BREAK-EVEN ANALYSIS OF MINING PROJECT

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS FOR THE DEGREE OF

BACHELOR OF TECHNOLOGY

IN

MINING ENGINEERING

By

FARAZ AHAMAD (10605034)

HEMANT KUMAR CHAUHAN (10605037)

Under the Guidance of

Prof. B. K. Pal

DEPARTMENT OF MINING ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

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COTENTS

National Institute of Technology
Rourkela

C E R T I F I C A T E

This is to certify that the thesis entitled **"Break Even Analysis of mining projects"** submitted by **Sri Faraz Ahmad** and **Sri Hemant Kumar Chauhan** in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Mining Engineering at the National Institute of Technology, Rourkela is an authentic work carried out by them under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any Degree or Diploma.

Date:

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My heart pulsates with the thrill for tendering gratitude to those persons who helped me in completion of the project.

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DATE:

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LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The economics of the resources industry are unique. All mining is subject to uncertainties not applicable to other industries. Every mine is different. Industry economics are difficult to quantify and categorize. Information is very costly.

In major mining countries, there is now a real dichotomy. The products of the minerals industry are essential primary ingredients in almost everything used in an advanced society, yet their availability is often taken for granted. In the developed world, the value of mining is increasingly being called into question. The difficulty in making profits is compounded by political uncertainties and environmental restrictions on top of the uncertainties created by nature.

Costing and evaluation of any mining development are necessarily based on a specific plan, which has to be prepared assuming certain ore body characteristics. However ore bodies are seldom clearly defined, and the effort to find and delineate them is itself an economically significant task. The economics of mining will determine what parts are or are not included in the definition of ore. When mine economics change, the amount of material in the ground does not change, but the amount of economically viable ore does change. The amount of economically viable ore is also dependent on the assumptions used for its calculation and can change with a change in assumptions.

The break-even point for a product is the point where total revenue received equals the total costs associated with the sale of the product. It has certain assumptions such as, selling prices will remain constant at all sales level, there is a linear relationship between sales volume and costs and production and sales quantities are equal. At the same time it suffers from certain limitations as break-even analysis is only a supply side (*i.e.* costs only) analysis, as it tells you nothing about what sales are actually likely to be for the product at these various prices.

CHAPTER: 01

INTRODUCTION

In our present day economy, finance is defined as the provision of money at the time when needed. Very enterprise, whether big, medium or small needs finance to carry on its operations to achieve its target. Engineering economics deals with the methods that enable one to take decision towards minimizing cost and maximizing benefits to business organization. Finance lies at the root of economic activity. Financial decision includes following sub-parts:

(i) <u>Investment decision</u>

The investment decision which is also known as capital budgeting is concerned with selection of an investment proposal and investment of fund in the selected proposal. Only those proposals are selected that assure higher return than required rate. Long term investment decisions may be both internal and external. In the former the firm has to decide which capital expenditure projects have to be undertaken the amount of funds to be committed and the ways in which the funds are to be allocated among different investment outlets. In the latter, the finance manager is concerned with the investment of funds outside business for merger with or acquisition of another firm. This is very important in the sense mergers and acquisition provide the firm an opportunity for fast expansion.

(ii) Working capital decision

The working capital decision takes into account the management of current assets and current liabilities. The management of current involves a couple of issues. The firm can maintain a current level of operation with a smaller size of current assets that may raise profitability; however danger of illiquidity then looms large. On the other hand, a large investment in current asset may ensure sufficient liquidity but the profitability may tend to decline.

The second issue is related to the share of current liability in total liabilities. This is because current assets are financed by a mix of long term capital and short term capital.

(iii) Financing decision

The financing decision is concerned with the raising of funds that finance assets. Funds should be adequate to procure the assets necessary for operation, at the same time if the funds are more than required, the excess would remain unutilized making no contribution to output but adding to the financing cost.

The major sources of long term capital are shares and debentures also in the form of loans and leases.

(iv) Dividend decision

A part of profit is distributed as dividend and the rest is retained with the firm for the purpose of investment. It is the dividend decision that helps determine how much of profit is distributed as dividend and how much is retained with the firm.

Factors influencing financial decisions:

1. Microeconomic factors
   - (i) Nature and the size of enterprise
   - (ii) Level of risk
   - (iii) Liquidity position
   - (iv) Asset structure and pattern of ownership
2. Macroeconomic factors
   - (i) The state of economy
   - (ii) Government policy

CHAPTER: 02

LITERATURE REVIEW

As per Introductory Mining Engineering by **Hartman Howard L**. costs incurred during different stages of mining are as follows:

2.1 EXPLORATION COST

Approximate costs for geologic prospecting and exploration are as follows.

2.1.1 AIR

Table 2.1 Cost for Aerial Survey

Aerial photography	Rs.1000-2500 /km^2
Photo interpretation	Rs. 1500-2750/ km^2
Total	Rs.2500-5250/km^2

2.1.2 GROUND

Table 2.2 Cost for Ground Survey

Geologic field work	Rs. 30,500-12,000/km^2

2.1.3 GEOPHYSICS

Geophysical survey costs, per km, are given in Table 2.3 for all methods. Additional air and ground costs for several methods are as follows:

Table 2.3 Cost for Geo-Physical Survey

	AIR	GROUND
Gravitational	N/A	Rs. 12,500-40,000/km
Electrical-IP	N/A	Rs. 1500-2750/km
Magnetic	Rs. 750-2000/km	Rs. 5000-6500/km

Electromagnetic	Rs.750-2000/km	Rs. 3250-6500/km
Radiometric	Rs. 1000-3250km	-

2.1.4 GEOCHEMICAL PROSPECTING

Table 2.4 Cost of Geochemical Prospecting

Water	Rs.1000-2000 /km^2
Soil	Rs. 25,000-125,000/km^2
Analytical determinations	Rs.200-500/sample

2.1.5 BOREHOLE LOGGING

Geophysical logging of drill holes, like drilling itself is often contracted out.

Table 2.5 Cost of Borehole Logging

Electromagnetic	Rs. 75-250/m
Electrical	Rs. 75-325/m
Radiometric	Rs. 35-75/m

2.2 DRILLING AND EXCAVATION COST

Drilling costs vary with hole depth, rock conditions, number of holes and footage drilled, terrain, location and the skill of the driller. For estimation purpose, the following unit cost ranges may be helpful.

TABLE 2.6 Different Drilling Types and Costs

Diamond drilling	Rs.1500-4000/m
Rotary drilling	Rs 1000-2500/m
Percussion drilling	Rs 750-4500/m

By comparison, excavation of small underground exploration opening costs approximately as follows.

Table 2.7 Cost of Excavation

Shaft sinking	Rs. 5000/m
Adit or drift driving	Rs. 1500/m

2.3 SURFACE VS. UNDERGROUND MINING COSTS

Inherently it is assumed underground mining costs to exceed surface mining costs. We now need to examine that premise to analyze the key elements of costs in each case, and to compare typical costs for similar circumstances.

Reasons cited for the alleged cost effectiveness of surface mining, based on hard rock industry. They include larger equipment, lower labor intensity, simpler development, higher energy efficiency, and less expensive auxiliary operations (ground control, ventilation, supplies etc). The analysis of unit operating-costs shows that for similar ore body configuration and comparable production rates, the major item of difference is labor. Aerials and supply costs (I.e. for explosives spare parts, fuels etc.) differ some – about 50% more- but labor costs are five times higher in underground mining. To reflect this in approximating mining costs, use a lower labor productivity and lower ratio of labor to operating cost.

Continuing this analysis, using a relative cost basis it estimates operating, capital, and overall unit costs for comparable but hypothetical surface and underground mines. This time operating cost was investigated on a unit operation basis. Surprisingly costs for the production operations differ little: rock breakage and loading are lower but haulage is higher in surface mining (the latter because surface truck on a steep grade is more expensive than underground conveyor or rail haulage on a flat grade, plus hoisting). The major difference is for auxiliary operations and development work which are many times costlier underground. Comparing unit operation costs for the two categories demonstrates that underground mining typically is over twice as expensive as surface mining.

