Course Structure
M. Tech. Mineral Engineering
With effect from Academic Year 2017-18

Department of Fuel and Mineral Engineering
Indian Institute of Technology (ISM) Dhanbad
Dhanbad, Jharkhand, India

April 2017

COURSE STRUCTURE OF M TECH (MINERAL ENGINEERING)
MINERAL ENGINEERING PROGRAMME
w. e. f. 2017-18

I SEMESTER

Sl No	SUBJECT CODE	SUBJECT NAME	L-T-P (Hours per week)	Credit Point
	THEORY			
1	FM C-51101	Coal and Mineral Processing Technology	4-0-0	08
2	FM C-51102	Coal Characterization and Utilization Technology	3-0-0	06
3	FM C-51103	Size Enlargement Processes	3-0-0	06
4	GL C-51101	Geology of Coal and Minerals	3-0-0	06
5	FME 51101 FME-51102 MER-51110	**Elective-I (Any one)** (a) Clean Coal Technology (b) Furnaces & Refractories (c) Mining Practices and Unit Operations (d) Global Elective of student choice	3-0-0	06
	PRACTICALS/PLANT VISIT ETC.			
6	FM C-51201	Coal and Mineral Processing Technology Lab	0-0-3	03
7	FM C-51202	Coal Characterization and Utilization Technology Lab	0- 0-3	03
8	FM C-51401	Seminar	0-0-3	03
9	FM C-51601	Plant Visit	0-0-0	03
		Total	**16-0-9**	**44**

II SEMESTER

Sl No	SUBJECT CODE	SUBJECT NAME	L-T-P (Hours per week)	Credit Point
	THEORY			
1	FM C-52101	Processing Plant Practice	3-0-0	06
2	MM C-52101	Bulk Material Handling Equipment	3-0-0	06
3	FM C-52102	Process Equipment Selection	4-0-0	08
4	FM C-52103	Extractive Metallurgy	3-0-0	06
5	ES R 52101 FM E-52101 FM E-52102	**Elective-II (Any one)** (a) Environmental Aspects (b) Cement Technology (c) Modelling and Simulation (d) Global Elective of student choice	3-0-0	06
	PRACTICALS/PLANT VISIT ETC.			Credit Point
6	FM C-52201	Analytical Technique Lab	0-0-3	03
7	FM C-52411	Seminar	0-0-3	03
8	FM C-52610	Plant Visit	0-0-0	03
9	FM C-52512	Comprehensive Viva- Voce	0-0-0	03
		Total	**16-0-6**	**44**

III SEMESTER

Sl No	SUBJECT CODE	SUBJECT NAME	L-T-P (Hours per week)	Credit Points
1	FM C53901	Industrial Training / Minor Project	0 - 0 - 0	04
2	FM C53402	Seminar & Viva-Voce on Industrial Training	0 - 0 - 0	02
3	FM C53503	Comprehensive Viva-voce	0 - 0 - 0	04
4	FM C53804	Dissertation (Interim)	0 - 0 - 0	15
5	FM C53405	Seminar & Viva-voce on dissertation	0 - 0 - 0	10
6	FM C53006	Teaching Assignment & Evaluation / Lab. Dev. Work etc.	0 - 0 - 0	05
		Total	**0 – 0 – 0**	**40**

IV SEMESTER

Sl No	SUBJECT CODE	SUBJECT NAME	L-T-P (Hours per week)	Credit Point
1	FM C54801	Dissertation	0 - 0 - 0	20
2	FM C54402	Seminar on Dissertation	0 - 0 - 0	05
3	FM C54003	Viva- voce on Dissertation	0 - 0 - 0	10
4	FM C54004	Teaching Assignment & Evaluation Lab. Dev. Work etc.	0 - 0 - 0	05
		Total	**0 – 0 – 0**	**40**

SEMESTER I

FMC 51101 Coal and Mineral Processing Technology 4-0-0

Course objective: To learn beneficiation and processing of coal and minerals.
To get fundamental understanding of operation of industrial coal preparation plants and mineral beneficiation plants.

Course outcome: At the end of the course, the students would be able to understand the construction and operation of crushers and screens used for coal preparation, understand the operation of beneficiation units for coal and mineral.

Course Content:

Module –I

Introduction to Mineral Processing, scope and importance; Basic unit operations, relative merits and demerits of processing of ores. Definitions: ore, mineral, gangue, concentrate, tailing, yield, recovery and ratio of concentration etc. Properties of different minerals relevant to their processing.

