

11. METALLURGY

PAPER - I

1. Mechanical Testing: Cohesion between atoms: bonds, potential energy Vs interatomic distance curves, Fundamentals of crystal structure of metals; tension testing: tensile properties, strain aging, ductile and brittle materials; Erichson cupping test, directionality; torsion test: specimen behaviour under torsion; hardness test: Brinell, Rockwell and Vickers test, relation between hardness and tensile strength, micro hardness testing; creep test: creep curve, stress rupture test; fatigue test: S-N curve, statistical nature, effect of mean stress; impact test: Charpy and Izod test, transition temperature; structures & properties of engineering materials.

2. Metallurgical Thermodynamics: Review of first and second laws of thermodynamics, Maxwell's relations; free energy concept and applications, general strategy of deriving thermodynamic relations; third law of thermodynamics; related problems. Solutions, partial molar properties, Gibbs-Duhem equation, fugacity, activity, equilibrium constant; regular solutions, integration of G-D equation, dilute solutions, interaction parameter; equilibrium in thermodynamic systems, structure of unary phase diagrams in (P,T) space, Clausius -Clapeyron equation, triple point, alternative representation of unary diagrams; Gibbs phase rule, Free energy-composition diagrams, Ellingham diagrams; activation energy, effect of activation energy on reaction rate, chemically controlled reactions (both ideal and non-ideal systems).

3. Physical metallurgy and phase diagrams: Structure of metals, space lattice, unit cells, crystal systems, metallic crystal structures, packing efficiencies, planes and directions, voids, imperfections in crystalline solids, dislocations and plastic deformation, theoretical shear strength, concept of dislocations, types of dislocations, Burgers vector, strain field associated with dislocations, dissociation of dislocations, climb and cross slip, dislocation interactions, plastic deformation by twin, yield point phenomenon, strain ageing, work hardening in single and polycrystalline materials, effect of temperature, composition and grain size on strain hardening, recovery, recrystallisation and grain growth, diffusion in solids, applications of diffusion concepts, solidification of metals, freezing of alloys, Scheil equation dendritic freezing in alloys, freezing of ingots, segregation, homogenization, growth of single crystals. PHASE DIAGRAMS : Types of solid solutions, Hume Rothery rules, intermediate phases, binary isomorphous system; phase rule and lever rule, miscibility gaps, eutectic systems, phase diagrams with intermetallic compounds; monotectics, syntetic, eutectoid, peritectic and peritectoid reactions in binary systems and solidification behaviour of typical alloys in these systems, Fe-Fe₃C phase diagram, other commercially important binary systems.

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4 Mineral dressing and principles of extractive metallurgy: Scope of mineral dressing in metallurgy, crushing and grinding, sampling and particle size analysis. Gravity concentration methods, froth flotation, magnetic and electrical separation cyclones, filters, solids conveyance and storage. Principles of extractive metallurgy: Sources of metals, pyrometallurgical processes, refining processes, hydrometallurgical processes, recovery of metal values from leach solution, electrometallurgical processes, electrorefining and electrowinning. copper: sources of copper, extraction from sulphide ores, refining, newer processes for copper extraction, hydrometallurgy of copper; zinc: sources, pyrometallurgical extraction, hydrometallurgical extraction, recovery of byproducts (cadmium); Imperial Smelting Process (ISP); lead: sources, extraction of lead, lead blast furnace, refining, modern developments in lead smelting, aluminium and magnesium extraction.

5. Fuels & Refractories: Definition & Classification of fuels. Distribution of fuel resources in India, their origin & geological formation. Classification of coal. Various tests for coal for selection of coal for metallurgical processes. Manufacture & testing of coke for various uses. Petroleum, its sources & distillation. Various tests for liquid fuel. Manufacture, uses & analysis of various gaseous fuels. Combustion calculation on solid, liquid & gaseous fuels. Classification & desirable properties of refractories. Testing of refractories. Special refractories. Use of refractories in ferrous & non ferrous industries. Manufacture of various refractories.