Capital costs are also higher for underground than surface mining. Here two different production rates are selected; the higher rate is some 25% more cost effective in both cases. Capital expenses broken down into equipment purchase price and utilities and facilities (higher interest accrues for the underground investment because of the greater cost and longer time frame). The result is a unit capital cost that is five times higher for underground than surface mining.

2.3.1 MINING METHOD COSTS

It is the absolute costs, of course, which provides the best measure for an economic analysis or comparison of mining methods. A survey of the literature provides us an overview of these values, keeping in mind that costs have to be referenced by date because of inflation. One approach to estimating overall costs is to total item or elemental costs, such as labor, power, explosives, and supplies. The largest and most important of these is labor cost, often expressed in units of productivity; the following are rank-ordered for principal methods, other than the coal methods (units are tons,. or tones, of run-of-mine material per face employee-shift):

Table 2.8 Production in Different System of Mining Per Shift

METHOD OF MINING	Tones/shift
Open cast mining (coal)	500-1000
Open pit mining	100-400
Long wall mining (coal)	75-180
Room and pillar mining (coal)	30-180
Stope and pillar mining	30-50
Sublevel caving	20-40
Block caving	15-40
Sublevel stoping	15-30
Shrinkage stoping	5-10
Square set stoping	1-3
cut and fill stoping	10-20

For approximate explosives consumption with the various methods, the values (as powder factor in lb/ton, or kg/tone) listed below are useful

Table 2.9 Explosive Consumption for Different Methods

MINING METHODS	POWDER FACTOR
Open pit mining	0.1-1.0
Open cast mining	0.2-0.5
Block caving	0.1-0.2
Square set stoping	0.3-1.1
Sublevel stoping	0.3-0.6
cut and fill stoping	0.5-1.2
Sublevel stoping	0.6-0.8

The same source lists timber consumption for different underground methods (of less importance because of the profusion of ground control methods in use today). Other materials and supply costs are computed for a particular mining method from manufacturer's price list, as are equipment costs. Energy costs are based on total rated machinery power, load factor, time of usage, and unit energy charge for a given method.

Overall mining costs for the various methods have been estimated or recorded by numerous authors. Unfortunately, cost data rapidly become obsolete or unreliable, even when adjusted for inflation. Further, they are often incomplete, omitting certain methods, or computed on different bases.

Not as precise measures of mining costs but only as indicators of absolute cost ranges, the information in table is presented for the traditional methods, with relative costs for comparisons. Data are estimated for current conditions. Values are overall (direct plus indirect) mining costs, including prospecting, exploration, development and exploitation, but excluding other costs (processing, transportation, taxes, royalties, etc)

2.4 BUDGETING AND COST CONTROL

The nomenclature and procedure employed in budgeting is prerequisite to an understanding of cost estimation and cost control. Some of the general terminology has been adopted in our cost examples, but acquaintance with more of the details of the mine budgeting will assist us in analyzing mine costs.

Table complies the elements of a typical budget, this for a mine. Customary cost categories, broken down in direct and indirect mining and other production costs, are tabulated for as many costs-profit centers as desired and can be isolated. In this case, there are four: mine development, mine exploitation, underground auxiliary and surface auxiliary. The cost of equipment identified for each centre is on an ownership and operating basis. Detailed cost entries are shown for consumables, power and special items. An entire mine budget would itemize all these costs for each centre in a complete computerized tabulation, usually on both a total and unit cost basis, for the period under consideration. Thus actual increased costs can be compared with forecast budget costs and other cost estimates to provide the epitome in cost control.

Table 2.10 Mine Budget Format

		Cost items	
Cost category	**Mining unit development (entry driving).**	**Underground auxiliary operations.**	**Surface auxiliary operations.**
Direct/ ownership cost	**Equipment**	**Equipment**	**Equipment**
Purchase depreciation	Continuous miner	Locomotives	Shaft hoist
Interest charge	Shuttle cars	Mine cars	Slope belt
Insurance, tax, etc	Roof drill	Jeeps, cars	Bins, hoppers
Equipment lease	Scoop tram	Main conveyor	Feeders

Equipment rental	feeder	Roof drill	Trucks, cars
Total ownership	Section conveyor	Scoop trams	Main fan
		Cages	Monitoring system
Direct/operating cost	**Consumable supplies**	Face fans	Buildings
Repairs, maintenance	Roof bolts	Pumps	Other structures
Consumable supplies	Timber		Waste disposal
Fuel, power	Rock dust	**Consumable supplies**	
Lubrication, hydraulics	Brattice cloth, tubing	Track	**Consumable supplies**
Labor, benefits	Miner bits	Conveyor belt	Plant supplies
Special	Drill bits	Timber, trusses	Office supplies
Total operating	Hand tools	Roof bolts	Safety supplies, clothing
Total exploitation	Miscellaneous	Concrete blocks	Training materials
		pipe	Miscellaneous
Other mining costs	**Fuel power**	Rock dust	
Prospecting	Diesel fuel	Hand tools	**Fuel, power**
Exploration	Electricity	Miscellaneous	Gasoline, diesel fuel
Development	Water		Electricity
Total other		**Fuel, power**	Natural gas
	Special	Electricity	Water

Indirect cost	Freight	Water	Telephone
Administration	Travel	Compressed air	
Clerical support	Entertainment		**Special**
Engineering		**Special**	Freight
Computing		Freight	Travel
consultants		Travel	Entertainment
Total indirect		Entertainment	
Total mining			

Other production costs.

Reclamation (post mining)

Processing

Transportation

Union welfare

Royalties

Taxes

Total other

Grand total expense

As per Financial Management by **Khan M.Y.** and **Jain P.K** different methods of capital budgeting is as follows:

2.5 CAPITAL BUDGETING: METHODS OF APPRISAL

The capital budgeting decisions pertain to fixed assets or long term assets which by definition refer to assets which are in operation, and yield a return over a period of time, usually exceeding one year. System of capital budgeting is employed to evaluate expenditure decisions which involve current outlays but are likely to produce benefits. Basic features of capital budgeting:

(i) Potentially large anticipated benefits
(ii) A relatively high degree of risk
(iii) A relatively long time period between the initial outlay and anticipated return.

Importance of capital budgeting:

(i) Capital budgeting decision determines the future destiny of the company.
(ii) A capital expenditure decision has its effect over a long time span and inevitably affects the company's future cost structure.
(iii) Capital investment decisions, once made are not easily reversible without much financial loss to the firm.
(iv) Capital investment involves coast and the majority of firms have scarce capital resources. This underlines the need for thoughtful investment decision