Comminution: Fundamentals of size reduction, purpose, liberation of minerals, degree of liberation, comminution laws, different types of crushers (reciprocating, impact, roll, etc.) and grinding mills, their features and application. Grindability indices.

Screening: Measurement of particle size. Introduction to various size separation processes and their importance, types of screens – static and dynamic, screening surfaces and screen efficiency, factors influencing screening, screening surfaces and Screen efficiency.

Classification: Movements of solids in fluid. Free settling, hindered settling, equal settling particles. Reynolds number and its importance. Types of classifiers, their principles and operations.

Module-II

Gravity Separation: Washability testing and applications. Principles, construction, operation, merits and demerits of industrial gravity separators: pneumatic jigs, dense medium baths, dense medium cyclones, spirals, tables, water only cyclones etc. Medium recovery circuits for dense medium separation. Enhanced gravity separation. Comparison between the gravity separators.

Performance evaluation: partition curve, misplacement, probable error in separation, imperfection, yield reduction factor, organic efficiency.

Magnetic and electro-static separation: Principles, different types of magnetic and electrical separators, their features and applications.

Flotation: Fundamentals and practice of flotation, types of reagents and their importance. Critical pH curves. Flotation circuits. Factors affecting flotation performance of coal and minerals.

Dewatering: Thickening, filtration and drying: Principles and practices

Typical flowsheets for preparation of different minerals (fuel, metallic and industrial)

Books:

1. Mineral Processing Technology (B. A. Wills)
2. Introduction to Mineral Processing (Kelly and Spottiswood)
3. Principles of Mineral Dressing (A. M. Gaudin)
4. Coal Preparation (J. W. Leonard)
5. The Coal Handbook: Towards Cleaner Production (D. Osborne)

FMC-51102 Coal Characterization and Utilization Technology 3-0-0

Course objective: The main aim of the course is to give an introduction to the different types of fossil fuels. The emphasis of the course will be on the characterizations and utilizations of solid fuels, basics of liquid and gaseous fuels.

Course outcome: At the end of this course students should able to analyze quality of fuels based on its properties and possible utilizations.

Course content:

Introduction: Introduction to energy resources, Indian perspective, Origin and formation of coal: Different theories on coal formation.

Coal Characterization: Coal, metamorphism, Rank of coal, coal petrography, classification of coal.

Properties and testing of coal: Size analysis, Proximate analysis, Ultimate analysis, Gross calorific value, Net calorific value, Free Swelling Index, Caking Index, Roga Index, LTGK, Dilatometric properties. Estimation of total moisture. Determination of HGI.

Coal Carbonization: Introduction to coal carbonization, Impact of coal constituents on coal carbonization, Behavior of coal at an elevated temperature, Pre carbonization techniques- Top charging, Stamp charging, Blending, Briquetting, Formed coke, Dry and wet quenching of coke.

Types of Carbonization- Low Temperature Carbonization and High Temperature Carbonization, Types of Ovens- Recovery and Non- recovery coke ovens, Flue arrangements. By- products recovery processes, methods of conservation of coking coal. Physical and Chemical properties of coke: Shatter index, Micum index, Coke reactivity index, Coke strength after reaction.

Coal Combustion: Fundamentals of coal combustion, combustion stoichiometry, Flue gas composition.

Coal Gasification: Fundamentals of coal gasification, producer gas, water gas.

Liquid Fuel: Introduction to crude oil and petroleum products.

Gaseous Fuel: Introduction to different types of gaseous fuels.

Books:

1. Fuels and Combustion: Samir Sarkar, University Press (India) Pvt Limited, India.
2. Elements of Fuels, Furnaces and Refractories: O P Gupta, Khanna Publishers, India
3. Fuels, Furnaces and Refractories: R C Gupta, PHI Learning Private Limited, India

FM C-51103 Size Enlargement Processes 3-0-0

Course Objective: The main aim of the course is to give fundamental concept of sintering and pelletization for iron ore fines.

Course outcome: At the end of the course student will be able to understand effective utilization of iron ore fine in blast furnace.

Course Content:

Introduction to different size enlargement processes, necessity and scope of size enlargement. Agglomeration: Fundamental forces of cohesion between particles, surface tension, forces between micro assemblies, pore size distribution, pelletization, sintering and other agglomeration methods – principles, mechanisms, use of additives, effect of induration and assessment of quality of agglomerates, Blaine index.

