Quarry Optimisation

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SUMMARY

Increased competition and the spiraling cost of cement production are leading cement manufacturers to identify avenues for reducing costs of input materials. Better quarry management offers significant opportunities for raw material cost reduction which is directly reflected in the minimization of the overall cement production cost. Sound quarry management practices can lead to increased deposit life, improvement in mine productivity, improvement in equipment performance, better maintenance practices, better manpower utilization, etc.

Mining cost is governed by various sub activities, viz. drilling, blasting, excavation, reject handling, etc. This paper outlines the approach used for identification of cost influencers for each activity and evaluation of their impact on cost of mining operations through benchmarking and discounted cash flow technique followed by identification of action plans to optimize mining operations. Case study of a Mine Optimization study carried out for a limestone mine in central India is presented.

1. INTRODUCTION

Cement manufacturers are constantly making efforts to reduce cement production cost. Efficient quarry management is also identified as an important component of cement manufacturing process which offers a vast potential for cost reduction. Holtec Consulting has carried out quarry optimization for a number of limestone quarries whereby various components of mining activity are identified as key influencers. The activities are then studied individually and evaluated for their potential for improvement by comparing them with the relevant activities of other similar geographical and geological conditions. The impact of each improvement potential of each activity is then quantified into savings per tonne of raw material.

2. METHODOLOGY

The various components contributing to cost optimization in quarry operations as identified by Holtec are:

- Identification of Objective
- Identification of improvement area
- Data collection
- Situation analysis
- Identification of cost heads & development of Activity-Cost Head matrix
- Bench marking
- Strategic actions
- Action plans

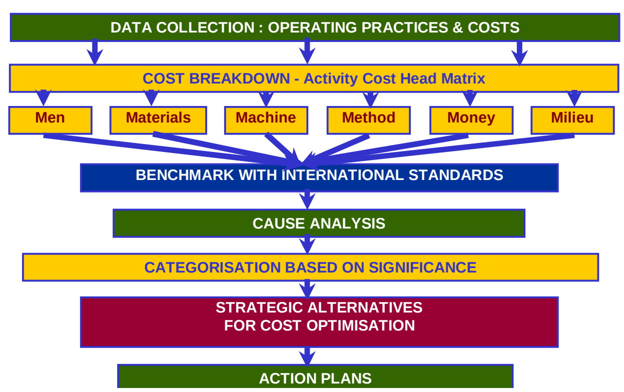

Figure 1: Components of Cost Optimization

2.1 Identification of Objective

The first step in the process of cost optimization in quarry operations is to identify the objective since the focal point and priorities of each quarry are different. The basic objectives can be broadly quantified in terms of the major outcomes like optimal utilization of raw material for longevity of deposit life, mine planning and mining infrastructure, equipment productivity/ performance, consumables, maintenance practices, material handling, manpower, and cost.

The above objectives are fulfilled using the steps detailed ahead.

2.2 Identification of Improvement Area

A preliminary assessment of mining operations is essential to study the various activities leading to identification of potential areas for improvement and their impact on cost. The assessment and evaluation of operating data is carried out for activities including mine planning, drilling, blasting, excavation, transport, repair and maintenance, reject handling, etc.

The outcome of this first hand assessment is analyzed and verified at site and compared to the other mines located in similar geographical and geological conditions. The potential area(s) of improvement and cost saving are then identified.

2.3 Data Collection

Mine operation data for the past one to three years of mining operations including raw material characteristics, reserves, mode and method of mining, drilling and blasting parameters, performance and productivity of mining operations are collected. Time motion studies for drilling operations and excavator and dumper operations are also conducted during the course of data collection.

2.4 Situation Analysis

A detailed analysis of the data collected is carried out for all the mining activities for comparison of consistent performance measures to identify the achievable improvements, which could lead to an impact on overall production cost. For example, by analyzing planned hours, running hours and their availability, utilization and efficiency, productivity of mining equipment can be judged. Similarly, the MTBF (mean time between failure) and MTTR (mean time to repair) analysis is the indicator of the efficiency of equipment maintenance and their productivity. The situation analysis leads to the identification of areas for improvements and cost influencers that could facilitate the achievement of the cost reduction in the identified activities.

