Department of Metallurgical & Material Engineering
Ahmadu Bello University Zaria
Course Description MSc Metallurgical & Material Engineering

MMEN 801 – Advanced Physical Metallurgy

Summary of heat treatment principles, and heat treatment structures. Formation and transformation of pearlitic, bainitic and martensitic structures in steels and cast irons. Mechanical properties of Iron-carbon martensites. Decomposition of martensite and retained austenite on tempering. Review of special heat treatments: austempering, martempering, marging and subzero treatments. Quench media and mass effect. Measurement and control of the austenitic grain size. Review of hardenability and its determination.

MMEN 802 – General Principle of Metal Working

Introduction – Review of the fundamental of metal forming. The nature and purpose of metal working theory, Principal stresses and yield criteria. Determination of working loads and considering of work and stress distributions. Determination of working loads by cement or metal flows Highlights on working processes.
Friction and lubrication in metallurgy.

MMEN 803 – Composite Materials (Electronic/Biomaterials)

Biomaterials

Engineered materials in medical applications with an emphasis on material properties, functionality, design, and material response in biological environment.

Advanced Biometrials

Formation and structure-function relations of biological materials, the interaction of tissue-synthetic biomaterials, advanced biomaterials design, biomimetic processing and current progress in drug delivery systems and biomedical devices.

Composite Materials

Understanding the properties and mechanical behaviour of composite materials emphasis on analysis, design, and manufacturing.

Biomimetic Materials

A comprehensive study of the structure-function relation of biological hard tissues, and their application to the design and processing of novel materials and devices.

MMEN 804 – Advanced Mineral Processing

Analysis of mineral concentration operations with emphasis on the metallurgical, economic and environmental aspects of the processes; surface chemistry (electrical double layer, zeta potentials, Gibb's equation, chemisorption, etc), chemistry of flotation, flotation of oxides, sulphides and silicates. Tailings disposal.

MMEN 805 X-Ray Crystallography

Properties of X-Rays and neutrons; Geometry of Crystals, Point and Space groups, Stereographic Projection. Reciprocal lattice., Diffraction: Direction of Beams, Diffraction: Intensity of Beams, anomalous Dispersion; Neutron Diffraction, Lane
Photographs, Powder Photographs, Diffractiometer, Orientation of Single Crystals, Polycrstalline

Aggregates, Determination of Crystal Structure – Indexing, Determination of Crystal Structure – Indexing, Precise parameters Measurements, Phase Diagram Determination, Lattice Parameters and Miscellaneous Applications;, Order-Disorder Transformation, Chemical Analysis, Stress Measurements.

MMEN 806 – Advanced Corrosion

Corrosion and Society; Theory and aqueous Corrosion i.e. Thermodynamic and Kinetics of Corrosion reactions, polarization, mix-potential theory, pourbaix diagrams. Corrosion types; Dissimilar, Selective, Crevice and pitting, Stress Corrosion Cracking, Intergranular.

* Corrosion Control by Design, Environmental change, Barrier coating, Material Selection, Cathodic and Anodic protection.
* High temperature corrosion

MMEN 807 – Experimental Technique (Physical Met) 6/3 months (72hours)

a) Physical

Atomic absorption spectrometer (AAS) X-ray.
Metallorgraphy examinations – metals and non-metals, non-destructive testing of materials.
Mechanical properties Measurement of metals (Hardness, strength, elongation, impact etc)
Solidification of metals-alloys homogeneous and heterogeneous solvents, dendritic freezing and coring.
Characterization of materials – measurement of properties (refractory), ceramics and Polymers) – shrinkage, porosity, thermal conductivity, cold crushing, refractoriness under load thermal shock.
Structure and theory of metallic phases, Typess of crystals, castings (sand mould).

(b) Mechanical Metallurgy (Forming)

Stress analysis by strain measurement mechanical strain gauges optical strain games, electrical strain games.
Grid techniques: Moire Method, Brittle coating for strain implication of stress analysis by photoelectrons and photoplasticals, stress analysis by photoelastic coating X-ray determination of residual stress coefficient of friction measures

c) Process

(1) Mineral properties potentially useful in concentrationin of mineral

(2) particle size analysis by sieving and analysis of data from sieve tests

i. Schuhman Function
ii) Rosin- Rammler Function
iii). Normal Function
iv). Log – Normal Distribution

subsieve size analysis techniques

i) Microscopy –Direct observation using
1 Optical Microscope
2 Scanning Electron Microscope
ii) Sedimentation technique: Settling of Particles in Fluids
iii) Elutriation technique
iv) Light scattering technique

(3) particles in fluids

(i) Application in mineral processing
(ii) Reynolds number
(iii) Stokes and Newton's laws
(iv) Equal Settling Particles
(v) Slurry Equations
(vi) Slurry Flow calculations

(4) **Basic principles, sample requirements, mode of analysis and areas of application of the following materials characterisation techniques**

(a) X-Ray fluorescence (XRF) Atomic Absorption Spectroscopy, (AAS) and X-Ray Diffractions (XRD)
(b) Scanning Electron Microscopy (SEM)
(c) Transmission Electron microscopy (TEM)
(d) Energy Dispersive X-ray Spectroscopy (EDXS)
(e) Scanning Transmissions Electron Microscopy (STEM)
(f) Electron Probe X-ray Microscopy Analysis(EPMA)

MMEN 809 – Advanced Iron & Steel Making

Iron Ore benefication, agglometaration techniques, palletizing, balling, sintering, briquetting; fluxes for iron and steel making; fuels for iron and steel making; analysis of blast furnace and direct reduced iron technology; cast and wrought iron production; refining of steel; open-hearth, converter, and electric are processes; de-phosphorization and desulphurization reactions, degasification; ferro-alloys and alloy steel production.

