminate, antisymmetric laminate, balanced laminate, quasi-isotropic laminate, cross-ply laminate, angle ply laminate. Orthotropic laminate. Laminate moduli, Hydrothermal stresses.

**REFERENCES:**

**21YN18 BIOMATERIALS**


**SYNTHESIS OF BIOMATERIALS:** Physical methods: electrophoresis - chemical methods: Sol-gel, combustion synthesis, cathodic deposition, anodization and precipitation methods, Mechanical methods: Mechanical alloying. Effect of alloying elements (like Na, Mg, Sr, Ag, carbonates) on compatibility bio-coatings and bio-mimetic materials properties and examples. Biomimetic coating techniques: plasma spraying, sol-gel, electrochemical methods, laser and ion-implantation. Characterization: coating roughness, adhesion strength, wettability and contact angle measurements.

**CHARACTERIZATION OF BIOMATERIALS:** Important characterization techniques – principles and applications of biological microscope, Transmission Electron Microscope (TEM), Atomic Force Microscopy (AFM), Inductively Coupled Plasma – Atomic Emission Spectroscopy (ICP - AES) technique, Magnetic Resonance Imaging and their application to biomaterials.


**REFERENCES:**

**21YN19 EMERGING MATERIALS**

METALLIC AND CERAMIC MATERIALS: High strength alloys, quasicrystals, immiscible alloy systems and in-situ composites, metallic glasses, single crystals, metallic foams, Shape Memory Alloys-advantages and applications. Insulators, ceramic matrix composites, biomaterials - need, properties. advantages and applications. Thin films, coatings - glass ceramics. (11)

HIGH AND LOW TEMPERATURE MATERIALS: Introduction-high and low temperature materials, superconductors, super magnetic materials, high entropy alloys, dispersion strengthened alloys, intermetallics, super-alloys-refractories-their advantages and applications. (11)

MATERIALS PROCESSING AND CONSOLIDATION TECHNIQUES: Mechanical alloying, Rapid Solidification Processing, Melt spinning, atomization techniques, sol-gel, Self-Propagating High Temperature Synthesis - processing capabilities - process parameters - examples and advantages. Consolidation techniques for ceramics and metallic powders - Cold and Hot Isostatic Pressing, Powder extrusion, Equal Channel Angular Pressing and Spark Plasma Sintering. (12)

REFERENCES:

21YN20 HEAT TREATMENT OF ALLOYS 3 0 0 3


REFERENCES:

21YN21 SURFACE MODIFICATION TECHNOLOGY 3 0 0 3

INTRODUCTION: Introduction to thermodynamics of surfaces-surface dependent properties - physical, chemical and mechanical. Surface degradation and their characteristics - analysis of surface initiated degradations. Approaches and classifications of surface engineering techniques. Introduction to surface cleaning techniques (physical, mechanical and chemical). Surface modifications techniques- Summary of surface modification methods applicable to metals and alloys. Economics and design of surface engineering processes. (11)


PAINTING AND VAPOUR DEPOSITION METHODS: Surface painting- basic paint technology, essential concepts of paint formulation and paint properties, paint preparation (pigment dispersion), surface preparation and paint application techniques and their characteristics. Thin film technologies - metallic and ceramic thin films by Physical Vapour Deposition (PVD) technique (thermal
evaporation, sputtering and ion plating) and Chemical Vapor Deposition (CVD) technique. Diamond Like Carbon (DLC) coatings. Testing methods.

**SPRAYING METHODS:** Flame spraying processes, Wire Arc Spraying process, Cold Gas Dynamic Spray Coating (CGDSC), Plasma spraying, Detonation Gun (D-gun) coating, High Velocity Oxy Fuel (HVOF) coating. Hard facing, LASER cladding, Thermal Barrier Coatings. Testing methods for these coatings.

**REFERENCES:**

**21YN22 CASTING SIMULATION AND DESIGN**

**OVERVIEW OF CASTING PROCESSES:** Introduction to casting simulation-types of casting simulation software, requirement and methoding of castings. Optimization of casting defects- cause-effect diagram, fish bone diagram, WHY method and FMEA.

**CASTING DESIGN AND ANALYSIS:** Minimum section thickness, hot spots and hot tears, junctions, ribs, and bosses. Design for moulding, core making and cleaning. Design for continuous casting.