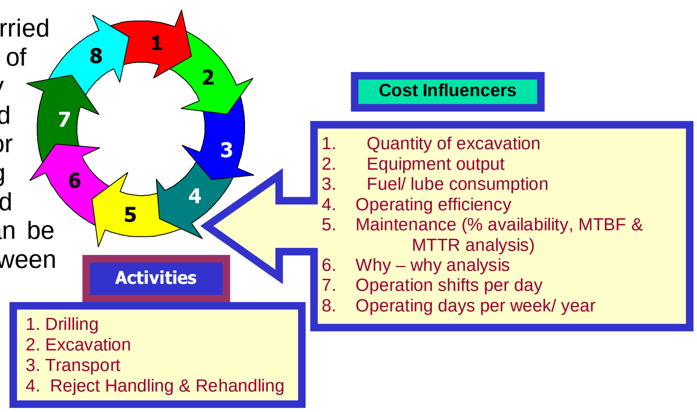

Figure 2: Situation Analysis

The root cause analysis of problem is carried out by application of Ishikawa analysis and why-why analysis to delineate the possible problems of the cost heads.

2.5 Identification of Cost Heads & Development of Activity-Cost Head Matrix

Analysis of the cost breakdown of individual mining activity is carried out and the areas for cost reduction are identified and ranked in order of their impact on cost so as to give immediate attention to improvement priorities.

A cost head matrix for all mining activities and cost components thereof is generated for comparison with other mines operating under similar conditions. The individual cost components with high cost are identified for potential cost reduction.

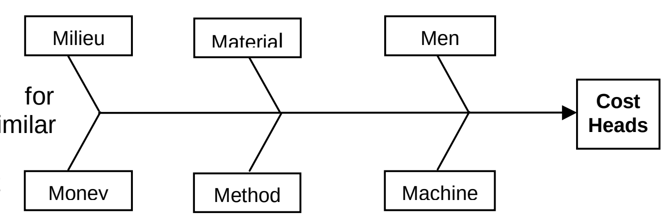

Figure 3 : Identification of Cost Heads

2.6 Bench Marking

Benchmarking is a method for improving and setting goals by comparison with another enterprise involved in similar activities. The performance data for each activity is compared with the corresponding data of each activity from the best operating mine in our database. The main components of bench marking in cost optimization study include drilling rate, drilling output, powder factor, diesel consumption of individual equipment, lubricant consumption, etc.

2.7 Strategic Actions

Various options for improvement are evaluated for areas that need improvement in some respect or the other. The evaluation of positive and negative implications of strategic actions leads to the formulation of actions for implementation.

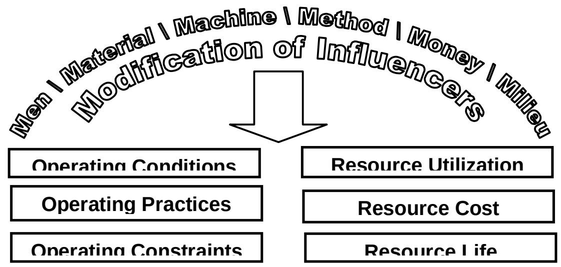

Figure 4 : Strategic Actions

2.8 Action Plans

Formulation, selection and prioritization of action plans in cost optimization is carried out for different scenarios. The Action Plan details the observations initiating the action plan, recommendation, its applicability, the expected benefits, the proposed timing for implications, the major job activities involved in its execution, its time frame, the capital investment involved, the payback period expected, etc.

3. CASE STUDY

Holtec Consulting has carried out a Quarry Optimization and Management Study for a leading cement plant of 2.0 million tonnes per annum capacity. The limestone mine under reference is located in the central part of India. Mining was started in 1993.

The limestone is marginal grade. About 99.5% of the raw mix comprises of Run-of-Mine limestone and balance 0.5% is iron ore. The inventory of the deposit in terms of quality and quantity of reserves in the form of block model is shown in Figure 5.