Pelletization: Raw material preparation, Characteristics of raw materials for pelletization, additives, binders etc.

Green-ball formation, effect of process parameters on size and strength of green-pellets, testing of Green-balls. Drying and firing of Green Balls, testing of indurated pellets like Tumbler-test, Reducibility, Swelling index, Reduction Degradation Index, Compressive strength etc.

Pelletization Equipment - Construction and operation of Disc and Drum-Pelletizers, Different types of pellet-firing system, Shaft-furnace, Grate-system and Grate Kiln System.

Uses of pellets for Blast Furnace and Direct Reduction Iron-making.

Sintering: various raw materials used for production of sinter. Preparation of fuel mix and flux and their effect on the process of sintering. Calculation of charge-components for producing desired quality of sinter to be used in Blast-Furnace for Iron making. Proportioning of Raw-materials, Primary and secondary mixing together with Moistening, Sintering-Mineralogy, its effect on strength of sinter, Productivity of sintering moisture, Control of various parameters for improving quality of product.

Fluxed Pellets and Sinters

Books:

1. Iron Making and Steelmaking: Theory and Practice- Ahindra Ghosh, Amit Chatterjee, PHI Learning Pvt. Ltd., 2008
2. An Introduction to Modern Steel Making- R.H. Tupkary, Khanna publishers
3. Pelletizing of Iron ores – Kurt Meyer, Springer-Verlag 10980

GLC-51101 Geology of Coal and Minerals 3-0-0

Course Objectives: The mail objective of the course is to learn the properties of coal and mineral and its implication on mineral beneficiation.

Course Outcome: At the end of the course, student will be able to understand the mechanism of formation for coal and ore minerals, their distribution in India and beneficiation requirement and strategy of these natural resources.

Course content:

Basics of Ore Geology: Mineral, ore and gangue mineral, Grade, Tenor, co-product and by-products, Ore-gangue relationship in natural condition.
Classification scheme of ore minerals, ore deposit types. Brief introduction on various processes of ore-formation. Depositional controls and textures.

Distribution of some important ore deposits of India.

Introduction to ore microscopy. Various parts and functions of ore-microscope.

Properties of common sulfide, oxide and complex ore minerals, their textures and Para genesis.

Introduction to coal Geology: Origin and formation of coal, different varieties and ranks of coal, geology and distribution of coalfields in India.

Identification of ore minerals by examining the physical and optical properties.

Applications of ore-microscope with special reference to mineral technology and beneficiation. Mineralogical and micro textural characterization of ore minerals for liberation studies.

Book reference:

1. Prasad, U. Economic Geology, CBS Publisher, 319 p.
2. Jansen ML & Bateman AM (1982). Economic mineral deposits. John Willey and Sons.
3. Evans, A. M. (1997) An introduction to Economic Geology and its environment. Blackwell Science.
4. Banerjee, D.K. (1998) Mineral resources of India. Word Press Ltd, 2nd Edition.
5. Craig, J.R and Vaughan, D.J. (1981) Ore Microscopy and Ore petrography. John Wiley & Sons.
6. Robb, L. (2005) Introduction to Ore-Forming Processes. Blackwell Publishing Ltd.

ELECTIVE

FME 51101 Clean Coal Technology 3-0-0

Course objective: The main aim of the course is to give fundamentals concept of efficient way of utilizing coal in different applications with minimum environmental impact.

Course outcome: At the end of the course student will be able to identify various techniques of utilizing coal for cleaner environment.

Course Content:

Introduction to clean coal technology: Coal quality parameters for utilization in thermal power plant, cement, steel and DRI plant. Pre-combustion cleaning, during combustion cleaning, post-combustion cleaning, burning time, unburned carbon estimation and control. Biological and chemical cleaning methods.

Emission control: Fly ash, SO_x and NO_x control strategies during combustion and after combustion. Use of ESP, Cyclones, Filters and settling chambers.

Coal gasification: Gasifying agents: oxygen, air, steam, reactions involved in gasification. Effect of fuel properties on product, blending of fuels. Syn gas, Fuel gas.

Types of gasifiers: Fixed bed, moving bed, fluidized bed, entrained bed etc. Product gas cleaning and energy utilization, removal of H_2S, NH_3, tar, suspended particulate matter.