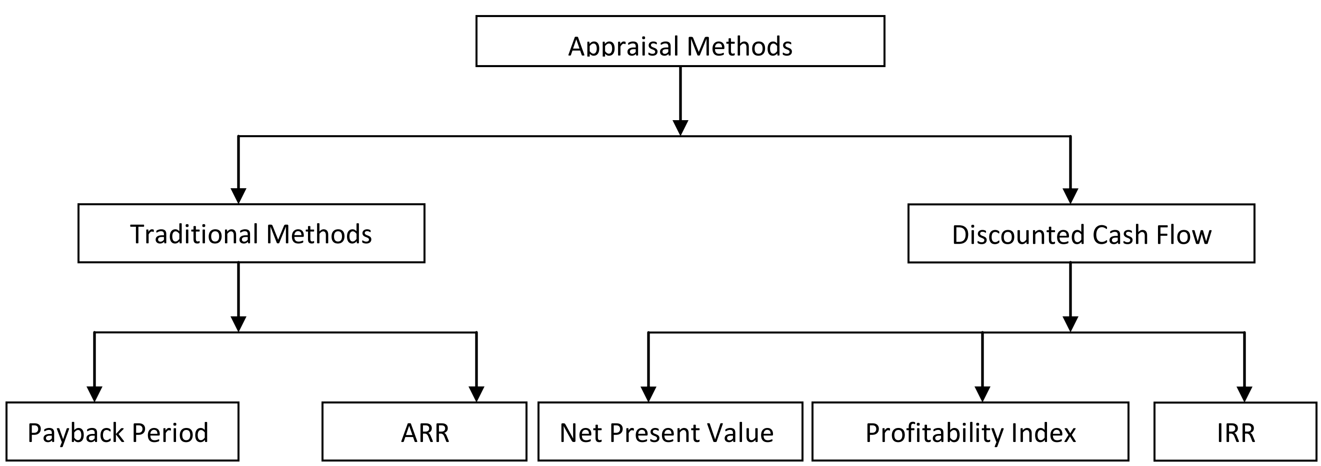

Fig 2.1 Different Appraisal Methods

2.5.1 TRADITIONAL METHODS

2.5.1.1 PAYBACK PERIOD METHOD

The payback method sometimes called as payoff method is a traditional method of capital budgeting. It is the simplest and most widely employed quantitative method for apprising capital expenditure decisions. This method is based on the principle that every capital expenditure pays itself back within a certain period out of the additional earnings generated from the capital assets. Thus the pay-back method measures the number of years required for cash benefit to payback the original outlay.

In case of evaluation of single project, it is adopted if it pays back for itself within a period specified by the management and if the project does not pay back itself within a period specified by the management then it is rejected.

The payback period can be determined in the following manner:

(i) Calculate annual net earnings (profits) before depreciation and after taxes; these are called annual cash inflow.

(ii) Divide the initial outlay (cost) of the project by the annual cash inflow, where the project generates constant annual cash inflows.

$$\text{Pay back period} = \frac{\text{Cash outlay of the project}}{\text{Annual cash inflow}}$$

(iii) When the annual cash inflows are unequal the payback period can be found by adding up the cash inflows until the total is equal to the initial cash outlay of the project.

Advantages of payback period method:

(i) Simple to understand and easy to calculate.

(ii) It saves cost, require less time and labour as compared to other methods of capital budgeting.

Disadvantages of Pay-back period method:

(i) It does not take into account the cash inflows earned after the payback period hence true profitability of the project cannot be assessed.

(ii) This method ignores the time value of money and does not consider the magnitude and timing of cash inflows.

2.5.1.2 ACCOUNTING RATE OF RETURN METHOD

This method takes into account the earnings expected from the investment over their whole life. Under this method accounting concept of profit, profit after tax and depreciation is used rather than cash inflows.

$$\text{ARR} = \frac{\text{Average income after taxes and depriciation}}{\text{Average investment over the life of the project}} \text{ X } 100$$

Advantages:

(i) It is simple to understand and easy to operate.

(ii) It uses the entire earnings of a project in calculating rate of return and not only the earning up to the payback period.

(iii) As the method is based upon accounting concepts of profits, it can be readily calculated from the financial data.

Disadvantages:

(i) This method ignores the time value of money.

(ii) It does not take into consideration the cash flows which were more important than the accounting profits.

(iii) It ignores the period in which the profits were earned.

(iv) This method cannot be applied to a situation where investment to a project is to be made in parts.

2.5.2 DISCOUNTED CASH FLOW METHODS

2.5.2.1 NET PRESENT VALUE (NPV)

A variation of the present value decision criterion is NPV. NPV is defined as the summation of the present value of cash proceeds in each year minus the summation of present value of the cash outflows in each year.

$$\mathrm{NPV} = \left(\frac{P_1}{(1+i)} + \frac{P_2}{(1+i)^2} + \cdots + \frac{P_n}{(1+i)^n}\right) - P$$

Where,

$P_1, P_2, \ldots P_n$= Cash inflows of 1st, 2nd and nth year.

P= Cash outlay

i = discounting rate

2.5.2.2 INTERNAL RATE OF RETURN

The second discounted cash flow method or time adjusted method for capital budgeting is the internal rate of return method. This technique is also known as yield on investment, marginal efficiency on capital or so on. While arriving at the required rate of return for finding out present values the cash flow, inflow as well as outflow are not considered. It depends on the initial outlay and the cash proceeds of the project.

It is the rate of return which equates the aggregate present value to net cash inflows. It is the rate at which NPV=0

$$\sum \frac{P_n}{(1+i)^n} - P = 0$$

Where,

$\sum \frac{P_n}{(1+i)^n}$ = discounted cash inflows of different years.

P = initial cash outlay

2.5.2.3 PROFITABILITY INDEX METHOD

It is also a time adjusted method of evaluating the investment proposals. Profitability index is also called benefit cost ration or desirability factor is the relationship between present value of cash inflows and the present values of cash outflow.

$$\text{Profitability Index} = \frac{\text{Present value of cash inflows}}{\text{Present value of cash outflows}}$$

The profitability index may be found for net present values of inflows.

$$\text{P.I. (net)} = \frac{\text{NPV}}{\text{Initial cah outlay}}$$

CHAPTER: 3

CONCEPT OF COST

The term 'cost' means the amount of expenses [actual or notional] incurred on or attributable to specified thing or activity. As per Institute of cost and work accounts (ICWA) India, Cost is measurement in monetary terms of the amount of resources used for the purpose of production of goods or rendering services.

3.1 COST OF PRODUCTION

The costs of production include:

i. Purchase cost of raw materials, bought out components and subassemblies, procurement and transportation costs.

ii. Purchase cost of supplies such as oils, lubricants, tools of small value, fuel oil, machinery spares etc.

iii. Wages and salaries paid to direct production workers, maintenance inspection, stores staff, supervisors and other staff.

iv. Costs paid to subcontractors for the orders placed on them

v. Cost of production line rejections, wastages, spoilage and rework

vi. Interest on working capital to the extent it relates to inventory

vii. Cost of procurement of capital assets like machinery, equipment and depreciation of these capital assets.

3.2 CLASIFICATION OF COSTS

3.2.1 NATURAL CLASSIFICATION OF COSTS

This classification refers to the basic physical characteristics of the cost. In any production organization the total cost of product include the following five elements:

3.2.1.1 DIRECT MATERIAL

Direct material refers to the cost of materials which become a major part of the finished product. The following groups of materials come under direct material:

i. All materials purchased for a particular job, process or product

ii. All materials acquired from stores for production

iii. Components or parts purchased or produced

iv. Material passing from one process to another process

3.2.1.2 DIRECT LABOUR

Direct labour is defined as the labour associated with workers who are engaged in the production process. It is the labour costs for specific work performed on products that is traceable to the end products.

3.2.1.3 DIRECT EXPENSES

The expenditure incurred (other than direct material or direct labour) on a specific job or product is included in direct expenses.

3.2.1.4 FACTORY OVERHEADS

These are also called manufacturing costs. These include the costs of indirect materials, indirect labour and indirect expenses:

i. Indirect material refers to materials that are needed for the completion of the product but it is not possible to trace or identify it with finished product.

ii. Indirect labour refers to the labour hours expended which will not directly affect the composition or construction of the finished product.

3.2.1.5 DISTRIBUTION AND ADMINISTRATIVE OVERHEADS

Distribution overheads are also called marketing or selling overheads. These costs include advertising, salesman salary and commissioning, packaging, storage, transportation and sales administrative costs. Administrative overheads include costs of planning and controlling of general business operations.

3.2.2 CLASSIFICATION BASED ON ACTIVITY OR VOLUME

3.2.2.1 FIXED COST

The costs which do not change for a given period in spite of change in volume of production are called fixed costs. Examples of fixed costs are rent, taxes, salaries, depreciation, insurance etc. Fixed costs are normally expressed in terms of time period e.g. per day, per annum etc. the concept of fixed cost is associated with short run.