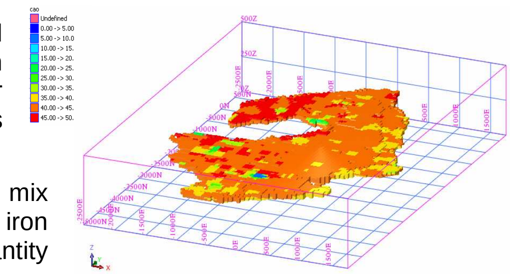

Figure 5 : Block Model of the Limestone Deposit

3.1 Data Collection

The actual mine data in respect of different mining parameters was collected and a time motion study was carried out. Data analysis for a few important parameters is summarized below:

3.2 Situation Analysis

Blasting: The powder factor is found to be highly variable.

Drilling: The yield per m is found to be low and there is 40% spare drilling capacity.

Excavation: The overall utilization and efficiency of excavators is low even though their availability is high. There is excess excavator capacity.

Transport: The average utilization and efficiency of dumpers is low and the workload on dumpers is unevenly distributed. The material handling by dumpers shows a highly variable pattern.

3.3 Activity-Cost Head Matrix

The cost of the limestone raising is influenced by various activities involved in the process. The cost for each activity is further governed by various sub-activities. The Activity-Cost Head Matrix developed is shown below.

Activity	Cost Head										
	Cost (‘000 USD)										Cost (USD) per tonne
	Store & Spares	Tyres	Explosives	Lubricants	General Consumables	Repair of Machinery & outside repair	Entertainment	High Speed Diesel	Miscellaneous	Total	
Drilling	26.7			9.33	0.55	7.4		73.4		117.35	0.05
Blasting	0.27	0.22	134.8		0.044	1.04		6.6		144.02	0.06
Dozing	4.38			1.51	1.95	2.27		14.6		24.73	0.01
Loading	96.35	2.67		17.93	6.67	9.13		146.3		279.04	0.12
Indirect loading	0.35	0.42			3.29	1.27	0.73			6.07	0.002
Limestone transport	122.67	45.11		13.0	4.2	25.04		178.69	0.73	389.4	0.17
Indirect transport	0.73	0.22		0.18	1.87	1.31				4.31	0.002
Limestone raising cost	251.45	48.42	134.8	41.95	18.58	47.46	0.73	419.59	0.73	964.92	0.424

The cost of limestone raising derived is compared and benchmarked against an optimally run mine in a similar geographical and geological condition.

3.4 Strategic Actions

After detailed analysis, a number of Strategic Actions for Implementation have been recommended, few of which are listed below.

Activity	Possible Improvement Actions	(+) Implications	(-) Implications
Raw Mix	Use of alternative corrective in the raw mix	▪ Saving per t of clinker ▪ Use of Overburden ▪ Decrease raw mix cost	▪ Segregated mining of alternative corrective
Mine Layout	Relocation of Crusher	▪ Decrease in lead distance from existing distance ▪ Saving in limestone transportation cost ▪ Use of substantial limestone blocked by existing crusher	▪ Payback period of 4 years
Drilling	Improvement in drilling rate	▪ Saving in cost/t of limestone	▪ Improved monitoring measures
	Change in drilling geometry	▪ Saving in cost/t of limestone ▪ Increased yield/m of drilling	▪ Improvement in monitoring of operations
	Induction of Top hammer hydraulic drilling machine	▪ Increased drilling rate	▪ High investment per machine
Excavation	Reduction in diesel consumption of excavators	▪ Saving in excavation cost	▪ Cost of engine improvements ▪ Cost of installation of auto idlers ▪ Planning and supervision efforts to minimize shifting and idling of excavators
Transportation	Reduction in diesel consumption	▪ Saving in transportation cost	▪ Cost towards improvement of loading area ▪ Close monitoring
	Induction of appropriate capacity trucks	▪ Low fuel consumption ▪ High productivity	▪ High Investment
Outsourcing of Services	Outsourcing of: ▪ Tyre Handling ▪ Engine overhauling ▪ Transmission line over-hauling ▪ Survey work ▪ ANFO mixing	▪ Saving in manpower cost	▪ Increased supervision ▪ Cost of outsourcing

3.5 Action Planning

Areas in which significant improvements could be effected, by virtue of the implementation of Action Plans are evaluated and the cost saving that could be derived after their implementation has been calculated. One such typical Action Plan for improvement in yield per metre of drilling is illustrated ahead.