Other technologies: Underground coal gasification (UCG), Coal bed methane, recovery methane from CBM (Coal Bed Methane), CMM (Coal Mine Methane), AMM (Abandoned Mine Methane), combined cycle power generation (IGCC), oxy-fuel combustion.

Books:

1. Clean Coal Engineering Technology: Bruce G Miller, Elsevier Publications.

2. Fuels and Combustion: Samir Sarkar, University Press (India) Pvt Limited, India.

3. The Chemistry and Technology of Coal: James G Speight, Marcel Dekker.

FM E 51102 FURNACES & REFRACTORIES 3-0-0

Course objective: The main aim of the course is to give detailed information about operations of industrial furnaces, role of refractories in furnace, fabrication and characterization of refractories.

Course outcome: At the end of the course student will be able to identify the refractory properties required for efficient operations of furnaces.

COURSE CONTENTS

Types of furnaces and classification, industrial application of furnaces, design and construction aspects of furnaces. Chimney design, process efficiency. Fundamentals of heat transfer, heat loss, thermal efficiency of furnace, fuel economy, excess air, waste heat recovery etc.

Refractories: refractory material and characterization, types of Refractories and their application in boilers and furnace construction. Properties and testing methods of Refractories. Manufacture of fire bricks, basic, acidic and neutral refractories, refractory mortars, cements and monoliths, special refractory and ceramics. Role of refractories in energy conservation.

Books:

1. Elements of Fuels, Furnaces and Refractories: O P Gupta, Khanna Publishers, India
2. Fuels, Furnaces and Refractories: R C Gupta, PHI Learning Private Limited, India

MER 51110 Mining Practices and Unit Operations 3-0-0

Course Objective: The main aim of the course is to give the fundamental unit operations in mining.

Course outcome: At the end of the course student will be able to understand the methods of mining.

Course Content:

Surface mining

Introduction; Mine Development; Unit operations; mine systems and mine equipment; Methods of working for sub-surface and hilly deposits; Waste dump formation.

Underground coal mining

Introduction; classifications and selection of mining methods; Bord & Pillar development layouts and extraction methods; Longwall mining; Stowing in underground coalmines; Mine ventilation.

Underground Metal Mining

Introduction; classification and selection of underground metal mining methods; Development layout and extraction for open stope; cut and fill; Shrinkage stoping and sub-level caving.

Books:

1. Elements of Mining Technology by D. J. Deshmukh
2. Introductory Mining Engineering, 2ed by Hartmann
3. Principles and Practices of Modern Coal Mining by R.D. Singh
4. Conventional Methods of Coal Mining by Boda Ramesh
5. Mechanized Methods of Coal Mining by N. Sampath Kumar

FMC 51201 Coal and Mineral Processing Technology Lab 0-0-3

Particle size distribution, dry and wet sieving, estimation of reduction ratios of Jaw and Roll crushers. Crushing of coal and ores. Determination of critical speed and bond work index. Performance analysis of laboratory screens. Washability analysis. Performance of Mozely mineral separator for gravity concentration, effect of water flow rate, angle of inclination and amplitude. Performance analysis of laboratory Jig. Determination of magnetic content of a sample using Davis tube magnetic separator, Separation of magnetic and non-magnetic particles with low and high intensity magnetic separators. Separation of particles using Wilfley Table. Calculation of probable errors and imperfection in separation. Flotation of coal, sulphides, Selective flotation of complex sulphides, flotation of chalcopyrite. Flotation of lime stone/dolominte and reverse flotation of silica. Effect of various parameters such as reagent dosage, pH, pulp density etc., on flotation.

FMC-51202 Coal Characterization and Utilization Technology Lab 0-0-3

Sampling of coal, Proximate analysis of coal, Ultimate analysis of coal, HGI of coal, Free Swelling Index of coal, Determination of Calorific Value of coal, Caking Index of coal, LTGK of coal.

SEMESTER II

FMC 52101 Processing Plant Practices 3-0-0

Course Objective: The main aim of the course is to give a knowledge of coal and mineral processing plant practices.

Course outcome: At the end of the course student will be able to design and operate different coal and mineral processing plant

Course Content:

Introduction to various processing plant practices: Gravity separation, Flotation, Magnetic separation, Electrical separation, leaching, etc.
Fundamental concepts of a processing plant design.
Plant practices by gravity methods: Jigging, Spirals concentration, Tabling, etc.
Plant practices by surface phenomena: Froth flotation, Flocculation, etc.
Plant practices by magnetic and electrical phenomena.
Industrial plant practices for the beneficiation of minerals such as: Lead, Zinc, Copper, Iron, Uranium, Industrial minerals etc.
Troubleshooting of common mineral/coal processing plant problems.