MMEN 815 – Surface Coating and thin Film Technology

It comprise of all surface treatments and protection against corrosion/general degradation and that of enhancing the mechanical properties of materials. It will include:

- Surface coating eg primer, ceramic/polymer coatings
- Duplex system and electroplating
- Electrodeposition
- Laser technology (steel and nonferrous metals/alloys) with emphasis using polymer and ceramics laser coatings
- Conductive surface coating and performance

- Coat measurement and engineering interaction between base materials and surface protection
- High temperature wear resistant coatings
- Special surface treatment of welded joint against corrosion
- Application of surface technology in oil and gas/marine industry
- Interfacial phenomena in process metallurgy
- Advance optimization

Introduction to basic aspect of phase transformation in metallic alloys: Isomorphous system, entactic, peritectic, congruent, monotectic, syntactic reactions need to be discussed to make the students familiar wih these reactions in equilibrium diagrams.

Phase diagrams: Introduction, Gibbs phase rule (P + F = C+2) binary isomorphous alloys systems, lower rate and examples in practical application. Binary eutectic alloy system, cooling curve, binary peritectic alloy system Fe-Ni, Pt-Ag etc. Phase diagram. For pure water, triple-point temp. Intermediate phases/compounds (Cu-Zn), Al_20_3 – $Si0_2$, Mg Ni systems can be considered. (Pb-Mg)., (Ti-Ni).
Ternary Phase diagrams, the distinction from the binary system and its importance in Metallurgy. Fe – Cr – Ni – Fe, Determination of the compositions of any given alloy in this system.

MMEN 821 – Advanced Phase Transformation

Introduction to basic aspect of phase transformation in metallic alloys: Isomorphous system, entactic, peritectic, congruent, monotectic, syntactic reactions need to be discussed to make the students familiar wih these reactions in equilibrium diagrams.

Phase diagrams: Introduction, Gibbs phase rule (P + F = C+2) binary isomorphous alloys systems, lower rate and examples in practical application. Binary eutectic alloy system, cooling curve, binary peritectic alloy system Fe-Ni, Pt-Ag etc. Phase diagram. For pure water, triple-point temp. Intermediate phases/compounds (Cu-Zn), Al_20_3 – $Si0_2$, Mg Ni systems can be considered. (Pb-Mg)., (Ti-Ni).
Ternary Phase diagrams, the distinction from the binary system and its importance in Metallurgy. Fe – Cr – Ni – Fe, Determination of the compositions of any given alloy in this system.

MMEN 822 – Interfacial Phenomenon in Materials

Introduction: characterization of interface properties- theories of adhesion and types of bonding, physico-chemical characterization of interfaces- measurement of interfaces/interlaminar properties – mechanical properties of fiber – matrix interfaces, inter-laminar/intra-lamina properties, inter-laminar fracture toughness; micromechanics of stress transfer across the interface – fiber fragmentation test. Fiber full out test, fiber push out, cyclic loading in fiber pull out and fiber push out; surface theories; improvement of transverse fracture toughness with interface

control; improvement of interlaminar fracture toughness with interface control. Interfacial reactions in molten steel alloys and welding zones in steel alloys.

MMEN 823 – Advanced Casting and Welding

Casting: Types of risers; cylindrical, spherical, open and closed risers, use of CaC_3 in risers; the use of chills. Core prints, patterns: fluidity as related to equilibrium diagrams e.g. eutectic alloys. Face machines moulding and special casting methods. Finishing operation.

Welding: an overview of important industrial welding processes, selection and applicatios. Weld joints, symbols and design of weldments. Heat distribution and penetration control, welding streses and distribution, weld defects, inspection and quality control. Welding fabrication of a boiler and pressure vessels ships, pipes bridges, offshore structures, aerospace materials, nuclear materials etc. repair and maintenance welding.

MMEN 831 – Fracture Mechanics and Failure Analysis

- Introduction:
- Types of Fracture: Brittle and Ductile fracture
- Fracture Mechanics: Griffith Theory of brittle fracture, Orowan/Irwin Relationship, Strain Energy release rate, Stress concentration, stress intensity factor, fracture toughness and its determination, Dislocation Theories of brittle Fracture, Crack initiation and propagation theories fracture mechanics for ductile materials: plastic zone correction crack – opening displacement, J – Contour integrals, R – curve.
    - metallograpic aspect of fracture - fractography
    - design using fracture mechanics
    - failure of materials in service

Review of Failure due to:

- corrosion
- oxidation
- wear
- creep
- fatigue

Procedure for failure analysis, theoretical and experimental techniques in failure prediction monitoring and analysis, selected case study, case study project.

MMEN 832 – Dislocation Theory

Defects of crystals discovery of dislocations, Description of the dislocation line, prismatic dislocation loop observation of dislocations. The stress field around a dislocation review of Elasticity Theory – Displacement, strain, stress, Linear Elasticity Theory. Equilibrium Equations, Stress and displacement. Field of a dislocation – stationary screw dislocations, stationary edge dislocation, mixed dislocations, Uniformly moving dislocations. Forces on a dislocation, Self-Energy of a dislocation line-strain Energy, Screw dislocation alternative, self-energy calculation, Edge dislocation, mixed dislocation, Energy of a curved dislocation line, line tension; forces on dislocation, forces between dislocations, chemical force on a dislocation. Total force on a dislocation.

Dislocation Reactions in crystals. Dislocation Multiplication, Pile-ups, Dislocation Jogs Pole Mechanism, twinning – Emissary dislocations, stacking fault Tetrahedral. Small angle boundaries, Peierls dislocation–solution hardening. Precipitation and dispersion hardening, work hardening Brillte fracture initiation.