3.2.2.2 VARIABLE COST

Variable cost varies with the variation in output. They are a function of output. Direct material cost and direct labour cost are generally variable cost. Variable cost includes cost of raw materials, running cost on fixed capital such as fuel, repairs, routine maintenance.

3.2.2.3 MIXED COST

Mixed costs are made up of fixed and variable costs. They are combination of semi variable and semi-fixed costs. Because of variable component, they fluctuate with volume, because of fixed component; they will not change in direct proportion to output.

3.2.3 COST FOR ANALYTIC AND DECISION MAKING

3.2.3.1 SUNK COST

It is an expenditure for equipment or productive resources which has no economic relevance to the present decision making process.

3.2.3.2 OPPORTUNITY COST

Opportunity cost is defined as the benefits lost by rejecting the best competing alternative to the one chosen. The benefit lost is usually the net earnings or profits that might have been earned from the rejected alternative.

3.2.3.3 CONTROLLABLE AND NON-CONTROLLABLE COSTS

A controllable cost is the cost over which a manager has direct and complete decision authority. A cost which cannot be influenced by the action of the specified member of an organization is referred to as uncontrollable cost.

CHAPTER: 4

BREAK EVEN ANALYSIS

The break-even point for a product is the point where total revenue received equals the total costs associated with the sale of the product. A break-even point is typically calculated in order for businesses to determine if it would be profitable to sell a proposed product, as opposed to attempting to modify an existing product instead so it can be made lucrative. Break even analysis can also be used to analyze the potential profitability of an expenditure in a sales-based business.

Break-even analysis is a technique widely used by production management and management accountants. It is based on categorizing production costs between those which are "variable" (costs that change when the production output changes) and those that are "fixed" (costs not directly related to the volume of production).

Total variable and fixed costs are compared with sales revenue in order to determine the level of sales volume, sales value or production at which the business makes neither a profit nor a loss (the "break-even point").

4.1 ASSUMPTIONS

1. Selling prices will remain constant at all sales level.
2. There is a linear relationship between sales volume and costs.
3. The costs are divided into two categories –fixed cost and variable cost.
4. Production and sales quantities are equal.
5. No other factors will influence the cost except the quantity.

4.2 BREAK EVEN POINT

$$\text{Break Even Point} = \frac{\text{Total Fixed Cost}}{\text{Selling Price per unit of production} - \text{Variable cost per unit of production}}$$

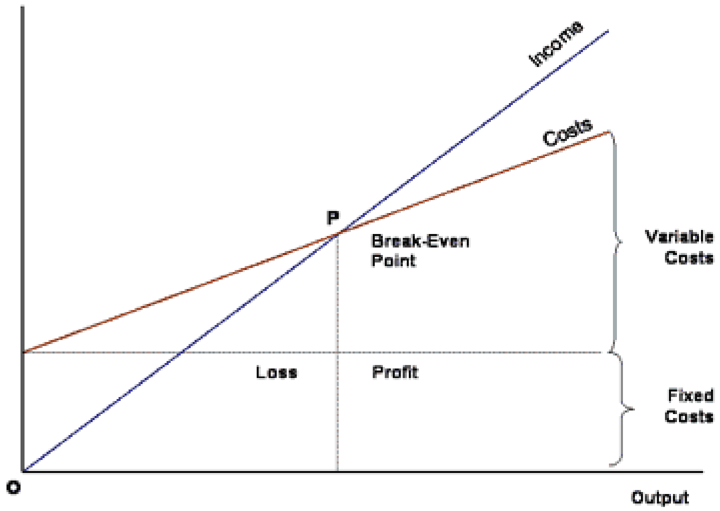

Fig. 4.1 General Graph of Break Even Analysis

4.3 LIMITATIONS

- Break-even analysis is only a supply side (*i.e.* costs only) analysis, as it tells you nothing about what sales are actually likely to be for the product at these various prices.
- It assumes that fixed costs (FC) are constant
- It assumes average variable costs are constant per unit of output, at least in the range of likely quantities of sales. (*i.e.* linearity)
- It assumes that the quantity of goods produced is equal to the quantity of goods sold (i.e., there is no change in the quantity of goods held in inventory at the beginning of the period and the quantity of goods held in inventory at the end of the period).

- In multi-product companies, it assumes that the relative proportions of each product sold and produced are constant (*i.e.*, the sales mix is constant).

CHAPTER: 05

BREAK EVEN CALCULATIONS

5.1 BREAK EVEN CALCULATION OF BOLANI IRON ORE MINES

5.1.1 GENERAL DESCRIPTION

Bolani ores mine is located 10 km west of Barbil in Champua subdivision of Keonjhar district of Orisa, adjoining the boundary of Singhbhum district of Jharkhand. It is spotted in the survey of India topo sheet no 73 F /8. The total mining leasehold area of Bolani is 12 sq miles.

Fig 5.1 Bolani Mines

Bolani ores mines were developed in the year 1960 to cater to the requirements to Durgapur Steel Plant. In November 1978, the mine was taken over by the Government of India and transferred to SAIL. Presently Raw Materials Division (RMD), unit of SAIL, is operating the mines. The main iron ore mining area is confined within 5.1 square miles, whereas the ancillary facilities viz. tailing dam, tailing disposal system, iron stock piling, loading and unloading activities, railway siding, housing colony etc are confined within 6.90 sq miles area. The geology of the area belongs to the banded iron formation of iron ore group of Precambrian age having the following ore types: Hard massive/ Hard Laminated, Laminated, Soft Laminated (aluminous), Soft Laminated (Siliceous), and Blue Dust and Lateritic ore. The wastes are: Laterite, shale and phyllites. Estimated ore reserve is about 157.00 MT with an average Fe content of 63 %.

Mechanized mining confined to “F” area and “G” area

Bolani Ores Mines has all the infrastructure and service facilities required for a large sized, fully mechanized opencast mining. These include well equipped workshops for earth moving equipment, mobile equipment, track mounted equipment, vehicles and electrical repair shops, power station, pump houses for industrial and domestic water supply including reservoir treatment plants, site offices, administration offices, telephone exchanges, stores for spares, fuel oil stores, first aid station, canteen etc.

A Centralized Base Repair Shop (CBRS) exists at the Hill Top Complex to cater maintenance and repair needs of heavy earth moving equipment of entire Bolani ores mines. Apart from the CBRS, a well equipped machine shop and equipment repair bay is provided at G –area.

There is also a Light Vehicle Repair Shed for repair and maintenance of all light vehicles used at the Bolani Ores Mines.

5.1.1.1 YEAR WISE QUALITY OF IRON ORE LUMPS

Table 5.1 Year Wise Quality of Lumps for Bolani Mine

YEARS	DESPATCHED QUALITY OF IRON ORE		
	Fe %	**Al_2O_3%**	**SiO_2 %**
2000-01	62.92	2.49	1.82
2001-02	62.82	2.25	1.75
2002-03	63.05	2.05	1.85
2003-04	63.11	1.85	1.93
2004-05	63.01	2.27	1.95

5.1.1.2 YEAR-WISE QUALITY OF IRON ORE FINES

Table 5.2 Year Wise Quality of Fines of Bolani Mine

YEARS	DESPATCHED QUALITY OF IRON ORE		
	Fe %	**Al_2O_3%**	**SiO_2 %**
2000-01	62.92	2.49	1.82
2001-02	62.82	2.25	1.75
2002-03	63.05	2.05	1.85
2003-04	63.11	1.85	1.93
2004-05	63.01	2.27	1.95