Books:

1. Mineral Processing Plant Design, Practice, and Control: by Andrew L. Mular, Doug N. Halbe, Derek J. Barratt

MMC 52101 Bulk Material Handling Equipment 3-0-0

Course objective: The objective of this course is to provide fundamental knowledge about different types of heavy equipment's, their design and operation and maintenance used in fuel industries.

Course outcome: after attending the course students will be able to understand design and regular maintenance activity of various heavy equipment's used in fuel industries.

Course Content:

Properties of bulk material sand their handle-ability; Construction and operation of crushers-jaw, gyratory, cone, roll, hammer, ring granulator, feeder breaker, rotary breaker, in-pit crushers.

Construction and operation of feeders, screens, conventional belt conveyors, high angle conveyors, cable belt conveyor, chain conveyors, stackers, reclaimers, wagon loaders, wagon tipplers, bucket elevators, bins, bunkers, silos, selection, productivity and power calculations.

Books:

1. Materials Handling Equipment, MP Alexand Rov, MIR Publishers.
2. Good year hand book of belting, conveyor and elevator
3. Pneumatic Conveying; H. A. Stoess; John Wiley & Sons

FM C-52102 Process Equipment Selection 4-0-0

Course Objective: The objective of this course is to give the concept of equipment selection.

Course outcome: At the end of the course student will be able to select an equipment for a particular process.

Course Content:

Basic concept of equipment selection, Selection and sizing of crushers and grinding mills and screens. Outline of selection of classifiers and concentrations equipments (gravity, magnetic, electrostatic and flotation), Estimation of number and size of flotation cells for minerals and coal. Through put calculations for process unit operation, safety and statutory obligations.

Books:

- A.Gupta and D.S.Yan: Introduction to Mineral Processing Design and Operation.
- Barry A. Wills, Tim Napier-Munn: Mineral Processing Technology.
- E. G. Kelly, D. J. Spottiswood: Introduction to Mineral Processing.

FM C-52103 Extractive Metallurgy 3-0-0

Course Objective: The objective of this course is to provide the principle of extraction of metal from its ores.

Course outcome: At the end of the course student will be able to learn raw material preparation for extraction of non-ferrous metal, iron making and steel making.

Course Content:

Extraction of non-ferrous metals: Raw material preparation, processing parameters, extraction and refining of the following metals – aluminium, copper, nickel, zinc, lead, titanium, magnesium, uranium silver and gold. Properties and uses of above metals and their alloys for industrial applications.

Brief introduction to extractive metallurgy, Ferrous Extractive Metallurgy: Iron making- raw material preparation, Blast furnace iron making, slag metal reactions, irregularities and remedies. S-R processes.

Steelmaking- Principles and different methods of steel making process such as BOP, BOH and Electric arc.

Books:

1. Ahindra Ghosh, Amit Chatterjee, Iron Making and Steelmaking: Theory and Practice, PHI Learning Pvt. Ltd., 2008
2. S. Venkatachalam, Hydrometallurgy, Narosa Publishing House, 1998
3. An Introduction to Modern Steel Making, R.H. Tupkary, Khanna publishers

4. H.S. Ray, R. Shreedhar and K.P. Abraham- Extraction of non-ferrous metals- affiliated East West press pvt. Ltd, Oscar Publications, New Delhi,2011.
5. R D Pehlke, Unit Processes in Extractive Metallurgy- American Elsevier pub.Co.,Mishigan, 1973.
6. J. D. Gilchrist- Extractive metallurgy- Pergamon Press, 1989.
7. W. G. Davenport, M. King, M. Schlesinger, A. K. Bishwas and - Extractive metallurgy of Copper, 4th ed., Pergamon Press, 2002.

ELECTIVE

ESE-52104 Environmental Aspects 3-0-0

Course objective: The aim of this course is to provide fundamentals knowledge about environmental protection during mining, processing and utilization of fossil fuels and well as various minerals.

Course outcome: After attending the course, students will be able to understand various reasons for environmental pollution and its preventive techniques in fuel processing industries.