ACTION PLAN

No	1	ACTION	Change in drilling geometry in successive steps	AREA	Drilling

OBSERVATIONS

- The existing drilling pattern is as follows:

Bench		Spacing (m)	Burden (m)	Remarks
I.	OB Bench	3	2.5	Limestone boulders with maximum soil
II.	Mixed Bench	4.5	3	Limestone with intercalated soil
III.	Limestone	6	4	Grey Limestone
IV.	Limestone	5.5	3.5	Grey Limestone
V.	Limestone	6	4	Grey Limestone
VI.	Marginal Limestone	6	4	Chocolate colour limestone

- The yield per meter of drilling is 41.21 t which is low compared to 65 t per machine of normal yield for similar deposit conditions

RECOMMENDATIONS

APPLICABILITY: Drilling and blasting

- Recommended drilling pattern in successive steps is as follow:

Bench		Spacing (m)	Burden (m)
I.	OB Bench	3	2.5
II.	Mixed Bench	6.5	4.5
III.	Limestone	6.5	4.5
IV.	Limestone	6	4
V.	Limestone	6.5	4.5
VI.	Marginal Limestone	6.5	4.5

- Demarcation of drill hole should be done by using measuring tape
- Uniform bench height for limestone benches No. III, IV, V and VI
- Drilling/ blasting engineer should ensure accurate blast hole depth and avoid excessive drilling
- Inclined drilling of 5^o to 7^o

EXPECTED BENEFITS

APPLICABILITY: Immediate

- The yield per hole shall be increased to 68.80 t per m in successive steps of drilling as follows:

Bench	Spacing (m)	Burden (m)
Spacing (Distance between two blast holes)	6 m	6.5 m
Burden (Distance between two blast rows)	4 m	4.5 m
Bench height	8 m	8 m
Sub grade drilling	0.5 m	0.5 m
Total drilling per hole	8.5 m	8.5 m
Specific gravity of insitu rock	2.5	2.5
Yield per hole	480 tonnes	585 tonnes
Yield per meter	56.47 tonnes	68.8 tonnes

- Increase in output per meter of drilling shall result in a saving of:
  - With initial target : USD 0.0135 / t resulting in saving of USD 40,667 per annum
  - After full optimization : USD 0.021 / t resulting in annual saving of USD 62,000 per annum

MAJOR JOB ACTIVITIES

PAYBACK (years): Investment is involved

- Computerized recording of drilling parameters
- Formulation of procedures to achieve the target
- Gradual change in drilling pattern in successive steps
- Demonstration blast to achieve optimal output

REMARKS

REFERENCE: Client supplied data

- The saving has been estimated considering the existing drilling cost of USD 0.05 / tonne of limestone

The cost head wise saving possible due to implementation of 18 Action Plans identified during the study is illustrated in Figure 6. An overall annual saving of 1,080,000 USD can be achieved in the mines.

4.0 CONCLUSIONS

Quarry management and cost optimization are continuous processes which have the potential to glean out the weak but important components of mining operations, address these issues, affect improvement and reap the benefits in terms of reduction in Cost /tonne of raw material.

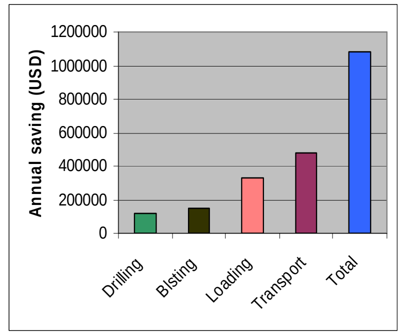

Figure 6 : Saving in annual operating cost