5.1.1.3 LIST OF MAJOR EQUIPMENTS

Table 5.3 List of Equipments at Bolani Mine

TYPE OF EQUIPMENT	MAKE/MODEL	CAPACITY	HP/KW	Nos. in fleet
Diesel powered hydraulic shovels	DEMAG HM H-121-D	5.5 cu m	720 HP	1
Diesel powered hydraulic shovels	BEML PC-1000-1 (D)	4.6 cu m	542 HP	1
Diesel powered hydraulic shovels	BEML BE -1000	4.6 cu m	542 HP	3
Electric powered rope shovels	HEC -A	4.6 cu m	250 KW	2
Dumpers-50T	BEML- HP LW-50	50 tones	635 HP	3
Dumpers-50T	BEML 210 M	50 tones	650 HP	6
Dumpers-50T	CATERPILLAR 773-D	50 tones	650 HP	2
Dumpers-50 T	BEML-BH-50 M	50 tones	635 HP	2
Water -sprinkler	BEML HP LW-3	28,000 liters	380 HP	2
Drills (Diesel powered)	IR-ROTOCOL-HYD	150 mm dia	400 HP	2
Drills (Diesel Powered)	IDM-30-ATLAS COPCO	150 mm dia	400 HP	2
Dozers	BEML D355A-3		410 HP	3
Dozers	BEML D355		410 HP	3
Dozers	BEML D155 A		320 HP	1
Motor Grader	BEML GD 605-R2		145 HP	1
Motor Grader	BEML BG-825		145 HP	1
Wheel Loaders (for loading of Rail Wagons)	BEML WA-400	3.1 cu m	197 HP	5
Wheel Loaders (for loading of Rail Wagons)	SEM ZL -60G SHANGDONG	3.3 cu m	234 HP	5

Crane	Coles Husky 640 M	40 tones	180 HP	1
Crane	Escorts	8 tones	49 HP	1

5.1.2 BREAK EVEN CALCULATION

5.1.2.1 VARIABLE COST

Table 5.4 Variable Cost for Bolani Mines

Cost head	Cost for 2 MT(in Rs)	Rs/tn
Annual explosive cost	1,85,00,000	9.25
Diesel, Petrol, Lubrication	8,31,00,000	41.55
Stores and spares	1,00,00,000	55
Power	7,85,00,000	39.25
Repair and Maintenance	4,21,00,000	21.05
Labour	59,00,00,000	295
TOTAL		461.1

5.1.2.2 FIXED COST

Table 5.5 Fixed Cost Of Bolani Mines

Sl. No.	Cost head	Rs.
1.	Equipments	4,03,30,50,000
2.	Haul Road	54,78,00,000
3.	Buildings	81,63,50,000
4.	Electrical systems	3,18,00,000

5.	Engineering and management	1,10,26,50,000
6.	Working capital and contingencies	1,35,58,50,000
Total		7,88,75,00,000

5.1.2.3 CALCULATIONS

Selling price of Iron/tn =Rs2368

$$\text{BEP} = \frac{\text{Total fixed cost}}{\text{selling price per unit} - \text{Variable cost per unit}}$$

$$= \frac{7{,}88{,}75{,}00{,}000}{2368 - 461.1}$$

= 4136294.509 tons

= 4.13 MT

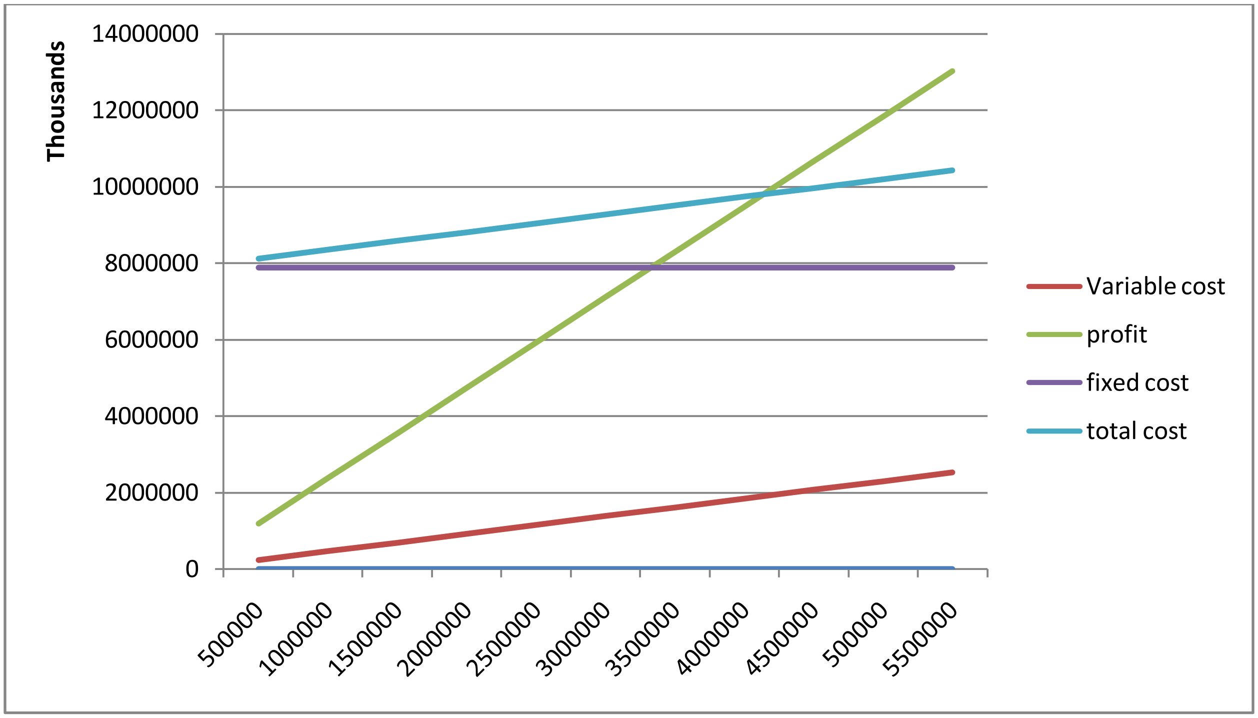

Fig 5.2 Graph of Break Even for Bolani Mines

5.2 BREAK EVEN CALCULATION OF SURDA MINES.

5.2.1 GENERAL DESCRIPTION

Indian copper complex (ICC) include six underground copper mines i.e Mosabani, Pathargara, Dhobani, Kendadih, surda and Rakha in Ghatshila area .These mines of the complex served by common services from Mosabani as detailed below:

- Electricity(power supply) and electrical workshop
- Mechanical maintenance and workshop
- Survey, geology, exploration, mine planning and quality control
- Civil maintenance and drinking water supply
- Hospital, civic amenities and transport

ICC has three concentrator plants in the area as follows:

- Mosabani -2700 tpd capacity
- TPSB -1000 tpd capacity
- Rakha -1000 tpd capacity

The smelter complex at Maubhandar has several plants, comprising of,

Flash smelter

Electrolytic refinery

Nickel Sulphate recovery plant

- Sulphuric acid plant
- Precious metal recovery plant

This Maubhandar plant produced blister copper, cathodes, wire bar and rolled products of copper along with sulphuric acid, nickel sulphate, selenium, silver,gold etc. as by products.

As per Indian Bureau of Mines, Govt. of India (2004), the resources of copper in Singhbhum Copper Belt (include ICC) is estimated to be 112 million tones with about 1% copper content. This accounts for 24% of total resources of this metal in the country i.e. 1.12 million tones of metal. As such, this area still continues to be a potential zone for mining of ore and extraction of copper.

5.2.1.1 NAME AND LOCATION OF MINE.

Name – Surda Mine.

Location - Surda mine is located at latitude 22 dregrees 35 minutes 17 seconds East and longitude 86 degree 26 minute and 4 second North. Mine is at distance of 11 km from Ghatshila Railway Station on Howrah-Bombay main line and 6 km from Maubhandar smelter and township of HCL.