**COMPUTER SIMULATION OF CASTING PROCESSES:** Mould filling simulation, solid modeling, thermal analysis, solidification simulation, feeder size and weight calculations, mold-metal filling optimization. Cost benefits of solidification simulation.

**DESIGN FOR CASTABILITY:** Product design for castability-process friendly design and castability analysis. Prediction of cooling curves - local microstructures and mechanical properties of metals and alloys. Prediction of mould erosion, sand burnt-on, sand penetration and sand inclusions.

**REFERENCES:**

**21YN23 QUALITY CONTROL IN FOUNDRIES**

**INTRODUCTION TO QUALITY CONTROL:** Definition of quality control- need for quality improvement and control- dissemination of quality information- quality and cost analysis-quality control and inspection-responsibility for quality control- quality control through standardization- quality control organization. Quality planning - record and documents. Reliability Engineering approach.

**STATISTICAL QUALITY CONTROL:** Introduction- probability and probability distributions - binomial, Poisson and normal distributions - Statistical Quality Control (SQC)-Statistical Process Control (SPC) in foundries- Process capability indices- process variables in foundries -acceptance control charts-applications of control charts in foundries - numerical examples.

**INSPECTION METHODS AND QUALITY APPRAISAL:** Need for inspection – inspection of castings- equipment and techniques methods to reduce energy consumption in foundry. Environmental pollution control. Experts system for casting defects analysis-accuracy evaluations and analysis of dimensions-Quality Function Deployment (QFD)-case studies on casting defect analysis.


**REFERENCES:**
21YN24 FUNDAMENTALS OF SOLIDIFICATION


SOLIDIFICATION OF COMMERCIAL ALLOYS: Eutectic and peritectic solidifications of binary alloys - solidification of titanium alloys, magnesium alloys, aluminium alloys and Metal Matrix Nano Composites -Directional Solidification: single crystal growth techniques-heat transfer requirement for Directional Solidification - Directional Solidification of Nickel base super alloys-investment casting of single crystal turbine blades, bulk single crystal growth of electronic materials.


REFERENCES:
5. https://nptel.ac.in/noc/courses/noc18/SEM1/noc18-me09/Transport phenomena in Materials
6. https://nptel.ac.in/courses/113/104/113104073/ Fundamentals of Material Processing

Total L: 45

21YN25 WELDING PROCEDURES AND QUALIFICATIONS

WELDING CODE PRACTICE: Review of welding metallurgy of important alloys-fundamentals, equipments, electrodes / filler metals classifications as per AWS. Familiarization of codes: ASME B&PV Code - sections IIC and IX. Essential variables, non-essential variables and supplementary essential variables. Welding Procedure Specification (WPS), Procedure Qualification Record (PQR) and Welding Procedure Qualification (WPQ) formats test requirements - qualifying range for varying values of essential variables.

WPS OF FERRITIC STEELS: Preparation of WPS’s for SMAW, GTAW, GTA+SMW, GMAW, SAW, SMAW+SAW, GTAW+SAW – preparation of WPS for carbon steels, low alloy steels, Cr-Mo steels with Post Weld Heat Treatment (PWHT) and without PWHT, stress relieving- other heat treatments. Welding of plates - 2 to 200 mm thickness. Preparation of WPS for dissimilar welding and weld overlaying involving ferritic grade steels.

WPS OF STAINLESS STEELS AND NON-FERROUS ALLOYS: Preparation of WPS for metal joining using process variation: SMAW, GTAW, GTA+SMAW, GMAW, SAW, SMAW+SAW, GTA+SMAW, WPS for stainless steels, nickel alloys, copper alloys, titanium alloys, aluminium alloys. Preparation of WPS for dissimilar metal joining for. SMAW, GTA+SMAW. WPS for welding of stainless steels to carbon steels, copper alloys to carbon steels-Preparation of WPS for weld overlay of stainless steels over carbon steel, nickel alloys over carbon steels, copper alloys over carbon steels, stellite over carbon steels and stainless steels.

PQR AND WPQ: Testing of weldments as per codes and standards. Preparation of PQR for selected WPS. Preparation of WPQ for selected WPS for various processes, material thicknesses, positions for butt welding, fillet welding and weld overlay: Model PQR for WPS of butt welding, fillet welding and weld overlay.

