Materials Science and Engineering
MET E 464 Metallurgical Engineering
Extractive Process Analysis (3 Credits)

Catalog Description:
Extractive processes analyzed by the methods of material and energy balances, computational thermodynamics, process kinetics and reactor theory.
Introduction to process optimization. Offered: Sp

Prerequisites: MSE 322 or equivalent.

Textbooks and other required materials:
The textbook, "Process Principles in Minerals & Materials production," by P. C. Hayes (Hayes Publishing Co., 52 Dewar Terrance, Sherwood, Queensland, Australia 4075) published in 1993 is required. The recommended references include: "Blast Furnace – Theory and Practice, Vols. 1 & 2," edited by J. H. Strassburger (Gordon and Breach, New York, 1969) and "Stoichiometry and Thermodynamics of Metallurgical Processes," by Y. K. Rao (Cambridge University Press, 1985).

Course objectives: Students will be able to

1. Describe mineral beneficiation and environmental protection: Crushing, grinding, flotation, tailings disposal.
2. Describe the raw materials for iron and steel.
3. Analyze blast furnace process for iron making: Coke requirements and potential substitutes (powered coal, oil, natural gas)
4. Describe the sulfur-problem: External desulfurization of hot metal.
5. Describe basic oxygen steel making: Capture of fine particulates from gases.
6. Analyze continuous Casting of steel; electric furnace-steel making from scrap.
7. Calculate energy and fuel consumption in metal extraction.
8. Describe sulfide smelting: copper, nickel, lead and zinc.
9. Analyze hydrometallurgical extraction: dump and heap leaching of copper and solvent extraction followed by electrowinning.
10. Describe fused-salt electrolysis: aluminum by Hall-Heroult cell: manufacture of magnesium and sodium.
11. Analyze zinc electrowinning from aqueous leach solutions: hydrogen over-potential.
12. Evaluate plant location and economic factors.
13. Recommend equipment selection; optimization by the Lagrangian undetermined multipliers.

Topics Covered:

Material and Energy balances in metallurgical processes
- Stoichiometry
- Conservation of mass
- Material balances of typical reactors
- First-law analysis – energy consumption.

Fuels and Combustion
- Coal resources, coal classification, and coal usage
- Oil and natural gas

Gasification and combustion'
Process analysis
Flame-temperature (adiabatic) and available heat in blast furnace
Thermodynamic and kinetic analysis
Second-law treatment of processes
Thermodynamic efficiency of metallurgical processes
Rate phenomena
Pre-diffusion and reducibility of prepared feed (pellets)
Reaction kinetics in the cementation of copper from leach solution
Process design
Algorithm for calcinations reactor
Algorithm for available heat
Plant location and process economics
Resource availability and environmental constraints
Optimization
Rate of return on investment: factors considered include choice of the process-route and capital costs.

Class schedule:
Three, one-hour lectures weekly
Quiz sections: None

Contribution of the course to meeting the professional component:
The course focuses on the exploitation of natural mineral resources with extraction and refining of metals as the principal objectives: students learn of the complexities entailed – availability of raw materials, environmental impacts and economic constraints. The course emphasizes application of the accumulated knowledge in addressing practical problems; such may include those that often arise from public reaction to actual or perceived threat to the environment emanating from the metal-extraction activities.

Contribution of course to program objectives:
This senior-level course prepares the student for a career in the metal extraction industry. Its scope is large as it encompasses both ferrous and nonferrous aspects, pyrometallurgical as well as hydro-and electro-metallurgical processes. The course is one of few that train the student in the application of FORTRAN algorithms to process analysis and process improvement. It fills a vital need in the program.

Prepared by: Y. K. Rao, Professor, October 16, 2000