5.2.1.2 SURFACE AREA, TOTAL ESTIMATED RESERVE IN MILLION TONNES.

Table 5.6 Reserves of Surda Mine

CATEGORY	RESERVE IN MILLION TONNES	GRADE % OF COPPER
Proved	4.93	1.20
Probable	3.66	1.20
Possible	10.71	1.14
Total	19.30	1.17

In the northern side of Surda mines, additional Geological resources of 6.79 million tones have been assessed by only drilling. This has not been confirmed yet and can be back up resource for future. Along with this the continuation of ore zone at depth proved by explorations would ensure adequate resources for future enhancement of production capacity of mine.

5.2.1.3 ADDITIONAL POTENTIAL RESOURCES

Table 5.7 Potntial Resources of Surda Mines

CATEGORY	RESRVE IN MILLION TONNES	GRADE % OF COPPER
PROVED	3.33	1.30
PROBABLE	2.28	1.29
POSSIBLE	1.08	1.27

Level and category wise estimated 19.3 million tones reserves and its lode wide distribution in different levels are placed in the given table

5.2.1.4 LODE WISE RESERVE IN LEVELS 4 TO 14 LEVEL IN MILLION TONNE.

Table 5.8 Load Wise Reserve of Surda Mines

LODE	TOTAL RESERVE 4^{TH} TO 14^{TH} LEVEL	11^{TH} LEVEL	12^{TH} LEVEL	13^{TH} LEVEL	14^{TH} LEVEL	TOTAL RESERVE 11^{TH} TO 14^{TH} LEVEL
HW	4.82	0.60	0.62	0.61	0.61	2.44
HW1	0.44	0.05	0.05	0.05	0.05	0.20
INTER LODE	1.82	0.14	0.14	0.14	0.14	0.56
Int. 1	0.11	-	-	-	-	-
FW	3.93	0.41	0.42	0.43	0.43	1.69
MERGED 1	1.73	0.55	0.39	0.34	0.34	1.62

HW AND INT.	6.45	1.12	1.12	1.12	1.12	4.48
TOTAL	19.30 in all lodes.	2.87	2.74	2.69	2.69	11.0

Out of 11.0 million tones within 11th to 14th levels, 9.2 million tones is in possible category and about 1.78 in probable category. Hence proving of these resources to higher confidence level is essential for future operations. Further, besides explorations planning and executions of development activities are very much necessary for both initial starting and also future, which is to be taken up simultaneously.

5.2.1.5 LIFE OF MINE.

- 28 Years.

5.2.1.6 AVERAGE MONTHLY OUTPUT

- Approximately 30, 000 Tones.

5.2.1.7 GEOLOGY OF THE AREA

- Copper deposits are located in the well defined shear zone between Chaibasa and Dhanjori stages of Iron Ore Series.
- Shearing coupled with silicification, felspathisation, tourmalisation and other metasomatic activities have resulted to a large extent in converting Dhanjori lavas biotite-chlorite-quartz-schists and associated rocks.
- The copper minerlisation is attributed to remobilization from Dhanjori lavas which have been deposited to form ore bodies in sheared and metasomatically altered schists and granites.
- Major rock types from hanging wall to foot wall are mica schists and phyllites, quartz-biotite-chlorite schists, metavolcanics, quartzites, granite felspathic schists etc.
- Though there are no major folds, minor folds in dip direction are common resulting in rolls of the ore body between levels.

- The N-S joints are with steep dip of 60 degrees to 70 degrees. Two transverse faults observed cutting across the strike having not dislocated the ore bodies.
- Medium to coarse crystalline chalcopyrite is the major copper mineral followed by pyrite, pyrrohotite and pentalandite.
- Within the shear zone intensity of mineralization is variable.
- Narrow zones of rich mineralization following closely spaced shears are termed as lodes.
- These lodes are mostly comfortable to the dip of host rocks.
- The lodes are mostly comfortable to the dip of host rocks.
- The lodes have generally sharp contacts along the hanging wall and foot wall.
- Very little disseminations outside the ore body are observed.
- There are 3 main lodes i.e. hanging wall, inner, and foot wall. Out of this footwall is prominent one.
- In the central and bottom sections of the mine, number of shoots with intervening lean zones have merged to form a wide ore zone of about 20 meters.
- At places this zone helps in bulk mining.
- The average width of the lodes in the mine is about 5.08 meters.
- The exploration conducted in the area include surface and underground diamond drilling followed by mine development and exploratory drives , winze and cross cuts.
- The bore hill drilled is mostly inclined with average depth of 300 meters and maximum up to 959.35 meters

5.2.1.8 LEVEL WISE RESERVES

Table 5.9 Level Wise Reserves of Surda Mine

LEVEL	PROVED	PROBABLE	POSSIBLE	TOTAL	PROVED AND AVAILAIBLE
4	0.24	0.04	-	0.28	0.23
5	0.42	0.15	-	0.57	0.41
6	0.71	0.17	-	0.88	0.69
7	0.85	0.32	0.07	1.24	0.81

8	0.88	0.27	0.27	1.42	0.82
9	0.75	0.31	0.44	1.50	0.69
10	1.06	0.63	0.72	2.41	0.93
11	0.01	1.54	1.32	2.87	0.01
12	-	0.09	2.66	2.75	-
13	0.01	0.07	2.61	2.69	0.01
14	-	0.08	2.61	2.69	-
TOTAL	4.93	3.67	10.70	19.30	4.60

5.2.1.9 MECHANICAL, ELECTRICAL ACCESSORIES.

Table 5.10 Mechanical and Electrical Accessories

Sr. No.	ITEM
1	Pipe line and dewatering
2	Refilling line and sand stoping line
3	Air pipe
4	Hoisting chutes
5	Ore bin chutes
6	Mine cars
7	G.B Car
8	Rails for shaft
9	Rail
10	Ore pass ring.
11	Cement
12	Filling tank
13	Mill tailing
14	Wooden sleeper for rail line
15	Explosive Magazine

16	Explosive Van
17	4000KW motor
18	KG Khosla 3500 CF motor
19	1500 CFM screw compressor motor
20	Cooling Tower
21	Overhead line
22	Lighting arrangement for 33KV substation and Yard.
23	Surface winder
24	Drills
25	Loco battery