REFERENCES:
21YN26 WELDING APPLICATION TECHNOLOGY

QUALITY ASSURANCE IN WELDING: Overview of welding processes and weldability, mechanical and metallurgical effects on welding, quality control and assurance in welding. Overview of welding discontinuities. Welding procedures and performance qualification for quality assurance. Welding automation and importance of welding fixtures for high quality welding. (12)

WELDING OF AEROSPACE AND AUTOMOTIVE COMPONENTS: Types of loads applied on components and joint design configurations. Specific materials and processes used in fabrication of aerospace structures-welding issues encountered in aerospace alloys: austenitic stainless steels, aluminum, titanium and nickel alloys. Specific processes and materials used for fabrication of automotive structures and components-challenges in thin sheet welding-specific methods to enhance fatigue life structures like truck frames, under frames and railway bogie frames. Specific processes used for fabrication of thin walled structures for stainless steel metro coaches-guidelines as per relevant codes & standards (11)

WELDING OF STRUCTURES IN HEAVY ENGINEERING SECTOR: Loads and stresses in welded structure-failure modes in static and dynamically loaded structures-welded connections used in structures. Design requirements of static and dynamically loaded structures-weld joint configurations-weld symbols. Materials, consumables and processes used in fabrication of structures-specific metallurgical issues encountered in the fabrication of boilers, ships and buildings structures and measures to overcome these issues. Specific methods to enhance fatigue life of welded structures-guidelines for welding of structures as per AWS D1.1 structural welding code. (11)

WELDING IN PRESSURE VESSEL FABRICATION: Loads and stresses in pressure vessel components -failure modes in pressure vessels: Design requirements of pressure vessels-type of weld joint configurations used in pressure vessel components-weld category and joint efficiency. Specific materials, consumables and processes used in the fabrication of boilers & pressure vessels, air receiver tanks, vessels for low temperature service, line pipes used in petro-chemical sector. Inspection of welds, guidelines for fabrication of pressure vessels and piping as per ASME sec VIII & welding of line pipes as per API 1104 hydro testing of pressure vessels. (11)

REFERENCES:
2. AWS Structural welding code D 1.1 2020, Published by AWS committee-2020.

Total L: 45

21YN27 NONDESTRUCTIVE TESTING

SURFACE TECHNIQUES: Discontinuities and defects - basics of Visual Testing (VT)-remote visual examination of components using optical and mechanical aides -Visual Inspection of welds. Basics of Penetrant Testing (PT) - precleaning methods, penetrant groups and penetrant removal techniques-types of developers, inspection procedures, sensitivity and resolution-interpretation of indications-applicability and limitations. Fluorescent Penetrant Test (FPT) - codes and standards of VT and PT - practical demonstrations of VT and PT. (11)


RADIOGRAPHY TECHNIQUES: Sources of radiation and their characteristics- X-ray and Gamma ray Radiography Test (RT)- radiation protection and radiation detectors-Film Radiography (FR) and Digital Radiography (DR)-sensitivity and definition. Image Quality Indicators (IQI) and other accessories-characteristics of discontinuities-exposure parameters. Procedures and acceptance standards-Interpretation of radiographs-RT of castings, welds and pipes-practical demonstrations of RT film interpretation. (11)

Total L: 45
REFERENCES:

21YN28 ADVANCED NDT TECHNIQUES


REFERENCES:

21YN29 ADDITIVE MANUFACTURING


ADDITIVE MANUFACTURING SYSTEMS: Classification–liquid based systems-Stereo Lithography (SL) - principle, equipment, process, advantages and applications. Solid based systems - Solid Ground Curing (SGC) and Fused Deposition Modeling (FDM) - principle, process, advantages and applications, Laminated Object Manufacturing (LOM) - bonding mechanisms-materials - principle, process and advantages and applications. Case studies on SL, SGC, FDM, LOM approaches. Wire Arc Additive Manufacturing (WAAM). (10)

POWDER BASED ADDITIVE MANUFACTURING SYSTEMS: Direct process powder-bed systems – Selective LASER Melting (SLM), LASER curing and Direct Metal LASER Sintering (DMLS) and Electron Beam Melting (EBM) – principles, process, advantages and applications. Powder-fed systems - LASER cladding, directed energy deposition and LASER metal deposition. Three dimensional printing – principle- process, advantages and applications- LASER Engineered Net Shaping (LENS)- Introduction to direct rapid tooling and indirect rapid tooling. Case studies in SLM, 3D Printing and LENS. (12)