PAPER - II

1. Process engineering : Units and dimensions, applications of transport phenomena, properties of fluids, laminar and turbulent fluid flow, Stoke's Law, flow past submerged bodies, flow through packed and fluidized beds, Bernoulli's Equation, dimensional analysis, flow of compressible fluids, Fourier's law, conduction in solids, liquids and gases, concept of heat transfer coefficient; heat transfer, heat transfer in packed and fluidized beds; diffusion in solids, liquids and gases, Knudsen's diffusion, diffusion processing and homogenization of alloys, unsteady state mass transfer, concept of mass transfer coefficient.

2. Production of iron and steel: History of iron making, Evolution of Blast furnace, Distribution of Indian Iron ore, limestone and coking coal deposits, problems associated with Indian raw materials, iron ore beneficiation and agglomeration, theory and practice of sintering and pelletising, testing of burden materials, blast furnace reactions, thermodynamics and kinetics study, recent developments in the design and operation of the blast furnace, irregularities in blast furnace operation and their remedies, blast furnace refractories and instrumentation, blast furnace slag and gas : importance, formation and use. Direct reduction methods, details of some commercial processes like Corex process PRODUCTION OF STEEL : History of steel making, principles of steel making, LD/ BOF, QBOP/OBM, Energy optimising furnace(EOF), Inputs

required in oxygen Steel making, Yields from metallic inputs. Alloy and Stainless steel making, continuous steel making , steel making in induction furnaces, secondary steel making processes , steel degassing processes ,casting pit practice, continuous casting of steel, molds used for continuous casting use of casting powder, electromagnetic stirring , defects in continuous cast product .

3. Heat treatment : Nucleation and growth of austenite, pearlitic transformation, TTT diagrams, formation of martensite, annealing, normalizing, hardening and tempering, hardenability , heat treatment furnaces, austempering , martempering , ausforming ; thermo mechanical treatments; surface hardening of steels; effect of alloying elements on Fe-C diagram, structure and properties of steels; carbon and alloy tool steels, stainless steels, HSLA steels, maraging steels, dual phase steels; cast irons and their heat treatment, aluminium and its alloys .

4. Metal forming and corrosion engineering : Elasticity and plasticity, yield criterion theories of metal forming, hot, warm and cold working, , super plasticity and explosive forming, friction and lubrication in metal working processes, forging, CAD & CAM in forging, extrusion, mannesmann mill, rolling, drawing of rods, wire and tubes, dies, optimum die angle, bulk forming and sheet metal forming, deep drawing, redrawing, limiting draw ratio, role of texture defects in sheet metal working, bending, shearing, rubber pad forming, stretch forming, high energy rate forming, numerical problems and design aspects in forming. **CORROSION ENGINEERING :** Definition of corrosion, corrosion damage, classification of corrosion, electrochemical aspects, electrochemical reactions, mixed potential theory, polarisation, passivity, environmental effects, effect of oxygen and oxidisers, effect of temperature, effects of corrosive concentration, corrosion testing, standard expressions for corrosion rate, galvanic corrosion, erosion corrosion, crevice corrosion, intergranular corrosion, pitting, stress corrosion. Paint tests, sea water tests. Interpretation of results, Corrosion prevention ; cathodic and anodic protection , coatings, high-temperature corrosion .

5. Foundry technology Patterns, sand moulds, moulding processes, special casting process, evaluation and characterization of moulding materials, cores and core materials, mould production, core production, sand compaction, foundry machines, moulding equipments, foundry layouts, mechanization & automation, different types of foundries, solidification, growth structures in pure metals, applications of constitutional super cooling to castings, cast structures, gases & inclusions in castings, segregation, defects related to solidification, design of risers, runner systems and design of runners, elements of casting designs, foundry metallurgy of cast irons, production of S.G. iron and malleable iron, classification of gray cast iron, inoculation practice, ADI, steel foundry practice, melting practice, cupola, induction melting, melting of aluminium and copper alloys.