Course Content:

Introduction: Sustainable development, environmental carrying capacity concepts & principles; Environmental impacts of mining and associated activities.

Ecology: Introduction to ecology, ecosystem structures and functions.

Air pollution: Atmospheric composition and meteorology; sources of air pollution, point and non-point; emission factors; control measures, extraction, suppression and consolidation of dust.

Noise and vibration: Basic concepts, sources, monitoring and control measures.

Water pollution: Global hydrological cycle; Self-purification mechanism, sources of water pollution, important parameters–pH, turbidity, oil & grease, nitrates, DO, BOD, COD; Eutrophication, deoxygenation, acid mine drainage and heavy metal pollution– preventive and control measures.

Land environment: Land degradation due to mining; Physical and biological reclamation.

Environmental administration: Laws related to mining environment; EIA of mining projects.

Land Acquisition & Revenue: Concepts: Related laws and regulations.

Corporate Social Responsibility: Concepts and principles.

Mine and Plant closure: Concepts and principles.

Books:

1. Water Resources Engineering - LW Mays, Wiley Text Books, 2000.
2. Environmental Engineering- HS Peavy, RR Donald, G Tchobanoglous, MGH Int. Ed. NY, 1985.
3. Environmental Engineering - AP Sincero and GA Sincero, Prentice Hall of India, 1999.
4. Environmental Impact of Mining - CG Down & J Stocks, Applied Sc. Pub, London, 1978.

5. Environmental Impacts of Mining: Monitoring, Restoration and Control – M Sengupta, Lewis Publishers, Boca Raton, 1993.

FME-52101 Cement Technology 3-0-0

Course objective: The aim of this course is to provide fundamental knowledge about cement manufacturing processes and utilization of different types of fuels in cement manufacturing.

Course outcome: After attending the course students will be able to understand cement manufacturing process and role of various fuels in cement manufacturing.

Course Content:

Various processes of cement manufacture – dry, semi-dry and wet, overview of various unit operations. Indian cement industry, the global scenario.
Phase composition of clinker minerals and cement, pozzolanic reaction, hydration of cement, Raw mix proportioning, 2-, 3- and 4-component mixes, concepts of burn ability, absorption and effect of coal ash Different zones in a cement kiln, preheaters and precalcinators.
Coolers, burners, fuels, waste-derived fuels, Pet coke, refractory and refractory practices.
Approaches to energy conservation, energy audits, co-generation of power, Pollution control, noise abatement, concepts of LCA. EIA and EMP.

Books:
1. Chemistry of Cement and Concrete: F M Lea, Arnold, London
2. Cement Data Book: W. H Duda , Verlag G m Bh, Berlin, R. H. Bouge.
3. Chemistry of Portland Cement, Reinhold, New York

FME-52102 Modelling and Simulation 3-0-0

Course objective: The main aim of the course is to give information about modelling and simulations techniques used in various mineral and coal washeries.

Course outcome: At the end of the course, student will be able to optimizes the processes and theoretically analyze energy efficiency.

Course Content:

Introduction to the concept of mathematical modeling and simulations concepts of distribution, population balance models. Modeling of some mineral engineering systems - crushing, grinding, hydro cyclones, heavy media separation, Jigs, Tables, flotation, oil agglomeration and pelletization. Simulation of plant flow sheets.

Books:

1. R. Peter King, Modeling and Simulation of Mineral Processing Systems, Butterworth-Heinemann, 2001
2. E. G. Kelly, D. J. Spottiswood, Introduction to Mineral Processing, Butterworth-Heinemann, 1982
3. A. M. Gaudin, Principles of Mineral Dressing, Tata McGraw-Hill, 1980

LAB

FMC-52201 Analytical Technique Lab 0-0-3

Demonstration to different methods analytical techniques i.e. AAS, DTA/TGA, XRD, SEM, TEM etc. for qualitative and quantitative analysis

Chemical analysis of hematite/magnetite/chromite/goethite etc. for estimation of Fe, Mn, Al_2O_3, SiO_2, LOI and other elements.

Chemical analysis of limestone/magnesite/dolomite by volumetric/gravimetric methods Estimation of CaO, MgO, Fe, Al_2O_3, SiO_2, LOI in their respective minerals.

Chemical analysis of Copper, Lead, Zinc, Sulphide ore for estimation of Cu, Pb, Zn, Fe, Al_2O_3, SiO_2, LOI and other elements by volumetric /instruments methods.