DESIGN FOR AM AND APPLICATIONS: Design tools for AM-part orientation- removal of supports-hollowing out parts-inclusion of undercuts and other manufacturing constraints - interlocking features, reduction of part count in an assembly-identification of markings/numbers, application. Material relationship, application in design, application in engineering, analysis and planning for aerospace, automotive, jewelry and coin industries. Examples from aerospace, defense, automobile, RP, medical and bioengineering as well as general engineering industries. (13)
REFERENCES:

21YN30 MATERIAL AND PROCESS MODELING
3 0 0 3

INTRODUCTION TO CALPHAD APPROACH : Thermodynamic parameters for solid solution modelling – configurational entropy, enthalpy and free energy – chemical potential - free energy vs composition diagram - evolution of phase diagrams based on regular solution model - sub regular solution model - Redlitch-Kister polynomial - phase diagram determination by diffusion couple technique. (10)


REFERENCES:

21YN31 MATERIALS SELECTION
3 0 0 3

MATERIALS AND DESIGN: Design process - types of design - design requirements. Role of materials in design - strategically important categories of materials - design strengths and weakness of these materials. Material properties and their importance in materials selection- bulk mechanical and non-mechanical properties, surface properties, processing abilities and cost. Materials property charts and material records. (12)


MATERIALS SELECTION PROCESS: Materials selection methods: screening and ranking - weighted ranking. Performance indices-matierials selection charts-deriving property limits and material indices for tie rod, beam and shafts. Structural indices-shape factors, efficiency of standard sections, material limits for shape factors - material indices which include shape - co-selection of material and shape. (10)

SPECIFIC MATERIAL SELECTION APPLICATIONS: Rotating beams transferring moment - bicycle frame for light weight concept, heat absorbing material with tailored thermal expansion (vs. e.g. silicon in microelectronics device), wear resistant floor with antistatic properties, shell for a mobile phone, outdoor furniture, light and stable tooling for plastic injection moulding, shielding cover for engine exhaust system (behind the catalyst), brake discs for car, exhaust valve (car engine), aircraft landing gears, surgical knives and bone replacements, acid storage tanks and fuel carrying pipes. (13)
REFERENCES:

OPEN ELECTIVES

21YN91 DATA ANALYTICS

3003

INTRODUCTION: Big data-Volume, Velocity, Variety - Business Intelligence, Data Science- - Types of Analytics –Descriptive, diagnostic, predictive, prescriptive analytics, Data Analytics Lifecycle Overview – Discovery – Preparation – Model Planning. Introduction to R and python, basic programming.

EXPLORATORY DATA ANALYSIS: Data collection, Data preprocessing – understanding the data, basic visualization - dealing with outliers - dealing with null value- data standardization - scaling of data, Correlation, Multi collinearity - diagnostics, treatment, dimensionality reduction techniques, principle component analysis (PCA), Factor Analysis – applications.

MACHINE LEARNING: Introduction, types of machine learning algorithms, model building – unsupervised learning algorithms – Association rule mining, conjoint analysis, clustering, K means clustering, supervised learning algorithms - - types, linear and logistic regression analysis, Decision tree, classification and regression techniques, random forest, KNN, Naviebayes, LDA, support vector machines, Artificial Neural network, ensemble methods, applications in metallurgical and materials science data.

TEXT ANALYTICS, TIME SERIES FORECASTING AND WEB SCRAPPING: Text analytics - word cloud, sentiment analysis, web and social media analysis, time series data, components, stationery of the data, exponential smoothing model, Holt-winters model, ARIMA model – applications, web scraping – introduction and applications.

Total L : 45

REFERENCES:
1. EMC Education Services, "Data Science and Big data Analytics: Discovering, Analyzing, Visualizing and Preserving Data", Wiley, USA, 2015.

21YN92 OPTIMIZATION TECHNIQUES

3003


ADVANCED LINEAR PROGRAMMING: Revised simplex method: Development of the Optimality and Feasibility Conditions - Revised Simplex Algorithm - Bounded-Variables Algorithm – duality – parametric linear programming – goal programming

INTEGRATED LINEAR PROGRAMMING AND DYNAMIC PROGRAMMING: Branch & bound algorithm – Cutting plane algorithm – Illustrations: capital budgeting and Either-Or and If-Then Constraints -Recursive Nature of Computations in DP - Knapsack/Fly-Away models - Equipment Replacement Model


Total L : 45

REFERENCES:

290