OPEN PIT MINE SCHEDULING BASED ON FUNDAMENTAL TREE ALGORITHM

BY

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ABSTRACT

Long-term production scheduling design is a very important part of mining because it determines the economic outcome of a project. It is a very complex and difficult problem basically due to its large scale. Much effort has been devoted to solving the optimum pit scheduling problem, but there has been no success in developing a scheduling method to give optimum results in maximizing net present value of a mining project.

It is already known that the optimum result for the scheduling problem can be obtained using a mathematical programming method such as Mixed Integer Programming. However, it is not possible to formulate the scheduling problem as a mathematical programming model since the number of variables required for the mathematical model is too great to be solved by today's available computer technology. Therefore, a methodology is required to combine, or aggregate, the mining blocks and to decrease the number of variables in scheduling without losing the optimality. Therefore, fundamental tree concept is introduced in this thesis research to combine the blocks.

A fundamental tree is defined as any combination of blocks such that:

1. the blocks can be profitably mined,
2. the blocks obey the slope constraints and,
3. there is no proper subset of the chosen blocks that meets 1 and 2.

Linear Programming (LP) formulation is developed as a mathematical model to find a set of fundamental trees that exist for a deposit. Since the blocks are combined to form the fundamental trees, the number of variables required for the scheduling model is decreased significantly. This decrease in the number of variables makes it possible to mathematically formulate the scheduling problem.

Mixed Integer Programming (MIP) formulation is further developed to determine the yearly mine schedule from the fundamental trees. The material scheduled for each year is constrained to have the attributes of a real mine operation such as mine production capacity, processing mill capacity, grade of ore, etc.

The fundamental tree mathematical programming model is applied to a multi-mineral copper deposit in Peru, South America. The mine is scheduled to meet yearly production requirements using fundamental trees such that net present values (NPV) of the cash flows are maximized.

NPVs of annual after-tax cash flows are generated based on the schedule provided by the "Fundamental Tree Algorithm" developed in this research.

The deposit is also scheduled using three of the computer packages available to the mining industry. These are Mintec's M821V, Earthwork's NPV Scheduler, and Whittle's Milava open pit mine schedulers.

The results obtained in this study indicate that CSM-LP Scheduler gives the highest NPV among alternatives.

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