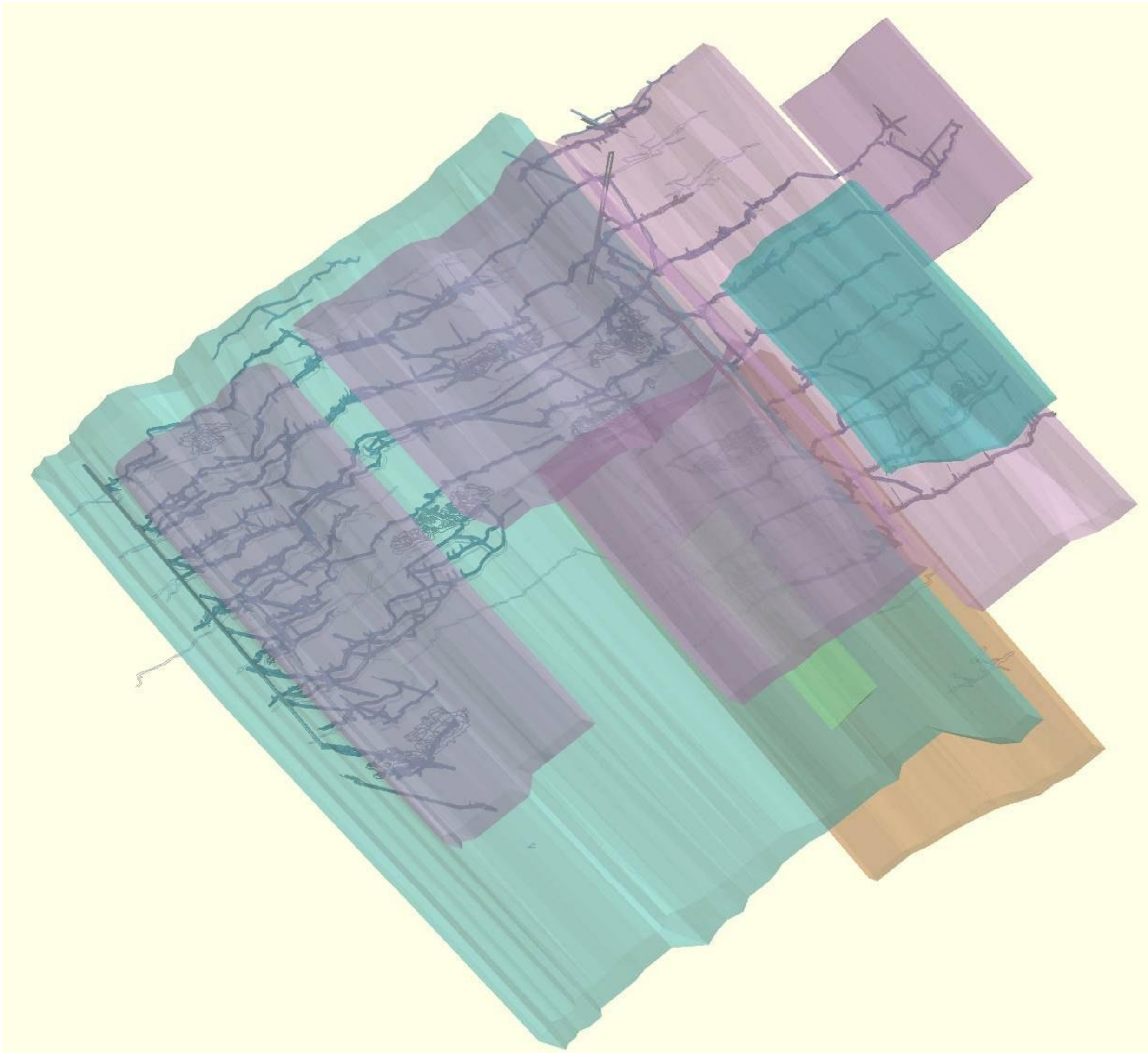

Fig 5.3 Oblique View From The South East Of Surda Wire framed Lodes. The Main Lode Is Pink In Colour, Hanging Wall Lode Orange, Footwall Lode Blue And SDH8 Lode Green

5.2.1.10 UNDERGROUND METHOD

- The underground Surda Mine is served by shafts from the surface i.e. No. 4 from southern side and No. 3 vertical shaft from central part.
- At the close proximity of the vertical shaft No. 3 There is sub incline shaft from 5^{th} level to 13^{th} level.

- Both the shafts are equipped with winders for movement of man, material and ore. Stopping activities of the mine are spread over different area.
- Development plans have already been prepared in blocks for future working of the mine.
- Stoping operations are planned for the ore zone at 1.5 to 20 meters thick with dip 35-40 degrees as indicated below:
- Room and pillar stoping for the ore zone with thickness varying from 1.5 to 4 meters.
- Cut and fill (HCF) for ore thickness between 4 to 6 meters
- Post and pillar (pp) for ore thickness more than 6 meters.

5.2.1.11 DETAILS OF MINING SYSTEM

5.2.1.11.1 MACHINERY

- Drilling
- Fan cut, wedge cut and burn cut are practiced.
- Drill rod is 2.5 to 3 meters long and drill rod diameter is 75 mm.
- Hydraulic feed mechanism is practiced
- Diamond drill bit is used.
- Diesel is the source of energy.
- Drill rate is 0.5 meters per minute.

5.2.1.11.2 PUMPING

Table 5.11 Pumps at Surda Mines

Pumps		
(1) 100 Hp	3	Can be managed with repair, spares required for emergencies.
(2) 75 Hp	2	Do
(3) 40 Hp	1	Do

(4) 20 Hp	2	Do

- Three pumps of 5th level near shaft No.3 pump out (1800lit/min) total water to outside, which is used for back filling of tailings or left to nature drains.
- Water from all levels above 5th level is collected at sump of 5th level; water from 6th to 10th level is collected at 10th level and water from 10th to 13th level is pumped to 10th level.
- Total water at 10th level is then pumped to 5th level for discharge.
- Adequate pumping and power supply system is in operation.
- Three types of pumps Face pumps, Stage pumps, Main pumps.
- Face pumps has a capacity 5 to 15 h.p, 50 mm suction and delivery pipe, with capacity of 250 to 450 liter per minute. Rotor pumps are used.

5.2.1.12 EXPLOSIVES AND BLASTING PRACTICES

5.2.1.12.1 PATTERN OF HOLES, LENGTH AND DIAMETER OF HOLES

- Wedge cut, Burn cut, Fan cut are the drilling pattern
- The bore hole drilled is mostly inclined with average depth of 300 meters and maximum up to 959.35 meters.

5.2.1.12.2 TYPE OF EXPLOSIVES

Slurry explosive and emulsion explosives are used.

5.2.1.13 STATUS OF MINE

Surda mine was opened in 1930 at a modest scale which was suspended later on. Production was resumed again in 1956. It was the major producing mine before it was closed in July 2003. With a production capacity of 1300 tpd it was supplying ore to Mosabani Concentration Plant which was also closed down along the Surda mine. Exploration continued upto 2002 and development planning was made prior to closure. This plan even envisaged beyond 13th level at that time.

5.2.1.14 STOPE POSITION

Position of working fronts and stopes at different levels as per the status is given below.

1. 7L/600 HCF — 3X cuts are ready for mining, while for 3X cuts at south, filling is needed for further development. 1000 T materials are available at north side.

2. 9L/1000 HCF — Filling undergoing in 3X cuts (North side)
   Filling preparation to be done in South side
   Require cleaning.

3. 4L/4000 PP — Last 2X cuts available for mining
   Filling preparation is to be taken up.
   Require cleaning.

4. 5L/285 HCF — 2X cuts ready for mining and require cleaning.
   Filling is required. Substitute stope development is required.

5. 6L/300 HCF — Require cleaning
   Filling is required in 2X cut.

6. 8L/150 HCF — 1X cut available for mining
   Filling preparation is required.
   One new HCF will come at 8L/700 South Surda.

7. 9L/250 still — 2 Virgin X cuts and development face is available
   North side filling preparation is to be made.
   One more stope to come.

8. 10L/240 HCF 2 Cuts available for mining.
   Filling preparation is to be done in South.
   North side of 10^{th} to 13^{th} level load has to be developed.

9. 5L/600 HCF It is a clean face.
   Filling preparation and filling is to be done.

An observed immediate development work can start in 5^{th} and 8^{th} levels and subsequently in 4^{th} and 9^{th} and 10^{th} levels. Simultaneously other area for development has to be planned, besides preparation for filling.

5.2.1.15 MINE EQUIPMENT, MECHANICAL AND ELECTRICAL ACCESSORIES AND SERVICE FACILITIES REQUIRED.

5.2.1.15.1 MINING EQUIPMENT:

Table 5.12 Mining Equipments at Surda Mines

EQUIPMENT.	AVAILAIBLE.	MODIFICATION NEEDED.
Winders	3	Ropes to be checked and replacement of about 1600 meters would be required with 600 meters spare.
LHD	7	Can be managed as adequate no. present.
Cavos	3	Do
Rock breaker	3	Do
Loaders	10	Do
Drills	50	Do
Compressors	3	One new 3500 cfm compressor required for replacement.

