ABSTRACT

An evolutionary multi-objective optimization framework is evolved to model the extraction process of manganese from lean manganese bearing resources. The primary objective of this thesis is to develop a generic flowsheet and to come up with a data driven modeling approach for this purpose. Flowsheets developed for processing low grade manganese ores, such as Polymetallic Sea nodules, via various processing routes are optimized using an Evolutionary Multi-objective strategy. The work also aims to provide a considerable insight towards understanding of the leaching processes pertinent to manganese extraction.

To analyze and optimize the process flowsheets for treatment of low grade manganese ores, two hydrometallurgical routes based upon ammoniacal and acid leaching in presence of reducing agents are taken up. The analyses suggested that of particular significance is the grade of the ore being treated, the energy consumed and the associated costs, options for byproduct recovery, and the relative price of the products. A process scheme has been optimized here for simultaneously maximizing the metal throughput and minimizing the direct operating costs incurred within constraints set for the operating variables. This leads to a multi-objective optimization problem, which has been conducted during this study for the leaching of polymetallic nodules.

To analyze the nonlinear kinetics of the leaching reaction of lean manganese bearing ores, an analytical model is developed along with a number of data driven models. Terrestrial lean manganese ores need to be processed

in acidic medium in presence of reducing agents like glucose, lactose and sucrose, in order to extract manganese values from them. In this study data driven models based on Neural Network and Genetic Programming are compared for two different categories of manganese ores leached in sulphuric acid medium. A Predator-prey Genetic Algorithm approach developed for this purpose is pitted against a number of other established evolutionary techniques, in addition to a commercial software. A leaching model is evolved using the fitted leaching parameters from different data driven models and is thoroughly tested for the goodness of fit against the experimental data. The strategy adopted, once again, is generic in nature and the framework can be extended for any kind of hydrometallurgical process flowsheeting.

Keywords: Lean manganese ores, polymetallic sea nodules, process flowsheeting, sequential modular approach, split fraction, evolutionary neural network, Genetic Programming, evolutionary algorithm, genetic algorithms