DG set	2	One additional required for emergency.
Pumps (5) 100 Hp (6) 75 Hp (7) 40 Hp (8) 20 Hp	 3 2 1 2	 Can be managed with repair, spares required for emergencies. Do Do Do

5.2.1.16 PRODUCTION PLAN FOR SURDA MINES.

Table 5.13 Production Plan for Surda Mines

AFTER AWARD OF CONTRACT.	DEVELOPEMENT	POST PILLAR MINING	HOIZANTAL CUT AND FILL MINING	TOTAL
8th month	1000	4400	5000	10400
9th month	2000	8000	8400	18400
10th month	2400	8000	8000	18400
11th month	2400	4000	23600	30000
12th month	2400	-	25600	32000
13th month	2400	4000	27600	34000
14th month	3000	-	35000	38000

5.2.1.17 SCHEME OF OPERATION.

5.2.1.17.1 PRODUCTION TARGET

From 14th month onwards, there has to be steady production i.e 1300 tpd, to be achieved in 3 shifts operations and 350 working days. Besides 10 days major maintenance, about 6 to 8 hours periodical maintenance can be planned. The annual production target could be 450000 tonnes. This can be achieved with planning for timely maintenance and proper coordination. Even the daily production can be increased to achieve the overall target particularly after production shortages due to any unavoidable reasons for some period. Mine has adequate capacity to achieve this.

5.2.1.18 PROCESSING OF ORE FROM SURDA.

Earlier it had a capacity of 2700 TPD to process the ore from Surda as well as other mines. Efforts are being made to bring down its capacity to 1300 TPD due to close down of some mines in ICC.

5.2.1.19 QUALITY CONTROL

With average quality of 0.95% Copper in ore, the desired quality of ore indicated above would meet the requirement of concentration plant. However, besides the penalty and bonus clause, HCL has to ensure quality control, starting from planning to supply to the plant. The conservation aspect would be the total responsibility of HCL so that the contractor does not waste ore. These aspect have to be critically assessed and monitored.

5.2.1.20 TRANSPORTATION

Ore from mine to concentration plant to mines in return trip is being handled by trippers. Presently 15 trippers are in use.

5.2.1.21 MANPOWER

Total 354 workers besides 45 support staff for survey are present in mine. Geology, Civil, filling operation, explosive magazine and handling is carried out by these people. Another 100 are there employed contractually for electrical and mechanical maintenance. It is planned such that maximum manpower is below 500.

5.2.1.22 MANAGEMENT

Contractor shoulder the responsibility of making strong public relation and other statutory compliances for smooth operation of mines. Hence HCL monitors each and every activity with records submitted by contractor. For this purpose skeletal staffs of HCL are placed in mines. So contractor maintains adequate spares, essential items, emergency equipments etc. which has to be physically verified. Environment, health and safety aspects are to be regularly monitored as well.

5.2.1.23 OPERATING FLOW CHART

Jaw crusher for crushing of Chalcopyrite bearing ore from 100 millimeter to 12.5 millimeter.

Capacity – 100 TPH

Stage 1 – Cone Crusher for crushing +12.5 mm to 12.5 mm

Capacity – 100 TPH (3 lines

Stage 2 – Cone crusher for crushing +12.5 mm to 12.5 mm.

Capacity – 100 TPH (3 lines)

Wet grinding Ball mill – 4*50 TPD + 1*700 TPD

Spiral classifier – 4*500 TPD + 1*700 TPD

Thickener – No

Floatation Cell (3 cleaner cells + 1 scavenger cell) – 5 Lines

Vacuum plate filters – 2 Nos.

Copper concentrate

Fig 5.4 Flow Chart of Operation at Surda Mine

5.2.2 BREAK EVEN CALCULATION

5.2.2.1 VARIABLE COST

Table 5.14 Variable Cost of Surda Mines

Cost head	Cost for 450000 MT (in Rs)	Rs/tn
Repair and maintenance	1,56,00,000	34.66
Electrical	1,24,00,000	27.55
Mining operation spares and consumables	65,00,000	14.44
Explosives	1,00,00,000	22.22
Handling of tailing, preparation , filling	1,20,00,000	26.66
Labour	6,60,00,000	146.66
Water and energy duties	80,00,000	17.77
TOTAL		289.99

5.2.2.2 FIXED COST

Table 5.15 Fixed Cost of Surda Mines

Sl. No.	Cost head	Rs.
1.	Civil work and infrastructure	50,00,000
2.	Working capital and contingency	55,00,000
3.	Mine development	40,00,000
4.	Workshop	30,00,000
5.	Contract and securities	2,40,00,000

6.	Medical and welfare	1,00,00,000
7.	Safety requirements and statutory obligations	85,00,000
8.	Equipments	1,97,87,50,000
Total		2,03,87,50,000

5.2.2.3 CALCULATION

Selling price of Copper/tn =Rs. 3551

$$\text{BEP} = \frac{\text{Total fixed cost}}{\text{selling price per unit} - \text{Variable cost per unit}}$$

$$= \frac{2{,}03{,}87{,}50{,}000}{3551 - 289.99}$$

= 625189.74 tones

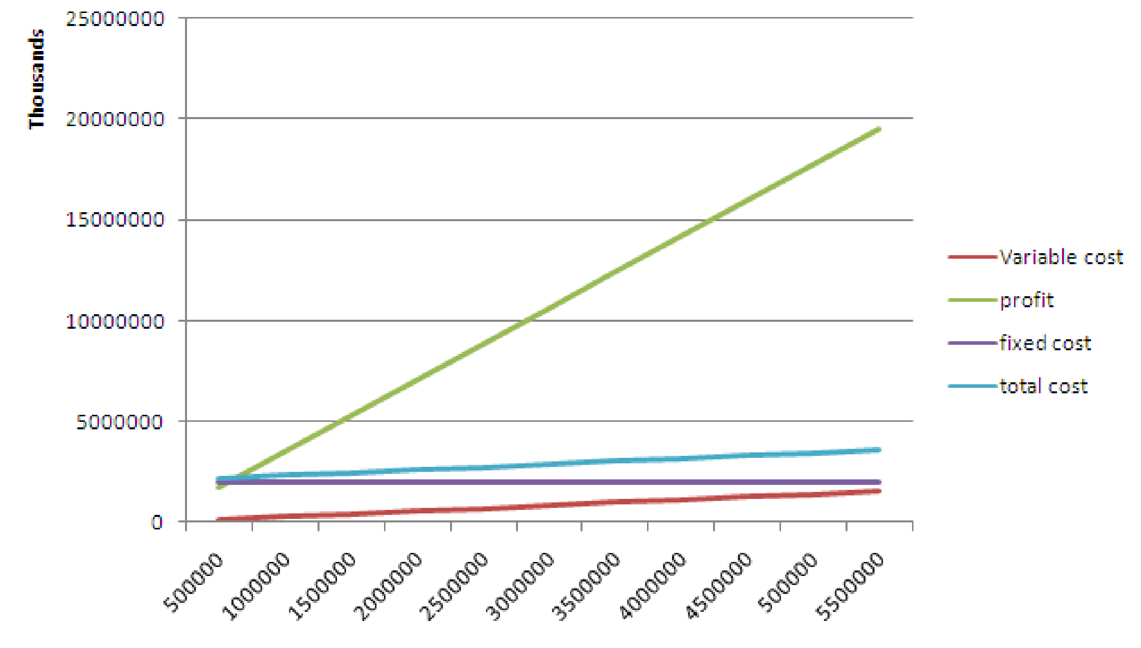

Fig 5.5 Graph Of Break Even For Surda Mines

CHAPTER: 06

DISCUSSION AND CONCLUSION

Break-even point for Bolani Ores Mines is calculated to be 4.13 MT. So it will take 26 months and 15 days to break-even at a yearly production rate of 2 MT.

Break-even for Surda Mine is found to be 625189.74 tn. It will take 16 months and 20 days to break-even after starting the production at a yearly output rate of 450000 tn.

Time taken to break-even for Bolani is more than Surda because as compared to Bolani whose life is around 75 years life of Surda mine is less, only 28 years.

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